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JULIAN FERNANDEZ MEJIA

ESSAYS ON INTERNATIONAL FINANCE

CBS

Copenhagen Business School
Department of Economics

Essays in International Finance

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ØKONOMISK INSTITUT
COPENHAGEN BUSINESS SCHOOL

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Sincerely,
Julian Fernandez Mejia

December, 2023

Summary

Preceding the global financial crisis, the 1990s witnessed a series of currency crises alongside the formation of the European Union. These events fostered a trend towards market liberalization, facilitating the capital flows of different types of assets. many nations adopted floating exchange rates to grant increased autonomy to their Central Banks, consequently altering monetary policy regimes. This evolution in exchange rate mechanisms was intricately linked to the expanding global trade and financial markets.

The returns and volatility of these markets became crucial tools for policymakers, not solely in managing international trade but also in forecasting capital flow behaviors within the countries. As a result, exchange rates began to influence not only trade dynamics but also the vulnerability of economies to external shocks from the global international financial markets.

In this thesis, I present three chapters that explore the determinants, behaviors, and consequences of foreign exchange rate fluctuations on the economy. It focuses on interest rate parity deviations, extreme movements, and responses in capital flows. As part of the research, I investigate stablecoins, digital currencies designed to streamline transactions and overcome the volatility constraints of traditional exchange rates. These investigations align closely with the research agendas of International Finance and Financial Economics, offering valuable insights for academics, policymakers, and industry practitioners. The research employs modern econometric methods to analyze the fluctuations of both traditional and electronic currencies, revealing their sensitivity to external and internal factors. It also offers insights for establishing an efficient stabilization mechanism within the context of macroprudential policies.

Chapter I

In the first chapter, titled "Exchange Rate Uncertainty and Interest Rate Parity," I construct a measure of exchange rate uncertainty to explain deviations in the Covered Interest Rate Parity. By aggregating exchange rate fluctuations using clustering methods and factor models, I create an uncertainty measure that captures the structure and shocks within global economies. I find that exchange rates have become more homogeneous since the

global financial crisis, organizing into distinct structures and patterns that align with the global financial cycle hypothesis, trade, and geographical characteristics. With this measure, I demonstrate that exchange rate uncertainty partially accounts for deviations in the Covered Interest Rate Parity, particularly in the case of both Libor and Government Bonds markets, with the latter being more severely affected. The effect remains statistically and economically significant even after controlling for benchmark models.

Chapter II

The second chapter, titled “The Uncertain Exorbitant Privilege and Duty,” builds upon the findings of the previous chapter, utilizing exchange rate and macroeconomic uncertainties to demonstrate how shocks impact capital flows and explain the United States’ Net Foreign Asset Position. To identify the shocks in the model, I estimate a Vector Autoregressive model that combines external variables, narrative, and shock-dependent restrictions. Within the context of the United States economy, I demonstrate that an increase in both types of uncertainty reduces the deficit in the Net Foreign Asset Position, with the macroeconomic effect exerting a lasting influence. When considering the reciprocal effects of one uncertainty on another, I observe that macroeconomic uncertainty increases the exchange rate while the inverse relationship holds true. Furthermore, I disaggregate the components of the gross flows to explore each individually and determine the mechanism that explains the aggregate results. The findings suggest that both uncertainties affect inflows and outflows, albeit with a more pronounced impact on inflows, contributing to an overall contraction in the net position. Furthermore, I delve deeper into the two main parts of gross capital flows: demand for bonds and stocks. I find that exchange rate uncertainty does not significantly impact foreign demand for US bonds but does affect US stocks. These results imply that shocks diminish the privilege of the United States but have limited influence on its duty to its debt holders.

Chapter III

In the third and final chapter, titled “Extremely Stablecoins,” I examine the factors that contribute to significant fluctuations in the largest stablecoins. I consider the asymmetric behavior inherent in financial assets and the different responses exhibited by various types of coins in the market. I establish a connection between each currency and the variables that define its intrinsic value and trading performance. Additionally, I analyze the fluctuations in the assets supporting these stablecoins and the overall market. I model quantile regression and the Cross-Quantilogram to assess behavior within the distribution’s tails and disentangle the time-dependence and directional predictability of the variables. I find that most extreme movements are linked to the specific stablecoin and general cryptocurrency market

conditions, alongside intermediary budget constraints and overall stablecoin illiquidity. The results suggest that the overall market and stablecoins exhibit heterogeneous responses to different factors, with the magnitude and dependence varying based on the stability mechanism and the specific distribution tail under analysis. The stablecoin market has predictive power over both tails of the distribution, aimed at countering movements and maintaining parity. The other factors are distribution dependent, where Cryptocurrency markets exert the most influence when their prices are high, intermediaries when they are constrained, and episodes of heightened liquidity take precedence over illiquid ones.

Resumé

Før den globale finansielle krise oplevede 1990'erne en række valutakriser samtidig med dannelsen af Den Europæiske Union. Disse begivenheder fremmede en tendens til markedsliberlisering, der lettede kapitalstrømmene af forskellige typer aktiver. Mange nationer vedtog flydende valutakurser for at give øget autonomi til deres centralbanker og ændrede dermed monetære politikregimer. Denne udvikling inden for valutakursmekanismer var tæt forbundet med den voksende globale handel og finansielle markeder.

Afkastet og volatiliteten på disse markeder blev afgørende redskaber for beslutningstagere, ikke kun til at styre international handel, men også til at forudsige kapitalstrømmenes adfærd inden for landene. Som følge heraf begyndte valutakurserne ikke kun at påvirke handelsdynamikken, men også sårbarheden i økonomierne over for eksterne chok fra de globale internationale finansmarkeder.

I denne afhandling præsenterer jeg tre kapitler, der udforsker determinanterne, adfærden og konsekvenserne af udsving i valutakurser på økonomien. Der fokuseres på afvigelser i renteparitet, ekstreme bevægelser og respons i kapitalstrømme. Som en del af undersøgelsen undersøger jeg stablecoins, digitale valutaer designet til at lette transaktioner og overvinde volatilitetsbegrænsningerne i traditionelle valutakurser. Disse undersøgelser harmonerer tæt med forskningsdagsordenerne inden for International Finans og Finansiel Økonomi og tilbyder værdifulde indsigter til akademikere, beslutningstagere og branchefolk. Undersøgelsen anvender moderne økonometriske metoder til at analysere udsvingene i både traditionelle og elektroniske valutaer, hvilket afslører deres følsomhed over for eksterne og interne faktorer. Den giver også indsigter til etablering af en effektiv stabiliseringsmekanisme inden for rammerne af makroprudentielle politikker.

Kapitel I

I det første kapitel med titlen *Valutakursusikkerhed og renteparitet*, opbygger jeg et mål for valutakursusikkerhed for at forklare afvigelser i dækket renteparitet. Ved at sammenfatte valutakursudsving ved hjælp af klyngemetoder og faktormodeller skaber jeg et mål for usikkerhed, der fanger strukturen og chok i globale økonomier. Jeg finder, at valutakurser er blevet mere ensartede siden den globale finansielle krise, idet de organiserer sig

i distinkte strukturer og mønstre, der stemmer overens med hypotesen om den globale finansielle cyklus, handel og geografiske karakteristika. Med dette mål demonstrerer jeg, at valutakursusikkerhed delvist forklarer afvigelser i dækket renteparitet, især i tilfældet med både Libor og statsobligationsmarkeder, hvor sidstnævnte påvirkes mere alvorligt. Effekten forbliver statistisk og økonomisk signifikant, selv efter kontrol for benchmark-modeller.

Kapitel II

Det andet kapitel med titlen, *Den usikre exorbitante fordel og pligt*, bygger på resultaterne fra det foregående kapitel og anvender valutakurs- og makroøkonomisk usikkerhed til at demonstrere, hvordan chok påvirker kapitalstrømme og forklarer USA's nettofremmedgæld. For at identificere chok i modellen estimerer jeg en vektorautoregressiv model, der kombinerer eksterne variabler, narrative og chokafhængige restriktioner. Inden for rammerne af den amerikanske økonomi viser jeg, at en stigning i begge typer usikkerhed reducerer underskuddet i nettofremmedgældspositionen, hvoraf den makroøkonomiske effekt udøver en varig indflydelse. Når man overvejer de gensidige virkninger af en usikkerhed på en anden, observerer jeg, at makroøkonomisk usikkerhed øger valutakursen, mens det omvendte forhold gælder. Desuden opdeler jeg komponenterne i bruttostrømmene for at undersøge hver enkelt individuelt og bestemme mekanismen, der forklarer de samlede resultater. Resultaterne antyder, at begge former for usikkerhed påvirker ind- og udstrømning, selvom der er en mere udtalt indvirkning på indstrømning, hvilket bidrager til en samlet kontraktion i nettopositionen. Desuden dykker jeg dybere ned i de to hoveddele af bruttokapitalstrømme: efterspørgsel efter obligationer og aktier. Jeg finder, at valutakursusikkerhed ikke har en betydelig indflydelse på udenlandsk efterspørgsel efter amerikanske obligationer, men har indvirkning på amerikanske aktier. Disse resultater antyder, at chok svækker USA's privilegier, men har begrænset indflydelse på dets forpligtelse over for sine kreditorer.

Kapitel III

I det tredje og sidste kapitel, med titlen, *Ekstremt stabile mønter,*, undersøger jeg de faktorer, der bidrager til betydelige udsving i de største stabile mønter. Jeg overvejer den asymmetriske adfærd, der er iboende i finansielle aktiver, og de forskellige reaktioner, der udvises af forskellige typer mønter på markedet. Jeg etablerer en forbindelse mellem hver valuta og de variabler, der definerer dens indre værdi og handelspræstation. Derudover analyserer jeg udsvingene i de aktiver, der understøtter disse stabile mønter og det samlede marked. Jeg modellerer kvantilregression og Cross-Quantilogram for at vurdere adfærd inden for distributionens haler og adskille tidafhængigheden og den retningssikre forudsigelighed af variablerne. Jeg finder, at de fleste ekstreme bevægelser er forbundet med den specifikke stabile mønt og det generelle kryptomarked samt mellemledernes budgetbegræn-

sninger og den generelle møntes illikviditet. Resultaterne antyder, at det samlede marked og stabile mønter udviser heterogene reaktioner på forskellige faktorer, hvor størrelsen og afhængigheden varierer afhængigt af stabilitetsmekanismen og den specifikke distributionshale, der analyseres. Stabile mønters marked har forudsigende kraft over begge haler af fordelingen med henblik på at modvirke bevægelser og opretholde paritet. De øvrige faktorer afhænger af fordelingen, hvor kryptomarkeder udøver den største indflydelse, når deres priser er høje, mellemlederne er begrænsede, og perioder med øget likviditet prioriteres over illikvide.

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Introduction

The continuous disparities from Covered Interest Rate Parity (CIP) in foreign exchange markets, which have persisted since the 2007 financial crisis, mark a departure from the stability observed in the years preceding the Global Financial Crisis (GFC). These deviations, documented by Du and Schreger (2016), Du, Tepper, and Verdelhan (2018), and Jiang, Krishnamurthy, and Lustig (2021), reflect uncertainties permeating the market, leading to mispricing of currencies and sustained volatility. Du, Hébert, and Huber (2022) argues that these deviations are generally associated with constrained financial intermediaries. Chapter One of the thesis examines how fluctuations in exchange rate uncertainty contribute significantly to the observed deviations from interest rate parity. This effect persists even after accounting for various channels, indicating unexplained risk premia characteristic of international events. Furthermore, it highlights the underpricing of these fluctuations in the US financial markets, emphasizing the need to incorporate the transmission of uncertainty to exchange rate prices.

With the general level of uncertainty from global intermediaries, the level of transactions and capital flows will change in response. This relationship comes from works such as the ones in Gabaix and Maggiori (2015), Farhi and Gabaix (2016), and Camanho, Hau, and Rey (2022), that explains the connection within the world international markets. In Akinci, Kalemli-Özcan, and Queralto (2022), they relate the uncertainty in the US market and how it is transferred through intermediaries, as they assume the international risk of foreign portfolio holdings. This relationship profoundly influences capital movements, illustrating the delicate balance between market uncertainties and their consequential impacts on global capital allocations. The Second chapter explores the endogenous nature of macroeconomic and exchange rate uncertainty in determining aggregate and disaggregated portfolio capital flows. This analysis unravels the intricate connection between uncertainty and the net foreign asset position of the United States, delineating the dynamics of the nation's exorbitant privilege and duty in the global financial landscape, as described by Gourinchas and Rey (2005, 2014, 2022).

Because of the privilege that the US has and the disadvantage of the CIP deviations of most emerging markets, new financial innovations have tried to facilitate international transactions without much volatility and the costs of the traditional exchange rates. From this, cryptocurrencies emerged as substitutes for traditional exchange rates, particularly Stablecoins. They are coins whose price is usually pegged to the USD, and the value is maintained by a stability mechanism guaranteed by a combination of assets, other cryptocurrencies, and an algorithm. Yet, they are still to provide the stability required. Asset pricing models applied to cryptocurrencies, like Liu and Tsyvinski (2021) and Liu, Tsyvinski, and Wu (2022), focus on the mean behavior, which omits the pegged nature of these coins. In chapter three, I apply quantile methods that show the heterogeneous dependencies within stablecoins concerning overall cryptocurrency behavior, market liquidity, and intermediaries' constraint levels.

Then, the thesis focuses on three interconnected topics, which provide information on the structure of international transactions in global financial markets. From the sources of deviations and fluctuations in the exchange rate system, the effects it has on the portfolio flows and concludes with an examination of the assets meant to mitigate these challenges. These chapters provide insights into fluctuations' sources and transmission channels, contributing essential perspectives for shaping effective macroprudential policies, risk management, and asset pricing.

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Chapter 1

Exchange Rate Uncertainty and Interest Rate Parity

Abstract

This paper presents a novel approach to measuring the exchange rate uncertainty to explain the Covered Interest Rate Parity (CIP) Deviations. It employs an endogenous factor clustering model that captures daily fluctuations in exchange rates, unveiling pervasive shocks influencing market volatility, even amid financial crises. This model determines distinct patterns, including a break coinciding with the Great Financial Crisis, that shape the variation of identifiable currency clusters. I applied this method to the CIP deviations of LIBOR and Government rates across major currencies, demonstrating the economically significant effects of uncertainty for both. These effects remain robust, even when considering different model specifications that account for interest rate dynamics and fluctuations in the broader dollar exchange.

1.1 Introduction

Opportunities for arbitrage in the foreign exchange market are supposed to occur rarely and under small time windows. Since the financial crisis, however, they have persisted longer than expected in the foreign exchange markets. Recent empirical evidence by Du and Schreger (2016), Du, Tepper, and Verdelhan (2018), and Jiang, Krishnamurthy, and Lustig (2021) showed that there had been persistent deviations from the interest rate parity since 2007. The deviation implies that an investor can make a risk-free profit from borrowing from a low-interest rate country and investing in a safe asset from a high-interest country, with or without hedging for risk. Under no frictions and rational expectations, the exchange rate should adjust and eliminate any opportunity for profit. The persistence of such deviations reflects uncertainty in the market, which generates mispricing of the currencies and persistent volatility. The fluctuations affect the gross capital inflows and outflows, determining the stock market behavior, prices, fiscal (through the Balance Sheet Effect), and monetary policy (Gourinchas and Rey, 2014).

In this paper, I analyze the effect that uncertainty in the fluctuations of the exchange rates generates on the deviations from the Covered Interest Rate Parity (CIP). I propose a new high-frequency measure of exchange rate uncertainty that reflects the foreign exchange market's fluctuations and state. I show that the measure provides information to explain the existence of arbitrage opportunities, even by controlling other factors commonly used. Models used in the literature use broad macroeconomic or financial volatility measures such as realized volatility, the implied volatility of the futures of the financial markets, or text mining of newspapers. Nevertheless, Colacito, Croce, Liu, and Shaliastovich (2022) shows that macroeconomic factors' volatility is not completely traduced in the exchange rates. By not including the behavior of the endogenous uncertainty generated from the fluctuations of exchange rates, it ignores the channel of the uncertainty coming from the microstructure of the exchange market. Then, to capture this puzzle arising from exchange rate markets, I estimate the uncertainty from the exchange rates to extract the additional information their variations entail.

The paper's main contribution is assessing the relationship between Exchange Rate Uncertainty and the Deviations of the Currency Interest Rate Parity for both Libor and Government bonds by providing a new measure of currency uncertainty. I find evidence that it significantly explains the deviations for most currencies and is a significant factor even with the inclusion of control variables, such as the dollar factor, which Avdjiev, Bruno, Koch, and Shin (2019) and Cerutti, Obstfeld, and Zhou (2021) proves to capture most of the variability. In general, it provides better goodness of fit to others, such as the CBOE's Volatility indices like the VIX and VXO, which are traditionally used in the literature. After an increase in a percent of the level of uncertainty, the CIP deviation increases on average by 28 basis points and the convenience yields of US government bonds by 82 basis points.

The Exchange Rate Uncertainty calculated captures the effect of international and currency-related events, such as currency crises, which differ from other broad measures in the literature. As a byproduct of the estimation, I obtained that a single common factor and different groups represent the exchange rate fluctuations, contrary to traditional ad-hoc clustering by commodity production, regional proximity, or interest rate spread. The fact that a common factor affects all the exchange rates aligns with the literature on the global financial cycle hypothesis of Rey (2015a) and the role of the USD as dominant currency (Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller, 2020; Boz, Casas, Georgiadis, Gopinath, Le Mezo, Mehl, and Nguyen, 2022). Furthermore, I use Barigozzi, Cho, and Fryzlewicz (2018) methodology and find a structural change in July 2007 that reduced the number of clusters, which goes under the Exchange Rate Reconnect evidence from Lilley, Maggiori, Neiman, and Schreger (2022). I use the break to divide the sample and show that the exchange rates became more homogeneous after the crisis, passing from four groups to three groups.

With the models of Menkhoff, Sarno, Schmeling, and Schrimpf (2012), Ismailov and Rossi (2018a), and Kalemli-Özcan and Varela (2021), my modeling strategy is one of the first approximations to estimate an exchange rate uncertainty, rather than more broad definitions such as macroeconomic or economic policy. The model differs from the other two since I define uncertainty as the conditional volatility of an unforecastable disturbance for economic agents (Jurado, Ludvigson, and Ng, 2015; Ludvigson, Ma, and Ng, 2021). I use the methodology of Ando and Bai (2017) that estimates common factors for a set of exchange rates and group-specific ones that target a cluster with a characteristic behavior. Brunnermeier, Nagel, and Pedersen (2008), Lustig, Roussanov, and Verdelhan (2011), and Verdelhan (2018) proved that the exchange rates tend to have comovements, so there is a significant amount of information that a group of exchange rates can provide to estimate the other. One of the main contributions is the construction of endogenously determined exchange rate groups that describe the relationship between the volatility currencies, which contribute to the ones found by Maurer, Tô, and Tran (2019), Greenaway-McGrevy, Mark, Sul, and Wu (2018), Lustig and Richmond (2020), and Aloosh and Bekaert (2022) for advance economies. I extend these clusters to include emerging markets and uncover different patterns between currencies using a new methodology that controls for different factors. These clusters are essential to determine how comovement affects economic policy and possible coordination between Central Banks' decisions to stabilize their currency.

The uncertainty measure has the advantage over other methodologies as factor models have higher accuracy over traditional models predicting the exchange rates, as highlighted in the recent survey of Kavtaradze and Mokhtari (2018). Several alternative methodologies use forecasts to define the model, such as Ismailov and Rossi (2018b). Nevertheless, it presents some shortcomings related to the identification, such as low frequency, survey representation, and expectations' reliability. First, Expectation data typically have monthly periodicity, while Nakamura and Steinsson (2018) mentions the advantages of using high-frequency data, as they capture the effects of "news" that may have been short-lived and adequately identify the timing of the shocks. Another shortcoming can be related to the survey itself, as forecasts may reflect divergence between the forecasters rather than the uncertainty itself. Finally, the reliability of the surveys for some developed and emerging countries diminishes as they have higher inattention to less liquid markets. In some cases, the number of forecasters surveyed can even be a tenth of the developed ones or have even biased forecasts[1]. Daily data factors contain the information inherently, as the prices reflect the conditions of the moment and the general expectations.

Literature Review. Before the Financial Crisis 2007, lasting arbitrage opportunities following the CIP deviations were deemed costly and short-lived Akram, Rime, and Sarno (2008); Burnside, Eichenbaum, and Rebelo (2007, 2011). Nevertheless, later evidence showed that this condition became persistent, as early empirical evidence from Jurek (2014) showed that by considering Uncovered Interest Rate Parity (UIP) strategies, currencies could deliver annual positive Sharpe ratios. Ivashina, Scharfstein, and Stein (2015) argue that in the European crisis in 2011, the lack of market liquidity prevented the Parity concerning the dollar market.

Recent empirical evidence in measures of the Libor and Government Bonds in Du and Schreger (2016), Du, Im, and Schreger (2018), Du et al. (2018), and Jiang et al. (2021) demonstrated the existence of persistence of such deviations in the Covered Interest Rate Parity. Du and Schreger (2022) resume the causes of such opportunities to Supply and Demand Reasons. For the first case, leveraged constraints in the intermediary markets due to financial regulations which limited the supply of hedging instruments (Cenedese, Della Corte, and Wang, 2021; Fang and Liu, 2021; Du, Hébert, and Huber, 2022) and for the second, the demand of the safe assets from the US bond and treasury markets has increased the spread between foreign and domestic markets interest rates, as mentioned in Krishnamurthy and Vissing-Jorgensen (2012), Gourinchas and Rey (2014), and Gourinchas and Rey (2022). Recent papers like Avdjiev et al. (2019) and Cerutti et al. (2021) have tried to explain the factors that generate such deviations. They focus on the role of the dollar fluctuations and other macroeconomic variables, such as the interest rates, the VIX to measure overall volatility and risk aversion, and the intermediary leverage. This paper tries

[1] In the appendix A.2 of Kalemli-Özcan and Varela (2021), they show the difference between the number of forecasters assigned between developed and emerging markets, where the average number is 55 and 17, respectively. The maximum and minimum average number of forecasters by country are 107 and 4 for Germany and Ukraine. Additionally, Gemmi and Valchev (2023) show that forecasters show strategic incentives.

to complement this result by proposing an uncertainty measure that provides additional information on the sources of both Libor and Government basis deviations, which I show is complementary to the other variables in the previous literature.

The effect of currency volatility and uncertainty in explaining the deviations of interest rate parity and the carry trade is a topic of interest and a growing literature. Berg and Mark (2018b), Husted, Rogers, and Sun (2018), Ismailov and Rossi (2018a), Kalemli-Özcan and Varela (2021), and Della Corte and Krecetovs (2022) of the effect of uncertainty in the UIP. Della Corte, Sarno, and Tsiakas (2011), Della Corte, Ramadorai, and Sarno (2016), Londono and Zhou (2017), and Corte, Kozhan, and Neuberger (2021) focus on the volatility risk premia as an explanation to the currency returns and carry trade. I contribute to this literature by proposing a measure of exchange rate uncertainty and extending it to the analysis of CIP deviations rather than the macroeconomic or volatility they used. The argument for having it as an explanatory variable for the deviation comes from its effect on generating expectation fluctuations. Due to uncertainty, individuals cannot efficiently price the future exchange rate and adequately reflect its expected value. Although measuring it seems straightforward by just following the definition, there is an increasing amount of different methodologies in the literature trying to determine the predictable variability of the series. The whole model structure depends on forecast, so it requires considering the recent developments in econometric modeling. Optimal models will guarantee that we can filter the most amount of possible information that can be used by economic agents and isolate unforecastable movements.

The base of my model is the one presented in Jurado et al. (2015), and Ludvigson et al. (2021), which use the Factor Augmented Vector Autoregressive (FAVAR) model of Bernanke, Boivin, and Eliasz (2005) to estimate the forecast by incorporating multiple macroeconomic and financial variables for the US economy. Scotti (2016) takes the difference between the realized value of macroeconomic variables and their forecasts and then aggregates them using a Dynamic Factor Model (DFM). Carriero, Clark, and Marcellino (2018a) propose using a Large Vector Autoregressive Model with stochastic volatility to incorporate the errors and the volatility straight in the model.

Other widely used measures of uncertainty follow methodologies different from those based on forecasting predictions. One is the one proposed by Bloom, Bond, and Van Reenen (2007) and Bloom (2009), which take Firm data to construct the uncertainty index. Gilchrist, Sim, and Zakrajšek (2014) and Chuliá, Guillén, and Uribe (2017) use stock market returns of many non-financial firms that trade in the US market to construct a financial uncertainty index based on factor models. Baker, Bloom, and Davis (2016a) complete the Economic Policy Uncertainty Index based on the news coverage frequency by taking the number of times policy-related words appear in newspapers. Finally, the measure of Rossi and Sekhposyan (2016) constructs an uncertainty index based on the historical forecast error distribution built by using professional surveys and then analyzing if it is the upside and downside uncertainty[2].

The exchange rate uncertainty has, in comparison, a lower amount of literature behind it that is not a measure of the volatility premium of the currencies. In contrast to the previously mentioned work of Ismailov and Rossi (2018b), which uses the Survey of Forecasters density forecast, Menkhoff et al. (2012) uses a proxy for global FX using weighted absolute returns of different exchange rates, and the Kalemli-Özcan and Varela (2021) which construct an Economic Policy Uncertainty (EPU) type of measure based on newspaper keywords as Baker, Bloom, and Davis (2016b). Most of the rest of the models that focus on measuring uncertainty use different variations of a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, such as the case of the VAR-GARCH model of Caporale, Spagnolo, and Spagnolo (2017).

1.2 Econometric Model

I estimate the uncertainty measures for Exchange Rates based on the model of Jurado et al. (2015) and Ludvigson et al. (2021) and combine it with the model of Ando and Bai (2017). The procedure has two benefits; the first is the possibility to endogenously determine clusters of exchange rates that share the same approximate behavior and uncover potential hidden structures of the market. The second is to estimate the model with targeted factors, which offer an improved forecasting performance than standard factor models (Bai and Ng, 2008). Furthermore, I filter the model with other variables commonly used in the literature to forecast exchange rates. Finally, I estimated the conditional volatility of the factors by calculating the model's unforecastable errors following a stochastic volatility model.

1.2.1 Clustering the Exchange Rates

I follow the methodology of Ando and Bai (2017) to endogenously determine the clusters of exchange rates. In this case, the membership of each group and the number of variables are unknown. The previous ones either assume that the clusters are known, or the explanatory variables are assumed to be fixed. They estimate the following model,

$$y_{i,t} = X'_{i,t}\beta_i + F'_{g_i,t}\lambda_{g_i,t} + F'_{a,t}\lambda_{a,t} + \varepsilon_{i,t} \tag{1.1}$$

where $y_{i,t}$ are the exchange rate returns, X_t are the observable factors that affect the exchange rates, $F_{a,t}$ are the unobservable factors that have an aggregate effect, $F_{g_i,t}$ are the

[2] Bloom (2014), Ferrara, Lhuissier, and Tripier (2018), and Castelnuovo (2019) present further literature on the topics

factors that are characteristic to group g_i, $t = 1, 2, ..., T$ is the time index, $i = 1, 2, ..., N$ is the index of the variable of interest, and N is the total number of data points. The groups g_i are such that there is a set of underlying groups $G = \{g_1, g_2, ..., g_S\}$, where S is the number of exchange rate groups such that the number of variables in the group $N_S \in N$. The factor loading's $\lambda_{g_i,t}$ are the coefficients (sensitivity) of the variable to the group' g_i factor, and $\lambda_{a,t}$ are the loadings that effect, in general, the exchange rates. $\varepsilon_{i,t}$ is an i.i.d. error that is assumed to be uncorrelated with the regressors[3].

1.2.2 Estimation of the Model

The model described by Equation (1.1) requires estimating the factors in each group r_j, the general factors r, and the number of the groups g_i. The estimator of (1.1) is given by the minimizer,

$$\begin{aligned} &L\big(\beta_1, \beta_2, ..., \beta_N, G, F_a, F_{g_1}, F_{g_2}, ...F_{g_S}, \lambda_a, \lambda_{g_1}, \lambda_{g_2}, ...\lambda_{g_S}\big) = \\ &\sum_{i=1}^{N} \|y_{i,t} - X'_{i,t}\beta_i - F'_{g_i,t}\lambda_{g_i,t} - F'_{a,t}\lambda_{a,t}\|^2 + T\sum_{i=1}^{N} \varrho_i\big(\beta_i\big) \end{aligned} \tag{1.2}$$

where the right-hand side's first part corresponds to the model's squared error (ε^2) and the second part to the penalty function $\varrho_i\big(\beta_i\big)$. The penalty function corresponds to the Smoothly Clipped Absolute Deviation (SCAD) of Fan and Li (2001). The Penalty function allows for variable selection that will determine the values of parameters β_i, assigning the value towards zero in case that is not relevant to the estimation of the currency returns. This guarantees the sparsity of the predictive model. The penalty function is such that,

$$\varrho_i\big(\beta_i\big) = \begin{cases} \kappa_i|\beta_{i,j}| & |\beta_{i,j}| \leq \kappa_i \\ \frac{\gamma\kappa_i|\beta_{i,j}| - 0.5(\beta_{i,j}^2 + \kappa_i^2)}{\gamma - 1} & \kappa_i \leq |\beta_{i,j}| \leq \gamma\kappa_i \\ \frac{\kappa_i^2\left(\gamma^2 - 1\right)}{2\left(\gamma - 1\right)} & \gamma\kappa_i < |\beta_{i,j}| \end{cases} \tag{1.3}$$

where $\kappa_i > 0$ and $\gamma > 2$, where Ando and Bai (2017) uses $\gamma = 3.7$ that minimizes the BIC as used by Fan and Li (2001). The model does not assume a particular value for the regularization parameter κ_i, but it is determined endogenously by the model. The model follows an algorithm that follows an iterative scheme to determine the value of each one of the parameters to estimate.

The algorithm requires that first, the values of $\kappa_1^0, \kappa_2^0, ...\kappa_N^0, r^0, r_1^0, r_2^0, ..., r_S^0$, and S be fixed. The model's β_i^0's are first estimated by regressing the variables against the endogenous, assuming that the factor loadings have zero value. In this case, the Hierarchical

[3] In section 2.3 of Ando and Bai (2017), they give further assumptions made in the model.

Algorithm determines the initial group membership following a Divisive Analysis clustering (DIANA). It determines multiple clusters and the membership of each variable bounded by a predetermined maximum of groups. The given values of β_i^0 and the clusters G^0 are then used to estimate the values of the common factors F_a^0 and later, the group factors $F_{g_i}^0$.

Given the previously estimated coefficients, then the optimal value of g_i is updated following,

$$\tilde{g}_i = argmin_j \; \|y_{i,t} - X'_{i,t}\beta_i - F'_{g_i,t}\lambda_{g_i,t} - F'_{a,t}\lambda_{a,t}\|^2 \tag{1.4}$$

where $\tilde{g}_i$ is the minimizer of the squared error of the model. This optimal membership of the groups and the estimated factors are used to re-estimate the $\tilde{\beta}_i$. Furthermore, this can be used to obtain the common and grouped factors' new factors and their respective loadings. Hence, the procedure is repeated continuously until convergence is achieved[4].

Finally, the optimal model is selected following a modification of the Hallin and Liška (2007) criteria defined as,

$$\begin{aligned} PIC^c = & \frac{1}{NT}\sum_{j=1}^{S}\sum_{g_i=j} \|y_{i,t} - X'_{i,t}\tilde{\beta}_i - \tilde{F}'_{g_i,t}\tilde{\lambda}_{g_i,t} - \tilde{F}'_{a,t}\tilde{\lambda}_{a,t}\|^2 \\ & + C\frac{1}{N}\sum_{i=1}^{N}\tilde{\sigma}^2 log(T)\tilde{p}_i + Ck\tilde{\sigma}^2\left(\frac{T+N}{TN}\right)log(TN)\tilde{p}_i \\ & + \sum_{j=1}^{G} Ck_j\tilde{\sigma}^2\left(\frac{T+N_j}{TN_j}\right)log(TN_j) \end{aligned} \tag{1.5}$$

where $\tilde{p}_i$ are the non-zero elements of $\tilde{\beta}_i$, $\tilde{\sigma}^2$ is the estimated variance of the errors of equation (1.1), and C is some constant. The parameter $\tilde{p}_i$ reflects the number of variables selected by the model, and so, the effect of parameters κ and κ_i. Minimizing the PIC criteria will give the optimal quantity of groups $(G(S))$, common factors(k), group-specific factors(k_i), and the parameters $\kappa, \kappa_1, \kappa_2, ..., \kappa_N$.

The Equation (1.5) is the one that, combined with the algorithm defined previously, determines the unknown parameters in the model. The penalization of the model depends on the value of C; depending on its values, the common and group factors will reduce considerably. The approximation to the optimal value will be related to the characteristic function of the empirical variance given by the following,

$$\begin{aligned} V_C^2 = & \frac{1}{A}\sum_{a=1}^{A}\left(r^C\left(N^a, T^a\right) - A^{-1}\sum_{b=1}^{A} r^C\left(N^b, T^b\right)\right)^2 \\ & + \sum_{j=1}^{S_{max}}\left[\frac{1}{A}\sum_{a=1}^{A}\left(r^C\left(N^a, T^a\right) - A^{-1}\sum_{b=1}^{A} r^C\left(N^b, T^b\right)\right)^2\right] \end{aligned} \tag{1.6}$$

[4]As noted by Ando and Bai (2017), this procedure can be seen as equivalent to the one used by Bai and Ng (2002) to estimate the factor structure.

The Equation (1.6) measures the variability of the common and the group-specific factors. From here, we can derive the final algorithm to determine the model's optimal coefficients, as detailed by Ando and Bai. The optimal 8-step model algorithm is then given by

1. Choose the initial optimal values of the number of common and specific-group factors $(r, r_1, r_2, ..., r_S)$, the regularization parameter $(\kappa_1, \kappa_2, ..., \kappa_N)$, and the number of groups S (estimated through Hierarchical Clustering).

2. Fix the number of groups S and, based on them, determine the number of common and group-specific factors.

3. Given the current values of the parameters S, k, and $k_1, k_2, ..., k_S$, optimize the regularization parameters κ_i using the criteria defined in equation (1.5).

4. Using the previously estimated parameters, re-optimize the value of the common factors k using Equation (1.5).

5. with the previous parameters and the estimated k in step 4, estimate the group-specific factors k_g using equation (1.5).

6. Repeat the previous steps until the model achieves convergence.

7. Change the value of the number of groups and repeat the previous steps until achieving convergence

8. Compare the results of each group and select based on the minimizer of the Information Criteria, PIC.

We can obtain the optimal number of common and group-specific factors based on the estimated initial values and the algorithm of Ando and Bai (2017) detailed previously. The importance of β_i expresses the significant exogenous variables.

Once estimated, from the model, we can obtain the information that data cannot explain and get the unforecastable fluctuations of the exchange rates [5]. We can obtain this by

$$\varepsilon_{i,t} = y_{i,t} - X'_{i,t}\beta_i - F'_{g_i,t}\lambda_{g_i,t} - F'_{a,t}\lambda_{a,t} \tag{1.7}$$

Following Jurado et al. (2015) and Ludvigson et al. (2021), I estimate the conditional volatility using the stochastic volatility of Kastner and Fruhwirth-Schnatter (2014) for each exchange rate.

[5] Bai and Ng (2006) and Jurado et al. (2015) mention that for samples of data big enough, we can treat the estimated Factors as the forecasts of the variables in the next period

1.2.3 Stochastic Volatility Model

The stochastic volatility model described by Kastner and Fruhwirth-Schnatter (2014) estimates the conditional volatility based on filtered series in Equation (1.7) by assuming the form for each i as

$$\begin{aligned} \varepsilon_t =& e^{\frac{h_t}{2}} \epsilon_t \\ h_t =& \mu + \phi\big(h_{t-1} - \mu\big) + \sigma \upsilon_t \end{aligned} \tag{1.8}$$

and also,

$$\begin{aligned} \varepsilon_t \sim& N\big(0, \omega e^{\sigma h_t}\big) \\ h_t =& \phi h_{t-1} + \sigma \upsilon_t \end{aligned} \tag{1.9}$$

where ϵ_t and υ_t correspond to i.i.d. errors that distribute standard normal, h_t is the unobserved latent time-varying volatility process such that it follows a stationary distribution $h_0|\mu, \phi, \sigma \sim N\big(\mu, \frac{\sigma}{1-\phi^2}\big)$. The model described by Equation (1.8) defines a "Centered Model" and the one in Equation (1.9) as "Non-Centered." As suggested by Kastner and Fruhwirth-Schnatter (2014), the estimation estimated by the two equations involves interweaving between the two in the Ancillarity-Sufficiency Interweaving Strategy (ASIS) algorithm. The convenience of the model is that the Centered model deals with high volatilities, as it takes the mean, while the non-centered captures the volatility when the variance is low. As the likelihood of both equations is not observable, it is approximated to the data using the Markov Chain Monte Carlo (MCMC) method. The uncertainty of the exchange rate is defined as the conditional volatilities u of i; $\hat{U}_{i,t}(h_t)$.

1.2.4 Uncertainty Measure

The uncertainty measure can be determined by either aggregating the total uncertainties of the exchange rates against the USD by turnover or using the particular exchange rate uncertainties estimated in the previous model. I calculate the wide measure of uncertainty as,

$$\hat{U}_t = \sum_{i=1}^{N} W_i \hat{U}_{i,t}\big(h_t\big) \tag{1.10}$$

where W_i is the weight of the exchange rate in the economy. In Jurado et al. (2015) and Chuliá et al. (2017), they use equal weights ($W_i = \frac{1}{N_i}$) in each one of the variables, so they determine the factors as a simple average of the whole uncertainties. A possible weight that can be applied is the percentage of the market turnover of the exchange rate, so uncertainties of the fewer trade currencies have less weight than the most traded and relevant ones. Nevertheless, that will downplay the effect of currency shocks coming from them, which will be the case of the Asian crisis.

1.3 Data

I use daily data of 31 exchange rates against the USD from July 1993 to December 2019, a total of 6906 days. I focus on the most traded exchange rates on the market that have both fluctuations in the exchange rates and available data. Table 1.1 presents the exchange rates used with their respective country, turnover[6], the "Coarse" Classification of Exchange Rate Arrangements (ERA) of Ilzetzki, Reinhart, and Rogoff (2019), and the Monetary Policy Framework classification of the International Monetary Fund (2020). These exchange rates corresponded to the last price of the domestic currency against the US dollar (USD). They were downloaded from the Bloomberg database[7].

Furthermore, I use thirteen variables as additional predictors and fundamentals of the model selected based on the literature on exchange rate prediction. The data used in the models is the one presented in Cheung, Chinn, and Pascual (2005), Chen, Rogoff, and Rossi (2010), Rossi (2013), Kavtaradze and Mokhtari (2018), Cheung, Chinn, Pascual, and Zhang (2019), and Lilley et al. (2022). The chosen predictors of the exchange rates are the Morgan Stanley Capital International (MSCI) World Index that captures 1517 large and mid-sized stocks prices of firms in 23 developed countries, the 3-Month Treasury Constant Maturity Rate (T-Bill), the 10-Year Treasury Constant Maturity bond, the three month ahead monthly fed funds futures (FF4), the three-month ahead monthly WTI Futures (CL3), the Bloomberg Commodity index, the $S\&P500$ Index, the DXY Dollar Spot Index, the West Texas Intermediate (WTI) price of Oil, the Chicago Board Options Exchange (CBOE)'s volatility index (VIX), and the Shadow Short Rates (SSR) of USA, Japan, UK, and Euro-area calculated by Krippner (2013a, 2015). The previous variables come mostly from Bloomberg, but the SSR series are from LJK Limited webpage. The period is chosen based on the availability of the data and to further include episodes of high exchange rate uncertainty and volatility, as in the last half of the 1990s, the next period of the GFC and euro debt crisis.

For the Covered Interest Rate Parity model, I follow the data used in Du and Schreger (2016), Du et al. (2018), Du et al. (2018), and Du and Schreger (2022) daily data for the exchange rate spot price against the USD, the three-month Forward exchange rates,

[6]The BIS calculates the turnover in the Triennial Central Bank Survey of Foreign Exchange and Over-the-counter (OTC) Derivatives Markets in 2019. It takes data from the Central Banks' surveys of banks and dealers on their FX transactions.

[7]Appendix 1.5 present some descriptive statistics of the series.

Table 1.1. Exchange Rates by Country and Turnover

Currency	Country	Mnemonic	BIS Turnover	ERA	MPF
Euro	European Union	EUR	2	1	Other
Japanese Yen	Japan	JPY	3	4	IT
Pound Sterling	Great Britain	GBP	4	4	IT
Australian dollar	Australia	AUD	5	4	IT
Canadian dollar	Canada	CAD	6	4	IT
Swiss franc	Switzerland	CHF	7	3	Other
Chinese Yuan (Renminbi)	China	CNY	8	2	Comp.
Hong Kong dollar	China	HKD	9	1	CB-USD
New Zealand dollar	New Zealand	NZD	10	3	IT
Swedish krona	Sweden	SEK	11	3	IT
Korean won	Korea	KRW	12	3	IT
Singapore dollar	Singapore	SGD	13	3	Cr-Comp.
Norwegian krone	Norway	NOK	14	3	IT
Mexican peso	Mexico	MXN	15	3	IT
Indian rupee	India	INR	16	2	IT
Russian ruble	Russia	RUB	17	3	IT
South African rand	South Africa	ZAR	18	4	IT
Turkish lira	Turkey	TRY	19	3	IT
Brazilian real	Brazil	BRL	20	3	IT
Taiwanese Dollar	Taiwan	TWD	21		
Danish krone	Denmark	DKK	22	1	Peg-Euro
Polish zloty	Poland	PLN	23	3	IT
Indonesian rupiah	Indonesia	IDR	25	3	IT
Hungarian forint	Hungary	HUF	26	2	IT
Czech kruna	Czech Republic	CZK	27	3	IT
Israeli new shekel	Israel	ILS	28	3	IT
Chilean peso	Chile	CLP	29	3	IT
Colombian peso	Colombia	COP	32	3	IT
Malaysian ringgit	Malaysia	MYR	34	3	Other
Argentine peso	Argentina	ARS	-	5	Mon. Aggr.
Peruvian sol	Peru	PEN	-	2	IT

Notes: There are 31 exchange rates in the model from different countries. The table presents the currency, the country, their Mnemonic, BIS's Turnover from the Triennial Central Bank Survey of Foreign Exchange and Over-the-counter (OTC) Derivatives Markets in 2019, the Exchange Rate Arrangements (ERA) of Ilzetzki et al. (2019), and the Monetary Policy Framework of the International Monetary Funds' Exchange Rate Arrangement from the Annual Report on Exchange Arrangements and Exchange Restrictions. The last presents two types of classification, Fine and Coarse, which ranges from 1-13 and 1-6. They go from low flexibility being a currency union to high flexibility being a Free floater. The coarse is classified as: 1-Peg or Currency Board, 2-Crawling Peg, 3- Crawling Band and Managed Floating, 4-Free Floating, 5- Free-Falling, 6-Dual Market with parallel data missing. Free Falling refers to an economy with free-floating ER and high Inflation. *Sources:* Bloomberg, Bank of International Settlements, IMF, and Ilzetzki et al. (2019).

and the 3-month Libor inter-bank benchmark and Government rates for the countries from Bloomberg. I follow their data to replicate their cross-currency basis and compare the results to theirs. Additionally, I will center the CIP analysis on the G10 currencies: The Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Danish Krone (DKK), Euro (EUR), British Pound (GBP), Japanese Yen (JPY), Norwegian Krone (NOK), New Zealand Dollar (NZD), and Swedish Krone (SEK). I did not include emerging markets to avoid possible Peso problems, as described in Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) and Engel (2014), that may distort the results.

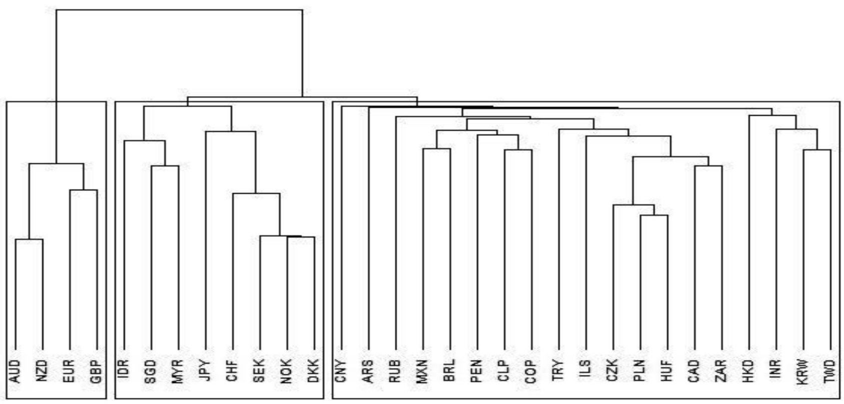
1.4 Empirical analysis

In this section, I will present the paper's empirical results. First, I will give the estimation results of the general and specific uncertainty indices and the endogenous clusters determined by the model. Second, I will use uncertainty as a key variable to explain the variations in the Libor and Government cross-currency basis of different Developed currencies.

Measuring Exchange Rate Uncertainty

As a first step to the empirical implementation of the model, I adjust the series and transform them to be approximately stationary. Then, I test them for the presence of a non-stationary process using the Augmented Dickey-Fuller test and convert them to logarithms and logarithmic returns depending on the case. I present the test results of the ADF test in Appendix 1.5.

Figure 1.1. Dendrogram of Exchange Rate Groups with Hierarchical Clustering



Note: The figure plots the Dendrogram and estimated clusters using Hierarchical Clustering following the Divisive Analysis (DIANA) approach. The number of optimal groups was determined using the Gap statistic. *Sources:* Author's calculations.

One of the starting points in the model is establishing the initial clusters of the exchange rate. To this end, I estimate them using Hierarchical Clustering, an unsupervised learning methodology. As a reference, I impose the existence of at most eight groups, each with at least four currencies. I follow Tibshirani, Walther, and Hastie (2001) and use the Gap Statistic to determine the optimal number of groups that described the currencies, which was defined as three groups for the whole distribution[8]. Figure 1.1 shows that the grouping of the Dendrogram, especially in the lower divisions, reflects a geographical relationship between currencies, where there is a cluster of Latin American, Nordic, Euro, and Asian countries. The relationship between the Australian Dollar and the New Zealand dollar is not only one of geography, but they also reflect that are "high-interest rate" economies as described in Lustig et al. (2011), due to exposure to productivity shocks for being commodity producers as in Chen and Rogoff (2003), Ready, Roussanov, and Ward (2017a), and Ready, Roussanov, and Ward (2017b). This methodology captures the general trends of the series and is probably a consistent first approximation to understanding the relationship between them. From Chuliá, Fernández, and Uribe (2018), one aspect that we can expect but was not present is a liquidity effect on the series. They found that exchange rates tend to co-move based on their level of turnover, while my results reflect that the clusters are also based on geographical vicinity and development level. The same applies to commodity currencies; although it shows that the Australian Dollar and New Zealand Dollar are together, they are not clustered with others such as the Ruble (RUB), the Canadian Dollar (CAD), and the South African Rand (ZAR).

I estimate the model of Ando and Bai (2017) by imposing a higher number of common factors and group-specific factors of 8 for each and again restricting the number of currencies in the groups to at least four. The group structure introduced as the prior is the one that corresponds to the hierarchical group structures presented previously. The model algorithm determined that the optimal number of groups is two for the whole sample, one common factor, and a group-specific factor for each. The number is not a surprise, as a small number can capture a high level of information (Sargent and Sims, 1977; Bernanke et al., 2005; Stock and Watson, 2016). It is coherent to have that group-specific (targeted) factors for a variable can capture a higher level of information than a general common factor that measures a more global trend.

In Table 1.2, I present the result of the estimation of Ando and Bai (2017) model with the prior groups estimated in Figure 1.1. We can see that the model had different groups than the Hierarchical Clustering Model. One characteristic is that group one preserved the EUR and NZD and gained the IDR, SGD, MYR, NOK, and DKK. The changes in group two of the original clustering method remain the relationship of the Dendrogram of the southwest Asian countries and one of the two Nordic countries.

Figure 1.2 plots the aggregate common factor estimated in the model, $F_{a,t}$, and the

[8]The Gap Statistic is a goodness of fit statistic that measures the dispersion within the groups to assess the clustering fit of the model. I contrast the estimated Gap statistics of the specifications from one to eight groups. I calculated the statistic using the Euclidean Difference around the cluster means and determined the expected error through a thousand replications using bootstrapping. Further information on the Hierarchical Clustering Method can be found in Tibshirani et al. (2001) and James, Witten, Hastie, and Tibshirani (2013).

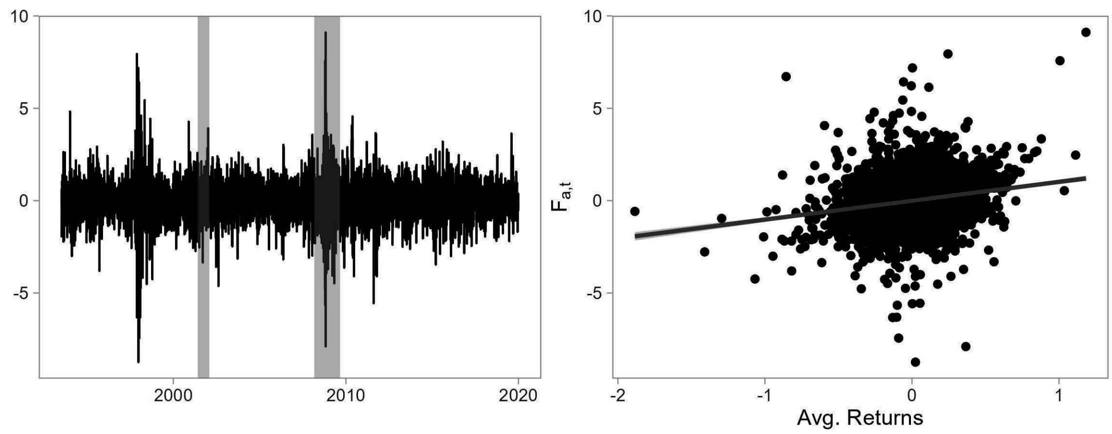
Table 1.2. Estimated groups following Ando and Bai (2017) endogenous clustering methodology

Group 1 (7)				Group 2 (24)			
EUR	NZD	NOK	DKK	JPY	GBP	CAD	AUD
SGD	MYR	IDR		CHF	SEK	ZAR	TRY
				PLN	CZK	HKD	KRW
				TWD	INR	MXN	BRL
				CLP	COP	ARS	PEN
				RUB	HUF	CNY	ILS

Notes: The table presents the estimated groups for each of the 31 exchange rates used in the model of Ando and Bai (2017) and assuming there are no breaks in the series. *Sources:* Author's calculations.

correlation with respect to the average returns of the G10 currencies. From the factor, we can see that it does not capture the crisis in the early 2000s, but it captures the volatility from the late 90s product of the Asian and Russian crises. If we compare the estimated common factor with respect to the average returns of the G10 countries, the correlation between the two is just 0.2. If we include the whole sample of currencies, the correlation between the average returns will be 0.02. Reducing the model increases the correlation, meaning that the aggregate shocks come primarily from the developed economies and transfer to the rest of the world. The result supports the hypothesis of the great financial cycle of Rey (2015b).

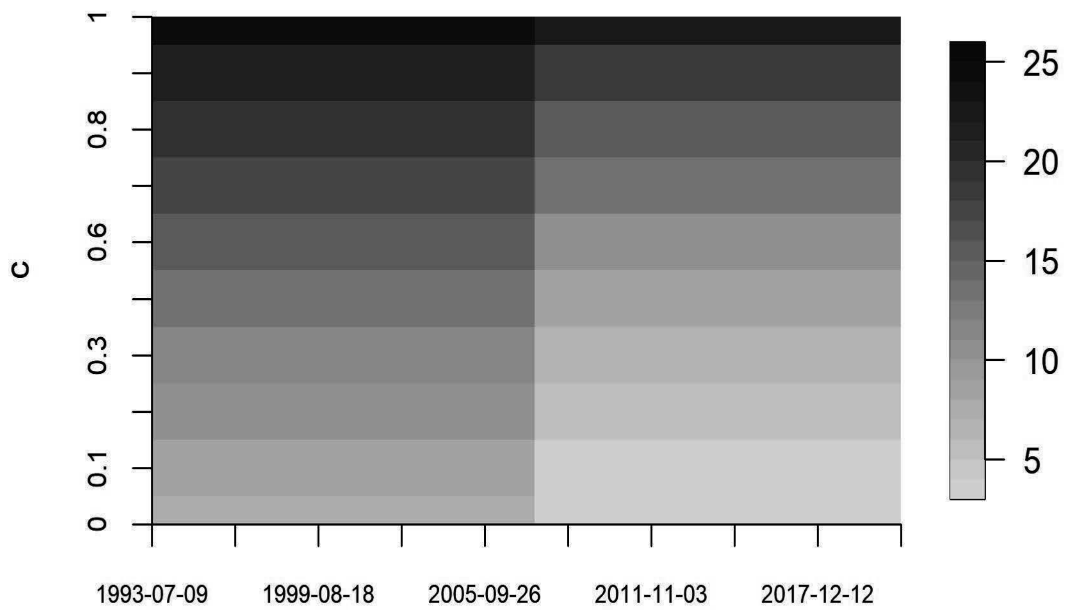
Figure 1.2. First Common Factor and the USD Returns



Note: The figure presents the relationship between the estimated common factor of the currencies' returns of the G10. The left panel plots the common factor's daily behavior and presents the behavior of the Calculated Common Component $F'_{a,t}$. Shaded areas correspond to the recession periods dated by the NBER. The right panel presents a Scatter plot of the factor and Average Returns of the G10 currencies, showing the correlation between the two variables. *Sources:* Bloomberg and author's calculations.

Although it is plausible that the factor structure remained consistent in time, evidence in the behavior of Libor and Government Cross-currency Basis in Du et al. (2018) as well as the results in Bussière, Chinn, Ferrara, and Heipertz (2022), Cheung and Wang (2022), Engel, Kazakova, Wang, and Xiang (2022), and Lilley et al. (2022), suggest the existence of a structural change in the behavior of exchange rates after the Financial Crisis of 2007. That is why I applied the methodology of Barigozzi et al. (2018) that determines the existence of breaks in the general factor structure of the series, in this case, the $F'_{a,t}$ in equation 1.1. If the Aggregate factor changes, we can expect that the group structure will also change. For the analyzed period, there is a break in July of 2007, in the Financial Crisis, as assumed by most of the literature. The model gives us a break and the number of principal components needed to capture available information. Hence, in Figure 1.3, we can see that after the change, the amount of factors is reduced, showing that the fluctuations of the exchange rates became more homogeneous in 2007-2019.

Figure 1.3. Regime Change in the General Factors Structure



Note: The Model plots the estimated factor structural change in the whole 1993-2007 sample using the methodology of Barigozzi et al. (2018). I use a rolling window of years to calculate the dynamic measure in the model. The model found a break in July 2007, at the beginning of the GFC. The y-axis plots the percentage of information contained in the factors. The figure shows the number of factors needed to capture the information; a darker color means more factors. Less-heterogeneous exchange rates characterize the post-GFC, and a few factors can capture its fluctuations. *Sources:* Author' calculations.

The break found and the evidence of different structures in the factors between 1993-2007 and 2007-2019 tells us that the specification of just one model for the whole sample may not be adequate. Hence, I divided the piece into those two periods and re-estimated the model for each. In Table 1.3, I present the estimated groups for each period, which yield a different and higher number of groups with respect to the no-break model. We can conjecture that because we have misspecified the model, the results will be biased towards a smaller number. The inability to correctly identify heterogeneous behavior will converge to a single common subfactor that aligns with the great financial cycle hypothesis and define the rest of the variability as idiosyncratic in nature.

In the first group, we have the European currencies and New Zealand, and group two has mostly peripheral European countries and the Yen and Rupee. The third has Latin American and emerging countries, while the last has mostly South Asian countries with the Canadian Dollar and the Swiss Franc. Consistent with the results of 1.3, I find that the number of groups needed to represent the time-series relationship between the exchange rates is reduced in the last period. Figure 1.4 presents the transition between groups, where we can see that, in general, there are four for the first part and three groups for the second, but we notice that there are still relationships between variables that remain close in the groups. In group one, three out of the four variables, seven in group two, and five in group four, while five of the currencies (LATAM countries, except Argentina) in group three went to group two.

Table 1.3. Estimated groups with Breaks

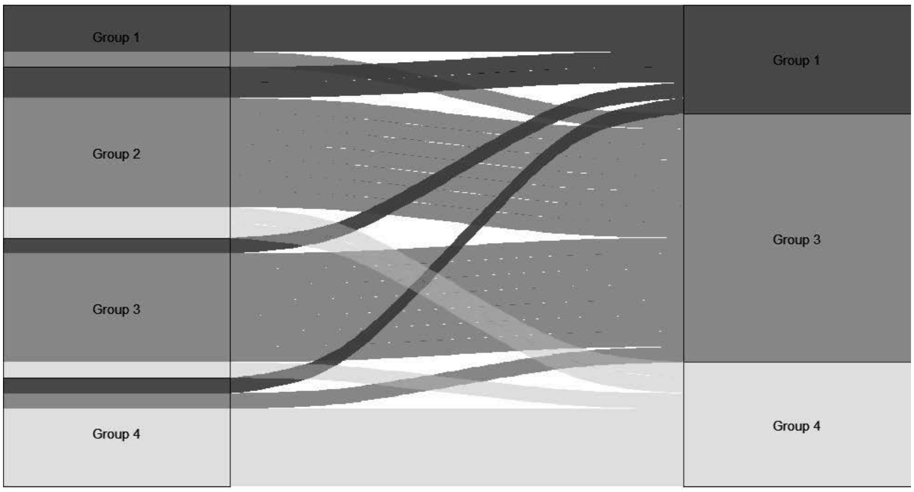
Sample 1993-2007							
Grupo 1 (4)				Grupo 2 (11)			
EUR	GBP	**NZD**	**NOK**	JPY	**AUD**	**SEK**	DKK
				ZAR	**PLN**	**CZK**	HKD
				INR	**RUB**	**HUF**	
Grupo 3 (9)				Grupo 4 (7)			
TRY	MXN	BRL	CLP	**CAD**	CHF	SGD	**KRW**
COP	ARS	PEN	CNY	**TWD**	**MYR**	**IDR**	
ILS							
Sample 2007-2019							
Grupo 1 (7)				Grupo 2 (16)			
EUR	**NZD**	**NOK**	JPY	GBP	**AUD**	**SEK**	**ZAR**
CHF	DKK	ARS		TRY	**PLN**	**CZK**	SGD
				MXN	BRL	CLP	COP
				PEN	**RUB**	**HUF**	
Grupo 3 (8)							
CAD	HKD	**KRW**	**TWD**				
MYR	INR	**IDR**	CNY				

Notes: The table presents the estimated groups for each of the 31 exchange rates used in the model of Ando and Bai (2017) for the two periods. Bold names are exchange rates that remain from the original group. Group 2 from the first part constitutes a great part of the peripheral European Countries in the sample. Group 3 has mostly Latin American Countries. Group 4 has a majority of South-East Asian Countries. After the crisis, the European and Latin American joined in a single group. Controlling for the West Texas Intermediate (WTI) eliminates the existence of a group with commodity currencies. *Sources:* Author's calculations.

From the previous results, we can construct the errors of the model and estimate the conditional volatility (uncertainties) of each one of the Exchange Rates. I calculate the value of the exchange rate uncertainties in Equation 1.10 by giving equal weight to each, as in Jurado et al. (2015) and Ludvigson et al. (2021) [9]. Figure 1.5 presents the result of

[9] I tried other specifications, such as using weights by turnover or trade, but it had a higher concentration only on the Euro, Yen, and Pound. This will reflect their market power and influence, but will underestimate

Figure 1.4. Group Transition between 1993 to 2019



Note: The graph plots the change of the group membership between the sample 1993-2007 (left) and 2007-2019 (right) for each of the groups. *Sources:* Author' calculations.

estimating the general level of Uncertainty and the occurrence of events that coincide with the peaks of the distribution.

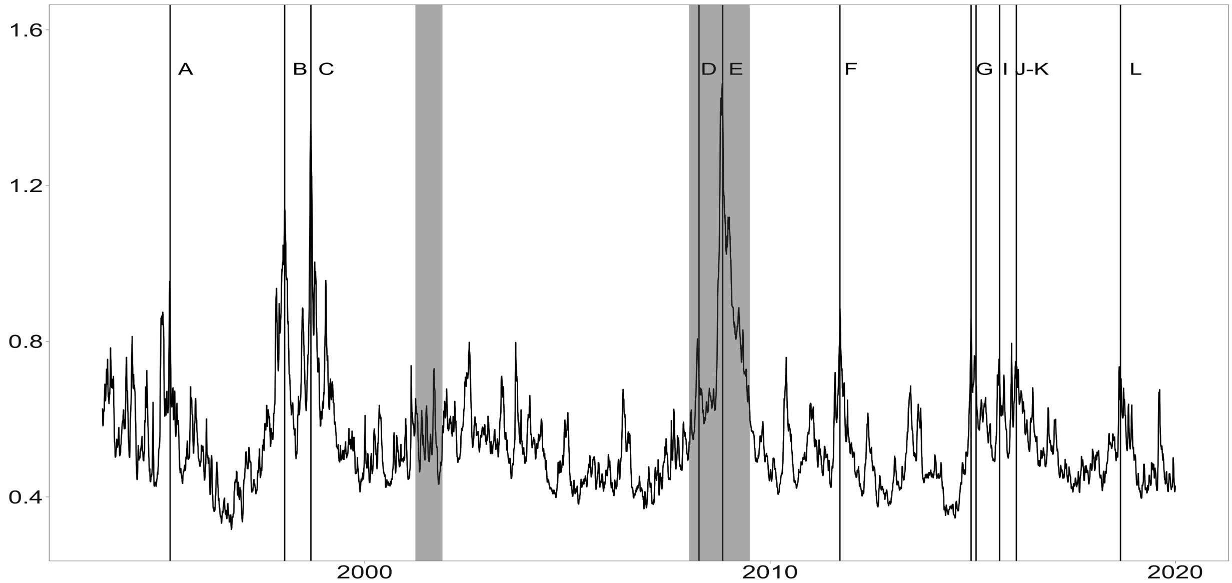
The uncertainty index reflects the market's economic conditions and mainly measures general economic Uncertainty. After the "Tequila" crisis ended, it decreased until 1997. In that year, the Asian exchange rate crisis of Hong Kong, Singapore, South Korea, and Taiwan occurred. The turmoil generated that most countries implicated abandoned a fixed/pegged exchange rate and converted to a (managed) floating exchange rate regime. The event might be part of the explanation behind the high level in this period. The developed countries started retrenching their capital from the developing countries, which devalued a significant amount of the emerging world exchange rates and impulsed a financial crisis that affected Russia, Brazil, and Latin American Countries. A considerable spike at the end of the 2000s represents the Great Financial Crisis of the USA that escalated quickly into a world financial crisis. The crisis created a financial flow from the affected countries to others that offered a higher return rate, as mentioned by Caballero, Farhi, and Gourinchas (2008a,b). Global imbalances generate capital migration and high exchange rate fluctuation.

From the figure, we can see that the index does not capture the 2001 dot-com bubble. It was just an event of the stock market and did not spill over to a world financial crisis; it did not generate disruption in the exchange markets. In which case, we can say that the uncertainty index itself is robust to measuring other types of uncertainties, such as the Economic Policy Index of Baker et al. (2016a) or the macroeconomic and financial uncertainty indexes of Ludvigson et al. (2021)[10].

the shocks coming from other developed and emerging countries.

[10] In appendix 1.5, I compare the results of the index to the mentioned uncertainty measures, and some

Figure 1.5. Exchange Rate Uncertainty Index with Breaks

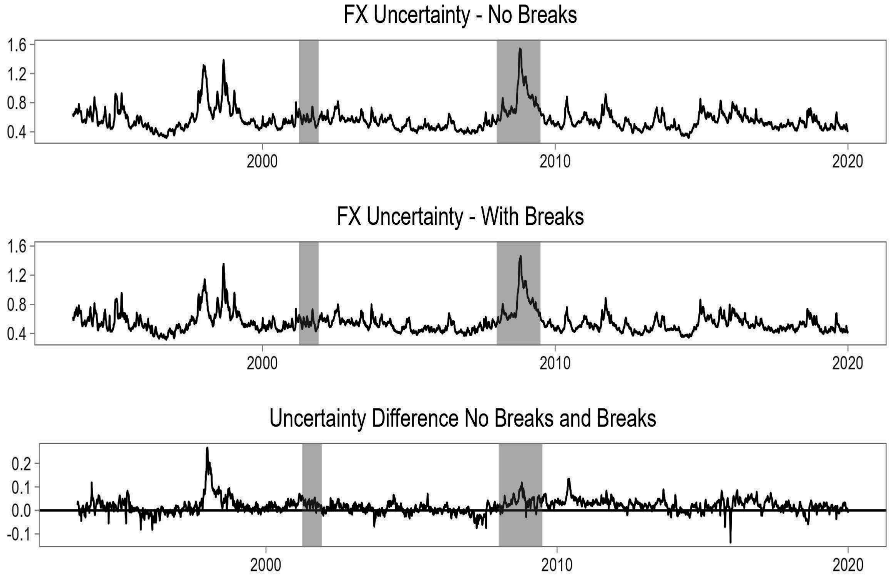


Note: The graph plots the general Exchange rate index calculated by the model. The letters in the plot correspond to events that affected the uncertainty level. A-Mexican Bail-out, B-Asian Crisis, C-Russian Bail-out, D-9/11, E-Term Auction Facility, F-Lehman Bankruptcy, G-Quantitative Easing, H-Quantitative Easing 2, I-Operation Twist, J-Bernanke's Taper Tantrum, K-Forward Guidance/Swiss Ending Peg, L-Brexit Vote. Shaded regions are the NBER recession dates for the periods. *Sources:* Author' calculations and NBER.

Two aspects need to be contrasted in the model: the difference between accounting or not for the breaks and the relationship between the changes in the level of Uncertainty and the dollar movements. In Figure 1.6 I plot the uncertainty without breaks (UN_{NB}), with breaks (UN_B), and the difference between them (UN_{NB} - UN_B). The graph shows that both series behave similarly, so that we can expect a high correlation. The last plot makes the difference clearer, as UN_{NB} is biased toward the right side of the distribution, showing higher Uncertainty. The difference is not related to episodes of crisis or recessions, except for the Asian crisis in the second part of the 90s. Then, I contrast the relationship between the Dollar and the Uncertainty by regressing the returns of each currency to the Uncertainty and the Dollar separately. Figure 1.7 plots the returns and the betas of each of the currencies in a CAPM-like model to show the difference between the returns and Dollar effect and compare the results of Avdjiev et al. (2019) in which the VIX and Dollar captured similar effects. The graph shows that the effect of Uncertainty and the Dollar, measured through the DXY dollar index, differs in both level and sign. There is no clear trend of the dollar beta with returns, but there is a higher level of Uncertainty with higher returns (depreciation), as a risk/return expected by the risk-return trade-off. The New Zealand dollar, the British Pound, and the Australian Dollar face both negative effects, the

other commonly used in the literature.

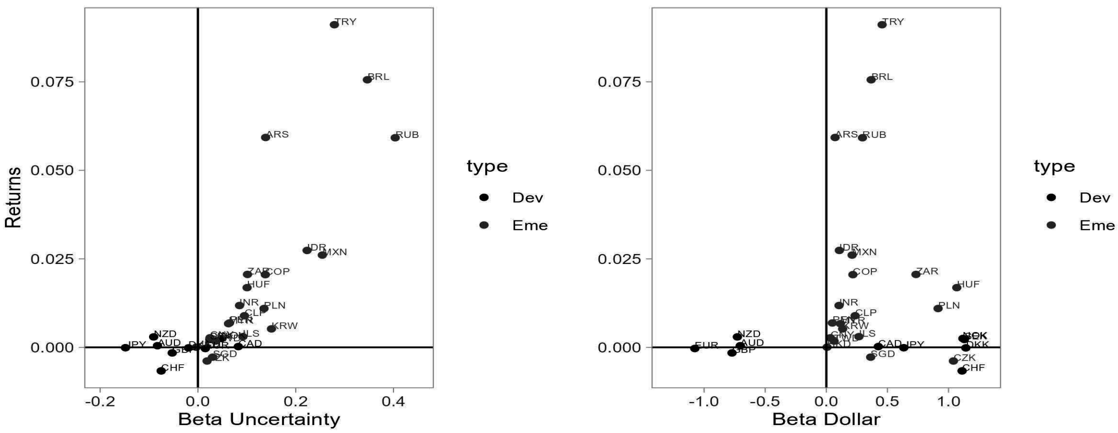
Figure 1.6. Exchange Rate Uncertainty Index with Breaks and No Breaks



Note: The graph plots the Exchange Rate Uncertainty Index without considering the Breaks, with the breaks, and the difference between them. Shaded regions are the NBER recession dates for the periods. *Sources:* Author' calculations and NBER.

Uncertainty and the Dollar. In contrast, analogously, the Canadian Dollar, the Swedish Krona, and the Norwegian Krone positively affect both. On the other hand, the Japanese Yen, the Euro, the Danish Krone, and the Swiss Franc have a contrary sign. Then, we can see that a few currencies show that the Dollar and Uncertainty have similar effects.

Figure 1.7. Uncertainty and Dollar Effects on Returns



Note: The figure plots the estimated beta between returns of each developed and emerging currency and both Uncertainty and the Dollar. The left panel presents the returns against the estimated parameters β of the regression against the logarithmic of the uncertainty measure. The right panel follows the same estimation but against the DXY dollar index. I estimate a lineal model using Newey and West (1987) and Newey and West (1994) lag selection procedure. Developed Markets are in black, while the emerging markets are in dark grey. *Sources:* Bloomberg and author's calculations.

Covered Interest Rate Parity

The Covered Interest Rate Parity (CIP) measures the Parity relating to the investment returns between two countries and the exchange rate returns. It states that under rational expectations and no transaction costs, the differences between riskless investments of different countries should be equivalent once defined in the same currency. Following Du and Schreger (2022), we can define the CIP condition as,

$$(1 + y_{t,t+n})^n = (1 + y^*_{t,t+n})^n \frac{S_t}{F_{t,t+n}} \tag{1.11}$$

where $y_{t,t+n}$ is the n-period risk-less interest rate in the domestic currency, $y^*_{t,t+n}$ is the n-period risk-less interest rate of the foreign currency, S_t is the spot rate between the domestic currency and the foreign currency, and $F_{t,t+n}$ is the n-period forward exchange rate of domestic currency relative to foreign for time $t + n$ negotiated at time t. If we transform in logarithms and rearrange, we obtain the following identity:

$$\begin{aligned} \lambda_{t,t+n} =& y_{t,t+n} - (y^*_{t,t+n} - \rho_{t,t+n}) \\ \rho_{t,t+n} =& \frac{log(F_{t,t+n}) - log(S_t)}{n} \end{aligned} \tag{1.12}$$

where $\rho_{t,t+n}$ is the annualized forward premium and $\lambda_{t,t+n}$ is the CIP deviation, also called the n-period Cross-currency Basis or Libor Cross-currency Basis, because we use each countries' Libor rates as the risk-less interest rates. If the CIP holds such that there are no opportunities for arbitrage, the basis value should be zero. So, the equation measures the difference between the domestic and synthetic domestic rates. Hence, if the Basis is negative, it implies that the synthetic rate is higher than the domestic rate, or the inverse if it is positive. Any deviation from the zero value means an opportunity for arbitrage to any market participant.

We can extend the CIP model from risk-free rates in the market to government bonds. Following the notation in Du and Schreger (2022), we can refer to the Government cross-currency basis as

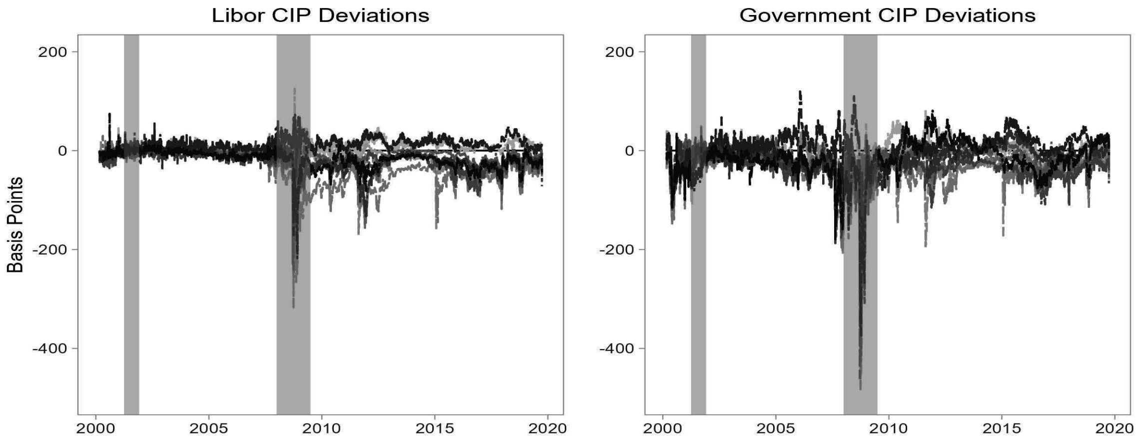
$$\lambda^{Gov}_{t,t+n} = (y^{Gov*}_{t,t+n} - \rho_{t,t+n}) - y^{gov}_{t,t+n} \tag{1.13}$$

where $\lambda^{Gov}_{t,t+n}$ is the n-period Government Cross-currency basis, $y^{Gov*}_{t,t+n}$ is the n-period government interest rate in the foreign currency, and $y^{Gov}_{t,t+n}$. We can notice that the Equations 1.12 and 1.13 are different because the Government Cross-currency basis is the negative specification of the Libor Cross-currency Basis. As the authors mention, the definition binds the Cross-currency Basis with the concept of the Convenience Yield defined in Feldhütter and Lando (2008), Krishnamurthy and Vissing-Jorgensen (2012), and Jiang et al. (2021).

Convenience Yield refers to the benefits of the liquidity and safety that the government treasury bonds of the domestic economies confer related to the foreign. The high valuation of these assets maintains the yield lower than other safe assets with the same maturity, creating a spread that gives the issuer/holder a liquidity premium.

In Figure 1.8, I present the calculated Libor and Government Cross-Currency Basis using Equations 1.12 and 1.13[11]. As we can see, the basis points, although expected to be closely related, are different, with the Government CIP deviations being the highest. One clear pattern we can see is the behavior of both Basis before and after the Financial Crisis of 2007; this change will be reflected in the behavior of the forward premium. As the size of the currency basis increases afterward, especially after the crisis, we can suppose that the higher uncertainty level affects the level of deviations, as higher Uncertainty raises the demand for safe foreign assets, especially the USD debt.

Figure 1.8. Libor and Government CIP Deviations for the G10 Currencies



Note: The graph plots the Libor and Government Cross-currency basis for the G10 currencies. I graph the inverse of $\lambda^{Gov}_{t,t+n}$ for comparison to $\lambda_{t,t+n}$, but in the rest of the paper, I will use it in terms of convenience yield. The shaded region corresponds to NBER recession dates *Sources:* Bloomberg, NBER, and author's calculations.

Previous literature as Brunnermeier et al. (2008), Berg and Mark (2018a), Berg and Mark (2018b), Husted et al. (2018), and Kalemli-Özcan and Varela (2021) show the relationship between interest rate parity and uncertainty. Yet, they mostly focus on traditional Uncertainty measures unrelated to exchange rates. Still, macroeconomic or financial markets, such as the VIX as recent work by Avdjiev et al. (2019) and Cerutti et al. (2021). They find that this variable loses significance by controlling for broad dollar variations. By constructing an exchange rate-specific Uncertainty, I argue that we can show an innate

[11]The calculation of the Basis reBasisd me to annualize the forward premium of the currencies and interest rates. I follow the measures of Du and Schreger (2022) presented in Appendix A of the paper to replicate their results. I match the days of the maturity of the forward with the interest rates to guarantee that there are no specifications or biases in the CIP, as mentioned by Bekaert and Hodrick (1993)

variability in the currencies not accounted for in the broad index. In this section, I provide evidence of the significance of this result by comparing it to different traditional models in the literature. I center on the period of 2007-2019 using daily weekday data, the period after the financial crisis, as the previous variation of both Libor and Government cross-currency basis have low levels that are not significant for arbitrage opportunities.

I will construct different measures of Uncertainty to asses whenever they may have some power over explaining the Basis to assess the effect of Uncertainty on the Libor and Government Cross-currency Basis shown in Equations 1.12 and 1.13. I use both UNC_{NB} and UNC_B that I presented previously. Considering the existence of breaks, I construct a group-specific uncertainty for the model, such that I take the equal weight of the Uncertainty specific to the group membership. Then, we will have the Uncertainty for groups one and two with no breaks presented in Table 1.2; $UNC_{G1,NB}$ and $UNC_{G2,NB}$. If we account for breaks, then we will three groups as in Table 1.3 after 2007; $UNC_{G1,B}$, $UNC_{G2,NB}$, and $UNC_{G3,B}$. Additionally, I only consider the G10 currencies' Uncertainty by assuming no break, $UNC_{10,NB}$, so I can assess the contribution of only the most commonly analyzed currencies.

Table 1.4. Dollar Factors and Uncertainty

	CIP	UNC_{NB}	UNC_B	$UNC_{G1,NB}$	$UNC_{G2,NB}$	$UNC_{10,NB}$	VIX	DXY	$UNC_{G1,B}$	$UNC_{G2,B}$	$UNC_{G3,B}$
CIP	1										
UNC_{NB}	-0.48	1									
UNC_B	-0.44	0.99	1								
$UNC_{G1,NB}$	-0.46	0.99	0.98	1							
$UNC_{G2,NB}$	-0.50	0.91	0.89	0.85	1						
$UNC_{10,NB}$	-0.46	0.89	0.89	0.86	0.92	1					
VIX	-0.47	0.79	0.78	0.77	0.76	0.77	1				
DXY	-0.01	0.01	0.01	0.01	0.005	0.01	0.09	1			
$UNC_{G1,B}$	-0.41	0.95	0.97	0.95	0.84	0.85	0.73	0.01	1		
$UNC_{G2,B}$	-0.42	0.89	0.89	0.86	0.89	0.95	0.74	0.01	0.83	1	
$UNC_{G3,B}$	-0.40	0.86	0.87	0.86	0.75	0.68	0.68	0.01	0.74	0.68	1

The table presents the correlations between the different types of Uncertainty and the average Cross-Currency Basis (CIP). UNC_{NB} is the calculated Uncertainty assuming no breaks, UNC_B assuming breaks, $UNC_{G1,NB}$ and $UNC_{G2,NB}$ are the ones formed by the estimated groupBasish no breaks, VIX is the Chicago Board Exchange's Volatility index for the S&P500, DXY is the DXY Dollar index, and $UNC_{i,B}$ are uncertainties formed by groups $i = G1, G2, G3$ with breaks.

In Table 1.4, I show the correlation of the different measures of Uncertainty and the average level of Libor Cross-currency basis as the benchmark measure of future models. We can see a high correlation between the various measures and the ground, with low magnitudes of difference between them. Let's turn to the correlation between the uncertainties calculated. We can see that coherent to Figure 1.6, the break and no break uncertainties have a near one correlation, and the other groups have similar levels of correlation. The high relationship between them indicates that even accounting for the break in 2007, the uncertainty relationship is generally homogeneous between the currencies. The homogeneity of Uncertainty suggests that currency variability loads heavily on a common variation of the dollar, but it is not captured by dollar index measures, such as the DXY. The VIX has a high correlation concerning the uncertainty level, which tells us that a significant part of the currency fluctuations are due to the variations in the financial markets of the United States market. Still, there is other information that is not contained in those fluctuations.

I then analyze the effect of Uncertainty on Libor's cross-currency basis. I follow a CAPM-like model to analyze the sensitivity of the Libor cross-currency basis from the Uncertainty for 2007 to 2019. I estimate the following model,

$$\lambda_{t,t+n} = \alpha + \beta_1 UN_{i,t-1} + \varepsilon_t \tag{1.14}$$

where $\lambda^i_{t,t+n}$ is the 3-month Libor cross-currency basis and $UN_{i,t} = \{\ UNC_{NB},\ UN_B,\ UN_{G,NB},\ UN_{G,B},\ UN_{10},\ VIX\ \}$ are the different types of Uncertainty used [12]. In Table 1.5, I present the results of each currency basis against each Uncertainty. We can see if a single uncertainty provides a better fit or if the uncertainties vary with the currency. We can see that there are heterogeneous effects, where for the AUD and the JPY, I find no uncertainty measure provides enough statistical relevance to the basis. If we select based on how well the model in equation 1.14 explains the data, we can see that VIX has higher significance for the CAD, DKK, and NOK. At the same time, the rest of the countries have a better fit with either uncertainty measure. A critical aspect of the result is that it provides evidence that it is not the case of a single measure that fits all but that every country has its idiosyncratic behavior. In most cases, high Uncertainty increases the cross-currency basis, but it is positive for the CAD and NZD. The highest exposure to Uncertainty comes from DKK, GBP, and EUR, while the lowest comes from SEK and CHF.

Table 1.5. Libor Cross-currency Basis and the Uncertainty 2007-2019

	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
UN_{NB}	-6.777	16.182	-23.609	-76.653	-43.901	-56.901	-10.166	-47.959	8.761	-38.239
p-value	0.262	0.00002	0.019	0	0.0001	0.0001	0.198	0.00001	0.009	0.001
$Adj.r^2$	0.013	0.063	0.064	0.313	0.163	0.345	0.015	0.225	0.033	0.205
UN_B	-4.196	16.242	-20.934	-73.293	-39.971	-56.757	-7.651	-45.650	10.858	-37.108
p-value	0.505	0.00003	0.046	0	0.001	0.0002	0.347	0.0001	0.001	0.004
$Adj.r^2$	0.004	0.060	0.048	0.271	0.128	0.325	0.008	0.193	0.048	0.183
$UN_{G,NB}$	-7.329	14.603	-22.434	-72.052	-41.746	-45.159	-9.485	-45.093	2.727	-34.600
p-value	0.139	0.0001	0.021	0	0.0003	0.001	0.217	0.0001	0.435	0.001
$Adj.r^2$	0.020	0.052	0.059	0.281	0.150	0.284	0.013	0.202	0.004	0.220
$UN_{G,B}$	-1.501	14.771	-19.912	-62.445	-32.792	-40.248	-7.402	-36.683	9.837	-28.116
p-value	0.770	0.00002	0.026	0.00000	0.004	0.010	0.256	0.001	0.0004	0.017
$Adj.r^2$	0.001	0.063	0.055	0.250	0.110	0.217	0.009	0.159	0.052	0.139
UN_{10}	-8.388	18.068	-22.915	-75.635	-39.102	-50.650	-5.081	-46.270	3.760	-35.677
p-value	0.125	0.00001	0.035	0	0.001	0.001	0.460	0.00001	0.312	0.003
$Adj.r^2$	0.020	0.080	0.062	0.312	0.132	0.280	0.004	0.215	0.006	0.183
VIX	-4.846	19.863	-5.495	-49.079	-28.590	-33.166	6.008	-33.919	3.405	-19.761
p-value	0.117	0	0.467	0	0.0003	0.001	0.191	0.00000	0.121	0.024
$Adj.r^2$	0.018	0.257	0.009	0.347	0.187	0.317	0.014	0.305	0.013	0.148

The table shows the regression of different types of uncertainty against the LIBOR cross-currency basis for each currency. UN_{NB} is the uncertainty without taking into account breaks, UN_B is the uncertainty with breaks, $UN_{G,NB}$ is the uncertainty of the respective two groups without breaks, $UN_{G,B}$ is the group uncertainty. Still, for each of the three groups after the break, UN_{10} is the uncertainty of the Top 10 economies and the Chicago Board Exchange' Volatility Index VIX. The model is estimated following Newey and West (1987) with an optimal lag selection of Newey and West (1994).

[12] Ludvigson et al. (2021) and Carriero, Clark, and Marcellino (2018b) argue that uncertainty shocks may be endogenous to the production of the economy. As such, I take the lagged value as a partial solution to the endogeneity of the series. Although the last find that the effect may not be contemporaneous, Uncertainty may react in later periods to production shocks.

If we apply the same CAPM model in equation 1.14 to the whole sample, we could test if the uncertainty has relevance in explaining the entire sample from 2000-2019. I take the Uncertainty with breaks, $UN_{t,B}$, as my benchmark uncertainty model, as I want to account for the change of the comovements of breaks and regress it against both the Libor and Government Cross-Currency basis. In Table 1.6, we can see the general results of the model, where the uncertainty is significant for most currencies but the AUD in both Libor and Government basis, while compared to the previous results, JPY is significant for the Libor Basis. Uncertainty is not significant for the NZD and GBP on a government basis. As mentioned earlier, the currencies and the AUD are coincidentally part of the Group 1 (1993-2007 sample) with NOK, which shows weak significance. Based on the results, we can expect uncertainty to be generally relevant to explain the cross-currency basis of both Libor and Government markets, with a higher magnitude for the Government deviations. The results are consistent with the theory and the effects of Jiang et al. (2021), as it suggests that higher levels of uncertainty and risk aversion increase the demand for safe assets and treasury bills, which in turn help the rates to stay low. At the same time, the international markets have the pressure to increase them (Gourinchas and Rey, 2007, 2014, 2022; Camanho, Hau, and Rey, 2022).

Table 1.6. Libor Cross-currency Basis and Uncertainty - 2000-2019

	Libor CIP Deviations									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
α	2.67	-4.60^{*}	-30.63^{***}	-86.16^{***}	-44.64^{***}	-42.99^{***}	-25.48^{***}	-47.45^{***}	16.00^{***}	-40.03^{***}
	(3.54)	(2.58)	(6.24)	(10.53)	(8.54)	(10.46)	(4.68)	(7.60)	(2.09)	(8.33)
β_1	-0.21	9.63^{***}	-24.09^{***}	-75.30^{***}	-40.92^{***}	-46.20^{***}	-13.87^{**}	-41.96^{***}	13.43^{***}	-34.72^{***}
	(5.05)	(3.48)	(8.67)	(14.71)	(11.76)	(14.70)	(6.59)	(10.77)	(3.02)	(11.76)
R^2	0.00	0.02	0.05	0.16	0.11	0.25	0.02	0.15	0.05	0.14
$Adj.R^2$	-0.00	0.02	0.05	0.16	0.11	0.25	0.02	0.15	0.05	0.14
Num. obs.	5173	5173	5173	5173	5173	5173	5173	5173	5173	5173
	Government CIP Deviations									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
α	25.01^{*}	52.74^{***}	83.14^{***}	98.70^{***}	48.87^{***}	26.86^{**}	94.10^{***}	62.16^{**}	25.23	75.86^{**}
	(13.01)	(17.57)	(11.06)	(26.21)	(16.14)	(13.25)	(28.67)	(28.12)	(18.78)	(32.72)
β_1	26.01	52.44^{**}	74.43^{***}	85.84^{**}	42.70^{*}	21.50	86.33^{**}	68.47^{*}	44.69	88.33^{*}
	(18.66)	(25.32)	(15.35)	(37.59)	(23.08)	(19.07)	(41.24)	(40.57)	(27.49)	(46.70)
R^2	0.03	0.15	0.19	0.20	0.10	0.03	0.23	0.17	0.09	0.20
Adj. R^2	0.03	0.15	0.19	0.20	0.10	0.03	0.23	0.17	0.09	0.20
Num. obs.	5173	5173	5173	5173	5173	5173	5173	5173	5173	5173

The model is estimated following Newey and West (1987) with optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

I extended the CAPM model type regression used earlier with additional control variables to assess the robustness of the results. To this end, I follow the models of Du et al. (2018), Verdelhan (2018), Avdjiev et al. (2019), and Cerutti et al. (2021), which are used in the literature as the benchmark to models to explain the deviations in Libor market. I estimate the following model,

$$\lambda_{t,t+n}^{CIP,i} = \alpha + \beta_1 TWDI_t + \beta_2 UN_{B,t-1} + \beta_3 \Delta Unc_{B,t} + \beta \mathbf{X} + \varepsilon_t \tag{1.15}$$

where $\lambda_{t,t+n}^{i}$ is the 3-month cross currency basis for $CIP = Libor, Government$ and currency i, $TWDI_t$ are the logarithmic returns of the trade-weighted broad dollar index from the Federal Reserve of St. Louis Economic Database (FRED), $\mathbf{X} = [ER_{i,t}, WTI_{t-1}]$ are control variables. $ER_{i,t}$ are the logarithmic exchange rate of i against the dollar, and the WTI is the West Texas Intermediate logarithmic returns. The inclusion of the Exchange rate and the Dollar index obeys to control for the effect of variations of the dollar and its implications of the "risk-taking channel" mechanism described in Bruno and Shin (2015a,b), Ivashina et al. (2015), Avdjiev et al. (2019), and Bräuning and Ivashina (2020). Following Bruno and Shin (2015a) and Avdjiev et al. (2019), I include both the level and logarithmic variation of the Uncertainty measure that I constructed to capture the variation and the general level of the uncertainty in the exchange rates. I include the change in the price of oil as the relationship between the predictability of commodity currencies and oil is a well-established stylized fact, as we can see in Amano and Van Norden (1998), Ferraro, Rogoff, and Rossi (2015), Chen, Liu, Wang, and Zhu (2016), and Boubakri, Guillaumin, and Silanine (2019).

Table 1.7 presents the estimation results of the univariate regression of equation 1.15. Even by including the dollar index, we can see that the uncertainty remains significant for both the Government and Libor Basis. The level of uncertainty has a significant effect for almost all variables but the AUD and JPY, coherent with the previous result. I find evidence that an increase of 1 percent of the uncertainty increases the Libor basis by at most 75 basis points. Nevertheless, I find that the variations in the uncertainty level do not affect the basis. Coherent with the results in the literature, the effect of the dollar on the basis is prevalent for the Libor, and it is economically significant. One puzzling result is the lack of significance of the Oil price; other than for the SEK, there is only a statistically weak effect in other currencies such as CAD, CHF, and DKK. Due to the basis level, the increase in the oil price reduces the deviations, as it is traduced in further increases on capital outflows for the US, which reduces the gap.

The government basis has a particular behavior compared to the Libor Basis. Neither the dollar nor the oil price has a statistically significant effect. The only significant impact comes from the uncertainty level. Uncertainty increases the retrenchment of gross capital flows back to the US as it also increases the rates of the domestic economy relative to the US by changing the time-varying risk aversion, as mentioned by Bekaert, Engstrom, and Xing (2009). Then, the regression results show a relationship between the level of uncertainty and increases in the convenience yield of the US government treasury assets. For economies like Denmark and Sweden, an increase in uncertainty generates a surge in the deviation by 115 and 119 basis points, an economically relevant amount.

I extend the model in 1.15 and include other macroeconomic variables to analyze the deviations from the parity. I base on the model proposed by Cerutti et al. (2021) of macro-financial variables to explain the basis of the different currencies. Kalemli-Özcan and Varela

Table 1.7. Cross-Currency Basis and the Exchange Rate Uncertainty with Controls 2007-2019

	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
	Libor CIP Deviations									
α	1.22	-6.69^{**}	-37.96^{***}	-105.23^{***}	-55.63^{***}	-53.95^{***}	-29.56^{***}	-58.02^{***}	19.93^{***}	-48.38^{***}
	(4.82)	(3.32)	(8.12)	(9.95)	(9.19)	(12.12)	(6.64)	(9.46)	(2.68)	(11.50)
$TWDI_t$	−51.11	-256.54^{***}	−185.17	−273.10	-305.30^{*}	−96.11	-428.96^{**}	−202.23	−25.75	-216.90^{***}
	(86.75)	(95.29)	(116.02)	(221.76)	(172.91)	(210.30)	(170.01)	(215.95)	(82.42)	(81.95)
ΔER_t	1.38^{**}	−0.19	-1.18^{**}	0.15	0.77	1.23	−0.34	0.21	−0.11	−0.23
	(0.56)	(0.53)	(0.50)	(1.13)	(0.76)	(0.88)	(0.67)	(0.65)	(0.39)	(0.23)
$UN_{B,t-1}$	−6.46	17.04^{***}	-21.83^{**}	-74.61^{***}	-41.14^{***}	-57.99^{***}	−6.86	-46.79^{***}	11.29^{***}	-37.24^{**}
	(6.79)	(4.26)	(11.12)	(13.72)	(12.03)	(16.87)	(9.39)	(12.79)	(3.92)	(16.66)
$\Delta UN_{B,t}$	−70.04	−29.11	−34.25	91.23	32.49	−4.98	−41.83	31.00	7.81	17.63
	(45.29)	(42.52)	(53.29)	(80.23)	(75.20)	(68.69)	(64.37)	(65.42)	(27.51)	(32.29)
ΔWTI_{t-1}	−5.52	25.35^{*}	26.03^{*}	36.79^{*}	27.01	22.21	13.98	23.38	8.40	59.60^{***}
	(14.84)	(14.66)	(15.73)	(22.07)	(17.35)	(26.05)	(15.90)	(17.02)	(12.38)	(16.98)
R^2	0.03	0.07	0.06	0.29	0.15	0.34	0.02	0.21	0.05	0.20
Adj. R^2	0.03	0.07	0.06	0.29	0.15	0.34	0.01	0.21	0.05	0.20
Num. obs.	2759	2759	2759	2759	2759	2759	2759	2759	2759	2759
	Government CIP Deviations									
α	33.87^{*}	69.27^{***}	98.94^{***}	125.52^{***}	60.85^{***}	39.97^{***}	116.26^{***}	79.27^{***}	28.75	89.95^{***}
	(17.84)	(19.73)	(10.10)	(24.10)	(18.24)	(15.42)	(28.07)	(22.83)	(18.31)	(28.25)
$TWDI_t$	124.52	136.20	−141.04	240.87	320.67	290.72	721.20	−101.03	283.38	87.88
	(279.61)	(215.15)	(200.69)	(376.99)	(276.10)	(374.72)	(489.68)	(308.35)	(285.05)	(413.20)
ΔER_t	−0.59	1.31	1.83^{**}	−0.26	−0.08	−0.62	−0.34	1.03	0.96	1.07
	(1.29)	(1.79)	(0.86)	(1.64)	(1.07)	(0.86)	(0.85)	(0.93)	(0.79)	(0.88)
$UN_{B,t-1}$	44.58^{*}	75.99^{***}	79.72^{***}	115.22^{***}	62.23^{**}	41.94^{*}	108.60^{***}	96.92^{***}	53.15^{**}	118.66^{***}
	(25.02)	(28.24)	(13.82)	(33.92)	(25.40)	(21.83)	(39.78)	(31.46)	(26.49)	(38.46)
$\Delta UN_{B,t}$	52.92	118.96	5.15	67.98	172.67	68.84	162.56	82.44	−24.85	162.74
	(137.83)	(111.26)	(95.68)	(171.53)	(161.43)	(127.86)	(194.69)	(132.19)	(82.02)	(149.05)
ΔWTI_{t-1}	11.80	−27.73	−10.54	−25.16	−12.07	−5.48	−59.80	−40.19	−61.20	−53.93
	(34.12)	(38.14)	(33.59)	(44.19)	(26.41)	(34.68)	(40.77)	(40.46)	(45.54)	(37.67)
R^2	0.10	0.28	0.28	0.34	0.18	0.13	0.33	0.28	0.15	0.31
Adj. R^2	0.10	0.28	0.27	0.34	0.18	0.13	0.33	0.28	0.15	0.31
Num. obs.	2759	2759	2759	2759	2759	2759	2759	2759	2759	2759

The model is estimated following Newey and West (1987) with optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

(2021) show that for the Uncovered Interest Rate Parity, the fluctuations are highly correlated with variations in the interest rate differentials. Consequently, I include the variations on the domestic USD LIBOR benchmark rates as the domestic rate (r_t), the currency country LIBOR rate (r_t^*), and He, Kelly, and Manela (2017)'s logarithmic returns of the squared leverage (L^2) as a measure of intermediary constraint, consistent with their paper and the literature of intermediary asset pricing effect on the carry trade and exchange rates such as Fang and Liu (2021), Du et al. (2022), and Niepmann and Schmidt-Eisenlohr (2023).

In Table 1.8, I present the results of the univariate regression by currency for Libor and Government basis. The dollar factor is again relevant in the models for each currency but the AUD, NOK, GBP, and NZD. The basis from those currencies was also not statistically significant in the previous model in Table 1.7, which shows the consistency of the effect of the dollar appreciations. The changes in the domestic rate are consistent and significant in explaining the basis for all currencies except the DKK and the GBP, which have a significant effect on their rate. In particular, CHF, EUR, and SEK have their interest rate and the US interest rate as significant effects. In this model, the level of uncertainty is again significant, but not for the AUD only. Like the results in Cerutti et al. (2021), I find that the increase in the leverage of the intermediaries does not have statistical significance in explaining the

Table 1.8. Extended Libor and Government basis regressions

	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
					Libor CIP Deviations					
α	1.08	−9.31***	−37.76***	−105.78***	−53.47***	−53.75***	−33.04***	−58.58***	19.32***	−48.34***
	(5.30)	(3.08)	(6.59)	(10.65)	(7.48)	(10.06)	(4.21)	(8.05)	(2.64)	(7.30)
$TWDI_t$	−100.96	−247.52***	−357.38***	−344.75	−330.80*	−179.98	−354.89**	−186.50	24.29	−289.87**
	(135.03)	(94.44)	(134.70)	(228.35)	(192.50)	(185.28)	(171.02)	(159.25)	(83.60)	(140.33)
Δr_t^*	−4.13	−11.80	189.79**	96.39*	399.91***	136.10**	−22.42	25.60*	−0.79	103.44***
	(13.14)	(46.58)	(75.12)	(55.29)	(155.02)	(69.29)	(201.92)	(15.16)	(12.84)	(33.49)
Δr_t	−135.11***	−124.22***	−231.23***	−135.34	−270.63***	−147.96	−312.19***	−106.46*	−38.28**	−83.07*
	(51.20)	(27.42)	(54.05)	(92.88)	(70.75)	(91.92)	(48.46)	(64.40)	(18.84)	(50.32)
$UN_{B,t-1}$	−5.86	11.50***	−20.23**	−73.49***	−36.44***	−57.63***	−12.01**	−46.36***	10.13**	−36.58***
	(7.58)	(3.85)	(9.15)	(15.32)	(10.29)	(14.15)	(5.94)	(11.23)	(3.97)	(10.48)
$\Delta UN_{B,t}$	−63.16	−35.02	−24.79	93.05	19.40	6.42	−22.69	31.18	14.22	23.15
	(43.36)	(40.82)	(59.43)	(76.72)	(70.05)	(65.85)	(46.45)	(71.14)	(28.41)	(54.93)
Δ L^2	−15.86	8.62	32.55	20.84	12.14	5.45	15.64	16.85	−1.52	8.04
	(12.02)	(12.69)	(24.24)	(21.90)	(18.18)	(19.58)	(13.91)	(16.64)	(7.23)	(21.25)
R^2	0.07	0.09	0.12	0.29	0.19	0.36	0.17	0.20	0.05	0.21
Adj. R^2	0.07	0.09	0.12	0.29	0.19	0.36	0.17	0.20	0.05	0.21
Num. obs.	2708	2708	2708	2708	2708	2708	2708	2708	2708	2708
					Government CIP Deviations					
α	32.57**	67.87***	96.99***	125.83***	63.23***	40.72***	118.96***	78.04***	26.60	88.68***
	(15.41)	(19.18)	(11.48)	(21.65)	(17.53)	(14.08)	(25.35)	(25.31)	(16.36)	(27.31)
$TWDI_t$	79.42	222.34	75.90	223.84	287.19	288.57	553.90	−16.79	174.25	170.84
	(372.58)	(338.02)	(250.69)	(446.19)	(297.96)	(284.48)	(500.94)	(288.52)	(264.12)	(437.94)
Δr_g^*	−66.20	−220.95**	−168.69**	115.82	159.18	−75.04	649.76	−67.08	−104.42*	−83.84
	(48.87)	(109.06)	(65.67)	(82.33)	(287.00)	(51.22)	(563.13)	(46.53)	(54.89)	(56.14)
Δr_g	117.21	103.21	103.05	131.29	205.93	232.85	265.35	60.94	35.85	92.91
	(182.17)	(194.43)	(116.60)	(213.49)	(201.42)	(168.61)	(226.38)	(195.61)	(90.16)	(242.37)
$UN_{B,t-1}$	43.12**	75.29***	74.45***	113.21***	63.92***	43.23**	111.93***	94.20***	48.98**	114.68***
	(21.99)	(28.11)	(15.66)	(31.04)	(24.56)	(20.03)	(37.09)	(35.56)	(23.65)	(37.60)
$\Delta UN_{B,t}$	34.67	118.10	−9.03	43.39	158.95	50.40	138.62	87.47	−22.96	140.00
	(148.73)	(111.34)	(95.27)	(170.37)	(136.71)	(111.33)	(170.59)	(132.08)	(86.34)	(156.54)
ΔL^2	5.34	−18.62	−18.09	−16.18	−11.34	−11.57	0.29	−12.70	−12.68	6.45
	(26.68)	(28.48)	(27.65)	(35.01)	(35.38)	(19.01)	(34.44)	(30.10)	(19.59)	(41.04)
R^2	0.10	0.29	0.26	0.33	0.19	0.16	0.35	0.27	0.14	0.29
$Adj.R^2$	0.10	0.29	0.26	0.33	0.19	0.16	0.35	0.27	0.14	0.29
Num. obs.	2708	2708	2708	2708	2708	2708	2708	2708	2708	2708

The model is estimated following Newey and West (1987) with optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

effect of the changes on the basis when the Dollar Index is present on the regression model. The results also remain consistent for the Government basis, as the central variable that explains the government basis is the level of uncertainty, which is a magnitude higher than the Libor basis. The foreign interest rate for the CAD and CHF is significant in explaining the convenience yield of their currency.

The previous results suggest that uncertainty is relevant to explain the Libor and Government Basis variations. Still, we are yet to see if the effect is consistent in the aggregate. As such, I estimate a Panel Model for all the G10 currencies using the relevant control variables from the univariate model and contrasting the result with different measures of uncertainty and volatility commonly used. One additional explanatory variable I add is the CBOE Volatility Index for the $S\&P100$ firms (VXO) to the other uncertainty measures used previously, the CBOES VIX, and the exchange rate uncertainty with and without

Table 1.9. Panel Model for Uncertainty and the Cross-Currency Basis

	Models									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$UN_{B,t-1}$	-25.88^{***}	-26.38^{***}	-26.35^{***}	-28.24^{***}	-28.51^{***}					
	(8.66)	(8.85)	(8.84)	(9.74)	(9.66)					
$\Delta UN_{B,t}$	-17.21	-9.00	-12.21	-2.13	5.71					
	(33.00)	(32.26)	(33.21)	(24.88)	(27.23)					
VIX_{t-1}						-15.10^{**}	-16.42^{**}	-16.55^{**}		
						(6.29)	(6.63)	(6.55)		
ΔVIX_t						-6.39	-6.41^{*}	-5.73		
						(4.27)	(3.87)	(3.52)		
VXO_{t-1}									-14.31^{**}	
									(6.21)	
ΔVXO_t									-5.43	
									(3.39)	
$UN_{NB,t-1}$										-30.38^{***}
										(8.69)
$\Delta UN_{NB,t}$										20.76
										(29.00)
$TWDI_t$		-257.80^{**}	-270.15^{**}	-202.76^{**}	-193.29^{*}	-288.62^{**}	-234.19^{**}	-228.23^{*}	-229.31^{**}	-187.82^{*}
		(104.85)	(108.78)	(96.63)	(99.71)	(120.22)	(113.71)	(117.48)	(116.81)	(96.14)
ER_t			0.03	-0.04	-0.14		-0.02	-0.12	-0.13	-0.14
			(0.26)	(0.28)	(0.29)		(0.28)	(0.30)	(0.30)	(0.30)
SR_{US}			-40.76^{*}							
			(21.31)							
r_t				-141.55^{***}	-149.14^{***}		-145.78^{***}	-151.77^{***}	-148.70^{***}	-150.34^{***}
				(32.02)	(34.07)		(34.67)	(37.87)	(37.99)	(32.61)
WTI_{t-1}					22.53^{**}			20.26^{*}	21.67^{**}	23.09^{***}
					(8.91)			(10.53)	(10.75)	(8.79)
Adjusted R^2	0.043	0.046	0.047	0.06	0.063	0.043	0.058	0.06	0.056	0.074
N	32420	32420	32420	32420	32420	32420	32420	32420	32420	32420

Notes: The Table reported the regression results of the daily balanced panel for the G10 currencies in 2007-2019. Currency and Time Fixed Effects. I estimate the standard errors robust to the Cross-sectional and Serial correlation of Driscoll and Kraay (1998) with the Newey and West (1994) automatic lag selection. The statistical significance follows $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

breaks UN_B and UN_{NB}. I include the US's Shadow Short Rate (SSR) as a control variable from Krippner (2013b, 2014). The shadow rates capture the effect of conventional and unconventional rates on exchange rates, policies which Inoue and Rossi (2019) show had an impact on exchange rates.

I run the panel regression and show the results in Tables 1.9 and 1.10 for the Libor and Government Cross-currency basis. In each column, I run different balance panel models to compare the fit of each uncertainty measure and the consistency under other control variables. We can see that for the Libor Basis, the logarithmic returns of the dollar index have statistical significance under any model specification. As shown by Gopinath et al. (2020) and Boz et al. (2022), the dollar is the dominant currency in which a considerable proportion of the trades are invoice, so we can expect that the fluctuations have been translated on the deviations that the country may have. Including the shadow rate is not traduced in a better fit than using the domestic Libor rate; in both cases, we can see that a change in the US rate increases the deviation of the CIP, as it modifies the interest rate parity. The Oil price is statistically significant and reduces the basis, as an increase in the prices translates into higher capital flows and the demand for foreign currency, which appreciates the money. The uncertainty measures reflect that the Exchange Rate Uncertainty has a higher magnitude effect than the VIX or VXO over the currency basis, almost doubling one of the volatility indices. The Goodness of fit suggests that the entire model with the Exchange Rate Uncertainty under no break and break provides a better fit for the Libor basis.

Table 1.10. Panel Model for Uncertainty and the Government Convenience Yield

	Models									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$UN_{B,t-1}$	74.72^{***}	78.05^{***}	77.85^{***}	79.77^{***}	81.90^{***}					
	(26.37)	(26.71)	(26.47)	(28.67)	(29.29)					
$\Delta UN_{B,t}$	94.62	82.69	81.37	76.48	81.21					
	(112.46)	(109.01)	(107.29)	(93.15)	(94.60)					
VIX_{t-1}						45.25^{***}	46.56^{***}	47.35^{***}		
						(15.75)	(16.83)	(17.16)		
ΔVIX_t						25.14^{*}	25.21^{**}	21.87^{*}		
						(12.98)	(12.57)	(12.07)		
VXO_{t-1}									43.62^{***}	
									(15.89)	
ΔVXO_t									19.22^{**}	
									(9.63)	
$UN_{NB,t-1}$										80.45^{***}
										(28.39)
$\Delta UN_{NB,t}$										75.62
										(96.09)
$TWDI_t$		231.32	215.66	178.92	186.29	308.95	253.77	289.45	295.74	183.45
		(275.88)	(255.57)	(233.66)	(230.38)	(336.35)	(296.19)	(298.07)	(298.87)	(229.63)
ER_t			0.18	0.14	0.45		0.09	0.37	0.38	0.45
			(0.45)	(0.42)	(0.43)		(0.39)	(0.39)	(0.39)	(0.43)
r_g^*			-14.62							
			(20.30)							
r_t				131.10	158.06		144.64	166.55	164.58	152.28
				(135.82)	(135.65)		(131.81)	(134.81)	(129.31)	(134.15)
WTI_{t-1}					-27.15			-22.58	-23.39	-31.36
					(26.07)			(33.77)	(33.64)	(27.11)
Adjusted R^2	0.168	0.179	0.179	0.185	0.195	0.17	0.176	0.182	0.186	0.199
N	32420	32420	32420	32420	32420	32420	32420	32420	32420	32420

Notes: The Table reported the regression results of the daily balanced panel for the G10 currencies in 2007-2019. Currency and Time Fixed Effects. I estimate the standard errors robust to the Cross-sectional and Serial correlation of Driscoll and Kraay (1998) with the Newey and West (1994) automatic lag selection. The statistical significance follows $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table 1.10 shows the Government Basis panel regression results with different uncertainty models. Consistently with the univariate results, the uncertainty measures are the only variables with statistical significance. Like in the Libor results, the Exchange Rate Uncertainty effect doubles the magnitude of the impact over the VIX and VXO. If we compare the goodness of fit, we have again that the Exchange rate Uncertainty does a better job adjusting to the basis than the other traditional measures.

Compounding the univariate and panel model results, we can conclude that the Exchange Rate Uncertainty provides a better fit than other volatility measures, especially for the benchmark used in most papers, the VIX. However, for some models, that index provides a higher R^2 than the uncertainty. As the construction of the uncertainty measures comes from the exchange rate rather than from the financial markets specific to the United States, it captures other international shocks that may have less impact in the domestic country but are highly relevant internationally. Along the same line, having a global measure allows us to weigh the difference between idiosyncratic and common shocks. Events such as the 2001 crisis and terrorist attacks have implications for the domestic market, but this will not be the case internationally.

Monthly Cross-Currency Basis and Different Portfolios

As noted in Du et al. (2018) and Du and Schreger (2022), a high-frequency cross-currency basis captures some seasonal effects as a product of obligations of the intermediary brokers and other financial institutions. To this end, I transform the data to monthly by taking the last trading day of the month to contrast the robustness of the previous results. Table 1.11 presents the results of the regression in equation 1.14 of the monthly cross-currency basis for the Libor and Government on the Uncertainty without breaks, $Unc_{B,t}$, for just the period of 2007 to 2019. If we compare the results to the daily in Tables 1.6 and 1.5, we can see that by using end-of-the-month data, the results became more dispersed than daily data for the Libor basis, making the Uncertainty not to be significant in currencies CAD, CHF, JPY, and NZD that used to be. The magnitudes have also changed; with higher standard errors, the parameters increase for the currencies where Uncertainty is relevant, with the e DKK being the most noticeable change. Contrary to the previous ones, the results of the Government basis show that for AUD, GBP, and NZD, Uncertainty became relevant in explaining the convenience yield of the USD dollar. The magnitudes, on average, are smaller than the ones in the daily data, contrary to the Libor basis.

Table 1.11. Monthly Libor Cross-currency Basis and Uncertainty - 2007-2019

	Libor CIP Deviations									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
α	1.95	−11.88	−37.74***	−120.03***	−65.04***	−60.42***	−31.70***	−65.04***	15.77***	−56.58***
	(6.83)	(7.98)	(10.57)	(19.81)	(12.27)	(16.61)	(5.78)	(14.06)	(2.98)	(18.17)
β_1	−0.42	11.98	−18.33	−94.84***	−52.36***	−66.59***	−8.43	−56.67***	7.94	−48.99*
	(8.89)	(10.90)	(14.35)	(28.06)	(15.37)	(23.10)	(8.81)	(18.56)	(4.88)	(25.66)
R^2	0.00	0.03	0.03	0.31	0.15	0.33	0.01	0.26	0.03	0.21
Adj. R^2	−0.01	0.02	0.02	0.31	0.15	0.32	−0.00	0.25	0.02	0.20
Num. obs.	149	149	149	149	149	149	149	149	149	149
	Government CIP Deviations									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
α	23.61*	59.79***	100.40***	122.43***	54.48***	35.07***	99.54***	71.55***	24.11	78.10**
	(12.35)	(22.37)	(17.04)	(27.73)	(17.40)	(12.54)	(21.46)	(26.90)	(18.23)	(34.09)
β_1	28.40*	61.25**	79.12***	109.32***	50.10**	34.32**	82.15***	86.67**	45.57*	100.62**
	(15.92)	(30.38)	(22.87)	(37.15)	(21.93)	(15.64)	(27.96)	(36.78)	(24.87)	(46.03)
R^2	0.04	0.15	0.20	0.22	0.09	0.07	0.16	0.24	0.12	0.18
Adj. R^2	0.03	0.15	0.19	0.21	0.08	0.06	0.15	0.23	0.12	0.18
Num. obs.	149	149	149	149	149	149	149	149	149	149

The table presents the regression of the monthly Libor and Government cross-currency basis against the exchange rate uncertainty for each currency. I estimate the following model,

$$\lambda_{t,t+n}^{CIP,i} = \alpha + \beta_1 UN_{B,t-1} + \varepsilon_t$$

where $\lambda_{t,t+n}^{CIP,i}$ is the cross-currency basis for currency i, $UN_{B,t-1}$ is the logarithm of the Exchange Rate Uncertainty with breaks, and α is the constant. The model is estimated following Newey and West (1987) with the optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

As we see previously, the results from the daily cross-currency basis, in general, are consistent with respect to the monthly periodicity in the univariate case[13]. Let us turn into the panel results in Table 1.12. I show that the Uncertainty has a consistent effect over the Libor Basis, using measures such as VIX and the Exchange Rate uncertainties calculated with breaks and no breaks. This is consistent with previous results as Menkhoff et al.

[13] In Appendix 1.5, I replicate the models for each currency previously estimated with different controls used in the literature with monthly periodicity as a robustness check.

(2012), Bruno and Shin (2015a), Bruno and Shin (2015b), Du et al. (2018), Cerutti et al. (2021), Jiang et al. (2021), and Kalemli-Özcan and Varela (2021) that find that Uncertainty provides information to understand the existence of deviations of the covered interest rate parity. If we compare the results against those in Table 1.9, we can see that, in general, they remain consistent with the daily data, where the basis is influenced mainly by the changes in the Uncertainty and the Interest rates of both the international and domestic economies.

Nevertheless, the results have two differences: the Trade Weighted Dollar Index does not have statistical significance, and the Uncertainty without breaks provides a better fit than the model with them. The effect of the dollar overlaps with the changes in interest rates. This result goes in line with Kalemli-Özcan and Varela (2021) argument that the interest rate changes have a higher correlation with the deviations than those of the exchange rates. The difference between uncertainties under different frequencies may reflect variability, yet correlations show they are close, so that the difference may be statistically negligible. A significant result complementary to the previous one is that the exchange rate uncertainty provides in both models, improving results that the ones in the standard VIX estimation. I expected that the effects of oil prices and the leverage level of the intermediaries would be significant; nevertheless, both did not provide enough evidence that they explained the basis fluctuations.

Table 1.12. Panel Model for Uncertainty and the Cross-Currency Basis

	Models											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$UN_{NB,t-1}$	-40.15^{***}	-38.38^{***}	-43.45^{***}	-42.15^{***}								
	(13.91)	(12.60)	(14.32)	(12.27)								
$\Delta UN_{NB,t}$	−34.40	−30.17	−31.03	−26.08								
	(26.33)	(21.65)	(19.16)	(16.45)								
$UN_{B,t-1}$					-38.73^{***}	-36.76^{***}	-42.65^{***}	-41.05^{***}				
					(14.71)	(13.30)	(15.35)	(12.93)				
$\Delta UN_{B,t}$					−34.55	−30.00	-32.28^{*}	-27.08^{*}				
					(26.89)	(21.53)	(19.60)	(16.18)				
VIX_{t-1}									-19.01^{***}	-18.14^{***}	-22.48^{***}	-22.45^{***}
									(5.74)	(5.25)	(6.24)	(5.64)
ΔVIX_t									-27.22^{*}	-23.76^{**}	-25.75^{**}	-22.05^{***}
									(14.53)	(10.51)	(10.12)	(7.36)
$TWDI_t$		−599.34	−204.30	49.34		−573.57	−150.26	98.64		−576.08	−143.38	56.71
		(614.88)	(296.14)	(223.15)		(607.30)	(273.60)	(214.50)		(625.60)	(295.86)	(200.41)
ΔER_t			-2.33^{*}	−2.25			−2.27	−2.19			−2.48	−2.32
			(1.40)	(1.39)			(1.41)	(1.40)			(1.57)	(1.52)
Δr_t^*			-136.54^{***}	-134.61^{***}			-138.59^{**}	-136.00^{**}			-121.21^{***}	-124.17^{***}
			(52.36)	(51.15)			(54.73)	(52.86)			(46.01)	(45.52)
Δr_t			-307.47^{***}	-344.30^{***}			-310.35^{***}	-345.97^{***}			-319.27^{***}	-355.53^{***}
			(83.54)	(97.15)			(86.04)	(100.09)			(83.38)	(101.23)
WTI_{t-1}				118.57				112.85				135.83
				(73.60)				(73.27)				(98.59)
ΔL^2				-13.10^{*}				-13.65^{*}				−9.94
				(7.78)				(7.92)				(9.51)
Adjusted R^2	0.085	0.089	0.157	0.166	0.075	0.078	0.147	0.156	0.06	0.063	0.133	0.143
N	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500

Notes: The Table reported the regression results of the daily balanced panel for the G10 currencies in 2007-2019. Currency and Time Fixed Effects. I estimate the standard errors robust to the Cross-sectional and Serial correlation of Driscoll and Kraay (1998) with the Newey and West (1994) automatic lag selection. The statistical significance follows $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Previous results show that the Government cross-currency basis behaves differently than the Libor. In Table 1.10, we saw that the only factor that affected the convenience yield was, in fact, the calculated exchange rate uncertainty or the VIX. In Table 1.13, I present the regression of the monthly government cross-currency basis against different measures of Uncertainty and factors such as the interest rates, oil, and the leverage level of the intermediaries. Contrary to the daily panel, we can see that not only is the Uncertainty significant for all models but also the Dollar fluctuations, the international interest rate, the variations of the exchange rate, and changes in the oil price. We can expect that the macroeconomic factors that determine the level of the convenience yield, the return of the dollar (in basis points), and the variations of the interest rate of the foreign country have increased the level of deviation. The oil reduces the average level of convenience yield. It increases the inflows of numerous countries such as Canada, Sweden, and other commodity countries, giving them a higher demand for their currency and increasing the overall economic growth, lowering their risk.

Table 1.13. Monthly Panel for Uncertainty and the Government Cross-Currency Basis 2007-2019

	Models											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$UN_{NB,t-1}$	79.93***	74.35***	79.28***	77.80***								
	(24.23)	(23.42)	(26.36)	(22.24)								
$\Delta UN_{NB,t}$	77.65	64.25	65.33	57.18								
	(50.47)	(44.61)	(42.58)	(35.25)								
$UN_{B,t-1}$					82.20***	76.19***	82.06***	79.92***				
					(25.13)	(24.53)	(27.97)	(23.46)				
$\Delta UN_{B,t}$					82.38	68.46	70.89	62.53				
					(55.59)	(49.10)	(48.50)	(40.24)				
VIX_{t-1}									44.22***	41.23***	45.62***	46.71***
									(8.85)	(9.03)	(10.91)	(10.09)
ΔVIX_t									53.95*	42.17*	44.64*	38.45*
									(29.77)	(24.93)	(25.89)	(22.16)
$TWDI_t$		1,896.33***	1,449.56***	951.78***		1,757.19***	1,276.73***	801.36***		1,962.35***	1,444.00***	980.59**
		(669.52)	(231.76)	(207.95)		(625.10)	(206.78)	(257.25)		(702.16)	(268.90)	(419.59)
ΔER_t			5.56**	5.27**			5.43**	5.15**			5.70*	5.26*
			(2.54)	(2.44)			(2.51)	(2.43)			(2.92)	(2.74)
Δr_t^*			166.03***	174.12***			172.84***	180.14***			145.63***	162.34***
			(41.34)	(36.00)			(44.29)	(38.38)			(26.44)	(18.83)
Δr_t			281.98	364.45			292.80	371.56			316.79	406.41
			(249.68)	(286.46)			(253.29)	(288.27)			(247.69)	(289.23)
WTI_{t-1}				−368.03**				−356.99**				−412.94*
				(179.79)				(176.02)				(222.70)
ΔL^2				14.86				14.81				12.17
				(11.90)				(11.76)				(10.05)
Adjusted R^2	0.169	0.187	0.224	0.259	0.169	0.184	0.223	0.256	0.142	0.16	0.201	0.244
N	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500

Notes: The Table reported the regression results of the daily panel for the G10 currencies in 2007-2019. I estimate the standard errors robust to the Cross-sectional and Serial correlation of Driscoll and Kraay (1998) with the Newey and West (1994) automatic lag selection. The statistical significance follows $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Finally, I compare different portfolios of currency' excess returns ranked by their forward discounts, as constructed in Lustig et al. (2011) and Verdelhan (2018), with the exchange rate uncertainty[14]. They construct six different portfolios, one of the lowest interest rate countries compared to the six with the highest level. We can then calculate the difference between the two as the portfolio that is long in the sixth and short in the first portfolio, to what they call the High-minus-Low (HML) carry trade factor. I do the regression of each portfolio against "the Dollar Factor" (Dol), which is the equally weighted average of the returns of the currencies against the dollar, and the calculated exchange rate uncertainty, $UN_{B,t}$. In table 1.14, I present the different regressions and the HML factor for each portfolio against the two factors. The dollar factor is relevant to explain the excess returns of each portfolio, whereas the Uncertainty is relevant only for the two extremal portfolios. An

[14]The portfolios were obtained directly from the webpage of Adrien Verdelhan, and correspond to the Monthly Currency Excess Returns for different portfolios as constructed in Lustig et al. (2011). The excess returns correspond to the difference between the logarithm of the price of the future (f_t) and the realized value of the exchange rate (s_{t+h}) at the maturity in period h. The data webpage is https://web.mit.edu/adrienv/www/Data.html

Table 1.14. Currency Excess Returns Portfolios and Exchange Rate Uncertainty 2007-2019

	Portfolios: Full Sample						
	1	2	3	4	5	6	HML
α	0.00^{*}	-0.00	0.00	0.00	0.00	-0.01^{***}	-0.01^{**}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$UN_{B,t}$	0.01^{***}	-0.00	0.00	0.00	0.00	-0.02^{***}	-0.03^{***}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Dol	0.89^{***}	0.82^{***}	0.90^{***}	1.06^{***}	1.10^{***}	1.22^{***}	0.33^{***}
	(0.06)	(0.07)	(0.03)	(0.05)	(0.06)	(0.06)	(0.10)
R^2	0.69	0.69	0.79	0.83	0.83	0.74	0.16
Adj. R^2	0.69	0.69	0.79	0.83	0.83	0.74	0.15
Num. obs.	238	238	238	238	238	238	238
	Portfolios: 2000 - 2007						
α	0.00	-0.01^{*}	0.00	0.01^{**}	0.00	-0.01	-0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
$UN_{B,t}$	0.01^{*}	-0.01	0.00	0.01^{**}	0.00	-0.02^{*}	-0.03^{**}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Dollar	1.00^{***}	0.98^{***}	1.01^{***}	0.98^{***}	1.03^{***}	1.00^{***}	-0.00
	(0.06)	(0.12)	(0.08)	(0.08)	(0.07)	(0.12)	(0.16)
R^2	0.74	0.62	0.77	0.71	0.82	0.50	0.04
Adj. R^2	0.73	0.61	0.76	0.71	0.82	0.48	0.02
Num. obs.	88	88	88	88	88	88	88
	Portfolios: 2007 - 2019						
α	0.00	-0.00	0.00	-0.00	0.00	-0.01^{***}	-0.01^{**}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$UN_{B,t}$	0.01^{*}	-0.00	0.00	0.00	0.00	-0.01^{***}	-0.02^{***}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Dollar	0.86^{***}	0.78^{***}	0.87^{***}	1.07^{***}	1.13^{***}	1.29^{***}	0.43^{***}
	(0.09)	(0.06)	(0.04)	(0.05)	(0.07)	(0.05)	(0.12)
R^2	0.68	0.75	0.81	0.88	0.83	0.82	0.23
Adj. R^2	0.68	0.75	0.81	0.88	0.83	0.82	0.22
Num. obs.	150	150	150	150	150	150	150

The model is estimated following Newey and West (1987) with optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

increase in Uncertainty increases the excess returns of the first portfolio while reducing the last by an outstanding amount. This relationship becomes less significant as we use the sample from 2000 to 2007 for both portfolios but increase the returns of the fourth portfolio. The Exchange rate uncertainty helps explain the carry trade factor in total and post-GFC samples with a negative sensitivity. With increasing Uncertainty, agents will move their investments from risky to developed countries, and capital flows will lower the demand of the high-interest rate country. As the gap between the excess returns diminishes, the carry trade factor loses its excess returns.

The results suggest that even changing the data to a lower frequency, the exchange rate uncertainty provides enough information to explain the basis of the Libor and Government cross-currency basis and the excess returns of the HML currency factor. It increases the deviations of the parity for the Libor bonds while increasing the convenience yields of the US government safe assets. Even if we control by different factors, the effect remains consistent in different benchmark models in the literature, such as the Avdjiev et al. (2019) and Cerutti et al. (2021) frameworks.

1.5 Conclusion

In this paper, I presented a model that measures exchange rate uncertainty by combining the base model of Jurado et al. (2015) and the Ando and Bai (2017), which allows me to construct a world and group-specific uncertainty index. This methodology takes advantage of the daily information accounted for by other exchange rates and exogenous variables used in the literature. I construct an index that captures the daily shocks and variations in the currencies that reflect on common shocks that generate fluctuations in the exchange market. The index captures high-uncertainty events, such as the Asian and global financial crises, yet differs from traditional uncertainty measures centered around a particular financial market. It is also robust to the changes of other economic variables or events unrelated to the general conditions of the exchange rate market, as it does not capture the financial crisis of 2000.

In the construction of the Uncertainty index, I find that if we omit the existence of breaks, the behavior of the exchange rates can be characterized by a single common factor and two group-specific factors, one that has the majority of currencies. The existence of a single common factor and a group with the majority of currencies goes in hand with the global financial cycle hypothesis of Rey (2015a). Nevertheless, I find a break in the common factor of the currencies in July of 2007, per the assumptions made in the literature on the effect of the Great Financial Crisis on the world markets and the Exchange Rate Reconnect of Lilley et al. (2022). If we divide the sample, we get that there are not only two groups but four for the earlier sample and three for the second. The changes in groups preserve clusters of currencies that obey in majority to geographical proximity.

I use the exchange rate uncertainty index to analyze the deviations of the Covered Interest Rate Parity puzzle for both the Libor and the Government basis. I find that the effect of uncertainty, as expected, is heterogeneous. By running different univariate regressions for each G10 currency, I show that either delay or volatilities increase the cross-currency basis to most currencies. Still, this is not the case for AUD and JPY. The Dollar is a significant factor in explaining the Libor but not the Government basis. Contrary to the results of Avdjiev et al. (2019) and Cerutti et al. (2021), I find that the dollar returns are unrelated to the uncertainty level. So, both are statistically significant in the univariate and panel models. In terms of goodness of fit, the exchange rate uncertainty has a better fit and has a higher effect on both the Libor and Government Basis, which almost doubles the magnitude of the VIX or VXO.

One limitation of the model is that as I focus on daily data, Du et al. (2018) and Du and Schreger (2022) show that some seasonal effects may induce problems with the specification of the models. Further works should focus on extending the models to a monthly context such that the data does not suffer from these effects. Alternatively, it will be easier to model or use a methodology that seasonally adjusts them, like the X13-ARIMA-SEATS used by the Census Bureau. Another venue for research is extending the model from Covered to Uncovered Interest Rate Parity. As many markets have constrained intermediaries, forward supply is scarce and costly, so firms decide to assume the exchange risk. In that case, the uncertainty may provide explanatory power for the deviation, as Kalemli-Özcan and Varela (2021) show in their paper with an EPU-type measure.

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Appendix A: Descriptive Statistics

In this section, I present the descriptive statistics of the exchange Rates data shown in Table 1.1 used in calculating the Uncertainty measure of the Ando and Bai (2017) model. In these tables, the underlying statistics reflect their general behavior and allow us to see both databases' stylized facts.

Table 1.15. Descriptive Statistics - Exchange Rates

	Obs.	Mean	Std. Dev.	Skew	Kurtosis	Std. Error	Sharpe	CorDollar	Corr. Unc.
AUD	5174.00	0.00	0.78	-0.34	9.74	0.01	0.00	-0.55	-0.03
CAD	5174.00	-0.00	0.55	0.10	2.99	0.01	-0.00	0.50	0.04
CHF	5174.00	-0.01	0.70	-3.76	118.95	0.01	-0.01	0.74	-0.00
DKK	5174.00	-0.00	0.61	-0.06	1.68	0.01	-0.00	0.92	0.01
EUR	5174.00	0.00	0.60	0.05	1.67	0.01	0.00	-0.93	-0.01
GBP	5174.00	-0.00	0.57	-0.76	10.77	0.01	-0.01	-0.68	-0.04
JPY	5174.00	0.00	0.61	-0.06	4.15	0.01	0.00	0.40	-0.04
NOK	5174.00	0.00	0.74	0.15	2.64	0.01	0.00	0.75	0.03
NZD	5174.00	0.01	0.80	-0.31	2.84	0.01	0.01	-0.53	-0.04
SEK	5174.00	0.00	0.74	0.04	2.56	0.01	0.00	0.78	0.02
BRL	5174.00	0.02	1.04	0.10	6.56	0.01	0.02	0.23	0.04
CLP	5174.00	0.01	0.63	0.28	4.48	0.01	0.01	0.23	0.04
CNY	5174.00	-0.00	0.14	0.04	28.67	0.00	-0.02	0.13	0.02
COP	5174.00	0.01	0.71	-0.02	8.84	0.01	0.01	0.21	0.03
HUF	5174.00	0.00	0.88	0.31	3.99	0.01	0.00	0.73	0.03
IDR	5174.00	0.01	0.59	-0.47	23.95	0.01	0.02	0.08	0.05
ILS	5174.00	-0.00	0.46	0.19	4.15	0.01	-0.01	0.36	0.04
INR	5174.00	0.01	0.39	0.27	9.10	0.01	0.02	0.17	0.05
KRW	5174.00	0.00	0.64	-0.69	54.97	0.01	0.00	0.14	0.04
MXN	5174.00	0.01	0.70	0.78	11.58	0.01	0.02	0.23	0.05
MYR	5174.00	0.00	0.34	-0.40	8.55	0.00	0.00	0.14	0.04
PEN	5174.00	-0.00	0.28	0.09	13.95	0.00	-0.00	0.14	0.03
PHP	5174.00	0.00	0.39	-5.00	141.30	0.01	0.01	0.12	0.05
PLN	5174.00	-0.00	0.84	0.25	4.65	0.01	-0.00	0.66	0.05
RUB	5174.00	0.01	0.77	0.43	102.28	0.01	0.02	0.22	0.03
THB	5174.00	-0.00	0.31	0.26	10.44	0.00	-0.01	0.21	0.03
TRY	5174.00	0.05	1.14	6.94	199.80	0.02	0.04	0.24	0.04
ZAR	5174.00	0.02	1.09	0.87	10.48	0.02	0.01	0.40	0.02

Notes: The table presents the descriptive statistics and the moments of the exchange rates used to estimate the uncertainty model. All series are in logarithmic returns. The range is the difference between the Maximum and the minimum value in the whole sample. I also calculate the Sharpe measure, the correlation with respect to the dollar, and uncertainty.

Appendix B: Unit-Root Test

In this section, I present the results of the Augmented-Dickey Fuller test on the exogenous variables used in the Ando and Bai (2017) part of the model. Under this test, the Null hypothesis is a non-stationary behavior (unit-root process). So, if the test statistic is in the accepting region, we must transform the series to make them approximately stationary. The table presents the statistics and critical values at 95% confidence for the endogenous and exogenous variables used in the methodology and the regressions. The last column represents the transformation of made to the variable according to McCracken and Ng (2016), where 2-Δx, 3-$\Delta^2 x$, 4-$\log(x)$, and 5-$\Delta \log(x)$

Table 1.16. Unit Root Test - Explanatory Variables

Variable	Stat.	Diff.	Trans.
MSCI WI	-1.64	1.77	5
$S\&P500$	-0.28	3.13	5
VIX	-7.39	-3.98	4
DXY	-1.79	1.62	5
B. Comm.	-1.48	1.93	5
FF4	-1.56	1.85	2
CL3	-1.72	1.69	5
3M	-1.56	1.85	2
10Y	-3.83	-0.42	2
WTI	-2.10	1.31	5
SSR_{US}	-1.34	2.07	2

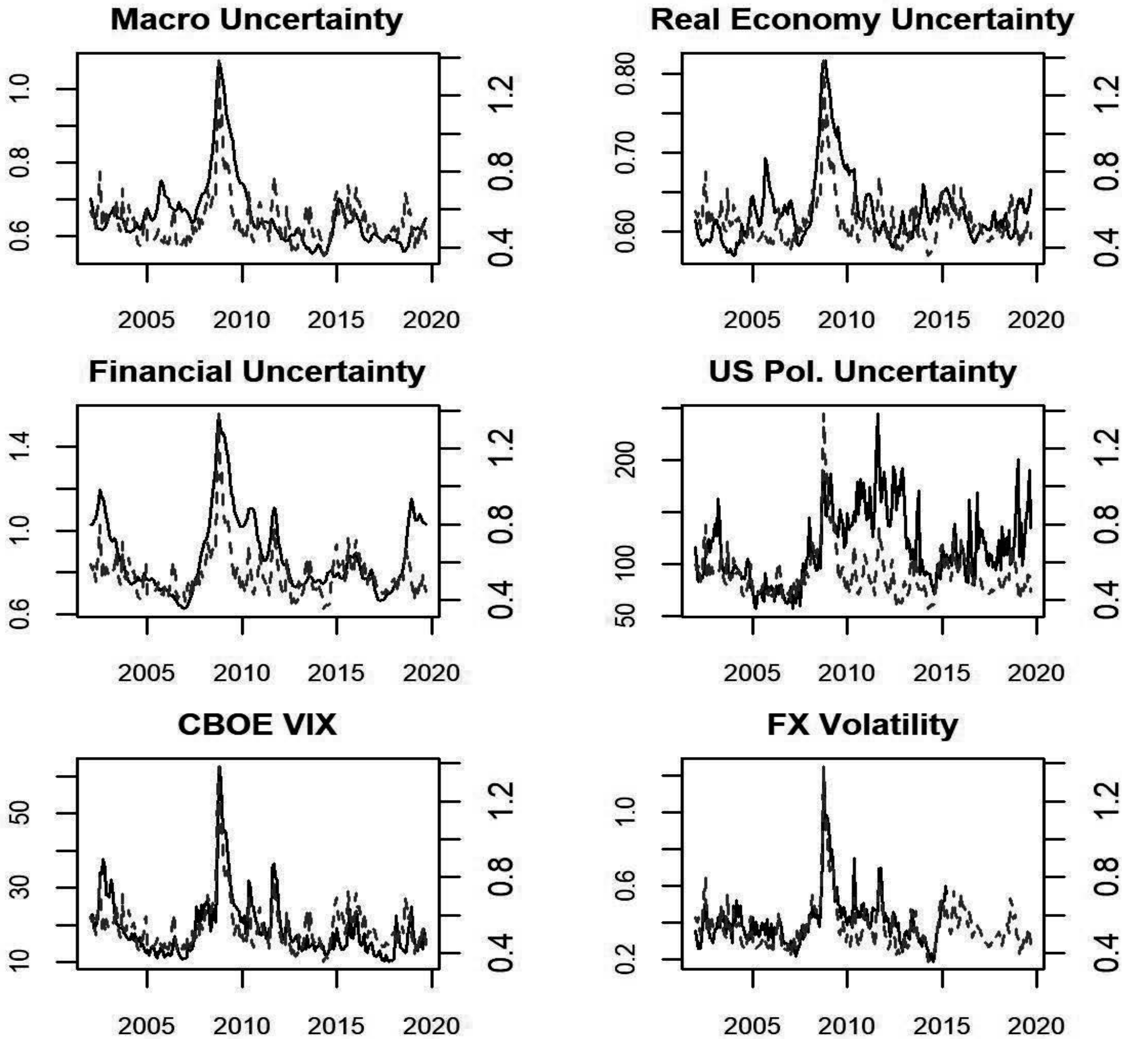
Notes: The table presents the Augmented Dickey-Fuller test for each explanatory variable. I did the test for the full sample from 2007 to 2019. The test run in the table is the specification with the trend. For each, I present the test statistic and the difference concerning the critical value on the 95%. A negative difference value will imply insufficient evidence that the series has a unit root.

Appendix C: Uncertainty Comparisons

In Figures 1.9 and 1.10, I compare the most used uncertainty measures in the literature and the exchange rate uncertainty calculated previously. The selection depends on the data to have monthly periodicity and the indices to be public, the methodology available to replicate, or the data provided by the authors. As the FX index is daily, I transform it into monthly by taking the monthly median. I compare my exchange rate uncertainty index with the Macroeconomic, Real Economy, and Financial uncertainty indexes of Jurado et al. (2015) and Ludvigson et al. (2021), the US and Global Economic Policy Uncertainty Indices of Baker et al. (2016a), the Chicago Board of Exchange Volatility Index (VIX), the FX Volatility Index of Menkhoff et al. (2012), Monetary Policy Uncertainty Index of Husted, Rogers, and Sun (2020), Global Uncertainty Index of Ozturk and Sheng (2018), Subjective Interest Rate Uncertainty of Istrefi and Mouabbi (2018), Trade Uncertainty index of Baker et al. (2016a), and the Geopolitical Risk Index of Caldara and Iacoviello (2018).

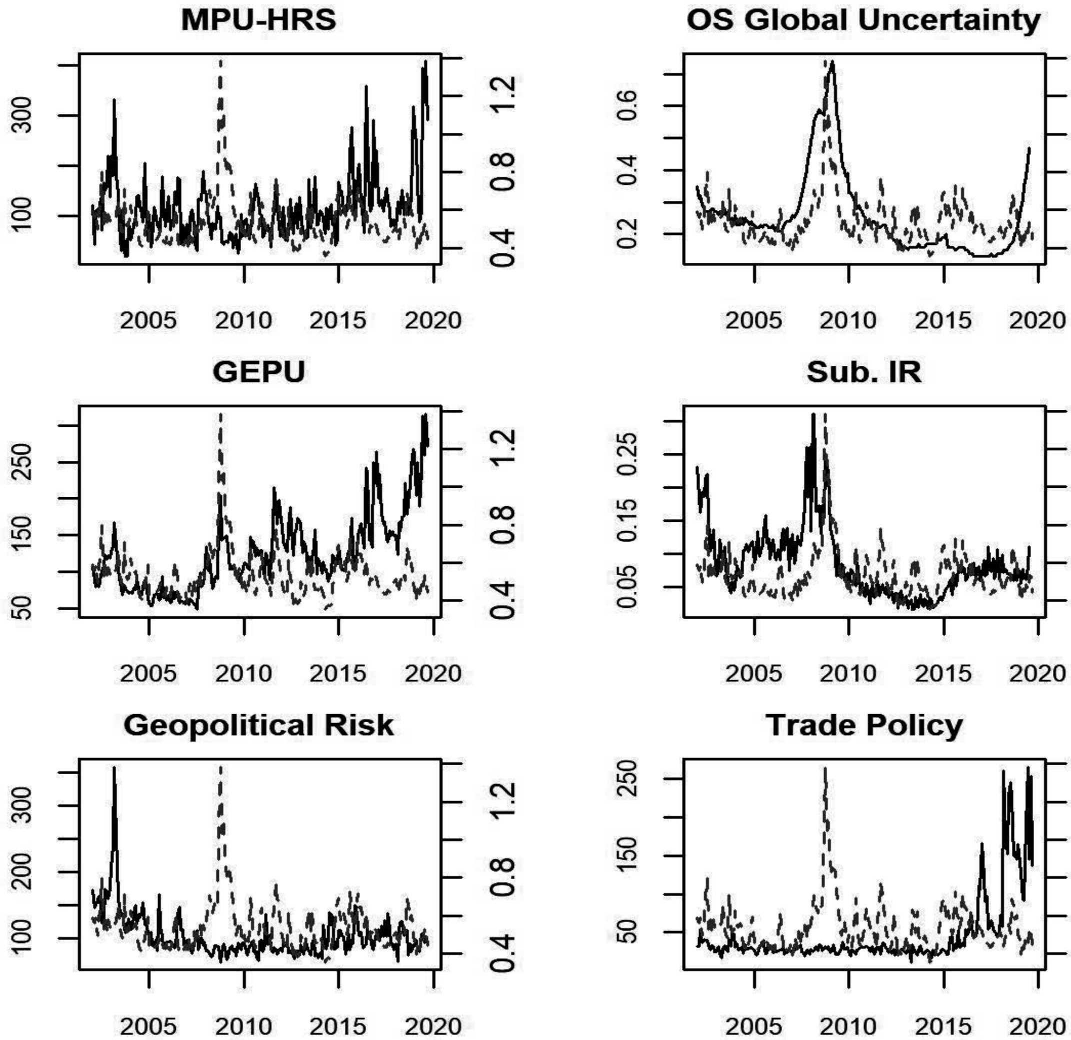
The Exchange rate uncertainty index correlates with the FX volatility index and the VIX, with 0.72 (up until 2012) and 0.78, respectively. By construction, the FX volatility index will have a common relationship by taking individual volatility of exchange rates. The VIX captures the effect of expectations of the US market, the dominant currency, and the liquid exchange rate. The correlation with the macroeconomic and financial uncertainty indices is relatively high, with ranges between 0.65 to 0.47. They differ in the persistence of the exchange rate uncertainty. Being the exchange rate inherently liquid, the shocks will dilute in time faster than macroeconomic shocks. The surprising result is the low correlation with the US Economic Policy Uncertainty (0.28), Trade (0.01), and Geopolitical Risk (-0.11), which is due to the relationship to the dependence on the exchange rate, which we could expect to be higher.

Figure 1.9. Uncertainty Measure Comparisons ER and Reference Models



Note: The Figure plots different Uncertainty Indices against the Exchange Rate Uncertainty proposed. The left y-axis corresponds to the value of the contrasted index. The top-left panel is the Macroeconomic Uncertainty Index of Jurado et al. (2015). The top-right and center-left are the Real Economies and Financial Uncertainty Indices of Ludvigson et al. (2021). The center-right is the United States Economic Policy Uncertainty of Baker et al. (2016a). The lower-left panel is the CBOE VIX. The lower-right panel is the FX Volatility Index of Menkhoff et al. (2012). *Sources:* The macroeconomic. real, and financial uncertainty indices come from their author's webpage, the US Economic Policy Uncertainty, and the VIX from the Federal Reserve of St. Louis, and the authors provided the FX Volatility.

Figure 1.10. Uncertainty Measure Comparisons ER and Reference Models



Note: The Figure plots different Uncertainty Indices against the Exchange Rate Uncertainty proposed. The left y-axis corresponds to the value of the contrasted index. The top-left panel is the Monetary Policy Uncertainty Index of Husted et al. (2020). The top-right is the Global Uncertainty Index of Ozturk and Sheng (2018). The Center-Left is the Global Economic Policy Uncertainty Index of Baker et al. (2016a). The center-right is the Subjective Interest Rate Uncertainty of Istrefi and Mouabbi (2018). The lower-left panel is the Geopolitical Risk Index of Caldara and Iacoviello (2018). The lower-right panel is the Trade Uncertainty index calculated by Baker et al. (2016a). *Sources:* Economic Policy Uncertainty webpage, the authors provided the Subjective interest rate uncertainty and Monetary Policy Uncertainty Indices and their calculations.

Appendix D: Dickey-Fuller Test on CIP

In the literature, some authors have differentiated the series of CIP to avoid possible cases of unit root on the individual currencies, such as the case of Jiang et al. (2021), Avdjiev et al. (2019), and Cerutti et al. (2021). Nevertheless, to avoid possible misspecifications of the model, I ran An Augmented Dickey-Fuller test on each of the calculated cross-currency basis. In Table 1.17, I present the test for each sample used in the paper. From it, we can see that we did not find enough evidence for every currency to accept the null hypothesis that the series has a unit root process. As such, I will not differentiate the series in the cross-currency models.

Table 1.17. CIP Augmented Dickey-Fuller Test

	Full Sample		1993-2007 Sample		2007-2019 Sample	
	Stat.	Diff.	Stat.	Diff.	Stat.	Diff.
AUD	-18.84	-15.43	-18.67	-15.26	-14.47	-11.06
CAD	-14.92	-11.51	-9.62	-6.21	-12.51	-9.10
CHF	-12.39	-8.98	-27.80	-24.39	-10.45	-7.04
DKK	-6.11	-2.70	-19.29	-15.88	-7.07	-3.66
EUR	-7.39	-3.98	-23.14	-19.73	-6.96	-3.55
GBP	-8.25	-4.84	-14.91	-11.50	-7.22	-3.81
JPY	-14.54	-11.13	-23.30	-19.89	-10.79	-7.38
NOK	-7.47	-4.06	-32.33	-28.92	-6.18	-2.77
NZD	-18.71	-15.30	-22.92	-19.51	-12.85	-9.44
SEK	-9.03	-5.62	-24.64	-21.23	-7.22	-3.81

Notes: The table presents the Augmented Dickey-Fuller test for each daily currency cross-currency basis ($\lambda_{i,t}$). I tested for the full sample before the 2007 break and after. The test run in the table is the specification with the trend. For each, I present the test statistic and the difference with respect to the critical value on the 95%. A negative difference value will imply insufficient evidence that the series has a unit root.

Appendix E: Monthly Results

In this section, I contrast the paper's main results using monthly data to guarantee that they hold under lower frequency. In table 1.18, I estimate the simple regression of the Libor cross-currency basis against the uncertainty measures, as in Table 1.5. As we can see in the results, the effect of the uncertainty in most currencies still holds for most cases. The uncertainty with or without breaks provides a better fit in cases other than the CAD and JPY than those of the VIX.

Table 1.18. Monthly Univariate Regression for each currencies' Libor Cross-Currency basis

	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
VIX	-2.348	19.223	2.641	-55.878	-29.845	-34.300	9.958	-34.804	2.250	-18.445
p-value	0.670	0.001	0.727	0.0003	0.007	0.020	0.068	0.002	0.469	0.213
$Adj.r^2$	-0.005	0.200	-0.005	0.284	0.128	0.226	0.018	0.255	-0.001	0.073
UN_{NB}	-3.500	11.258	-20.886	-94.694	-54.454	-65.295	-10.995	-56.960	5.327	-48.747
p-value	0.683	0.277	0.125	0.001	0.0002	0.004	0.221	0.002	0.265	0.048
$Adj.r^2$	-0.005	0.022	0.029	0.327	0.173	0.331	0.005	0.273	0.007	0.217
UN_B	-0.419	11.985	-18.328	-94.843	-52.355	-66.592	-8.426	-56.667	7.935	-48.985
p-value	0.962	0.274	0.203	0.001	0.001	0.005	0.341	0.003	0.106	0.058
$Adj.r^2$	-0.007	0.023	0.019	0.307	0.149	0.322	-0.0002	0.253	0.022	0.204

The table shows the regression of different types of uncertainty against the LIBOR cross-currency basis for each currency. UN_{NB} is the uncertainty without taking into account breaks, UN_B is the uncertainty with breaks, and VIX the Chicago Board Exchange' Volatility Index. All dependent variables are logarithmic. The model is estimated following Newey and West (1987) with an optimal lag selection of Newey and West (1994).

I present in Table 1.19 the regression of the Libor and Government monthly cross-currency basis against the uncertainty with breaks and using other controls. As controls, I use the log-returns Trade-Weighted Dollar Index calculated by the Federal Reserve of the United States, the spot log-returns of the currency against the dollar, the logarithmic and log-returns of the Uncertainty, and the log-returns of the West Texas Intermediate oil spot price. If we contrast the result with the daily results in Table 1.7, we see that for the Libor deviations, the uncertainty for most currencies remains significant but less so for CAD and NZD compared to the daily measure. In these, the change in the price of the oil price has a higher effect, characteristic of them being commodity currencies. The effect of oil prices is more apparent when considering the Government deviations. For most currencies, the oil reduces the level of deviation, reducing the convenience yield of the USD-denominated government safe assets. This is not the case of uncertainty, which increases the convenience yield for all currencies. Then, it confirms that uncertainty towards the exchange rate fluctuations causes investors to pay an additional premium to demand USD-denominated assets rather than domestic ones.

Finally, we compare the result of the univariate model with other regressors in Table 1.20 with the daily data of Table 1.8. If we include the interest rate of the country r_t and the US interest rate r_t^*, the foreign interest rate is not significant for most currencies, while the US is. This is coherent with the results of the literature, where the increase in the interest rate of the US increases the interest rate gap between countries that reflect higher deviations.

Table 1.19. Cross-Currency Basis and the Exchange Rate Uncertainty with Controls 2007-2019

	Libor CIP Deviations									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
α	0.16	-12.42	-40.08^{***}	-122.41^{***}	-64.41^{***}	-63.73^{***}	-33.02^{***}	-68.37^{***}	15.75^{***}	-57.10^{***}
	(7.19)	(7.84)	(8.77)	(14.54)	(9.00)	(11.53)	(6.44)	(11.45)	(3.27)	(14.06)
$TWDI_t$	-1044.78	-287.02	118.02	562.06	1538.63	-864.93	-700.65	300.50	-71.62	741.80
	(867.32)	(466.85)	(739.99)	(801.29)	(1015.03)	(617.03)	(685.86)	(691.99)	(250.74)	(618.99)
ER_t	-0.13	-2.37	-4.77	-9.69	15.40^{**}	0.19	-4.31	-2.64	-1.58	-8.68^{**}
	(2.02)	(2.21)	(7.08)	(9.05)	(7.46)	(2.64)	(4.32)	(3.18)	(1.08)	(3.58)
$UN_{B,t-1}$	-2.68	10.98	-21.76^{*}	-99.19^{***}	-53.12^{***}	-71.09^{***}	-10.37	-61.79^{***}	7.80	-50.16^{**}
	(9.41)	(10.52)	(11.52)	(21.45)	(11.06)	(15.83)	(9.04)	(12.99)	(5.08)	(19.68)
$\Delta UN_{B,t}$	-24.91	-10.29	-34.78	-56.80^{*}	-44.05	-38.53	-17.43	-29.45^{**}	3.93	-27.53
	(16.35)	(12.06)	(27.82)	(33.57)	(26.86)	(24.01)	(18.57)	(11.96)	(8.29)	(19.73)
ΔWTI_{t-1}	0.68	-88.23^{**}	111.01	170.61^{*}	41.71	130.64^{**}	-110.69	104.35	-84.40^{**}	37.45
	(68.27)	(39.80)	(95.83)	(94.85)	(77.98)	(61.95)	(88.77)	(71.90)	(35.97)	(81.94)
R^2	0.09	0.08	0.10	0.39	0.26	0.41	0.06	0.30	0.09	0.30
Adj. R^2	0.05	0.04	0.06	0.37	0.23	0.39	0.03	0.28	0.06	0.28
Num. obs.	149	149	149	149	149	149	149	149	149	149
	Government CIP Deviations									
α	26.02^{**}	64.55^{***}	105.06^{***}	127.52^{***}	57.38^{***}	37.76^{***}	107.73^{***}	76.19^{***}	25.50	84.76^{***}
	(11.36)	(18.12)	(11.30)	(19.51)	(10.97)	(10.90)	(15.86)	(23.61)	(19.66)	(26.15)
$TWDI_t$	2883.56^{**}	830.64	432.19	128.13	458.55	1036.71	2024.86	1359.40	1233.19	1010.84
	(1329.31)	(1063.85)	(988.95)	(994.48)	(881.10)	(905.53)	(1363.74)	(1161.27)	(1091.14)	(1435.15)
ΔER_t	9.65^{*}	4.91	5.44	12.46	-9.32	-1.83	7.12	1.66	2.74	7.27
	(5.52)	(4.91)	(8.41)	(12.86)	(9.27)	(5.00)	(6.02)	(4.80)	(4.25)	(5.04)
$UN_{B,t-1}$	29.55^{**}	67.99^{***}	85.41^{***}	117.33^{***}	54.58^{***}	37.33^{***}	93.55^{***}	92.70^{***}	46.86^{*}	110.04^{***}
	(14.80)	(24.89)	(14.62)	(27.09)	(13.72)	(12.74)	(20.34)	(31.58)	(26.15)	(33.97)
$\Delta UN_{B,t}$	41.65	61.32^{*}	65.08^{**}	100.45^{*}	70.46	33.86	94.93	56.74^{*}	17.29	95.98^{*}
	(35.37)	(35.64)	(30.21)	(60.16)	(45.44)	(30.14)	(58.80)	(30.28)	(17.50)	(49.11)
ΔWTI_{t-1}	-358.26^{***}	-302.30^{**}	-366.42^{***}	-388.82^{***}	-240.87^{***}	-213.02^{***}	-242.04^{***}	-261.03	-93.53	-299.14^{*}
	(136.00)	(117.16)	(106.80)	(147.97)	(85.25)	(78.37)	(82.84)	(181.98)	(147.03)	(164.27)
R^2	0.17	0.31	0.33	0.37	0.23	0.17	0.33	0.34	0.15	0.32
Adj. R^2	0.14	0.28	0.31	0.35	0.21	0.14	0.31	0.31	0.12	0.29
Num. obs.	149	149	149	149	149	149	149	149	149	149

The model is estimated following Newey and West (1987) with optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

The Uncertainty is significant for the DKK, EUR, GBP, JPY, NOK, and SEK. Compared to the previous results, including additional dependent variables reduces the Uncertainty effect of the Libor basis. This is the same result for the government basis, significantly increasing convenience yield by raising both variables.

Table 1.20. Extended Libor and Government basis regressions 2007-2019

	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
	Libor CIP Deviations									
α	-1.25	-12.11	-40.77^{***}	-129.56^{***}	-71.44^{***}	-62.29^{***}	-39.52^{***}	-68.87^{***}	14.99^{***}	-59.19^{***}
	(9.95)	(8.03)	(11.76)	(21.92)	(16.63)	(14.23)	(8.25)	(11.11)	(3.55)	(17.26)
$TWDI_t$	-382.46	-102.64	367.90	-170.53	384.25	-388.19	-268.64	-14.26	195.64	322.12
	(451.54)	(432.22)	(682.31)	(782.33)	(671.00)	(457.12)	(352.35)	(606.44)	(266.83)	(390.59)
Δr_t^*	-115.82^{***}	-237.26^{**}	1055.96	29.70	347.16	716.50^{***}	-372.30	-163.04^{**}	-35.98	588.25^{**}
	(35.48)	(101.85)	(638.52)	(191.77)	(532.14)	(222.78)	(316.97)	(79.41)	(26.41)	(265.02)
Δr_t	-342.30^{***}	-139.28^{**}	-682.03^{***}	-446.82^{***}	-561.59^{***}	-447.83^{***}	-545.11^{***}	-186.27^{***}	5.10	-391.04^{***}
	(125.30)	(62.20)	(232.42)	(87.56)	(138.18)	(161.23)	(116.62)	(46.08)	(29.47)	(119.04)
$UN_{B,t-1}$	-5.13	11.03	-23.34	-109.35^{***}	-62.31^{***}	-68.70^{***}	-20.11^{*}	-62.57^{***}	7.03	-51.71^{**}
	(13.70)	(11.22)	(16.57)	(32.09)	(22.47)	(19.65)	(11.69)	(13.74)	(5.54)	(23.65)
$\Delta UN_{B,t-1}$	-25.82	2.26	-32.50	-61.99^{*}	-49.89^{*}	-39.06^{**}	-21.32	-24.79^{*}	4.74	-24.07^{*}
	(16.83)	(8.43)	(21.28)	(33.53)	(25.79)	(18.02)	(16.11)	(13.12)	(11.26)	(14.48)
ΔL^2	-10.36	-18.47	-20.46	-8.85	-18.29	-16.40	8.16	-16.38	-4.23	-32.85
	(6.81)	(15.80)	(12.99)	(22.56)	(15.83)	(17.89)	(15.42)	(12.07)	(10.83)	(22.71)
R^2	0.33	0.20	0.32	0.44	0.36	0.49	0.43	0.38	0.06	0.41
Adj. R^2	0.30	0.16	0.29	0.41	0.33	0.47	0.41	0.35	0.02	0.39
Num. obs.	149	149	149	149	149	149	149	149	149	149
	Government CIP Deviations									
α	14.70	49.95^{***}	89.16^{***}	120.69^{***}	50.33^{***}	26.74^{***}	96.60^{***}	66.80^{***}	25.73	76.05^{***}
	(9.17)	(14.09)	(10.11)	(21.49)	(13.87)	(9.40)	(14.81)	(18.98)	(20.75)	(26.79)
$TWDI_t$	753.10^{*}	260.78	310.70	702.42	979.77	784.94	1456.91^{*}	911.19	806.13	1118.93
	(422.89)	(452.77)	(786.52)	(817.51)	(816.64)	(540.49)	(849.45)	(673.77)	(539.34)	(820.70)
Δr_g^*	-79.37	-242.58^{***}	274.89^{***}	52.28	234.72^{***}	-164.16^{**}	-310.10	-66.10	60.24	88.05
	(88.70)	(53.10)	(58.11)	(79.88)	(89.19)	(66.60)	(242.06)	(70.54)	(63.04)	(262.74)
Δr_g	364.08^{***}	287.44^{***}	247.45^{***}	488.99^{***}	362.71^{***}	300.82^{***}	471.74^{***}	258.42^{***}	100.58^{**}	396.79^{***}
	(74.73)	(56.47)	(91.57)	(149.30)	(132.57)	(49.07)	(153.26)	(57.04)	(44.49)	(119.92)
$UN_{B,t-1}$	19.43	51.31^{***}	65.85^{***}	111.50^{***}	47.54^{***}	25.62^{**}	82.04^{***}	81.89^{***}	48.35^{*}	101.20^{***}
	(11.77)	(19.39)	(11.80)	(29.69)	(16.92)	(11.24)	(19.22)	(25.44)	(27.40)	(33.76)
$\Delta UN_{B,t-1}$	-0.82	16.98	18.38	58.97^{*}	43.58	-1.20	54.38^{**}	25.02	11.67	56.51^{*}
	(15.26)	(14.79)	(22.27)	(32.58)	(27.85)	(18.23)	(25.82)	(15.79)	(19.54)	(29.27)
ΔL^2	16.84	30.61	36.15	34.93	15.84	-1.54	12.61	32.81	-5.96	46.42
	(23.26)	(27.23)	(23.15)	(24.98)	(21.81)	(16.54)	(30.95)	(30.96)	(33.64)	(36.15)
R^2	0.44	0.51	0.50	0.56	0.45	0.44	0.58	0.43	0.18	0.44
Adj. R^2	0.42	0.49	0.48	0.54	0.43	0.42	0.56	0.40	0.15	0.42
Num. obs.	149	149	149	149	149	149	149	149	149	149

The model is estimated following Newey and West (1987) with optimal lag selection of Newey and West (1994). The level of significance is given by $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Chapter 2

The Uncertain Exorbitant Privilege and Duty

Abstract

In this paper, I examine the effects of exchange rate and macroeconomic uncertainty shocks on the United States' net foreign asset position. I use a Structural Vector Autoregressive (SVAR) model that incorporates a combination of external variable, narrative, and shock-dependent restrictions that account for the endogeneity of the uncertainties and their respective relationship with the net portfolio flows. The results reveal that exchange rate shocks and macroeconomic uncertainty contribute to reducing the deficit of the United States' net foreign asset position. Notably, macroeconomic has a greater lasting impact than the exchange rate. It is important to note that reducing the deficit in the short run leads to increased macroeconomic fluctuations, while it has the opposite effect in the long run. Furthermore, my study demonstrates that shocks in macroeconomic uncertainty are associated with higher exchange rate fluctuations. Conversely, higher exchange rate fluctuations have a contrary effect, reducing macroeconomics. These findings align with the existing literature on convenience yields and dominant currency, as high fluctuations affect the core economy by influencing foreign demand for assets and the stability of the world's terms of trade.

2.1 Introduction

The relationship between the domestic and foreign asset prices of all countries that trade internationally is determined endogenously by the feedback between their capital flow behavior. Recent trends of exchange liberalization allowed economies to be more integrated, benefiting global investments, increasing sources of liquidity, and allowing capital to flow freely. Nevertheless, integration comes with a cost, as the inflow and outflows of capital generate volatility in the prices, which is reflected in exchange rate fluctuations. In recent years, the United States (US) has had the advantage of having a high demand for liquid financial assets, especially safe assets like bonds and treasury bills, which has allowed them to run deficits in trade and current account while keeping their interest rates low (Gourinchas and Rey, 2007, 2014, 2022). The demand for assets balances with high investment in foreign portfolios by domestic investors, which earn higher returns from the risk premia. This allows them the "Privilege" of making high foreign returns at a low cost, with the "duty" of providing foreign funding when the domestic economy has a downturn and the interest payments are high. However, as the Uncertainty increases, the domestic market premium becomes higher due to being paired with the high exchange rate volatility. In that case, the foreign investors may rebalance the portfolio, leading to a sudden stop or retrenchment of capital flows. Then, the US benefits and duty may change and affect the stability of the whole world economy.

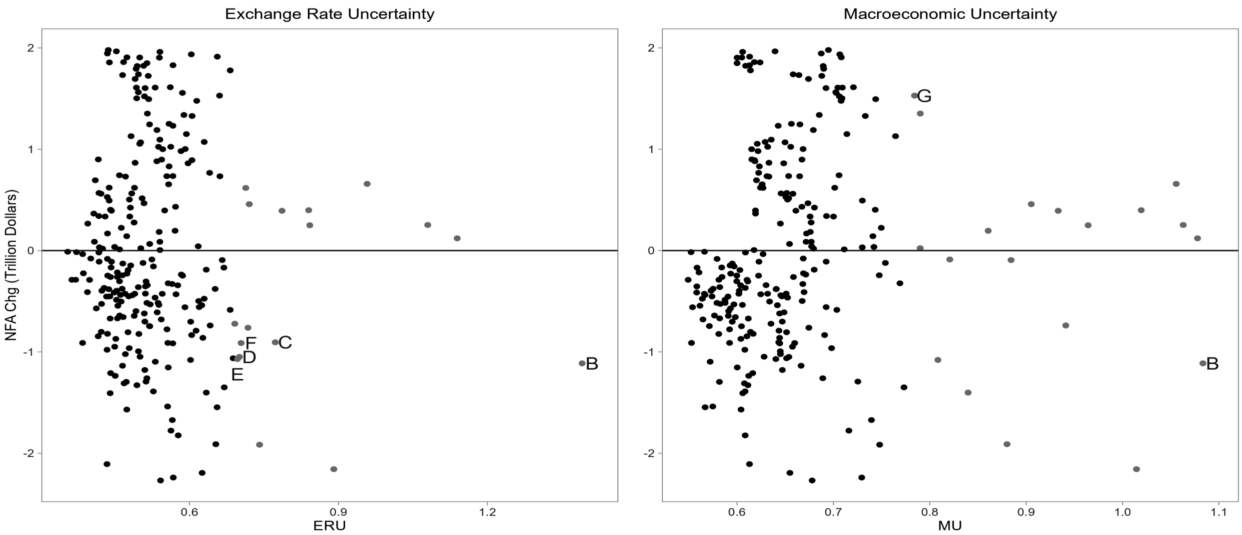
In this paper, I focus on studying the effect of the exchange rate and macroeconomic Uncertainty on the gross portfolio capital flows in the US, more precisely, its effect on the Net Foreign Asset (NFA) Position on long-term assets. This research goes in line with Gabaix and Maggiori (2015), Farhi and Gabaix (2016), Koijen and Yogo (2020), and Camanho, Hau, and Rey (2022), which explore the relationship between asset demand, capital flows, and exchange rates. In particular, this paper tries to disentangle the effects of global foreign exchange volatility around events perceived as rare disasters that trigger portfolio rebalancing by domestic and international investors. This will then determine if the inflows to the economy are persistent to episodes in which either macroeconomic or exchange rate uncertainty is high. Consistent with the literature on capital flows, we expect that under high Uncertainty, the inflows to the US will increase in search of safe assets such as government, treasury, and corporate bonds, increasing the Exorbitant Duty of the US. Meanwhile, there is also a sudden stop in outflows on corporate stocks as a precautionary measure by investors that rebalance their portfolio, losing their privilege. I find evidence that the increase of Uncertainty generates an increase in the NFA, as the domestic investors reduce their outside position in greater magnitude than the international. Macroeconomic shocks generate a contraction in foreign investors' demand for bonds and stocks. In contrast, domestic investors do not change their demand for international bonds, but they do their international. The effect of exchange rate is dissimilar to macroeconomics, as international investors do not change their demand for US safe assets, contrary to the US.

I follow the model of Ludvigson, Ma, and Ng (2017) and Ludvigson, Ma, and Ng (2021), which estimates a Structural Vector Autoregressive (SVAR) model that takes Uncertainty as endogenous rather than exogenous and controlled by the differences between general macroeconomic and the exchange rate sources. I use the Exchange Rate Uncertainty (ERU) from Fernandez-Mejia (2022) to explain the importance of currency fluctuations in the portfolio capital flows. I will calculate the Macroeconomic Uncertainty Jurado, Ludvigson, and Ng (2015), taken from the macroeconomic data from the United States data. As argued by Ramey (2016), it is difficult to say that its level will not have a contemporary relationship with macroeconomic variables, especially with variables with high persistence. As in Bloom (2009), Bloom (2014), and Alfaro, Bloom, and Lin (2023), the level of investment will be highly dependent and feedback with the level of Uncertainty, as agents will postpone or reduce expenditure considerably, which will cause more fluctuations about the firms and market's future.

The methodology offers a convenient identification of the shocks in which we can avoid making assumptions about either the short-run or long-run behavior of the dependence of the variables in the model. As in the SVAR literature, most restrictions can be indefensible or lead to incorrect conclusions, as shown in Kilian, Plante, and Richter (2022). We can consider the models with external identification as in Stock and Watson (2012) and Montiel Olea, Stock, and Watson (2021), yet as noted by Berthold (2023), disentangling the shocks for a separate identification implies a difficult task as there is high correlation between variables. Considering sign and inequality restrictions as in Uhlig (2004), the model presents some limitations in identifying the shocks. Wolf (2022) show that the sign restrictions may be susceptible to linear combinations of other shocks or insufficient to correctly identify the set of parameters of the response of interest. In that sense, I follow the Antolín-Díaz and Rubio-Ramírez (2018) and Ludvigson et al. (2017) model with narrative and shock restrictions that further identify the shocks pointing at events and magnitudes in those periods that help identify the model. In this case, the methodology centers on critical events of high Uncertainty to identify the model and forego the use of identification by either short or long-run restriction on the endogenous variables. I show that narrative restrictions allow us to identify the model compared to sign restrictions, significantly differentiating from the effects of macroeconomic and exchange rate fluctuations. This is the first to measure the effect of capital flows in the context of an endogenous feedback effect of the uncertainties and the flows.

One of the paper's contributions is using exchange rate uncertainty of the United States Dollar exchange rates to study capital flow fluctuations. Fernandez-Mejia (2022) show that although periods overlap with macroeconomic Uncertainty, this has effects that are not present in exchange rate fluctuations. As we can see in Figure 2.1, periods like the crisis in 2001 are not reflected in the index while they do in the uncertainty index of other measures such as the macroeconomic Uncertainty of Jurado et al. (2015) and the Economic Policy Uncertainty of Baker, Bloom, and Davis (2016)[1]. It is essential to analyze both Macroeconomic and Exchange Rate uncertainty shocks as increases of either will be priced in assets because foreign and domestic firms will require a higher risk-premia to trade internationally (Mueller, Tahbaz-Salehi, and Vedolin, 2017).

Figure 2.1. Uncertainty Indices and US' Net Foreign Asset Position



Note: The plot graphs the changes in the monthly NFA position for the US from January 1999 to December 2019 against the Exchange rate uncertainty and the Macroeconomic Uncertainty. The grey dots represent the extreme points that exceed the 90th percentile of the Uncertainty. The Points with the red letters are extreme historical events that impacted characteristically one or both uncertainties. B corresponds to October 2008, posterior to the Lehman Default, C is the beginning of talks of an overall European Debt Crisis and the Start of Operation Twist in September 2011, D is the event in which the Swiss Central Bank stopped the peg against the Euro as well as the expansion of the Asset Purchasing Program by the ECB in January 2015, E is when China decided to devaluate their currency on August 2015, F when Japan decided to allow interest rates to become negative and China's growth concerns on January of 2016, and G is the September 2001 crisis in the US market. *Sources:* Author's calculation, Fernandez-Mejia (2022), Jurado et al. (2015), and and Treasury International Capital (TIC) System.

Economies with high Uncertainty face volatility in inflows and outflows and present more extreme episodes, as the constant rebalancing of the portfolio will increase instabilities in the exchange rate. As the dominant currency and core world economy, the United States has particular conditions that other markets do not have (Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller, 2020; Gopinath and Itskhoki, 2022). It has a consistent

[1]In the Appendix A3 of Fernandez-Mejia (2022), the author shows that the exchange rate uncertainty has a higher correlation with the FX volatility measure of Menkhoff, Sarno, Schmeling, and Schrimpf (2012) and less so with the Volatility Index of the Chicago Board Exchange (VIX). It is less correlated with Economic Policy, Financial, Real, and Macroeconomic Uncertainty.

demand for its assets in periods of growth and crisis that offers a convenience yield on its safe assets (**?**Jiang, Krishnamurthy, and Lustig, 2021). The continuous demand for these assets has given them the Exorbitant Privilege of running deficits while maintaining their NFA position's demand stable. It was named the world's venture capitalist by providing the world with liquid, safe assets and reinvesting them in foreign economies. It is one of the primary sources of investment funds in core economies.

Nevertheless, with relatively higher Uncertainty, the demand for US assets may change and reduce the NFA's privilege. With higher levels of ERU, US investors may perceive the foreign markets as riskier and rebalance their portfolios to invest in the high returns of the domestic economy. The change in the yield and returns will generate a retrenchment in outflows, contracting even further the NFA deficit, as noted in Atkeson, Heathcote, and Perri (2022).

The Fluctuations of capital flows have implications for Central Banks and private firms' leverage, which depends on the value of their foreign exchange liabilities. Any instability in their capital structure will constrain their liquidity, increase their balance sheet risk, and impose a higher risk premium in their assets (Bruno and Shin, 2015b; Salomao and Varela, 2022). In turn, Uncertainty regarding the exchange rate and the macroeconomic conditions will increase the instability in the country's inflows and outflows. Firms will not price foreign goods correctly, which will disincentive investment and trade (**?**) and will increase the demand for safe assets as insurance (Caballero, 2016; Akinci, Kalemli-Özcan, and Queralto, 2022).

Literature Review The impact of Uncertainty on the economy is a topic that raises interest in the literature, as it recognizes the effect of expectations and shocks on the agents' decisions. Since the most recent crisis in 2007, there has been a focus on researching the idea of measuring uncertainty and its implications for the economy. The paper by **?** was one of the first analyses of Uncertainty regarding the stock market volatility. They used the Chicago Board of Exchange's Volatility Index (VIX) and the difference between forecasted and realized earnings for firms. Other traditional measures of uncertainty include those that use models based on news coverage, such as the Economic Policy Uncertainty (EPU) of Baker et al. (2016), or the distribution of errors in the distribution of the survey of forecasters of Rossi and Sekhposyan (2015). Jurado et al. (2015) proposed a new measure of Uncertainty derived from a VAR with factors to forecast different macroeconomic variables, subtract the realized values, and then calculate the Uncertainty as to the conditional volatility.

Recent research has implemented different methodologies to assess uncertainty and investigate how it influences capital flows. The VAR methodology is widely utilized for uncertainty analysis due to its ability to incorporate endogenous variables and determine the system's response to uncertainty shocks. Rey (2015) and Bruno and Shin (2015a) demonstrated that an increase in the VIX has negative consequences for capital flows, leading to decreased inflows into the country. Bacchiocchi, Bastianin, Missale, and Rossi (2020) used an SVAR with mix-sampling frequency and found that the outcomes may differ based on the frequency used, as higher periodicity shows higher reductions of flows to the US than lower ones. Mandalinci and Mumtaz (2019) analyze the impact of both regional and global variations on capital flows using a Factor Augmented VAR (FAVAR), incorporating the VIX and regional uncertainty measures from Mumtaz and Theodoridis (2017). This study contributes to the existing literature by introducing a novel framework to analyze the effects of uncertainty shocks on capital flows, emphasizing both the net position and gross capital flows. In the model, uncertainties arise endogenously rather than conditioned by ordering.

I will use the SVAR model of Ludvigson et al. (2021) that takes different types of Uncertainty, financial and macroeconomic, and estimates their shocks as endogenous. Early versions of the paper initiated the debate of treating Uncertainty as endogenous or exogenous shock and using instrumental variables. Caldara, Fuentes-Albero, Gilchrist, and Zakrajšek (2016) use an SVAR with a penalty function to distinguish between financial and macroeconomic, finding that the worst type of shocks combine both. Bonciani and Ricci (2020) calculate the financial Uncertainty using 1000 realized volatilities of different countries and taking the first principal component. They use linear projections to estimate the effects of different variables. Caggiano, Castelnuovo, and Figueres (2020) estimated the effect of Uncertainty using October 1987 and September 2008. Carriero, Mumtaz, Theodoridis, and Theophilopoulou (2015), Carriero, Clark, and Marcellino (2018), and Carriero, Clark, and Marcellino (2020) they proposed using external instruments using the Proxy-VAR of Stock and Watson (2012) and Mertens and Ravn (2013), which has the advantage of avoiding the problem of error measurement bias. Angelini, Bacchiocchi, Caggiano, and Fanelli (2019), and Angelini and Fanelli (2019) use variations of that methodology and present different applications to prove that Uncertainty is an exogenous shock to the domestic product. Carriero, Clark, and Marcellino (2021) reconcile the literature of both types of estimation and use a VAR with stochastic volatility that accounts for the effects of Uncertainty to mean and volatility.

The assessment of the impact of exchange rate uncertainty on capital flows involves a thorough examination of its influence on significant movements in gross capital flows, including surges, stops, flights, and retrenchments. The analysis of these extreme movements was initially carried out by Forbes and Warnock (2012) and further expanded upon in Forbes and Warnock (2021), which builds upon Calvo (1998) work on sudden stops to characterize their timing. Other authors, such as Schmidt and Zwick (2015), have also explored these extreme movements in relation to uncertainty, utilizing a panel with various uncertainty measures to analyze different instances of extreme capital flows in the euro area. Wang and

Yan (2021) used a dynamic panel with quantile regression to evaluate the impact of push and pull factors on capital flows, finding that the VIX affects both quantiles by reducing the flow level. The objective of this paper is to examine the changes in each component of gross capital flows and the influence of uncertainty on the portfolio decisions of international investors. Then, filling the gap in the effects product of macroeconomic and exchange rate uncertainty.

2.2 Econometric Model

I follow the VAR identification model of Ludvigson et al. (2017) and Ludvigson et al. (2021) that uses event restrictions to identify the effects of Uncertainty, particularly the effects of financial. Their measure uses event and external instrumental variables to identify uncertainty shocks. The model, like sign restriction identification, provides a set of outcomes that align with the recognition of the uncertainty around the true model. This differs with respect to point identification of the traditional VAR models, as it does not allow a point identification of the effect but rather a set of possible values it may take[2]. We can write the reduced form VAR model with an AB representation and p lags as;

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + B\varepsilon_t \qquad \varepsilon_t \sim N(0, I_N) \tag{2.1}$$

where y_t is an N-vector variable, A_i are the p autoregressive parameters, $B = H\Sigma$, H and Σ are diagonal matrices of ones and the variance of the structural shocks, and ε_t are the structural shocks. The reduced VAR model innovations are defined by the second term of the equation, such that we can write them as $u_t = B\varepsilon_t$, where $u_t \sim (0, \Sigma)$, $\Sigma = PP'$, and P is the non-negative lower-triangular.

We must restrict the reduced form model to identify the structural shocks. It implies imposing a contemporaneous relationship between the variables in y_t or including external instruments. The literature on the effect of uncertainty shocks in the economies presents disagreements towards identifying endogenous or exogenous shocks. I will follow Antolín-Díaz and Rubio-Ramírez (2018) and Ludvigson et al. (2021) and impose narrative restrictions on shocks on significant events, precisely where there is high Uncertainty. I will define the narrative restrictions on the uncertainty index data and historical events that will allow us to determine its effects robustly.

If we provide no additional restrictions, then we have the only restrictions that we have to correspond to the reduce-form covariance structure of u_t such that

$$\overline{g_z}(B) = vech(\Sigma) - vech(BB') = 0 \tag{2.2}$$

[2]A thorough explanation of both methods can be found in Kilian and Lütkepohl (2017).

Where the Σ is the estimated variance-covariance matrix of u_t. As the model requires for complete identification, $N \times N$ restrictions and $\overline{g_z}(B)$ only provide $\frac{N(N-1)}{2}$, it does not provide enough for the whole system to be identified. Then, it has infinite solutions, and shocks of the components of y_t cannot be retrieved (Kilian and Lütkepohl, 2017). We then will require additional restrictions or assumptions on the model to be able to identify it using conventional short or long-run restrictions. Nevertheless, we can β to construct different B that reflect the relationship of the variables and estimate the possible values of the shocks on relevant dates. We then construct multiple $\tilde{B} = PQ$ such that Q is an orthonormal matrix. As in Ludvigson et al. (2021), I construct 1.5 million random orthogonal matrices of Q to derive each $\tilde{B}$ from a QR decomposition. This will help us create different generated shocks and estimate possible values of shocks that events may take conditional on the unconstrained structure of the $\overline{g_z}$.

Event Inequality Constraints

The event inequality constraints used in the model will complement the model defined in Equation 2.1. The events focus on the historical peaks of the period analyzed for both the macroeconomic and exchange rate uncertainty[3]. Using the periods of high Uncertainty is coherent with identifying shocks that reflect the data, an improvement concerning general ad-hoc identification traditional of SVAR models. Event constraints allow us to use historical and data-driven events in which we can conclude unequivocally that the structural shock corresponds to a specific variable of interest. The events provide an identification of the model which is defensible both empirically and theoretically compared to traditional structural models. The identified events have to satisfy the following constraints:

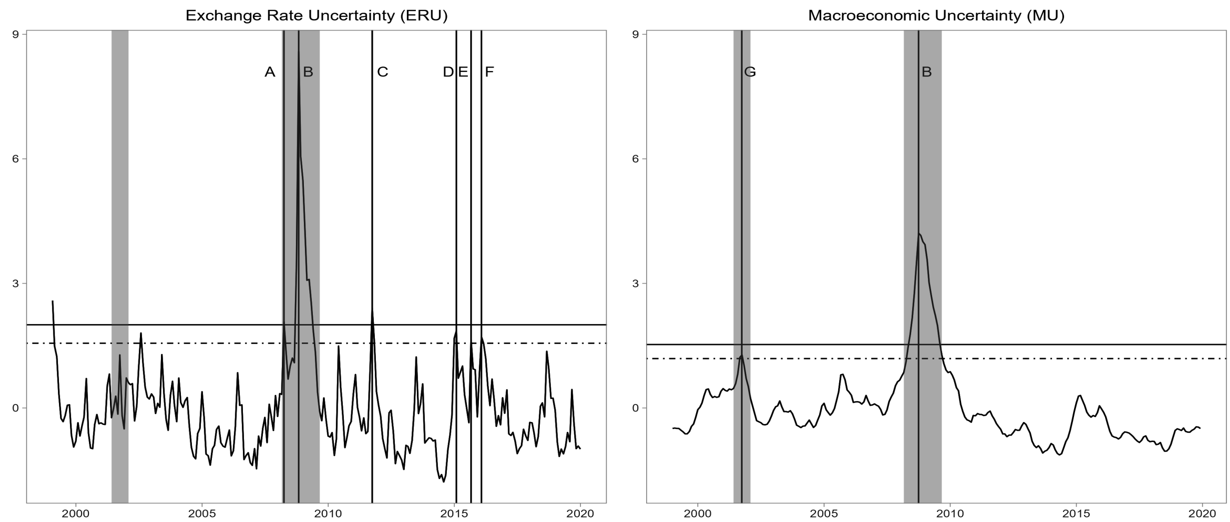
$$
\begin{aligned}
&\text{Event 1 } (\overline{g_1}) : \varepsilon_{M,1} \geq \delta_1 \text{ at September 2001} \\
&\text{Event 2 } (\overline{g_2}) : \varepsilon_{ER,1} \geq \delta_2 \textit{ or } \varepsilon_{M,2} \geq \delta_3 \text{ at October 2008} \\
&\text{Event 3 } (\overline{g_3}) : \varepsilon_{ER,2} \geq \delta_4 \text{ at September 2011} \\
&\text{Event 4 } (\overline{g_4}) : \varepsilon_{ER,3} \geq 0 \text{ at January 2015} \\
&\text{Event 5 } (\overline{g_5}) : \varepsilon_{ER,4} \geq \delta_5 \text{ at October 2015} \\
&\text{Event 6 } (\overline{g_6}) : \varepsilon_{ER,5} \geq \delta_6 \text{ at January 2016} \\
&\text{Event 7 } (\overline{g_7}) : \sum \varepsilon_{NFA,6} \leq 0 \text{ from September 2008 to June 2009}
\end{aligned}
$$

In Figure 2.2, I present the identified events using a threshold of the 1.64 and 1.28 standard deviations (95 and 90% percentile of the normal distribution) above the mean of

[3]Using the identified episodes from the Financial Uncertainty calculated by Ludvigson et al. (2021) may be attractive. However, as shown in Fernandez-Mejia (2022), and in Appendix 2.5, the estimated events for the ERU and the Financial Uncertainty are different. The ERU captures shocks from external events that might not capture the factor of their financial assets.

both macroeconomic and exchange rate uncertainty. The difference between both percentiles has implications on the identification itself, where we can see that exchange rate specifics have a lesser magnitude, which we could expect to have a lower effect on the variable of interest. For Macroeconomic Uncertainty, Events $\overline{g_1}$ and $\overline{g_2}$ correspond to the 9/11 attack on the Twin Towers and the Lehman Brothers Bankruptcy. The first event marked a terrorist attack directed specifically at the financial markets center, one of the only moments where the stock market in different parts of the world was shut down in fear of further attacks, but also preceded a fractured market after the dot com crash in 2000. The life costs and subsequent economic costs that it had at the time, accompanied by constant fear, characterized this period as one of high Uncertainty. Event 2 coincides with the greatest financial crisis in recent times, which triggered a contraction in the world markets, reduced the value of the foreign portfolios, and triggered a capital outflow in the US. Both events coincide with the ones used in Ludvigson et al. (2017), Ludvigson et al. (2021), and Berthold (2023).

Figure 2.2. Exchange Rate and Macroeconomic Uncertainty in Time



Note: The graph presents the ERU and Macroeconomic Uncertainty with the series' mean standardized to zero. The horizontal line corresponds to the 1.65 standard deviations above the mean, defining each series's important episodes. The dashed line is the 1,28 deviation line above the mean. The vertical line is the peak period of each period identified and used as the event constraint. Point A is the beginning of the Term Auction Facility (TAF) by the Federal Reserve; Point B is the Lehman default; C is the beginning of talks of an overall European Debt Crisis and the Start of Operation Twist in September 2011; D is the event in which the Swiss Central Bank stopped the peg against the Euro as well as the expansion of the Asset Purchasing Program by the ECB in December 2014; E is when China decided to devaluate their currency on August 2015; F when Japan decided to allow interest rates to become negative and China growth concerns on January of 2016; G is the September 2001 crisis in the US market. *Sources:* Ludvigson et al. (2021), **?**, and Author own calculations.

The other events correspond precisely to the Exchange rate Uncertainty and the NFA post-GFC behavior events. Event $\overline{g_3}$, corresponds to the increase in the overall concerns towards the ability to meet the debt obligations by the most prominent European countries, which began the overall pessimistic forecasts of the prospects of growth of the world economies in September 2011. During this time, the Federal Reserve decided to conduct Operation Twist by buying long-term and selling short-term to invert the yield curve. The high demand from the federal reserve for these assets impulsed the rebalance of both foreign and domestic investors, which reflected an increase in inflows of treasury bills during the time. Both high demand for the currency and the heightened Uncertainty about the economy may reflect higher exchange rate uncertainty during the month.

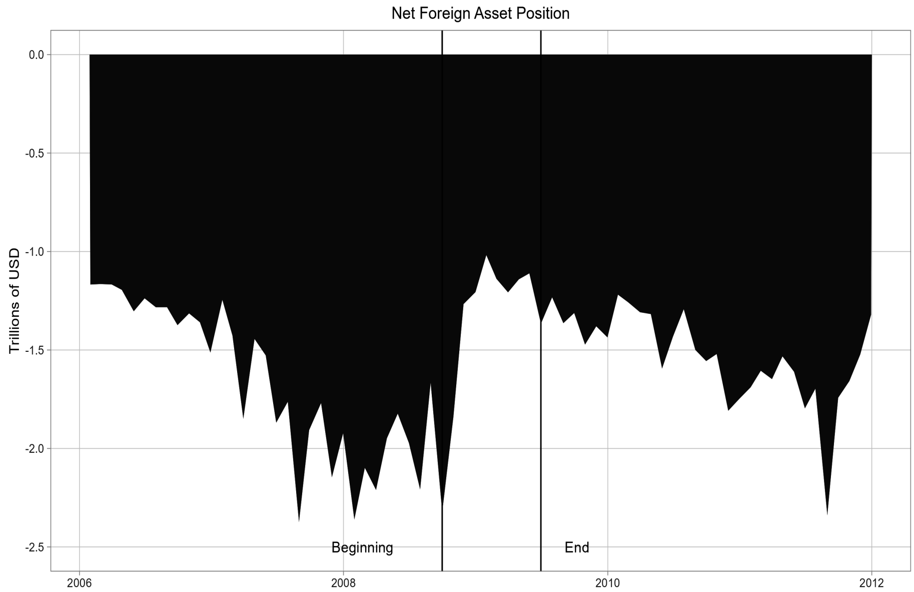
Event $\overline{g_4}$ is the announcement of the expansion of the Asset Purchasing Program (APP) by the European Central Bank and coincides with the end of the peg to the Euro by the Swiss Central Bank. The first of these events relates to the increased asset purchasing of assets that change its valuation, changing the demand for them by foreign investors. Benigno, Canofari, Di Bartolomeo, and Messori (2023) explains this effect as the interest rate channel of the ECB program, as the portfolio rebalancing increases in the exchange rate fluctuations during the period. On the other side, the Swiss cap removal created exchange rate fluctuations through changes in the liquidity of a safe haven currency such as the Swiss Franc and the changes of the foreign exchange accumulation by the Central Bank to a parity (Amador, Bianchi, Bocola, and Perri, 2020; Breedon, Chen, Ranaldo, and Vause, 2023).

China's devaluation of the Renminbi/Yuan, Event $\overline{g_5}$, triggered high financial market fluctuations as changes in the valuation of one of the most liquid currencies and one of the countries with the highest demand for US assets, will indeed have repercussions on capital flows. Also, with changes in the terms of trade of one of the central economies in world trade, the current account of most countries will be affected, and so will their exchange rates. The last Event shock restriction is the $\overline{g_6}$, which represents the beginning of the negative rates in Japan as a monetary policy tool and heightened concerns about the state of the Chinese economy. Both economies, the owners of a significant percentage of the US market assets, will have an impact on the capital flows and exchange rates, as both the Yen and Yuan have a higher turnover participation in the overall market.

The last restriction implies that the cumulative effect of the crisis shock and the increase in the interest rate by the Federal Reserve had a negative effect on the NFA. The US crisis and interest rate increase are a pull factor in the literature on capital flows, especially for emerging markets (Caballero, Farhi, and Gourinchas, 2008a; Koepke, 2019a; Davis, Valente, and van Wincoop, 2021). The crisis will create a retrenchment of capital inflows, and the tightening of the monetary policy will reflect lower valuations of the financial assets and an increase in the "Duty" of the Central Bank.

As in Ludvigson et al. (2021), I determine the values of the parameters $\delta = [\ \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6, \delta_7]$ that define the standard deviations above the mean, using the 75th percentile of

Figure 2.3. NFA and the restriction of event six ($\overline{g_6}$). 2006-2012



Note: The Figure presents the NFA position on long-term assets from 2006 to 2012. The beginning of the analyzed period is September 2018, with the failure of Lehman Brothers, and the end is June 2019, as dated by the end of the recession in NBER dates. *Sources:* Author's calculations and TIC data.

the random rotations of B of the unconstrained set. The estimated parameters are δ=[2.90, 2.74, 2.52, 1.84,2.16, 1.99], and they will define the identity of the IRF of the model.

We can define the event constraints as a system such that:

$$\overline{g}(\varepsilon_i(B), \delta) \geq 0 \tag{2.3}$$

External Variable Constraints

I use two variables to identify the model further, taking advantage of the information on the correlation with the identified shocks of interest. I will center around two stylized empirical results to determine the variables to include as external to the model. Gold and Oil prices are two variables standard in the literature for their relationship with the macroeconomic and exchange rate uncertainty from a global perspective. Then, we can define the External Variables as $EX = [EX_g, EX_o]$, where EX_g is the gold and EX_o are the oil return shocks. The constraints on the external variables follow the restrictions:

$$\text{External 1 } (\overline{EC_1}) : \rho(\varepsilon_i(B), EX_g) \geq 0$$
$$\text{External 2 } (\overline{EC_2}) : \rho(\varepsilon_i(B), EX_o) \leq 0$$

External variable constraints take advantage of the information on the correlation between variables related to Uncertainty. The first constraint, $\overline{EC_1}$ relates to the correlation between high levels of Uncertainty and the demand for gold as a consistent store of value in crisis periods, as shown in the model of Caballero, Farhi, and Gourinchas (2008b). The second constraint, $\overline{EC_2}$ uses the negative correlation between fluctuations in exchange rates and adverse shocks of fluctuations in oil prices, which is an empirical result derived from Känzig (2021). Oil and commodity shocks are known drivers of demand for exchange rates, as shown in Amano and van Norden (1998), Chen and Chen (2007), Chen, Liu, Wang, and Zhu (2016), and Basher, Haug, and Sadorsky (2012). So, we can use the relationship between both variables to identify the shocks of the model by its expected behavior.

We can define the external constraints as

$$\overline{g}_C(\varepsilon_i(B), EX) \geq 0 \tag{2.4}$$

2.3 Data

I will use different sources to estimate the shocks from Uncertainty to capital flows. First, the daily Exchange Rate Uncertainty measure constructed in Fernandez-Mejia (2022) from 31 exchange rates span between January 1999 to December 2019. I Transformed the data from daily to monthly by taking the monthly median, which is better than averaging the uncertainty shocks or ignoring its effects by only using the last month's value. Construction of the data from daily to monthly has identification advantages. Alessandri and Mumtaz (2019) show that using low-frequency data, rather than building from a higher frequency, creates identification problems. The data frame is a balanced panel with 249 data points for each time series. To control for the effects of macroeconomic Uncertainty, I will use the monthly macroeconomic Uncertainty of Jurado et al. (2015), which will help separate the exchange rate effects from the macroeconomic effects of the central economy[4]. The data from the Net Foreign Asset Position comes from The US Department of the Treasury's Treasury International Capital (TIC), which contains the portfolio capital flows between US residents and foreign residents in long-time securities[5]. I transform the data using the X13-ARIMA Seats algorithm to adjust the series of seasonal effects and differentiate if it

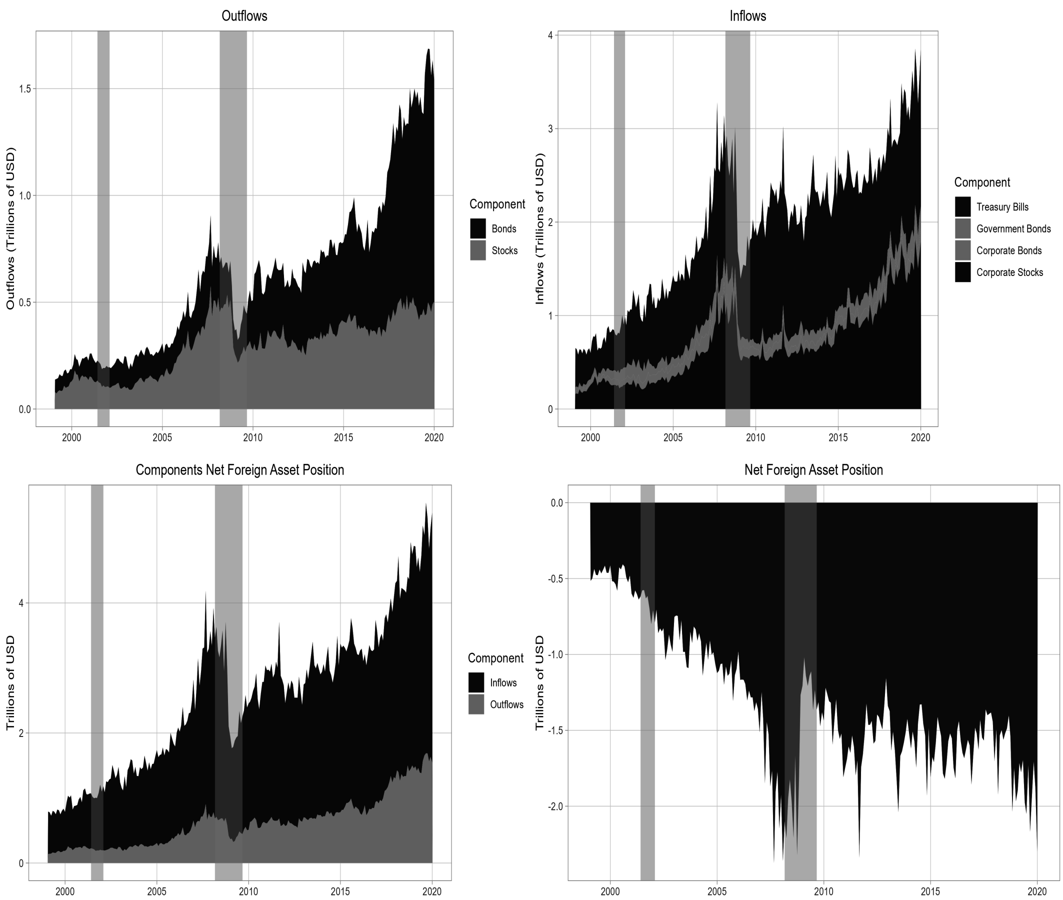
[4]They use the monthly FRED-MD macroeconomic database of McCracken and Ng (2016) that consist of 134-time series that combine both financial and macroeconomic variables of the US economy. I downloaded the 2020 vintage from Sydney Ludvigson's webpage at https://www.sydneyludvigson.com/macro-and-financial-uncertainty-indexes

[5]The data focuses only on portfolio transactions between US residents and foreigners and does not include Foreign Direct Investment (FDI). As noted in Koepke (2019b) and Forbes and Warnock (2021), capital flow volatility is given by the variation of the position in portfolio assets rather than FDI, as the last involves long-term investments with low liquidity. It is available to download from https://home.treasury.gov/data/treasury-international-capital-tic-system-home-page/tic-forms-instructions/securities-a-us-transactions-with-foreign-residents-in-long-term-securities

presents evidence of unit roots, to be approximately stationary[6].

The data includes the components of the portfolio capital flows as the gross purchases of assets by foreigners of US assets (Inflows) and sales of Foreigners to US residents (Outflows). The assets in the database are US Treasury Bonds, US Government Agency Bonds, US Corporate Bonds, US Corporate Stocks, Foreign Bonds, and Foreign Stocks. Consistent with the classification of Gourinchas and Rey (2007), Gourinchas and Rey (2014), and Atkeson et al. (2022), I follow the definition of the Net Foreign Asset (NFA) position as the market value of Foreign assets held by US residents minus the value of US assets held by foreigners. Then, I construct the NFA as the foreign stocks and bonds demanded by the US minus the Inflows after subtracting the demand of foreigners for foreign stocks and bonds.

Figure 2.4. Stacked Graph of Inflows, Outflows, and the Net Foreign Asset Position (Tril. USD)



Note: The Figure presents different stacked graphs of the Portfolio capital inflows, outflows, and their Net Foreign Asset Position. The position is derived from the demand for foreign assets by US residents minus the demand for US assets by foreigners. *Sources:* TIC and Author's calculations

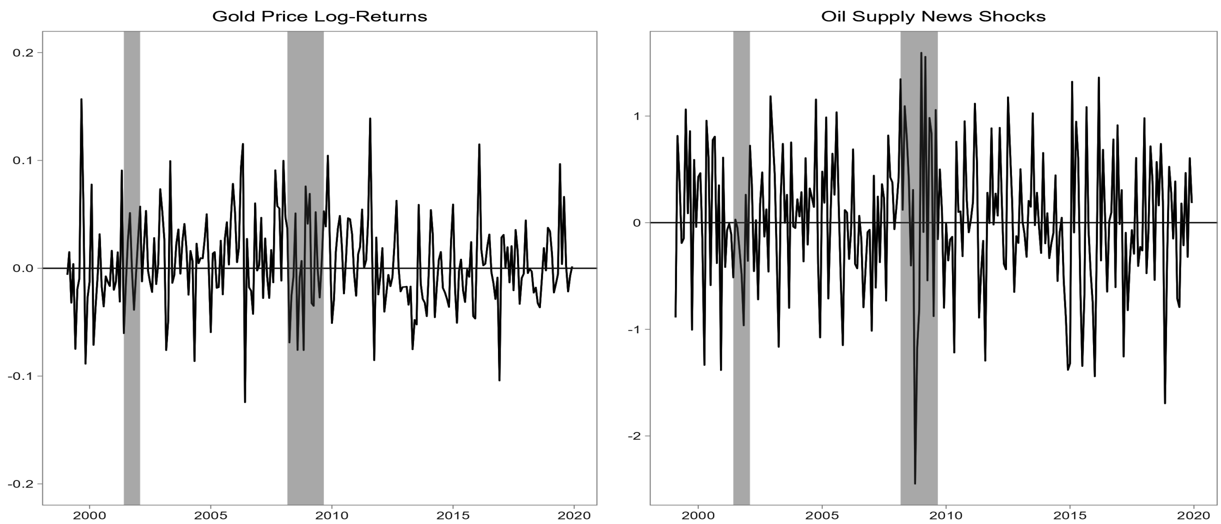
Figure 2.4 shows the behavior of Inflows and Outflows, as the behavior of our primary

[6] In Table C1 of the Appendix 2.5, I present the descriptive statistics of the variables and the unit root test of each series after adjusting for the seasonal effects.

variable of interest, the NFA[7]. Consistent with the narrative of Gourinchas and Rey (2007) and Caballero et al. (2008a), inflows to the US surpassed the outflows from the start of the 2000s and increased consistently until the global crisis. The surge in inflows and sudden stop in late 2018 is part of the restrictions imposed in the model on $\overline{g_5}$. After the crisis, the NDA stabilized at a deficit of approximately between -2 and -1.5 Trillion USD.

The Price of Gold is the average monthly USD per ounce from the London Bullion Market Association (LBMA), deflated by the US Consumer Price Index (CPI) from the Federal Reserve of St. Louis Economic Database (FRED). The other instrument will be the oil supply news shocks of Känzig (2021). Using the shock rather than the oil price returns will allow me to separate the effect of oil shocks from just the oil price changes and have a structured relationship between the variables. In Figure 2.5, I present the logarithmic returns of the gold prices and the oil shock, where we can see that both instruments present different levels of volatility and extreme episodes. The events that stand out are the financial crisis in 2007 and the negative shock of oil that affected its price between mid-2018 and early 2009.

Figure 2.5. External instruments - Log-returns of Gold and Oil News Supply Shocks



Note: The gold price logarithmic returns are calculated using the monthly auction averages of the London Bullion Market Association (LBMA) in USD per ounce of gold at 5 PM. The gold price is later deflated using the CPI from FRED with base January 2018. The Oil Supply Shocks are calculated in Känzig (2021). *Sources:* LBMA, Känzig (2021), and author's own calculations.

[7] In Appendix 2.5 I briefly present the components of the NFA that correspond to the components of the Outflow of domestic assets and the inflows from the demand of US assets by foreigners.

2.4 Results

I present the results in two parts. First, I will estimate the model focusing on the effect of macroeconomic and exchange rate uncertainty on the Net Foreign Asset Position. The second part will estimate the effect on each of the inflows and outflows, as well as the most significant contributions to their fluctuations, the demand for bonds and stocks. Focusing only on the net flows may give an incomplete view of the underlying mechanism and relationship between variables.

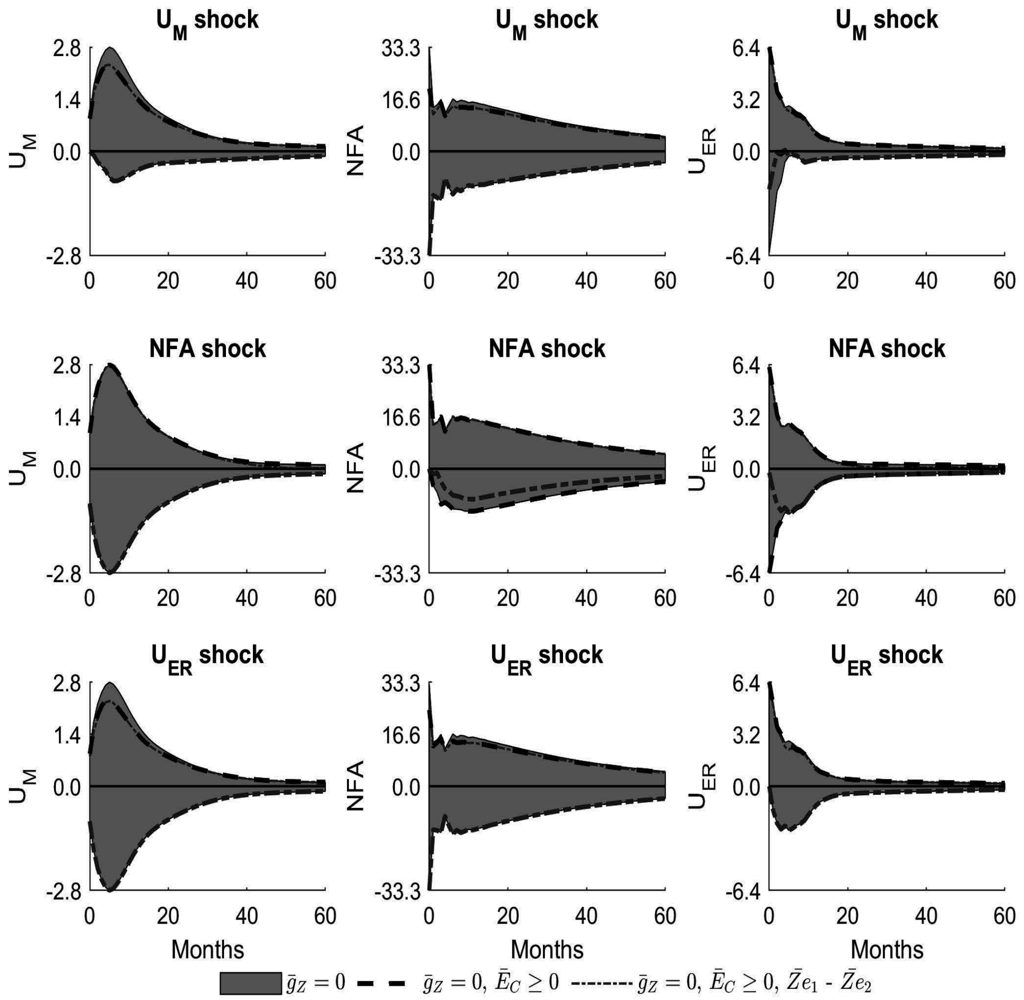
2.4.1 Net Foreign Asset Position

In Figure 2.6, I present the different types of Impulse Response Functions (IRF) for different specifications of the model described by Equation 2.1, but excluding the narrative restrictions. The vector of endogenous variables of the model is composed by $X_t = [U_{M,t}, NFA_t, U_{ER,t}]'$. Where $U_{M,t}$ is the Macroeconomic Uncertainty of Jurado et al. (2015) under one-month ahead structure, NFA_t is the Net Foreign Asset Position for the United States, and $U_{ER,t}$ is the Exchange Rate Uncertainty (ERU) of Fernandez-Mejia (2022). I estimate the VAR model with six lags; although initially, the optimal lag of the model suggested the use of two, the model had a persistent serial correlation. The Figure presents the IRF of different levels of restrictions on the model; with no restrictions, sign restrictions on the external variables defined in $\overline{g}_C$, and with the restrictions on the sign of some shocks ($\overline{g}_{4,7}$).

Based on the model's results following the reduced-form model such that $\overline{g}_z(B) = 0$, we can see that the IRFs do not produce any conclusive result. By definition, we cannot identify the shocks. It also reflects the need for further restrictions on the model to obtain causality results. The IRFs of the model with external variables $\overline{g}_C$ and some narrative sign restrictions $\overline{g}_{4,7}$ show slight improvements in the results, as they allow the model to be fully identified. There is some slight effect of the macroeconomic uncertainty shocks on the Exchange rate Uncertainty, but the rest of the results are not informative. Figure 2.6 shows the need to use further informative restrictions to optimally identify our shocks of interest. Having Big Event narrative shocks may give further information to adequately determine the effect of interest.

In Figure 2.7, we can see the results of the estimation of the model with the minimal restrictions $\overline{g}_z$, the external variable $\overline{g}_C$, and the complete narrative events $\overline{g}$. The complete estimation includes now the Big Event restrictions of 9/11 ($\overline{g}_1$), the European Debt crisis, ($\overline{g}_3$), China's currency devaluation ($\overline{g}_5$), and the negative interest rates of Japan ($\overline{g}_6$). The Figure graphs the identified shocks following the Full model under the shaded region. If we compare it with Figure 2.6, we assess the comparative advantage of specific narrative

Figure 2.6. Impulse Response Functions Different Restrictions

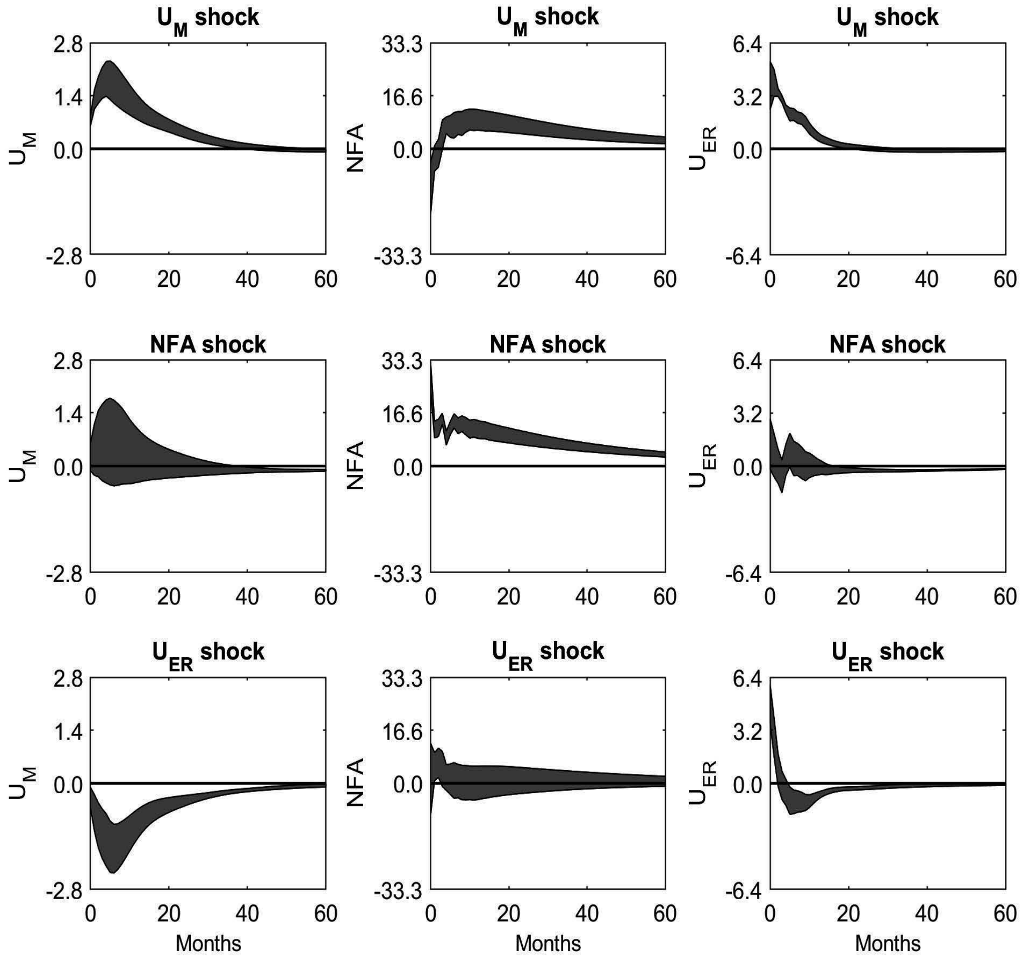


Note: The Figure presents the IRFs of the estimated model using the reduce-form model $\overline{g}_z = 0$, with sign restrictions on external variables $\overline{g}_c \geq 0$, and with some event sign restrictions $\overline{g}_c$ and $\overline{g}_{4,7}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. The NFA is the changes in the Net Foreign Asset Position in Trillions of Dollars. *Sources:* Author's calculations.

restrictions to the model with just sign restrictions.

The IRFs reflect that the Macroeconomic Uncertainty shock initially has a negative effect, deepening the NFA and reversing its effect with a high permanent increase in later periods. The response shows that high Uncertainty increases the demand for domestic assets, principally safe assets, as shown in Figure B1 of the Appendix 2.5. However, this may come from different channels. An increase in inflows increases the demand for foreign assets (increasing outflows). Another channel is reducing the demand for risky domestic assets (reducing inflows) and reducing the NFA deficit. Conversely, the exchange rate uncertainty has no representative effect on the NFA other than a negligible effect on the first periods.

Figure 2.7. Impulse Response Functions Full Model



Note: The Figure presents the IRFs of the estimated model using the Fully identified model $g_z = 0$, with sign restrictions on external variables $g_c \geq 0$, and with both general and narrative sign restrictions g_c and $\overline{g}$. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. The shaded region is the shock identified by the restrictions. The NFA is the changes in the Net Foreign Asset Position in Trillions of Dollars.*Sources:* Author's calculations.

The ERU effect is less pervasive than the macroeconomic; exchange rates absorb shocks rapidly, and we could expect the effects to be short-lived. The overall result suggests the benefits of macroprudential policies oriented to control the uncertainty levels, especially macroeconomic, to avoid instability of the NFA and its lasting effects on the international accounts.

One unique feature of the model is that it allows us to characterize the effect of the shocks on the NFA and the feedback effect between Uncertainty types. Macroeconomic affects the Exchange Rate by increasing it consistently in the first periods. Fluctuations in the state of the economy are a sign of fragility, which in turn limit the portfolio capital inflows and outflows. As the world's dominant currency and the base of the calculation of the ERU, the effect of the macroeconomic conditions is expected to have a higher effect. Exchange rate uncertainty shocks show a pattern of decrease in Macroeconomic Uncertainty consistently. The channel in which the Exchange rate affects macroeconomic conditions is through the depreciation of foreign currencies and changes in terms of trade for the US economy. An increase in the overall fluctuations of the world economy will trigger portfolio rebalancing, turning to safe-haven assets, mostly provided by the US (Camanho et al., 2022; Caballero, Farhi, and Gourinchas, 2016, 2021) .

2.4.2 Gross Capital Inflows and Outflows

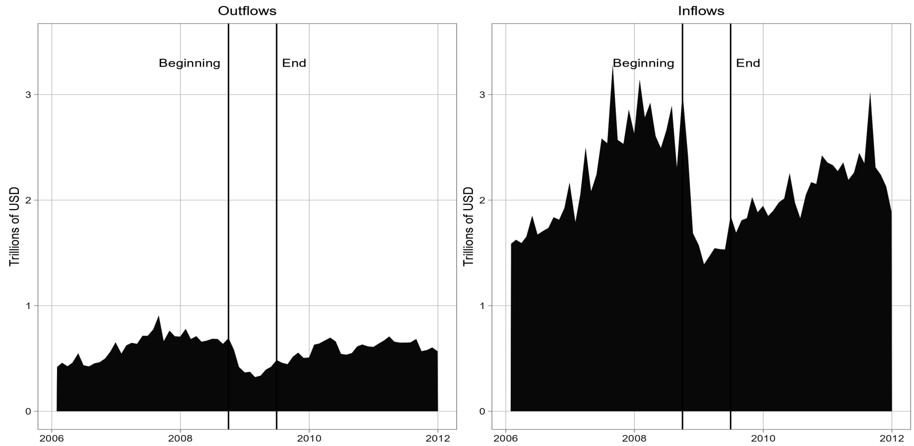
We now analyze Uncertainty's effect on gross capital inflows and outflows. This will help us understand the effect that predominantly changes the long NFA position, as both effects may counter each other and lead us to underestimate their impact. To this end, I will take the restriction on the behavior of the NFA in Event 7 and change them to match the events of gross capital flows. The events will be defined as,

$$\begin{aligned} &\text{Event 8} \qquad (\overline{g_8}) : \sum \varepsilon_{USO,8-9} \leq 0 \qquad \text{from September 2008 to June 2009} \\ &\text{Event 9} \qquad (\overline{g_9}) : \sum \varepsilon_{FI,8-9} \leq 0 \end{aligned}$$

where $\varepsilon_{USO,8-9}$ are the shocks to the Ouflows, while $\varepsilon_{FI,8-9}$ is the shock to the inflows. We can see the periods of analysis for both in Figure 2.8, which presents both the beginning and end of the restriction period—as in the NFA, the period remained between the crisis in September 2008 to the end of the recession in June 2009. There is an apparent decrease in both in that period, but the effect is steeper for the inflows. If we turn to the behavior of the gross capital flows in Figure 2.4, the post-crisis period reduced the overall flows to the economy, and the contraction of the position lasted during the period. Posterior to it, the inflows grew more than the outflows, worsening the position. This is due to the loss of position in the international markets and the growth of US residents' demand for domestic assets, contradicting the privilege earned before, as mentioned by Atkeson et al. (2022). Under a higher level of Uncertainty in both the exchange rate value and macroeconomic conditions, the high levels of risk aversion in the market reduce the demand for US assets and the capital inflows. Nevertheless, as noted by Caballero et al. (2016), the scarcity of safe assets in a high-risk period will increase the demand for them from international investors and central banks. We can see this rise in the level of demand for both inflows and outflows of bonds.

In figures 2.9 and 2.10, I plot the Impulse response functions of the outflows and inflows of portfolios following the previous model. Compared to the NFA VAR model, it is more restrictive, and the identified impulse responses are limited. Both uncertainties impact the

Figure 2.8. Restrictions to capital Inflows and Outflows. 2006-2012



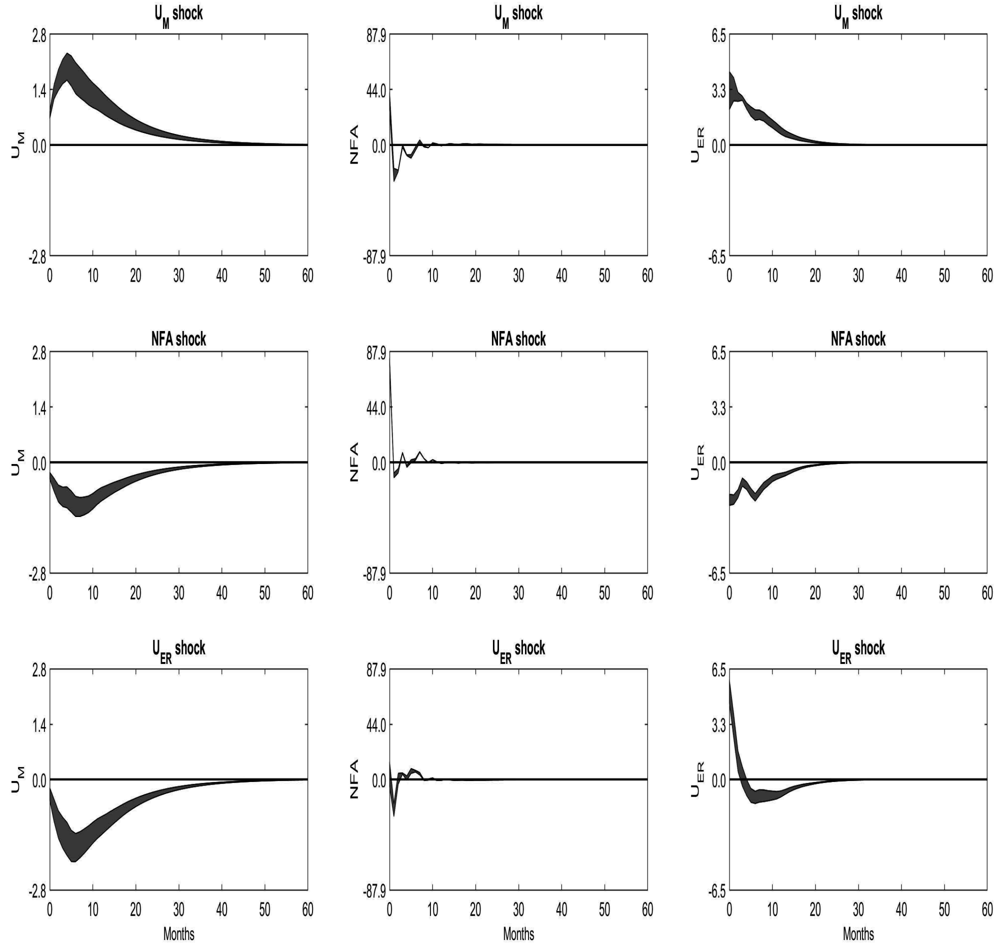
Note: The figure presents the restrictions imposed in $\overline{g_7}$ and $\overline{g_8}$ on outflows and inflows. They correspond to contractions of gross capital flows between the Lehman bankruptcy and the recession's end, as dated by the NBER's Business Cycle Dating Committee. *Sources:* Author's calculations and TIC data.

first months, reducing inflows and outflows (second column of both graphs). The outflow response to macroeconomic shocks exhibits a negative effect that lasts approximately a year, while the effect is pervasive in exchange rate uncertainty, lasting around two years. Then, the deterioration of the macroeconomic conditions in the US economy, which comes with an increase in the fluctuations of the exchange rates, deteriorates the demand for foreign assets that contract for the first year.

Nevertheless, the effect lasts less time than the normalization of the exchange rate uncertainty, suggesting that investors tolerate certain uncertainty levels. For the exchange rate, the shocks suggest a different scenario. As the previous general model for the NFA, exchange rate shocks have a negative effect on the uncertainty level and a negative effect on the outflows that later become positive. Then, the exchange rate, contrary to the macroeconomics, has an initial negative effect. Once perceived, it recovers later, suggesting investors reduce their position and readjust after the shock. We expect this to happen as exchange rates capture international shocks, which increase the demand for foreign assets because some of the shocks come in the form of increases in the dollar value that will decrease the cost of investments.

The shocks to the inflows in Figure 2.10 show a similar history to the one in the outflows. The effect of macroeconomic Uncertainty on exchange rate uncertainty and inflows have similar forms and signs. However, the reaction of inflows to both uncertainties differ in magnitude and the identified set. The shocks present an evident negative effect in Inflows compared to outflows, which may be the driving force of the positive effect obtained in the results of the general model in Figure 2.7. This is also the case for exchange rate, where shocks create an adverse effect, but it is more minor for outflows than inflows, which justifies

Figure 2.9. Identified Set Impulse Response Functions full model for Outflows



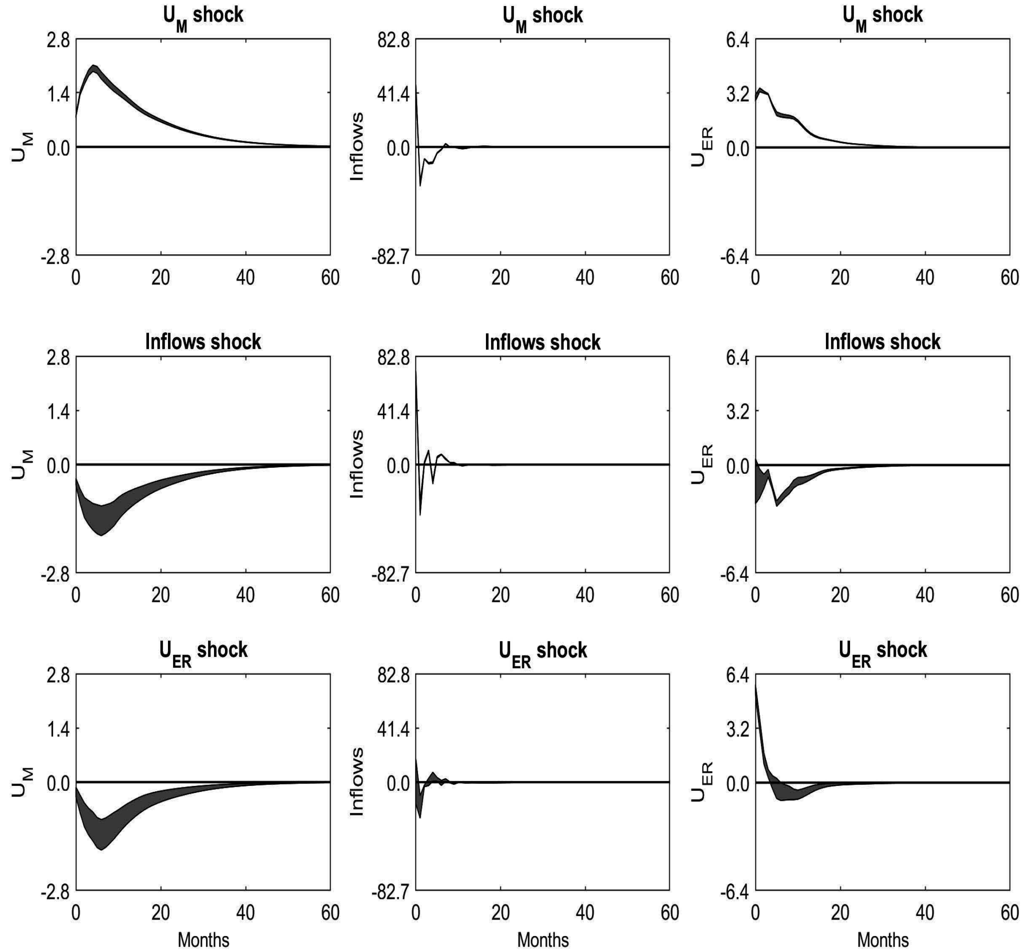
Note: The Figure presents the IRFs of the estimated model using the reduce-form model $\overline{g}_z = 0$, with sign restrictions on external variables $\overline{g}_c \geq 0$, and with both general and narrative sign restrictions $\overline{g}_c$ and $\overline{g}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. Sources: Author's calculations.

the increase in the NFA position increase. These increases imply that uncertainty shocks in the context of the analyzed period reduce the gap in the position of the US, being the macroeconomic the most relevant in closing the difference.

2.4.3 Components of the gross portfolio Inflows and Outflows

Suppose we decompose the inflows and outflows' highest components, the demand for stocks and bonds by foreigners. In that case, we can determine the sources of the fluctuations of inflows and outflows in greater detail. High risk will have implications on demand for risky assets like corporate stocks. However, it will be higher for macroeconomic Uncertainty than

Figure 2.10. Identified Set of Impulse Response Functions full model for Inflows



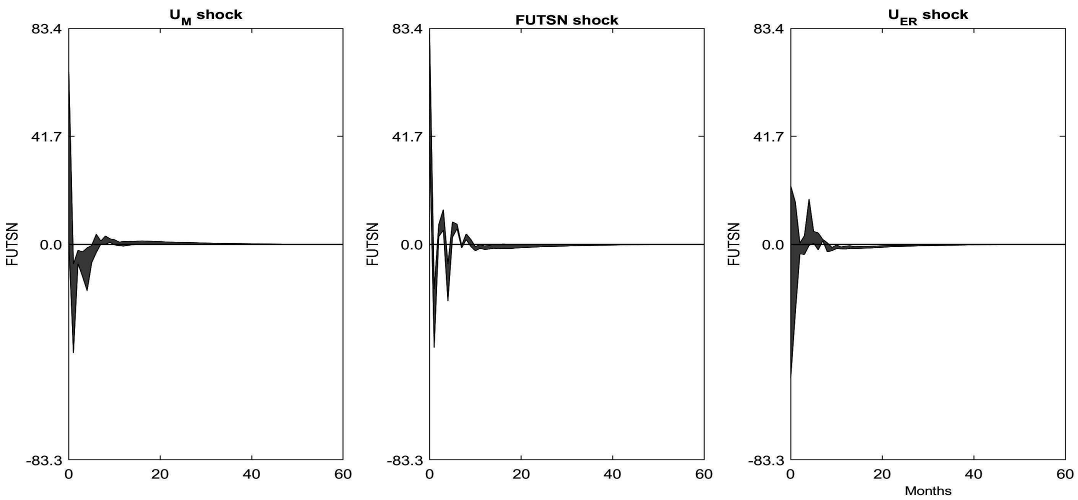
Note: The Figure presents the IRFs of the estimated model using the reduce-form model $\overline{g}_z = 0$, with sign restrictions on external variables $\overline{g}_c \geq 0$, and with both general and narrative sign restrictions $\overline{g}_c$ and $\overline{g}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. *Sources:* Author's calculations.

the exchange rate, as exchange rate volatility can be hedged, and valuations may outweigh the loss in value in the USD. Then, the increase in macroeconomic Uncertainty will reflect negative changes in the demand for risky assets from foreigners. In contrast, the exchange rate will have a rather short-lived effect. I will focus on the gross portfolio inflows and outflows with higher value components and the determinants of their fluctuations: Treasury Bonds and Corporate Stocks. I build on the previous model and restrictions imposed on the Outflows and Inflows to change their flow restriction to match;

$$\text{Event j} \quad (\overline{g_j}) : \sum \varepsilon_{j,8-9} \leq 0, \qquad \text{from September 2008 to June 2009}$$

The events will match the four components (j) of the inflows and outflows I analyzed: the Foreign Demand for US Treasury Bills and Notes, Foreign Demand for Corporate Stocks, US Demand for Foreign Bonds, and US Demand for Foreign Corporate Stocks. The analysis of these components allows us to assess the changes of the exorbitant privilege and the duty, in the sense of Gourinchas and Rey (2007, 2014, 2022), as the demand of US and foreign assets will determine the changes in the privileges that they have. In Figures 2.11 and 2.12, I present the IRFs of the inflows and outflows of bonds, represented by the FUTSN and the UFB.

Figure 2.11. IRFs for the Foreign Demand of US Treasury Bills and Notes (FUTSN)

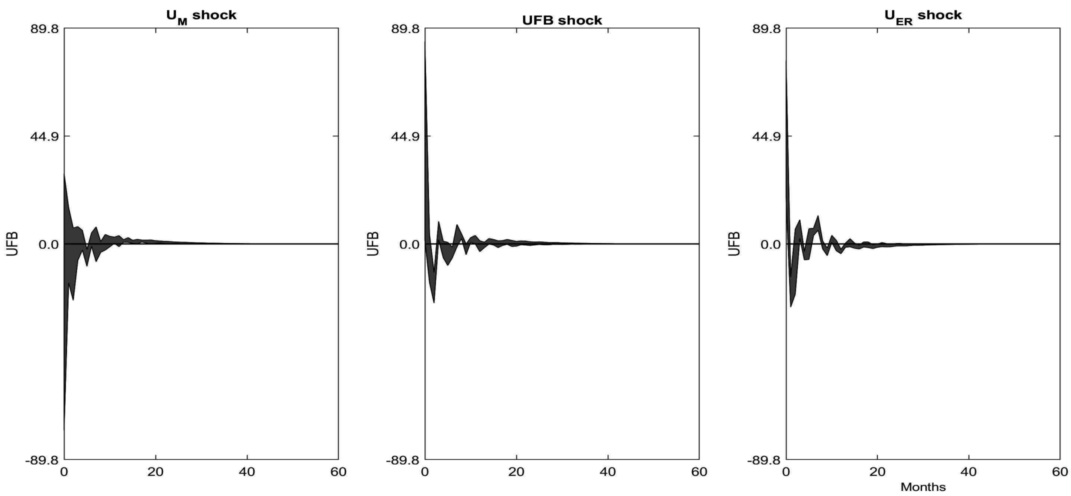


Note: The Figure presents the IRFs of the estimated model using the reduce-form model $g_z = 0$, with sign restrictions on external variables $g_c \geq 0$, and with both general and narrative sign restrictions g_c and $\overline{g}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the same source. *Sources:* Author's calculations.

We can see that the effect is not equal between the inflows and outflows of bonds, where an increase in macroeconomic uncertainty decreases the demand for Bonds from foreigners. At the same time, I find no evidence that it changes the demand for foreign bonds in the US market. This result is consistent with the fact that it will affect the perception of the economy's risk, that even though it is the provider of safe assets, it will still reduce the demand for their assets. This effect may be due to valuation effects, such as high Uncertainty, which can lead to interest rate increases to control fluctuations. Increases in interest rates lower the value of bonds and the value of the foreign position more than the volume demanded.

Conversely, we could expect a lack of connection between bond outflows and uncertainty, as the effect is mitigated by domestic investors rebalancing their portfolios to diversify sovereign risk with other foreign safe assets. As a significant percentage of the portfolio capital inflows and outflows are in bonds, the movements of the NFA will come due to changes in the inflows rather than increases in outflows. In contrast, exchange rate uncertainty has the opposite effect. Increases in exchange rate uncertainty do not affect foreigners' demand for treasury bills and notes. As the biggest provider of safe assets, they demand to provide insurance against extreme events, regardless of exchange rates. For the demand for foreign bonds, the result is the contrary, as the exchange rate uncertainty dampens the outflows initially, followed by an increase in posterior periods. Higher volatility in the exchange rate lowers the value of foreign returns of the coupons and returns of the bonds and is linked to high deviations of interest rate parity (Kalemli-Özcan and Varela, 2021; Fernandez-Mejia, 2022).

Figure 2.12. IRFs for the US Demand of Foreign Bonds (UFB)

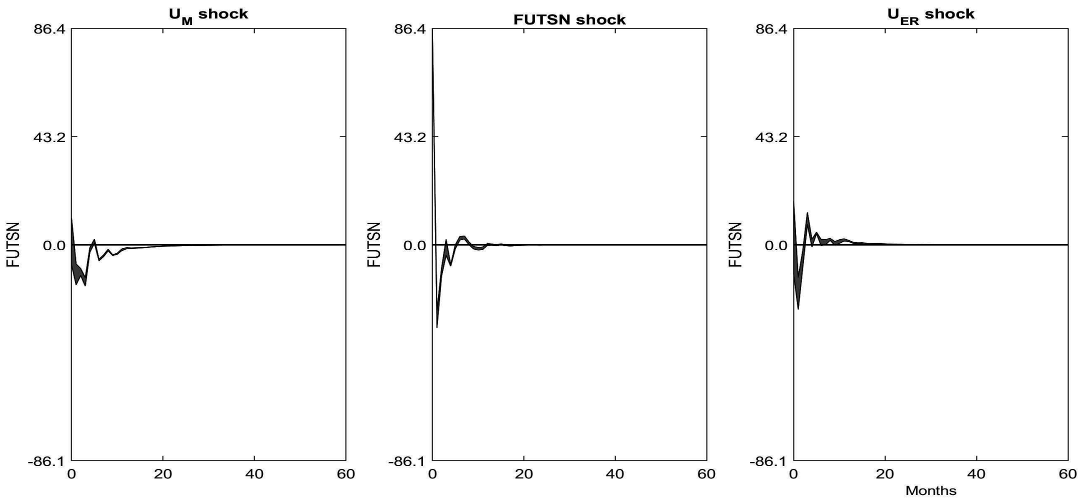


Note: The Figure presents the IRFs of the estimated model using the reduce-form model $g_z = 0$, with sign restrictions on external variables $g_c \geq 0$, and with both general and narrative sign restrictions g_c and $\overline{g}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. *Sources:* Author's calculations.

Let us consider corporate stocks in comparison to bonds. The demand has a symmetrical result between inflows and outflows but with a higher effect on outflows than on inflows. Macroeconomic uncertainty shocks have an initial decrease in the demand for foreign stocks, which is coherent with the effect of foreign investors taking a "wait-and-see" approach and deferring their investment decisions, as noted in Baker et al. (2016). The effect of the domestic market is more profound and more persistent in comparison. For the exchange rate uncertainty shocks, there is also an initial decrease in the gross flows accompanied by an increase in the amount for several periods. In general, for both types of uncertainties, the effect is somewhat similar.

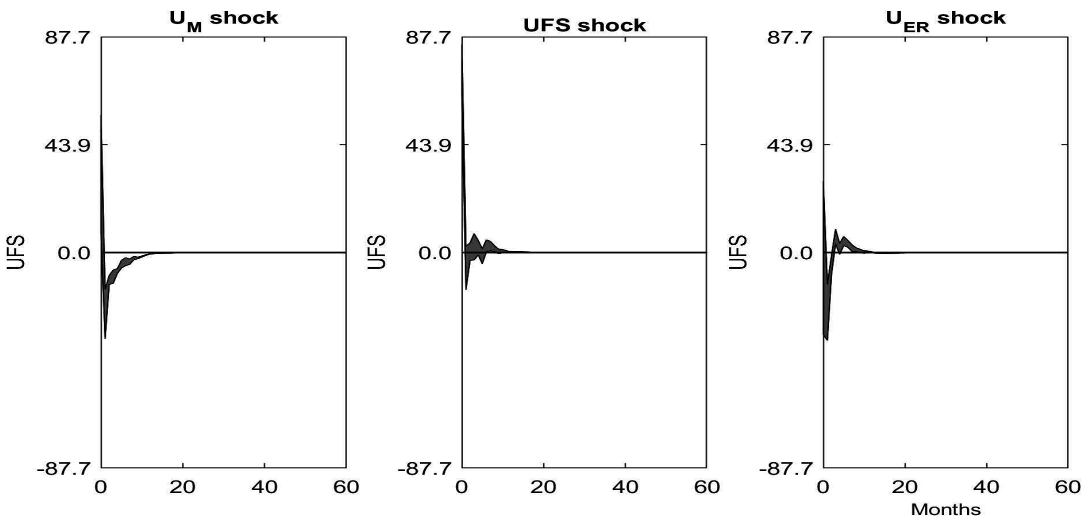
Based on the previous results, we can see that the components of the gross portfolio

Figure 2.13. IRFs for the Foreign Demand of Corporate Stocks



Note: The Figure presents the IRFs of the estimated model using the reduce-form model $g_z = 0$, with sign restrictions on external variables $g_c \geq 0$, and with both general and narrative sign restrictions g_c and $\overline{g}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. *Sources:* Author's calculations.

Figure 2.14. IRFs for the US Demand of Foreign Corporate Stocks



Note: The Figure presents the IRFs of the estimated model using the reduce-form model $\overline{g}_z = 0$, with sign restrictions on external variables $\overline{g}_c \geq 0$, and with both general and narrative sign restrictions $\overline{g}_c$ and $\overline{g}$. Based on the number of restrictions, only the last model has the least number of restrictions to identify shocks. The columns are the source of the shock, and the rows are the variables that receive the shock. Then, in the same row, all variables receive the shock of the same source. *Sources:* Author's calculations.

capital inflows and outflows have a heterogeneous and asymmetrical response to both the macroeconomic and exchange rate uncertainty. The effect of the inflows shocks is more significant than those of the outflows, which creates the result obtained in Figure 2.7. Shocks exhibit a positive effect on NFA position, so the transfer effect is similar to that found by Gourinchas and Rey (2022) after the crisis. Exchange rate uncertainty effects tend to be higher than macroeconomics, but they also tend to be less persistent. The lack of persistence is coherent with the shock absorption effect of exchange rates. If we compare both uncertainties in Figure 2.2, we can see those macroeconomic shocks tend to be less frequent but last longer. Consistent with the investment reduction, we can think that the privilege is reduced once the uncertainty shocks come, as foreign economies reduce the demand for bonds and stocks. The US also reduces its NFA position in the presence of Uncertainty, but this effect is lesser if there is only an exchange rate shock. If both occur, we can expect the shock to be more significant and the NFA to change considerably, which aligns with the exorbitant duty narrative. The loss of the position increases the value of the foreign debt position and can be seen as a transference of liquidity to the foreign markets.

2.5 Conclusions

I analyzed the exchange rate and macroeconomic uncertainty effect on the US's Net Foreign Asset position. I apply a VAR with different types of restrictions: sign, narrative, and external instruments, and estimate the model with each. Using different sets of restrictions helps me identify the shock of uncertainties by imposing big narrative shocks based on high-uncertainty episodes. This methodology allows me to determine the effect of macroeconomic and exchange rate uncertainty by differentiating both effects and the difference between both types of shocks. Because of the In this paper, the role of the US in the global economy, taking macroeconomic and exchange rate uncertainty as independent variables, may not be theoretical and empirically accurate. Using the methodology, I model both and show that their effect and interaction differ, as macroeconomic Uncertainty increases the exchange rate while we have the contrary effect if we consider the inverse relationship.

First, I show that the effect of macroeconomic Uncertainty on NFA differs from that of the exchange rate in the presence of high Uncertainty. The privilege characteristic of the US consistently deteriorates, especially if the source of the fluctuations is macroeconomic. The NFA shocks do not significantly affect either type of Uncertainty. The relationship between the uncertainties is different, as the macroeconomic shocks increase the Exchange rate, while the last has the contrary effect. This result supports the use of the methodology to determine the impacts of different types of uncertainties on the variables of interest. The macroeconomic uncertainty effect in the NFA may be explained through different channels such as the demand for foreign assets (outflows) through risk aversion and the higher demand for safe assets in market turmoil. Its role in the financial markets can explain its effect on Exchange Rate. Higher Uncertainty reduces capital flows and decreases the demand for foreign assets, generating volatility in the world markets and increasing risk.

If we desegregate the NFA by inflows and outflows, we can see that the model allows us to show that the effect of both components is more evident than the net model. The effect in outflows of uncertainties is smaller than that of inflows, which explains the contraction of the NFA.

In Capital flows in Bonds and Stocks, which constitute the most significant components of outflows and inflows, we can see that macroeconomic and exchange rates have different response patterns. Macroeconomic shocks change the foreign demand for safe assets, while the exchange rate does not. This effect is contrary to the demand for bonds from foreign investors, where the Exchange rate shocks (associated with depreciation) reduce the demand for Bonds. The effect is symmetrical for stocks, where, in both cases, it is reduced. This results in the context of the Privilege and the Duty, which means that under macroeconomic and exchange rate uncertainty shocks, we will see that the Privilege of the US decreases. In contrast, the duty has a contrary effect, as foreigners maintain the demand for safe assets. This implies that the US receives benefits while assuming higher costs in its debt.

The results may help parametrize the models of uncertainty shocks in the capital flows and the variation of the NFA. Further models could provide a formalization of the model that incorporates the effect of variations of exchange rate variations on capital flows and differentiates concerning domestic macroeconomic shocks. Based on the results, the macro-prudential models in the literature should target uncertainty reduction in both components through the lens of conventional and unconventional monetary tools.

An explicit limitation of the model is that as the data is aggregated in terms of flows, they do not separate the effects of valuations and lending, as in Gourinchas and Rey (2007, 2014) and Atkeson et al. (2022). Although the analysis in an endogenous model allows us to see the dynamic response and uncover the persistence of shocks, a model for the heterogeneous response of a different type of investors, in the light of the Camanho et al. (2022), may further explain the channel of exchange rate fluctuations and shocks on portfolio rebalancing. Additionally, the methodology, as it is based on set rather than on point identification, does not allow us to explicitly pinpoint the effect of uncertainty. This reflects that with wide intervals, we are not going to be able to explicitly explain the possible outcomes of the model.

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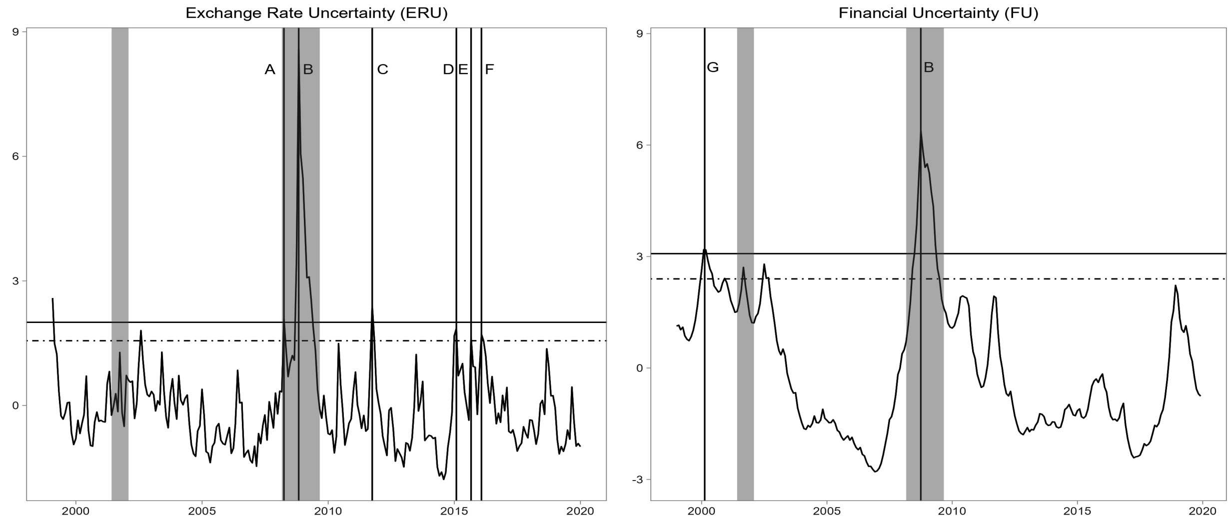
Appendix A: Uncertainty Comparisons

In Figure A1, I show the calculated for the ERU and the Financial Uncertainty of Ludvigson et al. (2021). Without looking at the events, it is clear that the behavior of both variables is different. The episodes of financial Uncertainty are given by: F is the dot-com crisis in 2000; G is the 9/11 terrorist attacks; H is the second market correction posterior to the crisis; I is the Lehman Default. None of the first three events is significant in the ERU.

Appendix Figure A1. Exchange Rate and Financial Uncertainty

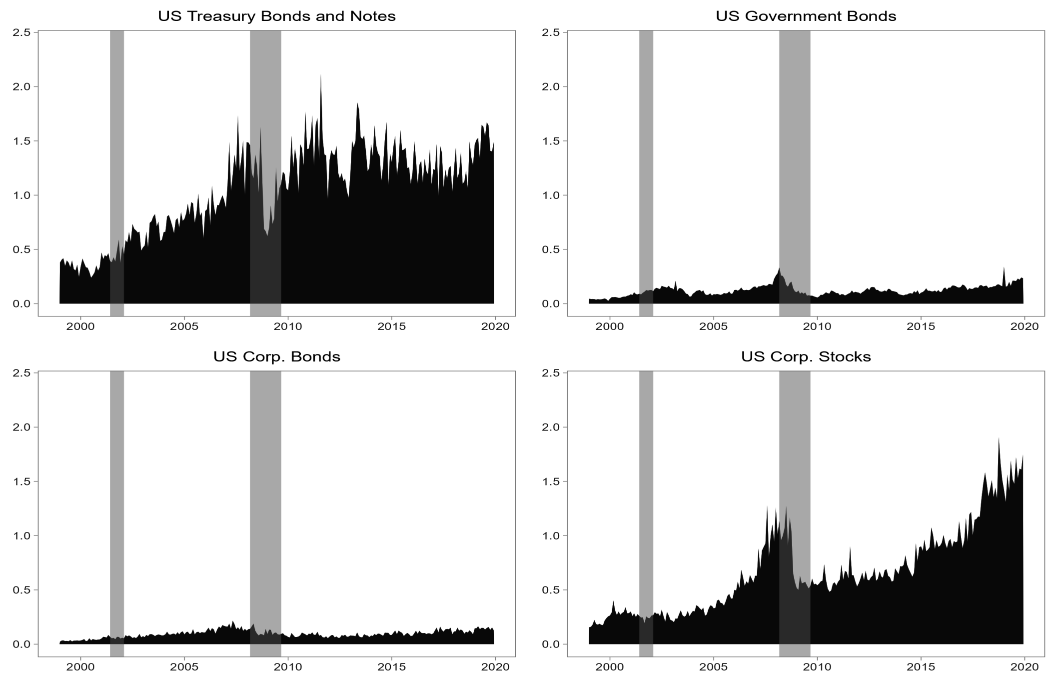


Note: The graph presents the ERU and Financial Uncertainty with the mean of the series standardized to zero. The horizontal line corresponds to the 1.65 standard deviations above the mean, defining each series's important episodes. The vertical line is the peak period of each period identified and used as the event constraint. *Sources:* Ludvigson et al. (2021), **?**, and Author own calculations.

Appendix B: Net Foreign Asset Position Composition

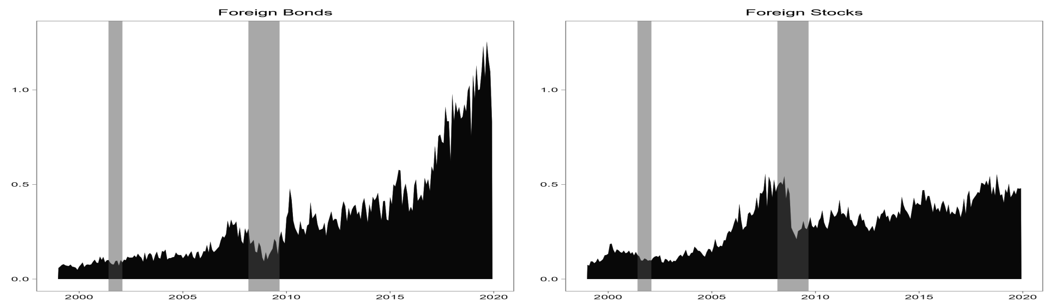
In Figures B1 and B2, I present the components of the Net Foreign Asset Position of the United States that define the gross portfolio capital inflows and outflows. The inflows are the purchases of US Treasury Bonds and Notes, US Government Bonds, US corporate bonds, and US corporate stocks. At the same time, the Outflows consist of the demand for Foreign Bonds and Foreign stocks. By looking at the magnitudes, we can conclude that foreigners' higher demand for US assets is related to the Treasury Bonds and Stocks, consistent with the literature on NFA and the Exorbitant Privilege. In comparison, the outflows go consistently to foreign bonds, which we can presume are for diversification motives and because of their high yields.

Appendix Figure B1. Gross Outflows of Portfolio Capital Flows



Sources: TIC

Appendix Figure B2. Gross Outflows of Portfolio Capital Flows



Sources: TIC

Appendix C:Descriptive Statistics

Table C1 presents the descriptive statistics of the raw data gathered to estimate the model of Equation 2.1. The whole data set includes the Uncertainty of interest, the price of gold, and the Oil Supply news shocks. The other variables correspond to the components of the portfolio inflows and outflows of the series. One part of the components is the gross purchases of the Foreigners of US Treasury Bills and Notes (FUSTN), Government Bonds (FUSB), Corporate Bonds (FUSCB), Corporate Stocks (FUSS), Foreign Bonds (FFB), and Foreign Stocks (FFS) which are the Inflows. The other part is the gross sales of foreigners to the US residents of US Treasury Bills and Notes (UUSTN), Government Bonds (UUSB), Corporate Bonds (UUSCB), Corporate Stocks (UUSS), Foreign Bonds (UFB), and Foreign Stocks (UFS) which are the Outflows. Finally, the Net Foreign Assets are defined as:

$$NFA = (UFS + UFB) - (FUSTN + FUSB + FUSCB + FUSS + FFB)$$

We can see that based on the Augmented Dickey-Fuller, the last column in the Table C1, the variables of interest U_M, U_{ER}, and Oil Supply do not need to be transformed as we find no evidence of the presence of unit root in the series. This is not the case with the Gold price, to which I calculate the logarithmic Returns.

Table C2 presents the Lag selection of the VAR model such that the optimal number of lags of the VAR model minimizes the majority of the criteria. We can see that according to each, the best model for the estimation is that it uses two lags. Nevertheless, it still presents some level of serial correlation in the errors. Then, I use the more parsimonious model with no evidence of serial correlation, the one with six lags.

Appendix Table C1. Descriptive Statistics

Variable	Min	Q1	Median	Mean	Q3	Max	St.Dev.	Range	ADF
Unc. Macro	0.55	0.61	0.64	0.66	0.69	1.08	0.09	0.08	-3.36
Unc. ER	0.35	0.46	0.51	0.53	0.57	1.39	0.12	0.12	-5.17
gold.inf	373.11	543.50	1138.01	1036.49	1362.01	2080.20	472.07	818.50	-1.14
oil.shocks	-2.45	-0.37	0.01	0.02	0.44	1.59	0.65	0.82	-10.92
FUSTN	0.25	0.72	1.17	1.04	1.35	1.91	0.40	0.63	-1.90
FUSB	0.03	0.09	0.12	0.12	0.15	0.34	0.05	0.06	-2.53
FUSCB	0.02	0.07	0.09	0.10	0.12	0.20	0.03	0.04	-2.45
FUSS	0.16	0.32	0.60	0.68	0.92	1.81	0.39	0.59	-0.35
FFB	0.06	0.12	0.24	0.33	0.40	1.22	0.28	0.28	1.02
FFS	0.08	0.15	0.31	0.29	0.39	0.56	0.13	0.24	-1.32
UUSTN	0.25	0.70	1.15	1.03	1.34	1.90	0.40	0.64	-1.89
UUSB	0.02	0.08	0.10	0.11	0.13	0.32	0.05	0.05	-2.58
UUSCB	0.01	0.07	0.08	0.08	0.10	0.18	0.03	0.04	-1.71
UUSS	0.16	0.32	0.59	0.68	0.92	1.83	0.40	0.60	-0.43
UFB	0.06	0.12	0.26	0.33	0.39	1.21	0.27	0.27	0.68
UFS	0.07	0.15	0.32	0.30	0.39	0.58	0.13	0.24	-1.46
FI	0.58	1.26	2.05	1.94	2.50	3.86	0.79	1.23	-0.99
USO	0.14	0.26	0.61	0.62	0.78	1.69	0.38	0.52	0.41
NDA	-2.37	-1.63	-1.41	-1.32	-0.98	-0.41	0.47	0.65	-2.15

Notes: The table presents different statistics for each of the 19 variables used in constructing the model. Min is the minimum, Q1 is the first quartile, Q3 is the third quartile, Max is the Maximum, St. Dev. is the Standard deviation of the series, Range is the Interquartile difference between Q3 and Q1, and ADF is the test statistic of the Augmented Dickey-Fuller test with drift. For the ADF test, the null hypothesis is that the series has a unit root. There are 249 data points, so the ADF test's critical value is -2.87.

Appendix Table C2. Lag Selection of the VAR Model

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
AIC	-6.69	-7.62	-7.62	-7.62	-7.58	-7.55	-7.50	-7.49	-7.43	-7.40	-7.37	-7.33	-7.27	-7.24
HQ	-6.62	-7.50	-7.45	-7.39	-7.30	-7.21	-7.11	-7.05	-6.94	-6.85	-6.77	-6.68	-6.56	-6.48
SC	-6.51	-7.32	-7.18	-7.05	-6.88	-6.72	-6.54	-6.39	-6.20	-6.04	-5.87	-5.71	-5.51	-5.36
FPE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

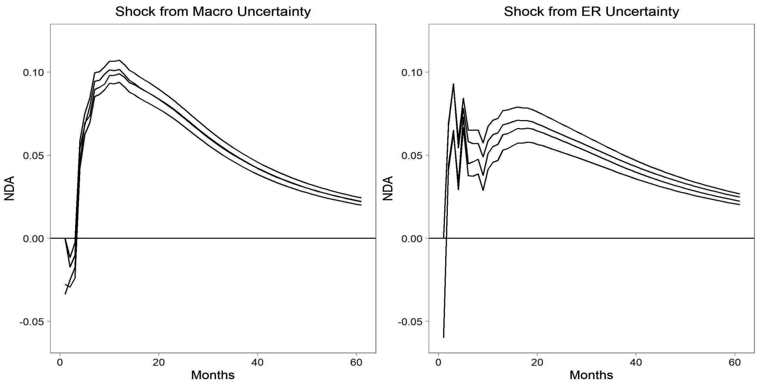
Notes: The table presents the different information criteria for selecting the number of lags for the VAR model. The optimal lag model should be such that it minimizes each.

Appendix C: Multiple Specifications of VAR

I estimate different combinations of the VAR model using the recursive identification by Cholesky decomposition to contrast the robustness of the model. The identification requires imposing contemporaneous relationships between variables and response delays between others. As there is no framework to define a strict order in which to accommodate the endogenous variables, I will estimate all the possible permutations of the vector of variables $X_t = [U_{M,t}, NFA_t, U_{ER,t}]'$. This implies estimating 2^3 VAR models and obtaining their respective IRFs. In Figure D1, I present the result of estimating two a shock of each Uncertainty shock on the Net Foreign Asset Position.

The result of the VAR shows consistency in the relationship indifferent to the ordering of the variables. The change in the different models reflects an order of magnitude rather than an effect change. The main difference with the results of Figure 2.7 is the initial effect of the shock in the NFA. In the VAR, the initial effect is a modest, non-significant decrease with a

Appendix Figure D1. Recursive VAR



Note: The Figure presents the orthogonal IRFs from the Macroeconomic and Exchange Rate Uncertainty shocks in the NFA under different models. Each line represents the mean IRF of one of the six models constructed from the permutation of the three variables that determine the recursive ordering identification. The calculated IRF error bands (not shown) are derived by bootstrapping with a thousand runs. *Sources:* Author's Calculations

later significant increase in the position's value. Due to the imposed narrative restrictions, I identify a substantial shock from macroeconomic and exchange rate uncertainty, the highest and most persistent for the first. As we see episodes like the financial crisis of 2008, we can compare the behavior of the uncertainties and NFA in Figures 2.2 and 2.4, where we can see that the increase in Uncertainty is related to episodes of lower positions. The difference highlights the advantage of the identification scheme used over the short and long-run identification restrictions in the VAR model.

Chapter 3

Extremely Stablecoins

Abstract

In this paper, I examine the response of stablecoin prices to various factors, including market-specific and general cryptocurrency returns and their collateral. To capture extreme price variations, I utilize quantile regression to approximate the tails of the return distribution. I construct different factors and demonstrate that general liquidity, return indices for both markets, intermediary constraints, and the crash of Terra USD significantly influence the prices of stablecoins. The impact on each stablecoin varies, with the magnitude and direction depending on the specific tail of the distribution being analyzed. Additionally, I measure the directional predictability of the covariate and find that the high returns of stablecoin and cryptocurrency markets can predict extreme events in both tails. At the same time, illiquidity forecasts a contraction in prices.

3.1 Introduction

Cryptocurrencies were initially conceived as a financial innovation aimed at facilitating transactions free from the constraints imposed by traditional financial intermediaries and national capital controls. However, their inherent excessive volatility and speculative nature led to the development of an innovative solution, stablecoins. These digital currencies are pegged to the value of the US Dollar (USD) or other assets, designed to mitigate the volatility concerns in traditional coins. The parity is ensured through a combination of centralized and decentralized (DeFi) stability mechanisms, relying on collateralization with USD, the incorporation of liquid fixed exchange assets, and the implementation of algorithms dedicated to preserving the peg (Arner, Auer, and Frost, 2020; Catalini, de Gortari, and Shah, 2022). However, as Eichengreen (2019) warns, stablecoins are yet to deliver on their promise of stability. They reference the historical challenges faced by Central Banks in maintaining pegged currencies in the early 90s and the currency crisis, emphasizing the complexities even well-organized institutions face in achieving stability. Hence, it becomes imperative to analyze the origins of peg deviations to design an optimal stablecoin and devise effective regulatory measures, considering their widespread use as a medium of exchange.

In this paper, I analyze the determinants of the extreme parity deviations from the stablecoins pegged to the USD through the lens of asset pricing and time series models. The main contribution of this research is accounting that as stablecoins are peg cryptocurrencies and financial assets, they exhibit periods of static prices and high volatility. Given their mean reversion resulting from the peg, linear estimation analysis of the determinants will lead to bias and under-identification of the sources of their fluctuations. To address this, I use quantile models to incorporate those stylized facts into the estimation and analyze the upper (95% and 99%) and lower (10%, and 1%) percentiles of the distribution of prices. Then, this paper will have two main sections: the static and the time-series dependence quantile model approach. In the first part, I estimate a linear and quantile model to approximate the sources of fluctuations in the mean and tails of various stablecoins. In the second, I test the directional predictability, in the Granger Sense, within a dynamic model in which the factors exhibit heterogeneous effects in the tails. I apply the measure of Han, Linton, Oka, and Whang (2016) to analyze the impact of each explanatory variable upon the distribution's tails.

These results offer insights into cryptocurrency prices across various segments of their distribution, shedding light on the origins of extreme events. The methodological framework employed aligns with the findings of Baur and Dimpfl (2018) and Yue, Zhang, and Zhang (2021), revealing the asymmetric nature of cryptocurrency responses to shocks. This approach constitutes a departure from previous research, which mainly focused on a limited set of determinants and stablecoins within a linear context. This approach overlooks the distinct stabilization mechanisms inherent in different currencies, crucial for comprehending their fluctuations and responses. To this end, I address this gap by constructing diverse cryptocurrency and market indices, capturing both general and specific market characteristics. The analysis is further enriched by an examination of how financial and macroeconomic factors influence variations in stablecoin prices.

I find that stablecoins respond to changes in the cryptocurrency market but with variations in the magnitude and direction of this response. Furthermore, currencies with higher market capitalization exhibit a robust positive correlation with overall market returns. Conversely, algorithm-backed currencies display a negative correlation of approximately -0.03 with cryptocurrency returns, while more liquid asset-backed stablecoins register a price increase of 0.01. Consequently, it becomes evident that not all stablecoins can be uniformly classified as safe-havens against cryptocurrency market fluctuations, as mentioned in the literature. I find consistent responses to changes in stablecoin market returns across most currencies throughout the distribution, with a pronounced increase in the upper tail compared to the lower tail. Higher price increases are associated with illiquidity, which is not a significant factor in the extremes, coherent with the relationship between exchange rates and liquidity in Banti, Phylaktis, and Sarno (2012), Mancini, Ranaldo, and Wrampelmeyer (2013), Ranaldo and Santucci de Magistris (2019), and Brauneis, Mestel, Riordan, and Theissen (2021). Building on the insights of Adrian, Etula, and Muir (2014), He, Kelly, and Manela (2017), and Baron and Muir (2022), the study reveals that an increase in the leverage level of intermediaries is associated with price variations, particularly in the lower tail. This increase diminishes the value of asset-backed currencies while augmenting the value of algorithm-backed currencies. Furthermore, as extensively detailed in Briola, Vidal-Tomás, Wang, and Aste (2023), I find that the Terra-Luna crash in May 2022, significantly altered the dynamics of various currencies. Following this event, prices exhibited reduced sensitivity, and several cryptocurrencies experienced diminished volatility. This finding underscores the enduring impact of specific market events on the overall behavior of cryptocurrencies, offering valuable insights into their post-event dynamics.

In the second part of the paper, I extend the results in a time series relationship between the determinants in the same conditional quantile framework. The Cross-quantilogram allowed me to establish that Tether, USD Coin, and Dai exhibit negative correlations in the lower quantile ($\tau_1 = 0.1$) when stablecoin prices are high, implying substantial subsequent losses. Conversely, in the higher tail ($\tau_1 = 0.9$), the market demonstrates significant predictive power, suggesting potential positive returns for Tether and USD Coin but forecasting a contraction in Binance. For the Cryptocurrency Market Index (CRYPT), results reveal that high cryptocurrency returns predict significant losses (for $\tau_1 = 0.1$) or gains (for $\tau_1 = 0.9$) in Tether and Frax, while Binance shows a contrary effect. Intermediaries Squared Leverage

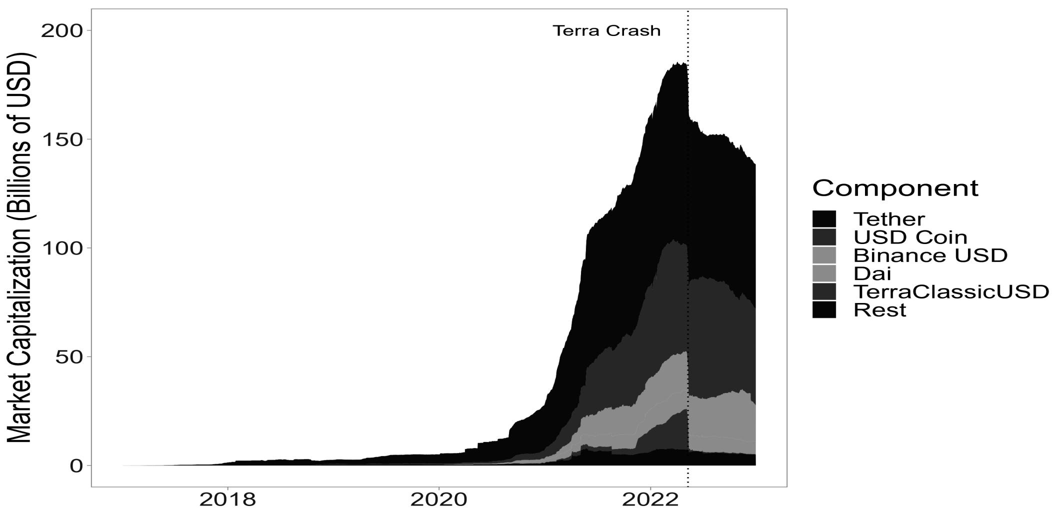
(HKML) impacts stablecoin prices in the higher tail, indicating that high leverage levels and low stablecoin returns predict subsequent price increases, with Frax exhibiting a shorter-term effect. In the lower tail, an increase in both values predicts price reductions for Tether, USD Coin, Binance, and Frax. Additionally, the Stablecoin Illiquidity (ILISTBL) suggests that higher illiquidity levels predict higher stablecoin prices in both tails, with a more pronounced effect in the higher tail. These detailed findings offer a comprehensive into the fundamental time dependence of stablecoin prices, contributing to a deeper understanding of the complex dynamics within the cryptocurrency market.

This research is relevant for policymakers and investors, as it provides insights into the determinants shaping stablecoin prices and the distinct responses arising from various stabilization mechanisms. Despite periodic peg deviations and volatility, we can see from Figure 3.1, that stablecoins have an increasing demand and usage that has raised their market capitalization in time. However, the inherent susceptibility to periodic instability raises considerable systemic risk for the broader market as its popularity grows. Unlike centralized stock and bond markets, the decentralized nature of stablecoins, coupled with their inherent opacity and limited traceability, poses challenges for regulators and policymakers in managing potential shocks. In that sense, comprehending the origins of their fluctuations and developing predictive models becomes imperative. Additionally, they require a substantial amount of collateral to back their price or emissions of new coins that will introduce volatility on their collateral assets, such as bills, bonds, and cryptocurrencies, as well as influencing the demand for USD and USD-denominated assets. Understanding these cryptocurrencies' numerous advantages and drawbacks will allow Central Banks to develop an efficient model for their own Central Bank Digital Currencies, risk hedging for foreign exchange markets transactions, and an efficient portfolio and risk management for investors.

I will center on ten stablecoins with the highest market capitalization and liquidity over the past two years. This selection aims to explain the effects of the most established coins, introduce variations in collateral dependence, and reduce the problems associated with liquidity. Part of the contribution of this paper is the analysis of additional stablecoins with lower capitalization, which gives a complete view of the overall market. Figure 3.1 shows the capitalization distribution in the stablecoin market, which reveals that 80% of the market is concentrated on the top three currencies. Tether has half of the market and is the most traded of them. The Terra collapse reduced much of the market capitalization of the stablecoin market, which, coherent with the results obtained, shifted the market dynamics.

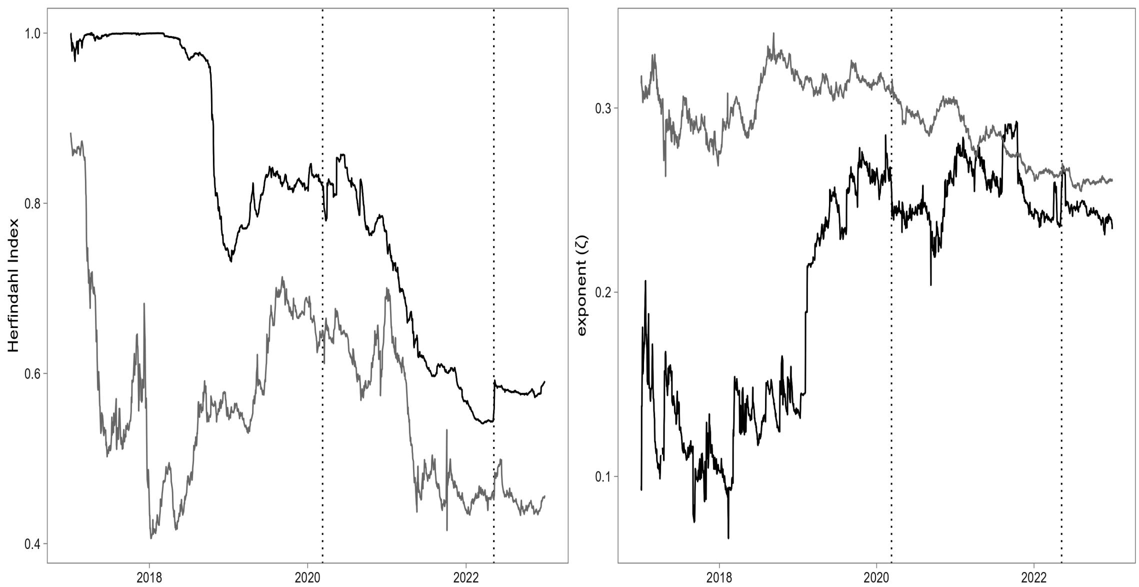
In Figure 3.2, I present two dynamic measures of market concentration: the Herfindahl Index and the coefficient obtained from regressing rank-size against the market concentra-

Figure 3.1. Stablecoin Market Capitalization (Billions of USD)



Sources: The graph plots the stacked market capitalization of the top five main stablecoins in the last two years: Tether (USDT), USD Coin (USDC), Binance (BUSD), Dai (DAI), and Terra (USTC). The vertical dashed line dated the Terra-Luna price crash on May 9, 2022. *Sources:* Coinmarketcap and Author's Calculations

Figure 3.2. Concentration in Stablecoin and Cryptocurrency Markets



Notes: The graph plots measures used to analyze the market concentration level, the traditional Herfindahl index, and the power law coefficient (ζ) of the size and rank regression. These market concentration indices are a common measure of market concentration and granularity in seminal works as Gabaix (2011), Gabaix (2016), and Gabaix and Koijen (2020). I do the cross-section calculation in each period of both measures and plot their time series evolution to see the dynamics of market concentration in the stablecoin market. The vertical dashed line dated the Terra-Luna price crash on May 9, 2022. *Sources:* Coinmarketcap and Author's Calculations tion of stablecoins[1]. Higher values of the Herfindahl Index, approaching unity, indicate a greater concentration in the economy, while the second measure exhibits an inverse relationship. The graphical representation highlights that the entry of new stablecoins into the market and their subsequent growth alter the trajectory of market concentration, impacting the volatility of events. However, prevailing literature predominantly focuses on Tether, neglecting other types of stablecoins. This emphasis on larger implies a trade-off, sacrificing insights into the diverse price patterns, demand motivations, and stability algorithms characterizing smaller stablecoins. This presents opportunities for the design of efficient stability mechanisms and streamlined transactions among users. Moreover, such a focus risks overlooking the impacts of significant events that may not directly involve these major stablecoins but can impact the entire market, as depicted by the Terra crash in May 2020.

Literature Review The evolving developments of digital finance came with a promise of an advanced era in digital payments and decentralized markets. The interest in these assets has increased the research in cryptocurrencies with both theoretical and empirical models to untangle their behavior and propose refinements to their existing structures[2]. From this literature, stablecoins emerge as a potential solution for facilitating digital payments while addressing the challenges posed by the volatility inherent in traditional coins. This has sparked interest in analyzing stablecoins to understand their unique architecture, stability mechanisms, and the broader implications they pose for financial markets. Driven by the need to address gaps in the existing literature, this research aims to examine the dynamics and characteristics of these currencies.

The primary contribution of this paper is to study the different factors shaping the price dynamics of stablecoins, expanding beyond established stablecoins to include structural, market, and collateral-related considerations. I follow the work of Karmakar, Demirer, and Gupta (2021), Ren and Lucey (2022), and Naeem, Gul, Farid, Karim, and Lucey (2023) which explore the relationship between the electricity and clean energy sources on the price of cryptocurrencies. Additionally, I take from Nguyen, Nguyen, Nguyen, Pham, and Nguyen (2022), which investigates the impact of interest rates on stablecoin prices and their higher volatility. Finally, I draw from the microstructure market research on stablecoins by Lyons and Viswanath-Natraj (2023), which uses investor trades to emphasize the stability of Tether and its exposure to events like the Terra crash and Initial Coin Offerings, and include this

[1]The regression of the logarithm of the rank and the size of the economy, is a commonly used measure to determine the grade of concentration of the economy using a power law. We will have the regression such that

$$Rank_i = \alpha MkCap_i^{-\zeta} \tag{3.1}$$

where α is a constant, the $Rank_i$ is the rank of the stablecoin i with respect to the other N and $MkCap$ is the market capitalization of the currency. So, we will have that coefficient ζ, which will be the power law exponent of the distribution. Additional power law information is found in Gabaix (2016)

[2]Corbet, Lucey, Urquhart, and Yarovaya (2019), Bariviera and Merediz-Solà (2021), and Catalini et al. (2022) offer comprehensive reviews of cryptocurrency literature and it's current research trends

effect on the stablecoins regressions.

Much of the literature has focused on the connection of cryptocurrencies with stablecoins, particularly in the relationship between Bitcoin and stablecoins, as a source of fluctuations and diversification for investment. However, empirical findings on this relationship remain inconclusive, with studies such as Griffin and Shams (2020) investigating Tether transactions' impact on Bitcoin prices and others like Wei (2018) and Kristoufek (2021) suggesting that crypto asset price changes drive the demand for stablecoins. Conversely, Grobys, Junttila, Kolari, and Sapkota (2021) study the second moments of both assets, discovering that Bitcoin's volatility has granger-causal effects on stablecoins. Recent findings by Hoang and Baur (2021) and Grobys and Huynh (2022) suggest that utilizing the intra-day price of stablecoins aids in predicting contrary responses in Bitcoin prices. These results align with our findings, indicating that variations in cryptocurrency prices manifest in stablecoins, particularly in the lower tails, where asset-backed stablecoins increase and algorithmic ones decrease.

A line of research in the literature on cryptocurrencies involves the use of quantile regression methods to unpack the intricate relationships between cryptocurrencies and diverse asset classes, particularly focusing on their price distributions' tails. This paper aligns with this methodology, and in particular, with the quantitative coherence analysis conducted by Kołodziejczyk (2023), probing into the potential of stablecoins as diversifiers for Bitcoin. Similarly, Nguyen, Chevapatrakul, and Yao (2020) applies the Lasso Quantile model to examine tail dependencies in cryptocurrency markets. However, these studies primarily emphasize stablecoin properties and time series relationships, leaving a gap in comprehending the determinants driving stablecoin fluctuations. In parallel, researchers like Balcilar, Bouri, Gupta, and Roubaud (2017) and Bouri, Lau, Lucey, and Roubaud (2019) use causality-in-quantiles to uncover the dynamic interplay between Bitcoin and various cryptocurrencies. Baumöhl (2019) reveals a negative relationship between coin returns and foreign exchange currencies using a quantile cross-spectral model. Bouri, Gabauer, Gupta, and Tiwari (2021) and Aharon, Demir, Lau, and Zaremba (2022) explore the link between Twitter sentiment and cryptocurrency returns using diverse quantile methodologies. This paper contributes to the literature by presenting key factors through a cross-quantilogram, shedding light on variations in the tails of price distribution changes. The findings highlight the importance of stablecoin and cryptocurrency markets, intermediary constraints, and stablecoin illiquidity in explaining and predicting the future dynamics of stablecoin price fluctuations.

3.2 Econometric Model

In this study, I employ two distinct methodologies to examine the relationship between stablecoin movements and the determinants of parity value: quantile regression and Cross-Quantilogram. Quantile regression is chosen as an appropriate analytical tool for studying stablecoins, given their pegging to the USD. The model's significance lies in its ability to capture deviations in the tails of price fluctuations. Furthermore, the Cross-Quantilogram model is implemented to conduct an exhaustive analysis of the time-series relationship and directional predictability associated with key variables influencing the price deviations of cryptocurrencies. Through the application of these methodologies, this research aims to offer a comprehensive understanding of the contributing factors to stablecoin deviations within the financial view.

3.2.1 Quantile Regression

In this paper, I use the Quantile Regression Model proposed on Koenker and Bassett (1978) using the Barrodale and Roberts (1974)' simplex algorithmic method to compute the fit, defined in Koenker and D'Orey (1987)[3]. The simplex method provides an efficient estimation method when the data samples are of small to medium sizes. We can define the linear model as

$$y = \beta_0 + \beta X_t + \varepsilon_t \tag{3.2}$$

where X_t is the vector of explanatory variables, and y_t are the dependent variables. Then, we can write the conditional quantile function of y as

$$Q_y(\alpha|X = x) = \beta_{0,\alpha} + \beta_\alpha X + Q_\varepsilon^{-1}(\alpha|X = x) \qquad \alpha \in (0, 1) \tag{3.3}$$

where $Q_y(\alpha|X = x)$ is the conditional quantile of y_t given a value of X for the quantile of interest α, β_α are the conditional coefficients of X, and Q_ε^{-1} is the distribution function of the errors that are supposed to have an expected value of zero. The model's coefficients are estimated by minimizing the deviations (expected loss) on the conditional quantile.

$$\beta_\alpha = \arg\min_\theta E[\rho_\alpha(y - \theta X)] \tag{3.4}$$

where θ are the estimated coefficients in the minimization problem and ρ_α is an assymetric loss function used in Koenker and Bassett (1978) as

$$\rho_\alpha = [\alpha - I_{\varepsilon \leq 0}] \tag{3.5}$$

[3]A detailed description of Quantile Regression models, and other quantile approximations are available in Koenker (2005) and Koenker, Chernozhukov, He, and Peng (2017).

where I_ε is an indicator function that takes the value of 1 if the condition in the brackets (deviations) is such that $\varepsilon \leq 0$, where it will take the value of $\alpha - 1$, conversely, if $\varepsilon > 0$, we will have that it will equal α. Then, the minimization of the errors is done through an asymmetric weighted average of the errors, $y - \theta X$, that are conditioned on the quantile of interest.

From this model, we will have that the interpretation of the coefficients is going to be different from those of the Linear Regression Models. We will have that for a monotone transformation of the dependent variable, given by $g(\cdot)$, and we will have that for

$$\frac{\partial Q_y(\alpha|X = x)}{\partial x_i} = \frac{\partial g^{-1}(x'\beta_\alpha)}{\partial x_i} \tag{3.6}$$

This will imply that the parameter should be interpreted as a partial derivative conditional on the quantile of interest conditional on the transformation of the dependent variable, g^{-1}. The implied condition is that the parameter will remain on the quantile of interest, as the model assumes it comes from the same distribution. We have to take into account that the conditional quantile defines the minimization problem of the quantile regression model.

3.2.2 Cross-Quantilogram

The second part of the paper will use the Cross-Quantilogram model of Han et al. (2016) to determine the directional predictability between the chosen regressors and the stablecoins. Their model is a generalization of the Quantilogram model of Linton and Whang (2007) into a multivariate setting, where we can see the cross-correlation between series in a conditional quantile framework.

For two time series defined as a pair $(x_t, y_t) \in (\{x_{1t}, x_{2t}\}, \{y_{1t}, y_{2t}\})$ which are strictly stationary with time $t = 1, 2, ...T$, we can define the Conditional Distribution Function (CDF) as $F_{y|x}(\cdot|x_{it})$ and density function $f_{y|x}(\cdot|x_{it})$ for a $i = 1, 2$. From these functions, we can define the Conditional Quantile Function as $q_{it}(\tau_i) = \inf\{z : F_{y|x}(z|x_{it}) \geq \tau_i\}$ for a defined percentile value of $\tau_i \in (0, 1)$ for each of the i series. Han et al. (2016) defines the Cross-quantilogram as the serial dependence between two events such that for a pair $\{y_{1t}, y_{2t}\}$ it defined by $\{y_{1t} \leq q_{1t}(\tau_1)$ and $\{y_{2t-p} \leq q_{2t-p}(\tau_2)$ where p is a defined lag and percentiles τ_i. We can define the Cross-Quantilogram as a Cross-Correlation measure with conditional quantiles as:

$$\rho_\tau(p) = \frac{E[I_{\tau_1}(y_{1t} - q_{1t}(\tau_1))I_{\tau_2}(y_{2t-p} - q_{2t-p}(\tau_2))]}{\sqrt{I^2_{\tau_1}(y_{1t} - q_{1t}(\tau_1)}\sqrt{I^2_{\tau_2}(y_{2t-p} - q_{2t-p}(\tau_2))}} \tag{3.7}$$

where I_{τ_i} is an indicator function such that $I(S)_{\tau_i} = 1[S < 0] - \tau_i$ and $p = 0, 1, 2, 3, ..., P$ are the established number of P lags. To calculate the cross-quantilogram, we have to estimate $q_{it}(\tau_i)$ using a linear quantile regression as defined in Equations 3.3 and 3.4. Once estimated, we can then turn to the sample Cross-Quantilogram, which estimates approximately the expectations to the sample averages,

$$\widetilde{\rho_\tau}(p) = \frac{\sum_{t=p+1}^{T} I_{\tau_1}(y_{1t} - q_{1t}(\tau_1)) I_{\tau_2}(y_{2t-p} - q_{2t-p}(\tau_2))}{\sqrt{\sum_{t=p+1}^{T} I_{\tau_1}^2(y_{1t} - q_{1t}(\tau_1)}\sqrt{\sum_{t=p+1}^{T} I_{\tau_2}^2(y_{2t-p} - q_{2t-p}(\tau_2))}} \tag{3.8}$$

The Cross-Quantilogram measures the correlation regarding deviations of the determined quantile between the series. As the lag structure defines the measure, it relates the directional predictability of the quantile in the lag p from the reference explanatory series to the dependent variable. The measure will also provide a magnitude of correlation $\widetilde{\rho_\tau}(p)$ that will be bounded in the set of $\widetilde{\rho_\tau}(p) \in [-1, 1]$, where a value of -1 implies the perfect inverse linear relationship, 1 on the contrary, is a perfect linear relationship. A value of 0 implies no relationship. From these values, we can then determine the directional predictability based on estimating each lag to determine the relationship structure at different times of the series.

3.3 Data

I collected the data on the available Cryptocurrencies and Stablecoins from Coinmarketcap.com, the primary data source used in the literature. This website aggregates information through an Application programming interface (API) from various exchanges such as Binance or Coinbase, providing complete details such as the Open, High, Low, and Close day prices, as well as the daily traded volume and market capitalization for each cryptocurrency. Notably, the cryptocurrency market operates continuously throughout the week and every day of the year, distinguishing it from traditional assets and allowing for increased transaction frequency and varied trading volumes. I gathered data on 1745 cryptocurrencies, compiling daily records spanning from January 2017 to December 2022, resulting in 2191 days of transactional data. As in Liu and Tsyvinski (2021) and Liu, Tsyvinski, and Wu (2022), I excluded currencies lacking data in any variable and possessing a market capitalization below one million dollars. Subsequently, I focused on stablecoins pegged to the dollar, totaling 39 of them. An exception was made for Terra USD, included due to its significance in one of the major stablecoin crashes, as documented in Briola et al. (2023) and Lyons and Viswanath-Natraj (2023). Most of the stablecoins have either been issued recently or have failed and disappeared, then it makes sense to focus on the biggest and with higher liquidity. The analysis of the first part centers on the top ten stablecoins by market capitalization over the past two years, each with more than one year of available data: Tether (USDT), USD Coin (USDC), Binance (BUSD), Dai (DAI), Terra (USTC), Frax (FRAX), TrueUSD (TUSD), Fei USD (FEI), Pax Dollar (USDP), and Liquidity USD

(LUSD). Among these, Tether, USD Coin, Binance, TrueUSD, and Pax Dollar are asset-backed stablecoins, primarily collateralized by USD or assets denominated in that currency. Dai, Frax, Terra, and Liquidity USD employ other cryptocurrencies as underlying assets, rendering them susceptible to cryptocurrency market fluctuations. Notably, Frax, Terra USD, and Fei represent algorithmic stablecoins, with their pegs maintained by algorithms designed to stabilize the coin around parity.

Table 3.1. Descriptive Statistic Stablecoins

ID	Stablecoin	Ticker	Start	Mk. Cap. (Bill. USD)	% Mk. Cap.	Volume (Bill. USD)
825	Tether	USDT	2015-02-25	47.22	50	62.33
3408	USD Coin	USDC	2018-10-08	25.27	26	2.68
4687	Binance USD	BUSD	2019-09-20	9.52	10	4.36
4943	Dai	DAI	2019-11-22	4.37	5	0.31
7129	TerraClassicUSD	USTC	2020-11-24	3.55	4	0.16
6952	Frax	FRAX	2020-12-26	1.06	1	0.02
2563	TrueUSD	TUSD	2018-03-06	0.80	1	0.18
8642	Fei USD	FEI	2021-04-03	0.73	1	0.03
3330	Pax Dollar	USDP	2018-09-27	0.69	1	0.14
9566	Liquity USD	LUSD	2021-05-04	0.56	1	0.01

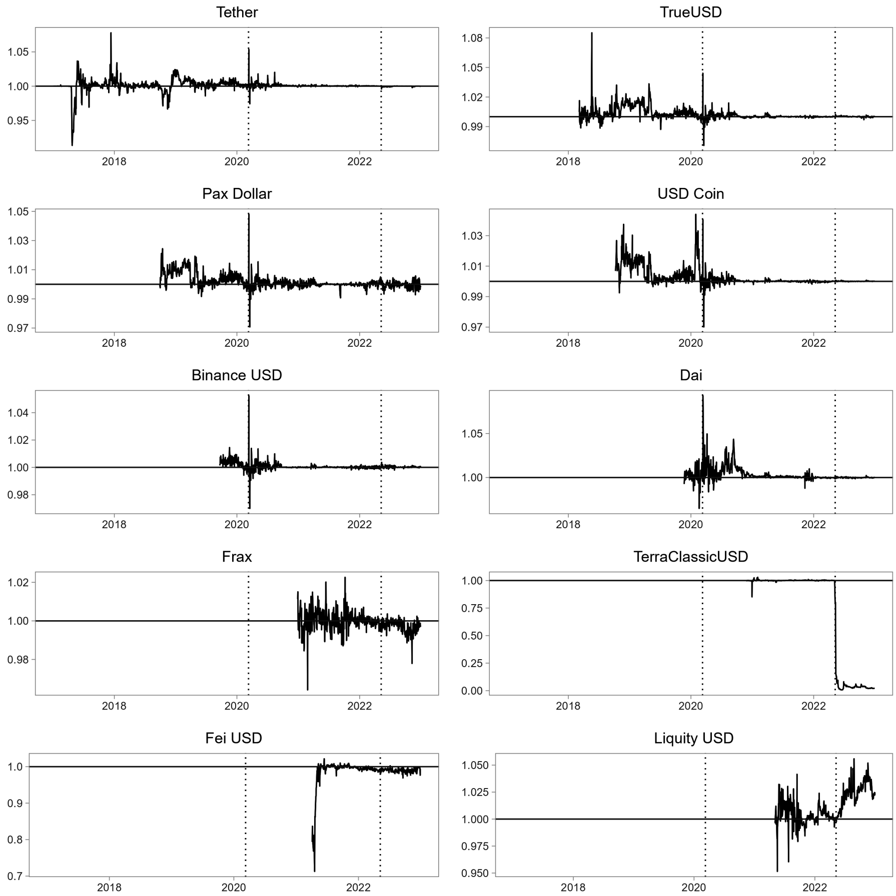
Notes: The table presents the top ten stablecoins regarding Market Capitalization from the particular start day to December of 2022. Market share is the percentage of market capitalization between the referenced stablecoins. The ID corresponds to the Coinmarketcap ID number. The start is the first period that I have the coin emission. The Volume corresponds to the value of the transactions in dollars in the twenty-four hour of the day. The Market Capitalization and the Volume correspond to the averages of the last two years, 2021-2022. *Sources:* Coinmarketcap.com and Author's calculations

In Table 3.1, I present the general information on each main stablecoin analyzed in the different estimated models. Tether is the oldest of the active stablecoins and is also the highest in both market capitalization and volume traded. It has half of the overall market capitalization of stablecoins and the highest liquidity, with the volume of transactions in the entire day that outmatches any other stablecoin by at least fifteen times. The other two highest stablecoins are the USD Coin and Binance USD, with twenty-six and ten percent of the market.

I present in Figure 3.3 the behavior of the prices of the ten different stablecoins. As we can see, the coins have episodes in which the prices deviate but tend to be mean-reverting to the parity (red line). This is consistent with the results of Lyons and Viswanath-Natraj (2023) that document that the liquidity and stability mechanisms of the currencies and the exchanges have eliminated or reduced the duration (half-life) considerably in recent years. Nevertheless, they are not homogeneous, as less liquid currencies still have higher volatility, crashes, or persistent premiums that may give them a more speculative status than one of stability. FRAX, USTC, FREI, and LUSD are in the sample of variables of interest. The case of USTC is the most critical event in the recent events for this type of cryptocurrency. In May 2020, it crashed and lost its market capitalization and value.

The prices show two essential characteristics to consider; the first is that the price may not change and remains in the unity, and also, episodes of persistent deviations that introduce nonstationarity to the data. Hence, we cannot analyze data calculating logarithmic

Figure 3.3. Prices of Different Stablecoins Against the USD



Notes: The graph plots the top ten stablecoins used, organized by their average market capitalization. The stablecoins are Tether (USDT), USD Coin (USDC), Binance (BUSD), Dai (DAI), Terra (USTC), Frax (FRAX), TrueUSD (TUSD), Fei USD (FEI), Pax Dollar (USDP), and Liquidity (USD). Deviations from the peg against the dollar (red line) imply they offer an arbitrage opportunity. The vertical dashed lines correspond to the "Dash for Cash" of March 2020 and the Terra-Luna price crash on May 9, 2022. *Sources:* Coinmarketcap and Author's Calculations

daily returns but rather as deviations, $\Delta P_t = P_t - P_{t-1}$. We can see the central moments of the data points in Table 3.2, where we can see the different characteristics of the series that show just how different stablecoins are. The average stablecoin is negatively skewed, with high kurtosis and negative mean deviations. The cases with other behaviors are the USD Coin, Frax, and Fei, which trade at a premium (positively skewed) and have positive mean deviations. Tether has a higher level of volatility than the others because of its high liquidity; being the oldest active stablecoins and the benchmark in the market, it brings exposure to investor attention.

Nevertheless, when we see the distribution of the returns, it can be reasonably symmetrical. The values on most of the tails are almost the opposite. The highest value loss (lower tail) per day is for the USDC, FRAX, FEI, and LUSD. On the other tail, only one stablecoin has a higher increase than the loss in value, which is the DAI.

Table 3.2. Stablecoin Descriptive Statistics

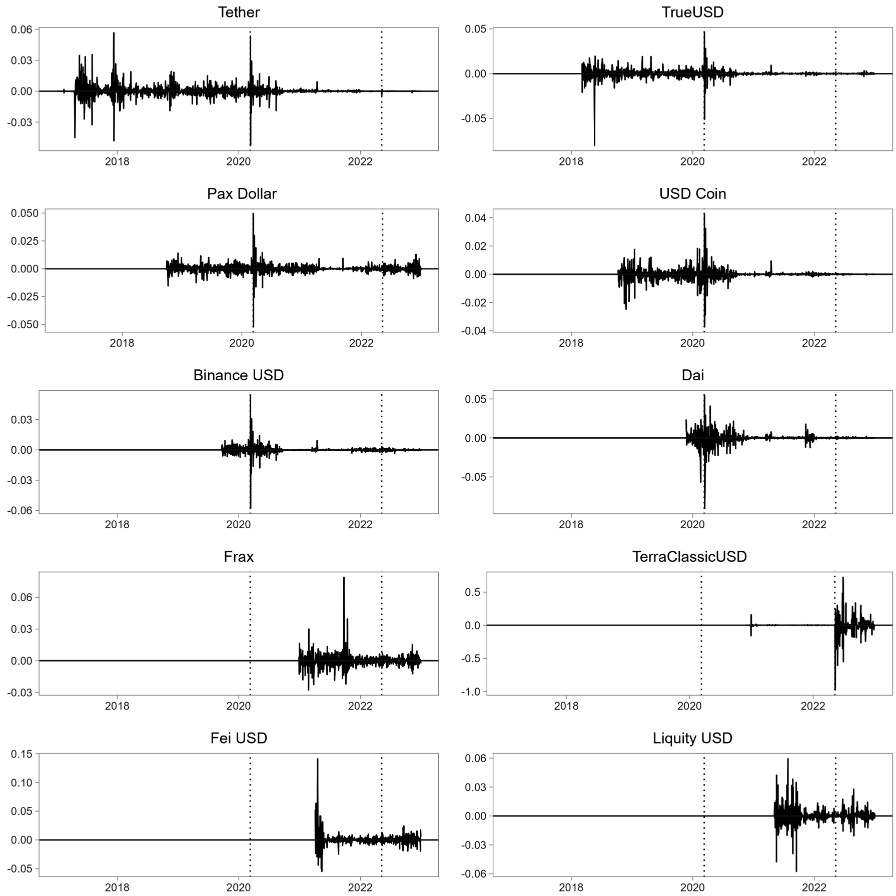
	USDT	TUSD	USDP	USDC	BUSD	DAI	FRAX	USTC	FEI	LUSD
N	2909	1809	1604	1593	1247	1184	783	815	685	654
Mean	-0.01	-0.00	0.00	-0.00	-0.00	0.00	0.00	-0.43	0.02	0.00
Std. Dev.	1.64	0.46	0.39	0.36	0.34	0.71	0.72	9.62	1.21	0.89
Skew	-15.49	-1.12	-0.07	0.54	-0.54	-0.89	0.19	-0.14	1.93	-0.41
Kurtosis	1354.52	92.78	40.78	31.64	118.77	38.64	37.87	35.17	36.90	14.82
Extreme Quantiles and the Median										
5%	-0.50	-0.50	-0.52	-0.49	-0.35	-0.82	-0.98	-11.87	-1.33	-1.23
10%	-0.27	-0.31	-0.37	-0.31	-0.17	-0.37	-0.62	-5.09	-0.81	-0.77
50%	0.00	0.00	0.00	0.00	0.00	-0.00	0.01	-0.02	0.00	-0.01
90%	0.27	0.30	0.37	0.26	0.18	0.37	0.66	1.93	0.82	0.79
95%	0.50	0.51	0.51	0.44	0.35	0.91	0.90	7.63	1.30	1.15
Augmented Dickey-Fuller Statistic										
ADF	-34.06	-30.43	-30.68	-27.81	-28.79	-27.25	-19.68	-16.84	-18.50	-20.30

Note: The table presents the different statistical moments of the ten returns of the stablecoins selected. ADF is the Augmented Dickey-Fuller Statistic for the test with drift, which has null is that the series has a unit root. The critical value of the test is -2.86. *Sources:* Author's Calculations and Coinmarketcap.com

Figure 3.4 presents the graph with the price difference calculated for each of the Stablecoins I will use in the paper. As we can see, the "Dash for Cash" episode in March 2020 was a relevant factor in explaining the early variations of the stablecoins. On average, the returns of most of the ones that traded during the time deviated consistently from the parity, having high volatility. This was primarily followed by stability periods, especially for Tether, USD Coin, True USD, and Binance. The second event, the Terra-Luna crash, occurred during relatively low volatility, so the effect was not as high as the other event. We can see from Figures 3.3 and 3.4 that most currencies did not have higher increases in volatility compared to the previous event. The more affected currencies were the most recent and small stablecoins, Frax, Fei, and Liquidity. The effect, other than to Tether that persisted in the case of Liquidity USD, has remained above par and trading with a premium. From them, we can expect to see that after the period, most exchange rates became more stable than others.

I use different covariates to explain the deviations in the distribution's mean and tails. The first is an index of the market deviations for the stablecoins ($STBL$) and the market returns of the universe of cryptocurrencies ($CRYPT$). I construct both using the value-weighted deviations and returns, where the first weight is on the total market capitalization of the universe of the 39 stablecoins and the second on the 1745 cryptocurrencies. We could expect that the stablecoins and the market will be highly correlated and the cryptocurrencies, to find that there is an inverse relationship. I use an equal-weight return index of the top ten currencies against the U.S. Dollar from developed countries (ER) as in Lustig, Roussanov, and Verdelhan (2011) to capture the effect of the demand for cryptocurrencies

Figure 3.4. Price Difference of Different Stablecoins Against the USD



Notes: The graph plots the price difference between the top ten stablecoins used, organized by their average market capitalization. The stablecoins are Tether (USDT), USD Coin (USDC), Binance (BUSD), Dai (DAI), Terra (USTC), Frax (FRAX), TrueUSD (TUSD), Fei USD (FEI), Pax Dollar (USDP), and Liquidity (USD). Deviations from the peg against the dollar (red line) imply they offer an arbitrage opportunity. The vertical dashed lines correspond to the "Dash for Cash" of March 2020 and the Terra-Luna price crash on May 9, 2022. *Sources:* Coinmarketcap and Author's Calculations

due to variations of different foreign exchange rates. I downloaded the exchange rate time series from Bloomberg. Recently, literature on the effect of intermediaries such as Adrian et al. (2014), He et al. (2017), and Du, Hébert, and Huber (2022) showed the importance of intermediary balance sheets and budget constraints in pricing different assets. As such, I included the variations of the squared leverage of the financial intermediaries ($HKML2$) of He et al. (2017)[4].

Recent literature has linked the behavior of cryptocurrencies and energy consumption and assets, as mining them requires an abundant level of permanent energy consumption and storage of data. Karmakar et al. (2021), Ghabri, Ben Rhouma, Gana, Guesmi, and Benkraiem (2022), and Long, Lucey, Zhang, and Zhang (2023) show that there are feedback and spillover effects between cryptocurrencies and energy prices, as the surge in the last

[4]I downloaded the data from Zhiguo He's personal webpage

introduces costs of coins and interiorized by investors. Conversely, the high demand for bitcoins increases the energy consumption of the grid, which increases the price of energy. As the effect of Cryptocurrencies on energy prices becomes significant, attention to this consumption affects investors' environmental attention, which is reflected in their prices (Das and Dutta, 2020; Wang, Lucey, Vigne, and Yarovaya, 2022). Hence, I use the Cambridge Bitcoin Electricity Consumption Index (CBECI) of the Cambridge Centre for Alternative Finance, which estimates the daily annualized electricity consumption by the Bitcoin network, as a proxy for the energy value consumption on stablecoins[5].

The price deviations may be due to changes in the value of the reserve assets that issuers use as collateral to back the currency's value. If the issuers do not have enough reserves to meet in case of high deviations in the value to guarantee parity, there may be a run on the stablecoin and crash. This was the case of Terra (USTC), which uses the Luna cryptocurrency to back its value. The types of stablecoins are backed against different assets, such as corporate and government bonds, treasury bills, USD dollars, and other cryptocurrencies, and a financial institution or an algorithm regulates the parity. I include the changes in the constant maturity interest rate of both 3-month secondary market treasury bills and 10-year Treasury bonds to account for changes in the value of different maturity safe assets and the difference in the term structure of interest rates[6]. The $CRYPT$ will capture the relationship between the cryptocurrency markets and the changes in the collateral and the ER the changes in the value of the dollar.

Finally, I will include the effect of illiquidity in both Cryptocurrencies and Stablecoins to account for the excess demand premium effects of using stablecoins as a hedge against cryptocurrency market volatility. Following Brauneis et al. (2021), I use the mean of the Corwin and Schultz (2012) and Abdi and Ranaldo (2017) bid-ask spread estimators to capture (lack of) liquidity effect of both stablecoins and cryptocurrencies [7]. From them, I then calculate a value-weighted Stablecoin Iliquidity ($ILISTL$) and Cryptocurrency Iliquidity ($ILICRYPT$) to capture the effects of both types of assets on stablecoin deviations.

Although the explanatory variables have daily information, their market does not work on the weekends. If we filter the days with enough data in all the variables, the sample reduces from 2909 data points for Tether to 1434[8].

[5]The Cambridge Bitcoin Electricity Consumption Index (CBECI) provides data on the estimated annualized consumption (Terawatt/hour) and daily power demand (Gigawatt), as well as the theoretical upper and lower bound energy consumption. More information is found on their web page: https://ccaf.io/cbnsi/cbeci

[6]I downloaded the data from the Federal Reserve Webpage. Table H.15 contains the daily interest rates of different U.S. government and Federal Reserve bonds and bills. The link to the data is: https://www.federalreserve.gov/releases/h15/default.htm

[7]In Appendix 3.5 I show how to calculate both bid-ask spread estimators on more significant detail.

[8]In 3.5 I present detailed descriptive statistics of the exogenous variables used on the model, sources, and detailed construction of the variables.

3.4 Results

Stablecoins, despite being classified as cryptocurrencies, exhibit distinct characteristics and drivers that set them apart from other assets. These coins are backed by collateral, either guaranteed by an institution or governed by an algorithm, with the sole purpose of maintaining a peg against the underlying asset, typically the USD. Functioning similarly to a small economy with a fixed exchange rate, stablecoins are susceptible to similar challenges, including the need for substantial liquid collateral reserves and vulnerability to speculative attacks. In this section, I delve into the factors contributing to deviations in parity, considering macroeconomic, cryptocurrency, and stablecoin-specific characteristics. If we account for the difference in the type of coins, time, and size, it makes sense to prioritize univariate analysis rather than panel regression. For the last, multiple sources of clustering methods can lead to misspecification of the model.

This paper focuses on two critical aspects: First, I will present the results of the linear regression model, highlighting outcomes in the mean, and later, I will explore the effect on the tails of the distribution where deviations are more pronounced. The overall results reveal disparities between the linear regression model and the different percentiles, drawing attention to the varying impact of each factor across different segments of the distribution.

3.4.1 Linear Regression Model

I analyzed the effect of different covariates on the deviations of the price. The stablecoins will likely have a heterogeneous response to each of the factors due to their diverse algorithms and liquidity profiles. This suggests that a richer analysis of the underlying process will be oriented to find the estimate of an individual model rather than a panel approach.

In table 3.3, I present the simple regression of the deviations of the stablecoin prices against the capitalization-weighted return index for the stablecoins ($STBL$) in a Capital Asset Pricing Model (CAPM) like framework. The table highlights that while most stablecoins exhibit higher index significance against their returns, the effects of market changes vary significantly among them. Tether (USDT) and Binance USD (BUSD) demonstrate the highest sensitivity to general returns/deviations, with changes approaching one for both. Conversely, Dai (USDC) and USD Coin (USDC) show lower significant effects, registering values of 0.23 and 0.67. In contrast, I could not find enough evidence that the returns affect the Fei and Liquidity USD deviations. An interesting anomaly is observed in the case of Terra, with a substantial change of 49.11 in its value. This result, along with the significance of the constant parameter, raises concerns about potential omitted variable bias and model misspecification of the simple model.

I construct different variables from the covariates to explain the behavior of particular

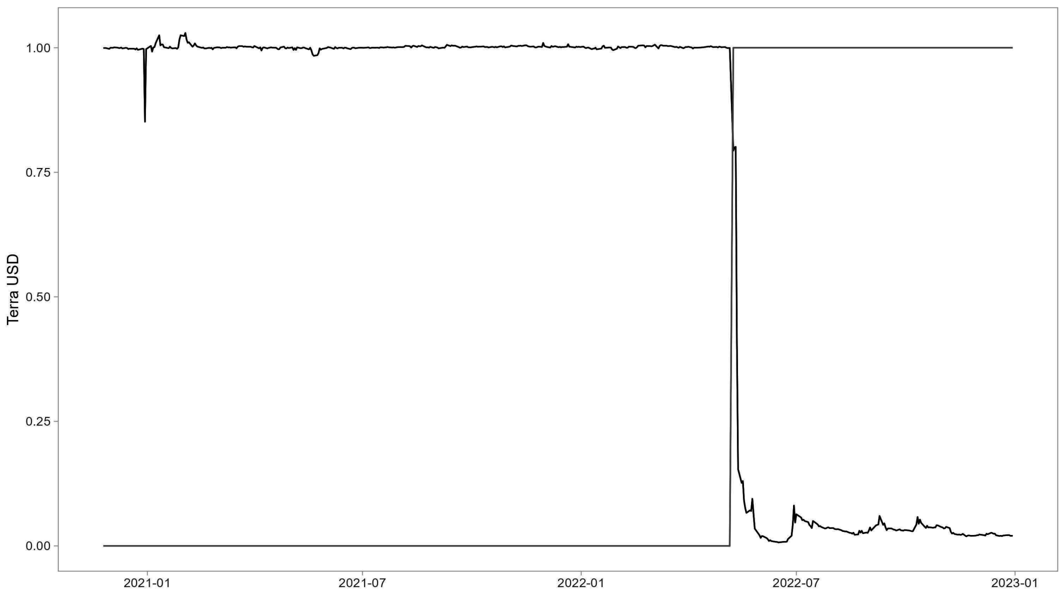
Table 3.3. Stablecoin One-Factor Model

	Stablecoins									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
α	0.00	0.00	0.00	−0.00	0.00	−0.00	0.00	−0.01**	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
STBL	1.01***	0.70***	0.77***	0.67***	0.95***	0.23*	0.71*	49.11***	1.82	0.72
	(0.01)	(0.11)	(0.12)	(0.11)	(0.09)	(0.13)	(0.41)	(9.02)	(1.45)	(0.71)
R^2	0.98	0.32	0.54	0.44	0.83	0.01	0.02	0.32	0.04	0.01
Adj. R^2	0.98	0.32	0.54	0.44	0.83	0.01	0.01	0.32	0.03	0.01
Num. obs.	1510	1215	1072	1065	827	782	507	528	441	419

Note: The model is estimated following Newey and West (1987) with an optimal lag selection of Newey and West (1994). Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

events, such as the Terra crash on May 9, 2022. Briola et al. (2023) show that the effects of the event were non-structural and did not translate into higher volatility in the cryptocurrency market. However, there is no analysis of the impact of the collapse on the other stablecoins. We could expect that it will generate a sell-off in other products of herding portfolio reallocation, especially the ones with less volume and market capitalization that are used as speculative investments. The dummy variable ($TERRA$) will permanently affect the price, so I modeled it as a Pure Jump on the stablecoin price, such that it can be treated as a change in the trend of the stablecoin. In Figure 3.5, I present the behavior of the Terra USD before and after the crash, with TERRA to see the period change.

Figure 3.5. The Terra USD - Luna Crash price Effect



Notes: The graph plots the Terra USD price before and after the Terra-Luna price crash on May 9, 2022. The red line is the dummy variable $TERRA$, constructed for the model. *Sources:* Coinmarketcap and Author's Calculations

Additionally, I use a dummy variable to account for the events of high illiquidity in cryptocurrency markets ($DILICRYP$). The variable takes a value of one if the illiquidity level of the cryptocurrencies, $ILICRYPT$, exceeds the 80% highest value. This is to capture the safe haven effects of stablecoins events where there is extreme behavior of the Cryptocurrencies as argued by Baur and Hoang (2021) and Kołodziejczyk (2023). Then, whenever there is high illiquidity in the cryptocurrency market, we could expect the stablecoins to deviate in price as a premium for the increased demand.

In Table 3.4, I present the results of the regression of the changes in the stablecoin price, defined as $\Delta P_{i,t} = P_{i,t} - P_{i,t-1}$ for Stablecoin $i \in N$ of our $N = 10$ variables of interest. As the explanatory variables, I use the Pure Jump Dummy for the Terra USD crash ($TERRA$), the Stablecoin Return Index ($STBL$), the difference in the Stablecoin Iliquidity Index ($ILISTL$), the High Iliquidity Cryptocurrency dummy ($DILICRYP$), the cryptocurrency return Index ($CRYPT$), the foreign exchange rate USD index (ER), the difference in the financial intermediary squared leverage ($HKML2$), the growth rate of the estimated annualized energy consumption in Bitcoin mining ($CBECI$), the difference in the interest rates of the constant maturity 3-month Treasury Bill ($TBILL$), and the difference in the 10-year Bond Treasury interest rate ($B10Y$). Furthermore, I introduce the interaction between the $TERRA$ and the $STBL$ index to capture the variation that the Terra/luna crash effect on the stablecoin returns behavior. Then, we can see it as a structural change in the parameter of interest. As we can see from the results of the goodness-of-fit of the model the model has an overall heterogeneous performance in measuring the determinants of the price difference of stablecoins[9].

As in the CAPM model, the STBL is significant for most variables, but for Terra USD. An increase in illiquidity reduces the prices of the Tether and Frax stablecoins but is not a relevant variable for the other. The cryptocurrency returns are significant in explaining the returns of stablecoins, but the effect is heterogeneous. Increases in the cryptocurrency market reflect variations by 0.01 of the most liquid stablecoins, Tether, Pax, USD Coin, and Binance. At the same time, the effect is the contrary for less liquid, with an average decrease of 0.03 in the price. Then, the growth in the market creates a migration to more liquid assets.

Furthermore, the less liquid ones exhibit a countercyclical behavior, in which the decrease of the market returns increases their price. In that sense, less liquid is a diversifier of the other coins. The intermediary leverage coefficients align with the literature, as the increase in their budget constraint is priced with reductions in stablecoins. Nevertheless, it is only statistically significant for Binance and Dai, which exhibit the contrary parameter. A variation on the short-term collateral, the 3-month interest rate, is the only collateral with

[9]In the Appendix 3.5 I present the descriptive statistics on each of the covariates used in the estimation of the model to provide a general overview of their characteristics. Additionally, I estimate the correlation matrix and show that the variables do not exhibit a high level of relationship between them, but between interest rates and the intermediary squared leverage.

Table 3.4. Stablecoin General Liquidity

	Stablecoins									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
Intercept	−0.00	−0.00	0.00	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TERRA	−0.00	0.00	0.00	0.00*	0.00	−0.00	0.00	−0.01	0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
STBL	1.02***	0.72***	0.80***	0.71***	0.98***	0.31***	1.74**	−1.81	7.59***	8.13***
	(0.01)	(0.08)	(0.10)	(0.08)	(0.05)	(0.10)	(0.69)	(1.43)	(2.80)	(2.33)
ILISTL	−0.00**	0.00	−0.00	0.01	−0.00	0.08	−0.01***	0.08	−0.01	−0.01*
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.08)	(0.00)	(0.11)	(0.01)	(0.01)
DILICRYP	0.00	0.00	−0.00	−0.00	−0.00	−0.00	0.00	−0.01	−0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
CRYPT	0.00	0.01***	0.01*	0.01*	0.01***	−0.03***	−0.03***	−0.00	−0.02***	−0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)
ER	−0.00	0.12	0.04	0.05	0.05	−0.09	0.01	−2.62	0.14	0.24
	(0.01)	(0.10)	(0.07)	(0.07)	(0.04)	(0.15)	(0.21)	(3.53)	(0.27)	(0.29)
HKML2	−0.00	−0.00	−0.00	−0.00	−0.01***	0.03**	−0.01	0.26	0.01	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.19)	(0.02)	(0.02)
CBECI	0.00	−0.00	−0.00	−0.00	−0.00	0.01	0.00	−0.11	−0.02	−0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.15)	(0.03)	(0.03)
TBILL	0.00	−0.00*	−0.00*	−0.00*	−0.00	−0.00	−0.00	−0.20***	0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.07)	(0.01)	(0.01)
B10Y	−0.00	0.00	−0.00	0.00	−0.00*	0.01	0.01	0.07	−0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.05)	(0.01)	(0.01)
TERRA x STBL	−1.08***	−0.73***	−0.67***	−0.74***	−0.97***	−0.25**	−1.45**	69.77***	−7.47***	−8.12***
	(0.01)	(0.08)	(0.11)	(0.08)	(0.06)	(0.12)	(0.71)	(18.69)	(2.82)	(2.31)
R^2	0.99	0.35	0.59	0.50	0.88	0.17	0.07	0.47	0.17	0.15
Adj. R^2	0.99	0.35	0.59	0.49	0.88	0.16	0.05	0.46	0.14	0.13
Num. obs.	1434	1153	1014	1008	783	742	481	501	419	397

Note: The model is estimated following Newey and West (1987) with an optimal lag selection of Newey and West (1994). Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

significant behavior. Still, the change does not reflect in more significant price changes but for the Terra USD. The changes in the returns after the Terra collapse have a price reduction compared to the previous period, where the effect of STBL is reduced consistently. This is coherent with the data, as we can see in Figure 3.3; after the crash, the stablecoins became less volatile than the previous time. The particular increase of the USTC to the STBL comes from the asset's values after the event, where there are increases in the prices, but they are nominally small, as we can see in Figure 3.5. As the price becomes almost cero, any price change is perceived as having a higher effect than it may be.

Using the market capitalization-weighted index, ILISTL may overweight the first three stablecoins, Tether, USD Coin, and Binance. I regressed the covariates in Table 3.4 but replaced the index to estimate the coin's illiquidity $ILISTL_i$, for coin $i \in N$. Table D1 presents the regression results. We can see that in terms of goodness-of-it, there are no sizable improvements in the model and relevant changes in the estimated parameters, but rather some reductions for Dai, and Terra, while there is an increase in Tether. In terms of the results, the individual illiquidity of Tether, Frax, and Liquidity USD stops being significant, which tells us that the liquidity of the overall market is more important for the investors than the specific liquidity of the stablecoin. The rest of the parameters remain the same as the model with the $ILISTL$.

Table 3.5. Stablecoin Especific Liquidity

	Stablecoins CAPM									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
Intercept	−0.00	−0.00	0.00	−0.00	0.00	0.00	0.00	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TERRA	−0.00	0.00	0.00	0.00*	0.00	−0.00	0.00	−0.01	0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
STBL	1.02***	0.72***	0.80***	0.71***	0.99***	0.31***	1.74**	−1.76	7.57***	8.09***
	(0.01)	(0.09)	(0.10)	(0.08)	(0.05)	(0.12)	(0.69)	(1.45)	(2.79)	(2.29)
$ILISTL_i$	−0.00	−0.01	0.00	0.00	−0.01*	0.00	−0.00	0.03	0.00	−0.00
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)
DILICRYP	0.00	0.00	−0.00	−0.00	−0.00	−0.00	0.00	−0.01	−0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
CRYPT	0.00	0.01***	0.01*	0.01*	0.01***	−0.04**	−0.03***	−0.02	−0.02***	−0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.03)	(0.01)	(0.01)
ER	−0.00	0.11	0.04	0.05	0.04	−0.13	0.01	−2.67	0.14	0.26
	(0.01)	(0.10)	(0.07)	(0.07)	(0.04)	(0.16)	(0.21)	(3.47)	(0.27)	(0.29)
HKML2	−0.00	−0.00	−0.00	−0.00	−0.00***	0.03*	−0.01	0.25	0.01	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.18)	(0.02)	(0.02)
CBECI	0.00	−0.00	−0.00	−0.00	−0.00	0.01	0.00	−0.08	−0.02	−0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.12)	(0.03)	(0.03)
TBILL	0.00	−0.00	−0.00*	−0.00*	−0.00	−0.00	−0.00	−0.20***	0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.07)	(0.01)	(0.01)
B10Y	−0.00	0.00	−0.00	0.00	−0.00	0.01	0.01	0.07	−0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.05)	(0.01)	(0.01)
TERRA x STBL	−1.08***	−0.74***	−0.67***	−0.73***	−0.98***	−0.16	−1.46**	69.58***	−7.45***	−8.08***
	(0.02)	(0.10)	(0.11)	(0.08)	(0.06)	(0.12)	(0.72)	(17.33)	(2.83)	(2.28)
R^2	0.99	0.36	0.59	0.50	0.88	0.13	0.07	0.48	0.17	0.15
Adj. R^2	0.99	0.35	0.59	0.49	0.88	0.12	0.05	0.46	0.14	0.13
Num. obs.	1434	1153	1014	1008	783	742	481	501	419	395

Note: The model is estimated following Newey and West (1987) with an optimal lag selection of Newey and West (1994). Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

3.4.2 Quantile Regression

Until now, we have focused on the mean response to the cryptocurrency, macroeconomic, and collateral factors. Nevertheless, as stablecoins are pegged coins rather than determined entirely from a demand and supply framework as most cryptocurrencies like Bitcoin, their prices are less volatile, are skewed, and are leptokurtic. Then, we should not only focus on the distribution's mean and approach the different parts of price changes, especially the tails that entail large deviations of the stablecoins. Hence, I will study the variations on the changes in the extremal variations of the price distribution, the distribution at the one, five, ninety-five, and ninety-nine percentile to see if the previous variables can explain the appearance of high price variations. For each regression, I compute the standard errors using the Wild Bootstrapping method of Feng, He, and Hu (2011) to account for the heteroskedasticity of the errors. This method to compute the standard errors is convenient for financial data with heavy tails that depart from the i.i.d. assumption. As Feng et al. (2011) and Koenker et al. (2017) show, it takes blocks from the errors to account for the serial dependence in the errors.

First, let's compare the results of the median and linear regression analyses to determine if using the percentile instead of the linear model provides a different perspective. If the data were symmetrical, we expect the parameters to be approximately the same. By comparing Tables 3.4 and 3.6, we observe that, for most variables, the parameters differ by

Table 3.6. Stablecoin: 50% Percentile

	Stablecoins: 50th % Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	0.0000	−0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	−0.01***	0.0003	−0.001
	(0.0000)	(0.0000)	(0.0003)	(0.0000)	(0.0001)	(0.0001)	(0.0004)	(0.004)	(0.001)	(0.001)
STBL	1.00***	0.74***	0.84***	0.74***	0.98***	0.58***	1.44**	0.81***	4.27***	4.36***
	(0.0000)	(0.05)	(0.06)	(0.05)	(0.04)	(0.16)	(0.60)	(0.24)	(1.58)	(0.99)
ILISTL	−0.00	0.001	0.001	0.002	0.005	0.003	−0.01	0.004	−0.001	−0.002
	(0.0000)	(0.002)	(0.003)	(0.003)	(0.004)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
DILICRYP	−0.00	0.0001	−0.0001	−0.0000	0.0000	−0.0000	0.0004	−0.0002	−0.0004	0.001
	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.001)	(0.0003)	(0.001)	(0.001)
CRYPT	0.00	0.002***	0.002*	0.001**	0.002***	−0.005***	−0.02***	0.004	−0.02***	−0.02***
	(0.0000)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.001)	(0.01)	(0.002)	(0.01)	(0.01)
ER	−0.00	0.02	0.02	0.02	0.01	0.01	0.28	−0.17	−0.09	0.12
	(0.0001)	(0.02)	(0.04)	(0.02)	(0.03)	(0.03)	(0.18)	(0.14)	(0.21)	(0.23)
HKML2	0.00	0.0000	−0.002	−0.001	−0.003**	0.001	−0.02*	0.01	−0.01	0.01
	(0.0000)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.01)	(0.01)	(0.01)	(0.01)
CBECI	0.00	−0.0001	0.0004	0.0001	0.002	0.001	−0.01	−0.005	−0.005	−0.02
	(0.0000)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.01)	(0.01)	(0.02)	(0.01)
TBILL	0.00	−0.002**	−0.002	−0.0000	−0.001	−0.0004	−0.004	−0.07**	0.004	0.01
	(0.0000)	(0.001)	(0.002)	(0.0004)	(0.001)	(0.001)	(0.005)	(0.03)	(0.01)	(0.01)
10YB	−0.00	0.0001	−0.0000	0.0000	−0.0002	0.0001	0.001	0.003	−0.01	0.004
	(0.0000)	(0.0004)	(0.001)	(0.0003)	(0.001)	(0.001)	(0.003)	(0.004)	(0.005)	(0.004)
TERRA x STBL	−1.06***	−0.72***	−0.70***	−0.72***	−1.03***	−0.45**	−0.80	101.07**	−4.73***	−4.40***
	(0.03)	(0.05)	(0.14)	(0.05)	(0.07)	(0.18)	(0.81)	(39.23)	(1.61)	(1.01)
N	1,434	1,153	1,014	1,008	783	742	481	501	419	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Barrodale and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with a 1000 replications. Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

a small percentage. The difference in the result arises from the parameters of the stablecoin market. Specifically, for Terra, Fei, and Liquidity USD, the parameter is smaller. In the median, Terra's parameters change, becoming also relevant for estimating the model. For them, the parameters become smaller, and for Frax, the illiquidity, and Terra crash become insignificant. The difference between the two results confirms two key aspects: first, the need to analyze different percentiles, and second, the heterogeneous effect of the covariates. Percentiles reveal different relationships, and some stablecoins demonstrate a higher sensitivity to changes in the distribution compared to others. We expect the distribution's tails (1%, 5%, 95%, and 99%) to reflect the same relationship.

We first focus on the top part of the distribution: the highest price increases. In that case, we can see that the results differ with respect to the changes in the mean model presented in Table D1. The top panel of the table presents the regression on the 95th percentile, in which we can see that for most variables, the stablecoin market beta does not change considerably, but in the cases of Dai, Frax, Terra, and Fei. These stablecoins are algorithmic, being Dai is the only one backed by assets but one of those cryptocurrencies. The prices become more sensitive to the general stablecoin behavior for Dai and Fei, while Fraax and USTC have the contrary effect. The illiquidity of the currencies became a significant factor in increasing the price and premium of the Pax, USD Coin, and Dai[10]. At the same time, we have a negative and negligible effect on the USDT. Cryptocurrencies are not relevant

[10]Because the weights are calculated by market capitalization, there may be concerns that it will capture mainly on the Tether illiquidity, and some of the USD Coin and Binance rather than the market. So, in Appendix 3.5, I do the quantile regression for both higher and lower tails and compare the results.

Table 3.7. Stablecoin: Quantile Regression Higher Tail

	Stablecoins: 95% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	−0.0005***	−0.003***	0.002***	−0.003***	−0.0002	−0.01***	−0.003***	0.22***	−0.004	−0.01**
	(0.0001)	(0.0004)	(0.001)	(0.0002)	(0.0002)	(0.001)	(0.001)	(0.04)	(0.003)	(0.002)
STBL	1.04***	0.78***	0.78***	0.73***	0.97***	0.45***	1.54	0.86*	23.35***	11.25**
	(0.01)	(0.06)	(0.05)	(0.02)	(0.04)	(0.13)	(0.95)	(0.47)	(3.74)	(4.56)
ILISTL	−0.002*	0.02	0.02**	0.01***	0.01	0.04*	0.05	−0.01	0.03	−0.04
	(0.001)	(0.02)	(0.01)	(0.005)	(0.01)	(0.02)	(0.06)	(0.15)	(0.11)	(0.09)
DILICRYP	0.001***	0.003***	−0.001	−0.0001	0.0002	−0.002	0.003*	0.001	−0.002	0.01
	(0.0001)	(0.001)	(0.001)	(0.0003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)	(0.01)
CRYPT	−0.001	−0.01	0.0004	0.001	0.01***	−0.03**	−0.04***	0.01	−0.03	−0.05*
	(0.001)	(0.004)	(0.004)	(0.002)	(0.003)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
ER	−0.01	0.04	−0.06	−0.09	−0.07	−0.63***	0.69**	−0.40	1.03	1.64**
	(0.02)	(0.15)	(0.17)	(0.09)	(0.10)	(0.22)	(0.29)	(0.44)	(0.91)	(0.70)
HKML2	0.002*	−0.01*	0.003	0.004	0.001	0.03**	−0.02	0.03	−0.09**	−0.01
	(0.001)	(0.01)	(0.005)	(0.004)	(0.003)	(0.01)	(0.02)	(0.02)	(0.05)	(0.03)
CBECI	−0.002	−0.004	−0.005	−0.003	−0.004	−0.05**	0.05**	0.03	−0.01	−0.07
	(0.001)	(0.01)	(0.01)	(0.004)	(0.01)	(0.02)	(0.02)	(0.02)	(0.06)	(0.05)
TBILL	0.0003	−0.003	−0.02***	−0.0000	0.002	−0.001	−0.01	0.0002	−0.03*	−0.01
	(0.001)	(0.003)	(0.01)	(0.001)	(0.002)	(0.01)	(0.01)	(0.04)	(0.02)	(0.02)
10YB	−0.001	0.001	−0.001	−0.001	−0.0001	0.0000	−0.001	0.004	0.01	−0.03
	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)	(0.005)	(0.01)	(0.01)	(0.02)	(0.02)
TERRA x STBL	−1.11***	−0.69**	−0.45	−0.72***	−0.98***	−0.10	−1.19	47.96***	−23.41***	−11.48**
	(0.12)	(0.31)	(0.29)	(0.06)	(0.10)	(0.37)	(0.98)	(6.60)	(4.05)	(4.81)
	Stablecoins 99% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	−0.001***	−0.01***	0.003*	−0.01***	−0.002	−0.01***	−0.01	0.44***	−0.01***	−0.01***
	(0.0001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.01)	(0.02)	(0.004)	(0.004)
STBL	1.03***	0.67***	0.79***	0.79***	0.94***	0.25	12.24	−0.02	34.99***	32.20***
	(0.01)	(0.10)	(0.11)	(0.08)	(0.07)	(0.22)	(8.32)	(0.81)	(1.68)	(6.81)
ILISTL	0.01**	0.05**	−0.001	0.003	−0.004	0.08	0.07	−0.03	0.06	0.02
	(0.003)	(0.03)	(0.03)	(0.02)	(0.02)	(0.07)	(0.12)	(0.35)	(0.09)	(0.32)
DILICRYP	0.002***	0.01*	−0.002*	−0.0003	−0.0001	−0.003	−0.001	−0.001	−0.01	0.02**
	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.003)	(0.005)	(0.003)	(0.004)	(0.01)
CRYPT	−0.002	−0.02**	−0.01	−0.01	0.01	−0.05	−0.05	0.03	−0.02	0.12**
	(0.002)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.05)	(0.03)	(0.03)	(0.05)
ER	0.05	0.13	−0.47	−0.08	−0.35	−0.62	−0.66	−1.45	1.39	3.14*
	(0.05)	(0.72)	(0.42)	(0.29)	(0.54)	(0.68)	(2.04)	(1.79)	(1.57)	(1.61)
HKML2	0.001	−0.03	−0.0002	−0.005	−0.002	0.07**	−0.11	0.15**	−0.21***	−0.10
	(0.002)	(0.03)	(0.02)	(0.02)	(0.01)	(0.03)	(0.11)	(0.07)	(0.06)	(0.08)
CBECI	−0.002	0.01	−0.03	−0.03	−0.02	−0.05	0.07	0.03	0.05	−0.27*
	(0.003)	(0.04)	(0.02)	(0.03)	(0.03)	(0.07)	(0.07)	(0.09)	(0.09)	(0.14)
TBILL	0.002	0.02	−0.02	−0.002	0.003	−0.02	−0.03	0.15	0.01	0.04
	(0.002)	(0.02)	(0.02)	(0.01)	(0.01)	(0.03)	(0.02)	(0.14)	(0.05)	(0.04)
10YB	−0.001	−0.001	−0.005	−0.0004	−0.01	−0.005	0.04	0.04	0.03	−0.06*
	(0.001)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.07)	(0.04)	(0.04)
TERRA x STBL	−1.09***	−0.42	−0.13	−0.88***	−0.84*	0.44	−11.57	61.13***	−34.88***	−32.39***
	(0.04)	(0.40)	(0.69)	(0.33)	(0.49)	(0.34)	(8.46)	(2.52)	(2.12)	(7.81)
N	1,434	1,153	1,014	1,008	783	742	481	501	419	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Barrodale and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with a 1000 replications. Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

factors in explaining the high price increases. However, in these events, currencies like Frax and Dai react by reducing their price, most probably due to the algorithm and the increase in cryptocurrency-backed collateral.

Compared to the linear model, exchange rates affect the prices of stablecoins, but this effect is heterogeneous. A currency depreciation lowers the Dai stablecoin's price while increasing the premium of Frax and Liquidity USD. As currencies lose value (ER increases), the demand for stablecoin should increase as they allow the owner to have a stable value in their transaction. The effect after the Terra collapse remains the same as the linear model, where the stablecoins tend to lose the sensitivity to the market's returns. It is essential to notice that Pax, Dai, and Frax, which used to have significant reductions in sensitivity, no longer have them. So, in this period, these stablecoins have a higher reaction than the other currencies to their market volatility.

If we turn to the highest percentile, of 99%, the results hold with the previous percentile. There is a decrease in the sensitivity of returns to the STBL changes, going from 0.78 to 0.67 for the True USD and 0.97 to 0.94, and a lack of significance in Dai and Terra. This is the opposite for Fei and Liquidity USD, which see an increase in changes in the high percentile. The leverage level of the intermediaries increases the price of Dai and Terra while reducing the Fei. Although the empirical evidence tells us that the price is supposed to increase as their financial constraints bind, the effect of Fei may be due to portfolio rebalancing, as lower demand may cause the price to reduce. This will support that the cryptocurrency is countercyclical, especially if we consider that after the Terra crash, currencies like Tether, USD Coin, and Liquidity USD changed to a negative beta to the STBL.

The lower tail of the distribution preserves the relationship between stablecoins and market change for most variables if we consider the distribution before the Terra Crash. Suppose we first concentrate on the fifth percent of the distribution in the top panel of Table 3.8. In that case, we can see some differences between the tails of the distribution that justify the analysis of each tail separately. FRAX significantly affects the STBL changes, consistent with a fast mean reversion to market deviations. Illiquidity increases only affect Tether, reducing the price, while I did not find any statistical evidence on the other coins. High periods of illiquidity in the cryptocurrency market that were significant in the higher tail are no longer significant in periods of high price reductions. Like STBL, the index of the need for cryptocurrencies (CRYPT) increases the price of Tether, True USD, Pax, and Binance, while it has the contrary effect on Dai, Fei, and Liquidity USD. This means that, for the last, the cryptocurrency market returns are pro-cyclical; when the distribution is on the lower tail (high loss of value), the decrease in their prices will decrease the cost of cryptocurrencies even further. Another relevant factor is the HKML2, where the high leverage reflects on lower prices on Tether, True USD, Pax, USD Coin, and Binance, so bad conditions for intermediaries are related to high losses in some stablecoins' prices. Nevertheless, this is not the case with FRAX or FEI, which have a price increase; coincidentally, as USTC, they are algorithmic coins.

When we consider the effect of the post-Luna crash and the effect of the stablecoins, we can see that the coefficients differ from those of the higher tail. Tether, True USD, and Binance have the opposite sign. USD Coin increased by the deviation of one unit of STBL by 0.2 while the previous was 0.01, and Terra increased by 142.78 while it used to be 47.98 in the right tail. The last effect is that a decrease in the STBL in the crisis episode created a reduction in price 142, consistent with its collapse.

The extreme price loss in the 1% of the distribution, representing the highest loss in

Table 3.8. Stablecoin: Quantile Regression Lower Tail

	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
	Stablecoins: 5% Percentile									
TERRA	0.0004***	0.003***	−0.001	0.003***	0.001	0.01***	0.005***	−0.14***	−0.001	0.004***
	(0.0001)	(0.0004)	(0.001)	(0.0003)	(0.0004)	(0.001)	(0.001)	(0.02)	(0.002)	(0.002)
STBL	1.02***	0.62***	0.73***	0.60***	1.00***	0.46***	2.00**	−0.44	5.97***	11.08***
	(0.004)	(0.05)	(0.05)	(0.04)	(0.04)	(0.15)	(0.94)	(0.84)	(1.43)	(1.90)
ILISTL	−0.004**	−0.02	−0.02	−0.01	−0.01	0.03	−0.05	0.02	−0.05	−0.07
	(0.001)	(0.02)	(0.03)	(0.01)	(0.02)	(0.03)	(0.06)	(0.09)	(0.10)	(0.14)
DILICRYP	−0.0001	−0.003*	−0.001	−0.003***	0.0002	0.003**	−0.0000	−0.0001	−0.01*	−0.002
	(0.0001)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.002)	(0.002)	(0.01)	(0.003)
CRYPT	0.002***	0.02***	0.02***	0.004	0.01**	−0.03***	−0.01	0.01	−0.03*	−0.04**
	(0.001)	(0.01)	(0.005)	(0.004)	(0.004)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
ER	−0.01	0.25*	0.03	0.05	0.26*	0.52	0.36	−0.20	0.59	0.99
	(0.02)	(0.15)	(0.17)	(0.07)	(0.14)	(0.34)	(0.56)	(0.63)	(0.91)	(0.71)
HKML2	−0.002**	−0.02***	−0.02**	−0.01*	−0.01**	−0.01	0.05**	0.07	0.08**	−0.06
	(0.001)	(0.01)	(0.01)	(0.003)	(0.004)	(0.01)	(0.02)	(0.05)	(0.03)	(0.04)
CBECI	0.001	−0.005	−0.01	0.002	0.004	0.03	−0.01	−0.03	−0.21***	0.08*
	(0.001)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.04)	(0.06)	(0.05)
TBILL	0.001	−0.005	−0.01	−0.001	0.001	0.01	0.01	0.01	0.01	0.01
	(0.001)	(0.004)	(0.01)	(0.002)	(0.002)	(0.01)	(0.01)	(0.05)	(0.02)	(0.02)
10YB	0.001	−0.001	0.002	0.003	−0.004**	0.004	−0.002	0.02	−0.0002	0.0001
	(0.001)	(0.003)	(0.005)	(0.002)	(0.002)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
TERRA x STBL	−1.01***	−0.72***	0.23	−0.39***	−0.90***	−0.43*	−1.36	142.78***	−6.42***	−11.35***
	(0.04)	(0.22)	(0.47)	(0.12)	(0.13)	(0.24)	(1.29)	(20.93)	(1.74)	(2.00)
	Stablecoins 1% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	0.0004	0.01***	0.0000	0.01***	0.001	0.01**	0.01***	−0.31***	0.001	0.01
	(0.0004)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.01)	(0.002)	(0.02)	(0.003)	(0.01)
STBL	1.01***	0.61***	0.62***	0.46***	0.96***	0.62	1.75**	1.32	−2.11***	24.66***
	(0.02)	(0.08)	(0.07)	(0.07)	(0.08)	(0.59)	(0.84)	(1.75)	(0.32)	(3.04)
ILISTL	−0.01	−0.04**	−0.01	−0.04	−0.01	0.06	0.05	0.03	0.08	0.06
	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.12)	(0.11)	(0.06)	(0.20)	(0.22)
DILICRYP	−0.0003	−0.01***	−0.002	−0.01*	0.001	−0.003	−0.002	0.004	−0.04***	0.01
	(0.0005)	(0.002)	(0.002)	(0.01)	(0.001)	(0.01)	(0.004)	(0.004)	(0.003)	(0.01)
CRYPT	0.01**	0.02***	0.02*	0.01**	0.01	−0.06*	−0.04*	0.03	−0.03	−0.05
	(0.003)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.02)	(0.03)	(0.05)
ER	−0.12	0.87*	−0.14	−0.27	0.47***	1.83	−0.63	−0.96	2.58**	3.15
	(0.10)	(0.50)	(0.30)	(0.33)	(0.15)	(1.95)	(1.01)	(1.54)	(1.10)	(2.20)
HKML2	0.0000	0.003	−0.02**	−0.01	−0.01	0.02	0.11***	0.15**	0.13**	−0.05
	(0.002)	(0.02)	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.06)	(0.06)	(0.07)
CBECI	0.02***	0.01	0.02	0.04**	0.01	0.12	−0.08**	0.02	−0.31***	0.01
	(0.005)	(0.02)	(0.02)	(0.02)	(0.01)	(0.08)	(0.04)	(0.08)	(0.03)	(0.09)
TBILL	0.003	−0.001	−0.004	−0.002	0.01***	0.0003	−0.002	0.01	0.02**	0.04
	(0.004)	(0.01)	(0.01)	(0.01)	(0.003)	(0.03)	(0.02)	(0.10)	(0.01)	(0.05)
10YB	0.003	0.01	−0.004	0.02*	−0.005	−0.003	−0.01	0.02	−0.02	−0.08
	(0.002)	(0.01)	(0.01)	(0.01)	(0.003)	(0.04)	(0.02)	(0.03)	(0.02)	(0.05)
TERRA x STBL	−0.68	−0.95	−0.29	0.17	−0.90***	−0.81	1.30	147.63***	0.44	−25.42***
	(0.48)	(1.02)	(1.17)	(0.86)	(0.34)	(1.10)	(2.04)	(15.55)	(0.82)	(3.26)
N	1,434	1,153	1,014	1,008	783	742	481	501	419	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Barrodale and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with 1000 replications. Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

value, has its particular response to the covariates. In the lower section of Table 3.7, we can see that some results are precise to this percentile. CBECI is an essential factor in explaining the price deviations, where energy consumption increases the value of Tether and USD Coin while having the inverse with Frax and Fei. The USD depreciation is a significant factor in increasing the prices of stablecoins, especially for FEI, which presents a higher sensitivity. The intermediary leverage is only relevant in increasing the price of the algorithmic coins and reducing the Pax. Regarding cryptocurrency effects, the increase in the market returns has decreased the price of crypto-backed currencies like Dai, Frax, Fei, and Liquidity USD. The result is puzzling; as they back it, increasing the collateral value should increase the coin's value. A possible explanation is that the increase in the matter is offset by the future cost of acquiring more to maintain the peg. The parameter of the TERRA crash was not significant for most currencies but for Binance, Terra, and Liquidity USD.

3.4.3 Cross-Quantilogram

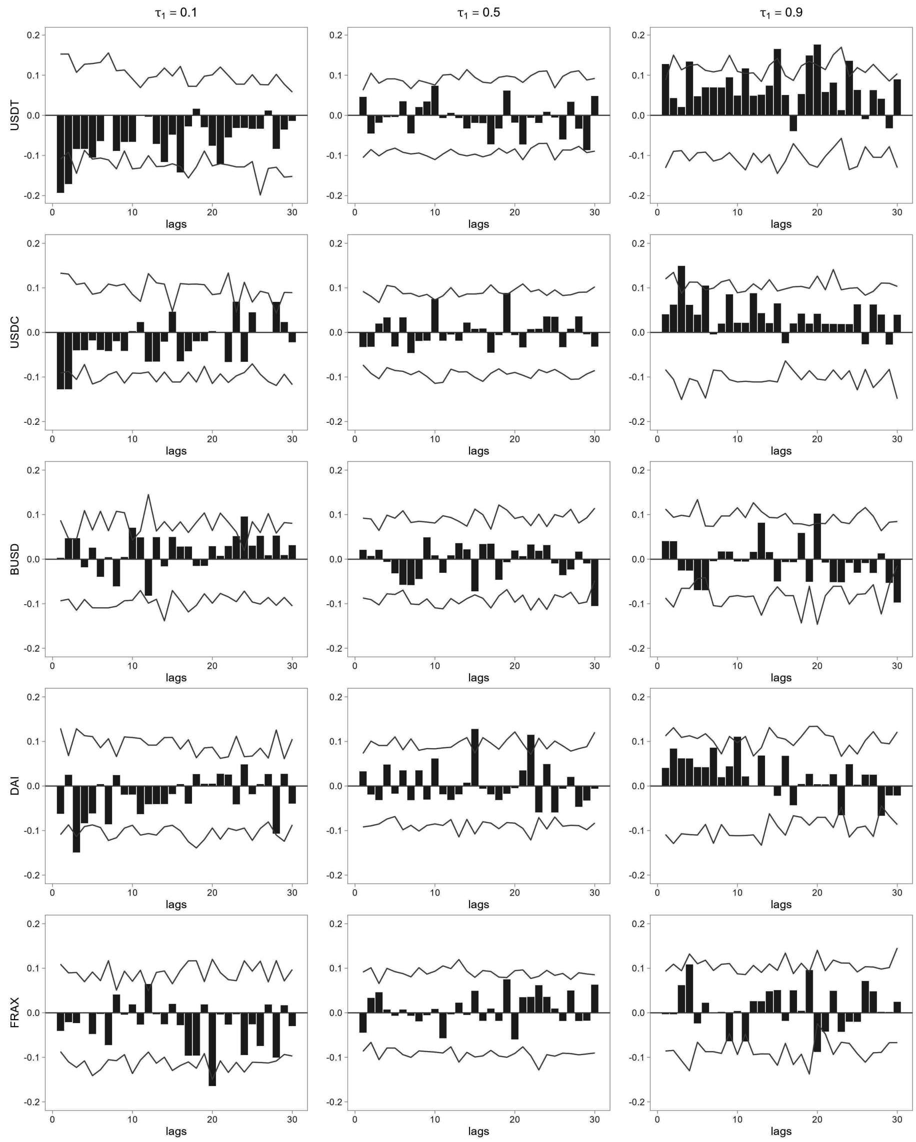
To complement the previous results, I use the cross-quantilogram model to assess directional predictability from four key variables to both the upper and lower tails of stablecoin distributions. The variables under consideration include the Stablecoin Market Index (STBL), the overall Cryptocurrency Market Index (CRYPT), Intermediaries Squared Leverage (HKML), and the Illiquidity Stablecoin Index (ILISTBL). This analysis is limited to the top five currencies by market capitalization, as they contribute most significantly to the overall variance of the cryptocurrency economy. I estimate the model for Tether, USD Coin, Binance, Dai, and Frax stablecoins, using daily data spanning from December 2020 to December 2022, comprising 507 data points for each stablecoin. Compared to the previous section, I omit the use of Terra (USTC), TrueUSD (TUSD), Fei USD (FEI), Pax Dollar (USDP), and Liquidity USD (LUSD) as they will have a lower incidence in the market fluctuations.

In Figures 3.6 to 3.9, I present the results of the directional predictability from the percentiles of four explanatory variables to the distribution of stablecoin price deviations[11]. If we focus on the Stablecoin Index results first, the relationship between stablecoins and the overall market exhibits variability based on the distribution of the conditional quantile. For Tether, USD Coin, and Dai, when the price of the stablecoin market is high, and they are low ($\tau_1 = 0.1$), as they have a negative value, they are likely to have a sizeable loss in the following days. This aligns with the stability mechanism of stablecoins, which involves reverting to parity by altering reserve composition. For Tether, in particular, the $\rho_{0.1}$ is closer to 0.2 than most of the others, signaling the exposition of the Tether to the market.

[11]In Appendix 3.5, I estimate the Ljung-Box Q-statistic for different lags to test the directional predictability of the data. The results provide insights into the significance of the estimated quantile correlation.

In the higher tail, the market has high predictive power in the same part of the distribution, $\tau_1 = 0.9$. Consequently, elevated stablecoin prices are associated with positive returns in Tether and USD Coin, whereas a contraction is predicted in Binance in recent periods. At the median of stablecoins, $\tau_1 = 0.1$, the market lacks predictive power when exhibiting extreme values, except for mid-week predictability in the case of Dai.

Figure 3.6. Directional predictability from the Higher Tail of Stablecoin Market Index (STBL) to Stablecoins



Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 90th percentile of the stablecoins' deviations. The grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

In terms of the cryptocurrency market, we could expect a relationship between this market and Tether in particular. Griffin and Shams (2020) and Hoang and Baur (2021) linked the use of the stablecoin to distort the prices and the volume of Bitcoin. As such, we could expect a high correlation between it and the market. In Figure 3.7, we can see that the results are consistent with the author's findings, where high values of the cryptocurrency returns are likely predicting either a high loss when stablecoins have negative returns ($\tau_1 = 0.1$) or a gain when the (for the $\tau_1 = 0.90$) when prices are increasing for Tether and Frax. An unexpected result is the behavior of Binance, which has a contrary effect to the mentioned previously. High cryptocurrency market values predict higher prices when the stablecoin is on the lower tail and increasing prices when it is on the higher tail.

The directional predictability findings for Intermediary Squared Leverage within the upper tail of the five stablecoins are illustrated in Figure 3.8. When intermediaries exhibit high leverage levels and stablecoin returns are low, they predict price increases in a two-week timeframe, particularly for Tether, USD Coin, Binance, and Frax. However, the effect is relatively shorter for Frax, indicating that high leverage leads to price increases in two days or less, with a cross-correlation of only 0.1. Conversely, when both intermediaries' leverage and stablecoin returns demonstrate increasing values in the upper tail of stablecoins, it anticipates price reductions for Tether, USD Coin, Binance, and Frax.

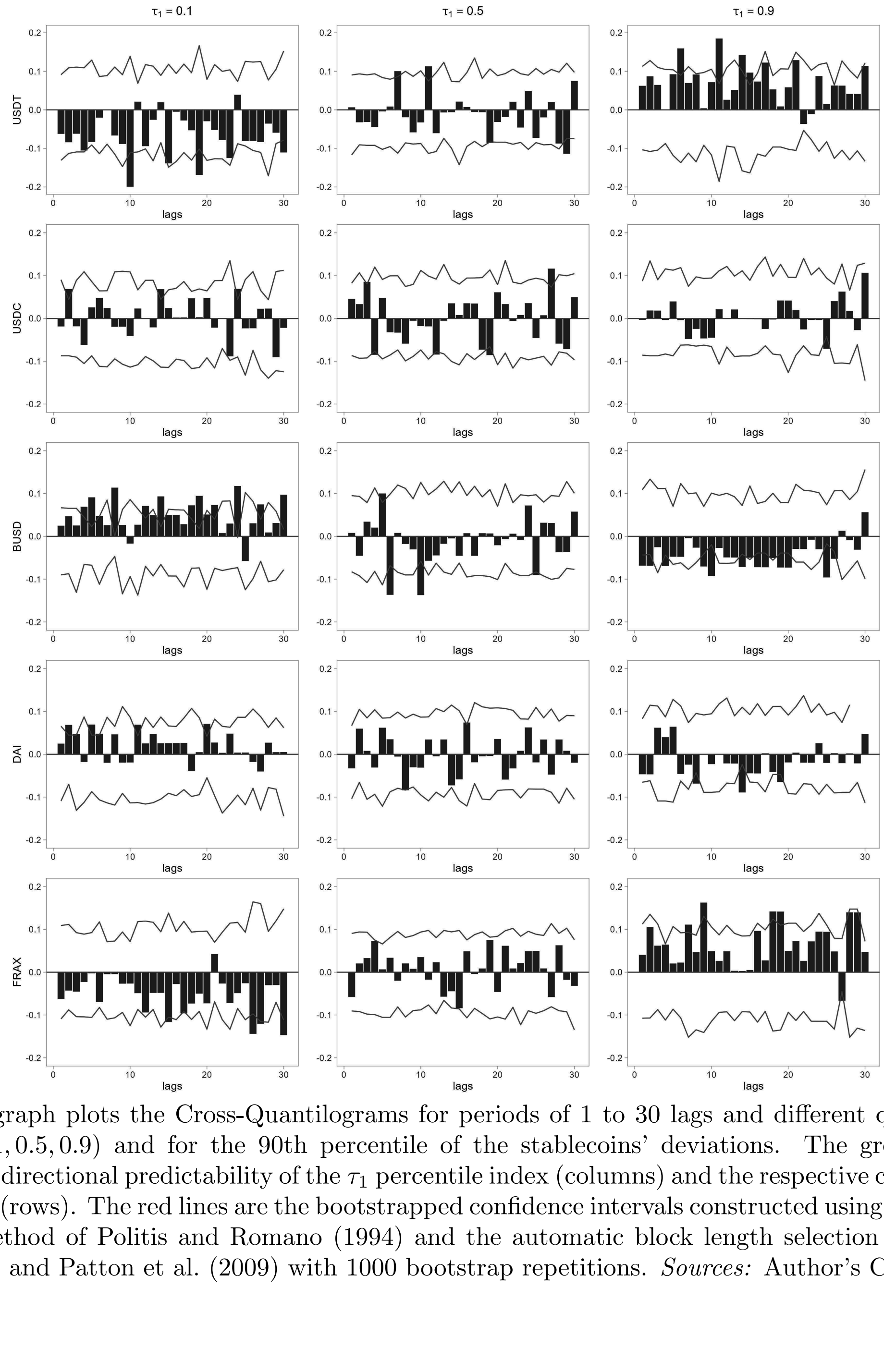
For the Stablecoin Iliquidity, presented in Figure 3.9, the values representing high illiquidity levels impact stablecoin prices in both upper and lower tails. Greater illiquidity predicts higher prices across all currencies in the upper tail of stablecoin price changes. While in the lower tail, higher illiquidity levels translate into lower price predictions. Conversely, in the lower tail, increased illiquidity leads to lower price predictions. However, the magnitude of the effect in the lower tail is, on average, lower than that in the upper tail. most confidence intervals closely align with the values, suggesting a generally mild effect in most cases[12].

Figures 3.10 through 3.13 show the Cross-quantilogram focused on the lower 10% tail of the distribution for the previous explanatory variables. The response of most stablecoins within this lower tail differs notably from their behavior in the upper tail. When the Stablecoin market is on the lower tail of the distribution, a noticeable effect is observed in the upper tail ($\tau_1 = 0.9$) of stablecoin distributions, indicating that most currencies tend to increase in price in the future when the overall market price falls. This tendency is suggestive of the stabilization mechanisms inherent in these currencies.

For the cryptocurrency market effects, the Cross-Quantilogram displays no discernible pattern. Binance shows a relatively clear effect is seen where lower tail, low cryptocurrency returns predict increases in the stablecoin prices, although not to a high magnitude. Similarly, in the lower tail of the Intermediary Squared Leverage, there's only a significant effect

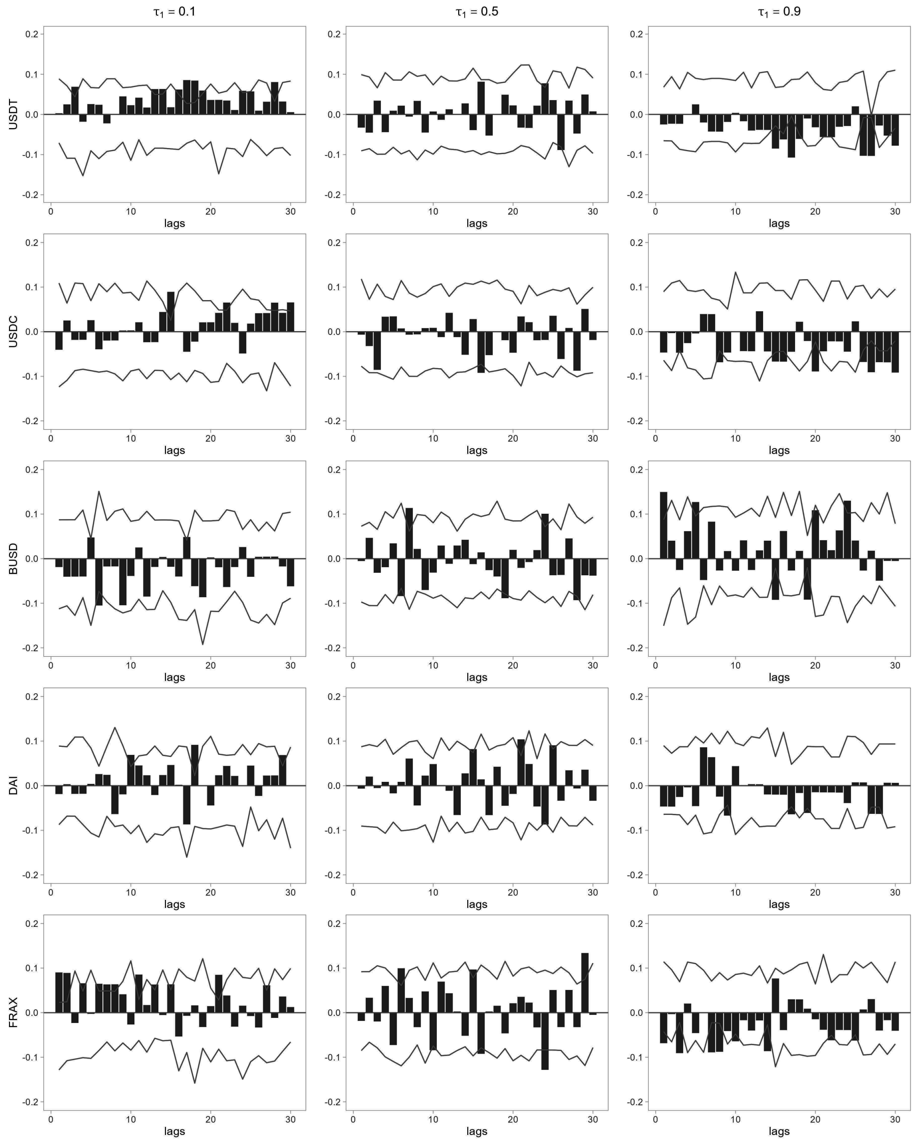
[12]If we look to Figure E4, in Appendix 3.5, we can see that we cannot reject that the null that none of the lags provide significant information to give a statistically significant prediction.

Figure 3.7. Directional predictability from the Higher Tail of Cryptocurrency Market Index (CRYPT) to Stablecoins



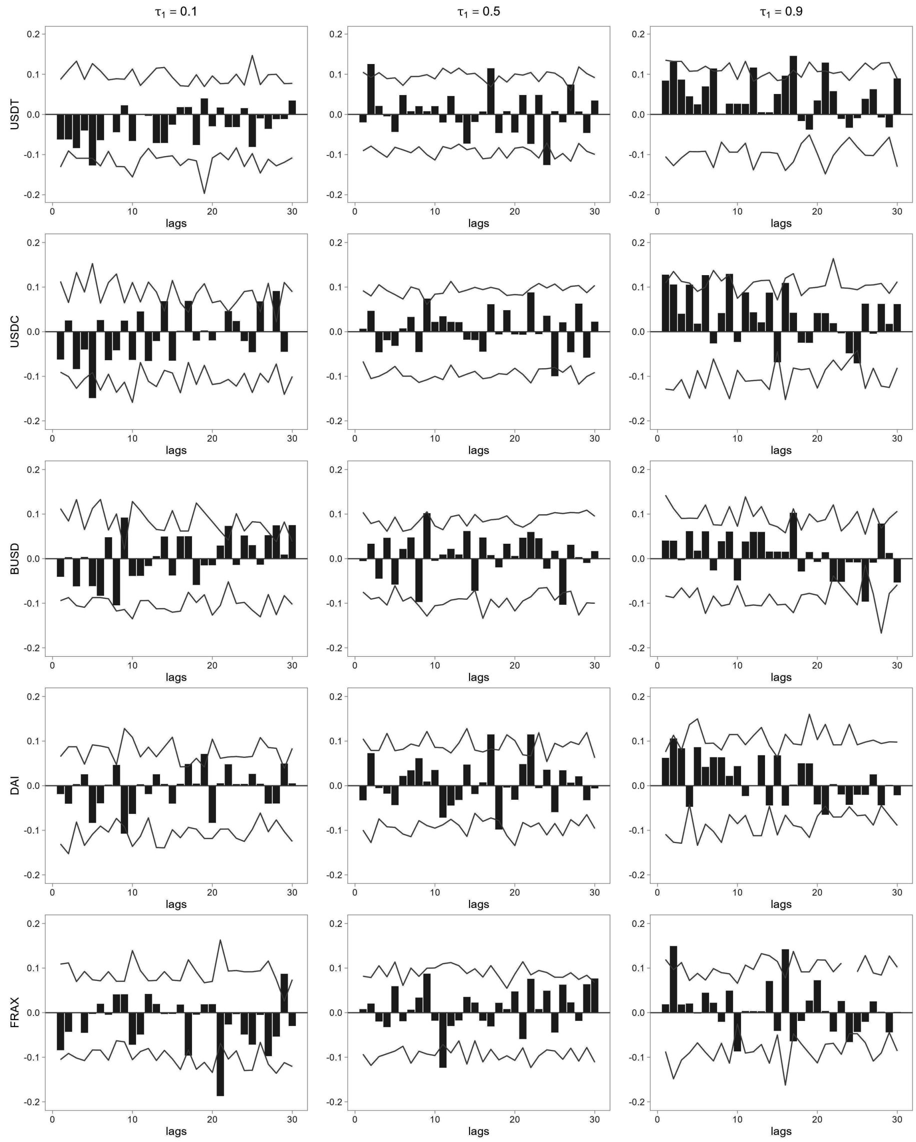
Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 90th percentile of the stablecoins' deviations. The grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure 3.8. Directional predictability from the Higher Tail of Intermediary Squared Leverage (HKML) to Stablecoins



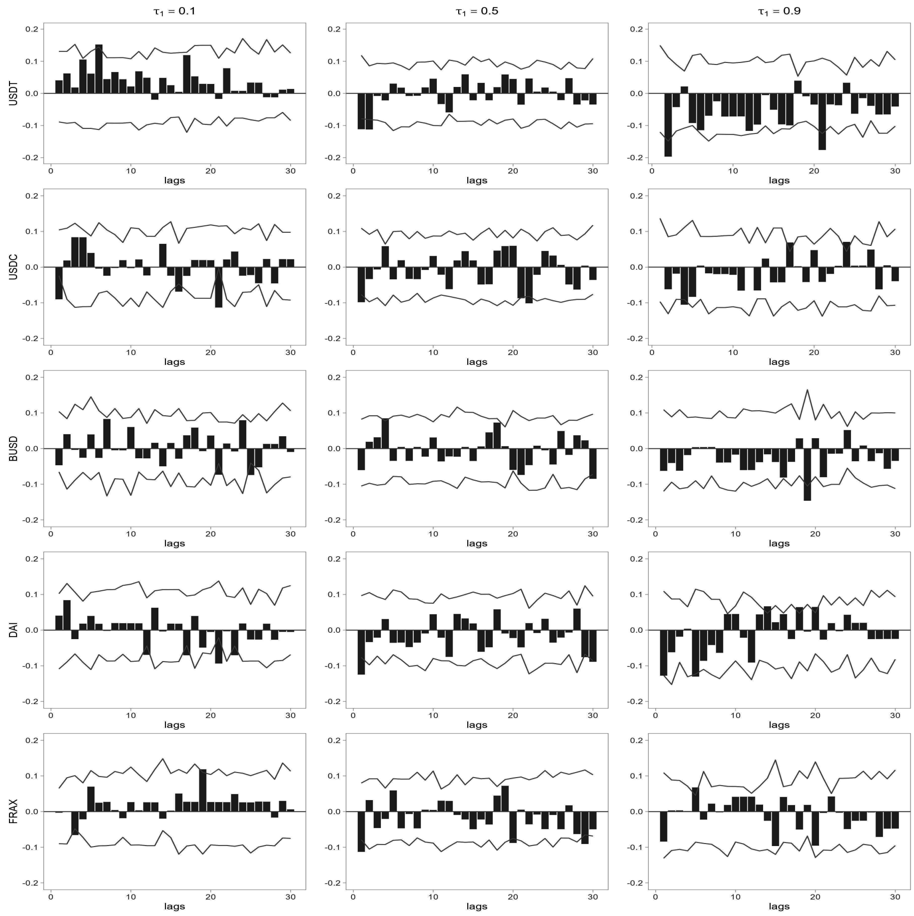
Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 90th percentile of the stablecoins' deviations. The grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure 3.9. Directional predictability from the Higher Tail of Iliquidity Index (ILISTL) to the Stablecoins



Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 90th percentile of the stablecoins' deviations. The Grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure 3.10. Directional predictability from the Lower Tail of Stablecoin Market Index (STBL) to the of Stablecoins

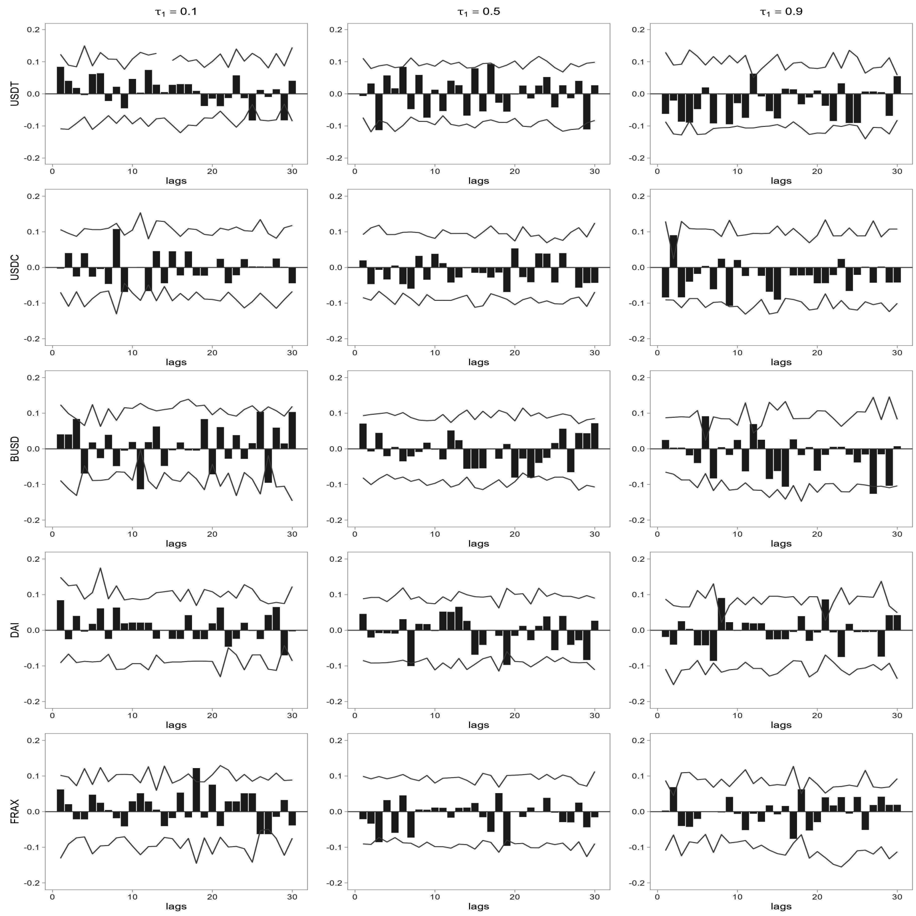


Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 10th percentile of the stablecoins' deviations. The grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

observed, notably in Tether's upper tail. Moreover, with respect to stablecoin tightness in the intermediaries and significant price changes, a decrease in price by more than 0.1 is predicted within a week.

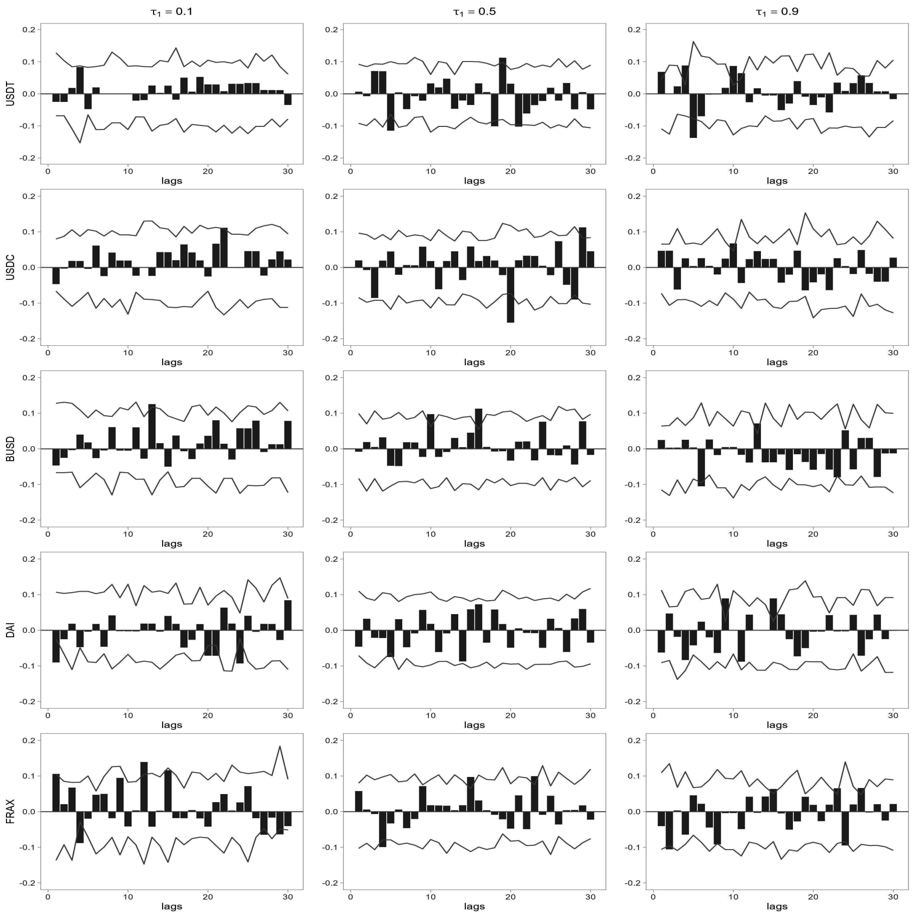
Finally, examining the effect of illiquidity measures in the lower tail, an increase in liquidity in the overall market appears to positively impact stablecoin prices when they are in the lower tail. Conversely, in the upper tail, increased liquidity tends to predict price reductions whenever there are substantial price increases in stablecoins.

Figure 3.11. Directional predictability from the Lower Tail of Cryptocurrency Market Index (CRYPT) to the Stablecoins



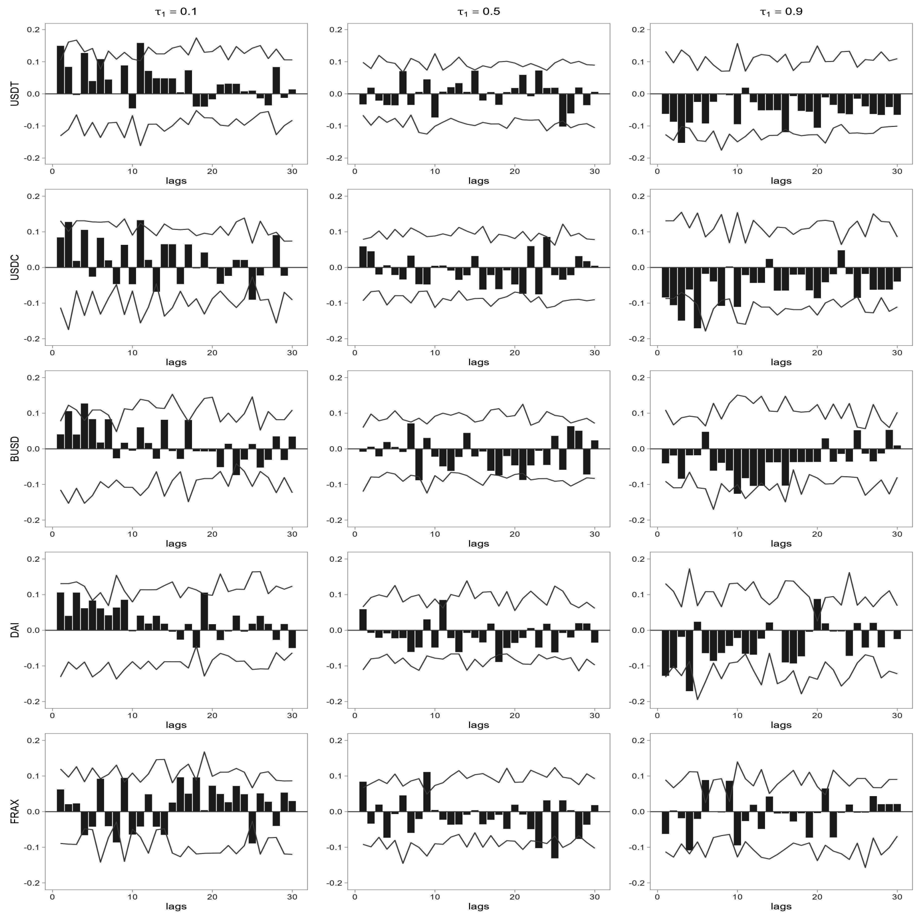
Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 10th percentile of the stablecoins' deviations. The grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure 3.12. Directional predictability from the Lower Tail of the Intermediary Squared Leverage (HKML) to the Stablecoins



Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 10th percentile of the stablecoins' deviations. The grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure 3.13. Directional predictability from the Lower Tail of the Illiquidity Index (ILISTL) to the Stablecoins



Notes: The graph plots the Cross-Quantilograms for periods of 1 to 30 lags and different quantiles given by $\tau_1 = (0.1, 0.5, 0.9)$ and for the 10th percentile of the stablecoins' deviations. The Grey bar graphs represent the directional predictability of the τ_1 percentile index (columns) and the respective cryptocurrency deviation lag (rows). The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

3.5 Conclusions

In this paper, I analyze what causes stablecoins to fluctuate in price. I examine both the average price changes and the extreme price movements. I construct different variables and indices to explain how the prices react under different percentiles and use quantile regression to express the heterogeneous response to other factors. I construct two return indices—one based on market capitalization-weighted returns for stablecoins and another for cryptocurrencies to track the difference between the market behavior and each currency's idiosyncratic fluctuations. Additionally, I draw on existing research and utilize two Bid-ask spread estimators to develop a liquidity measure for each cryptocurrency and aggregate them by general and stablecoin-specific indicators. In addition, I consider factors related to intermediaries, how stablecoins respond to changes in collateral value, and historical events. By examining how each explanatory variable interacts with returns and analyzing their performance across different percentiles, I obtain valuable insights about the distribution of stablecoins, moving beyond a simple linear regression model.

A general result is that stablecoin prices are heavily influenced by the behavior of other coins of the same type. In most cases, the market's returns provide statistically significant insights into explaining the price variations. However, this relationship is not permanent. Recent data suggests a diminishing connection, corresponding to the decrease in parity deviations observed in larger capitalized coins. I find that after the Terra-Luna collapse, most of the coins severed their relationship with the market returns. After the collapse of Terra-Luna, most coins severed their connection with market returns. As expected, the response of USD assets, algorithmic stablecoins, and crypto-backed currencies varied significantly. When there is an increase in general crypto returns, the prices of cryptocurrency collateralized and algorithmic stablecoins decrease, while the opposite is true for higher capitalized coins. Other covariates do not show any statistical relevance in the linear model.

When analyzing the quantiles, distinct patterns emerge in the consistent differences between the Tails and the factors that affect both. The price of stablecoins is increased by illiquidity in both Stablecoins and Cryptocurrency markets. Most of the covariates significantly impact the price deviations of algorithmic stablecoins such as FRAX, Dai, and Fei. In the lower tail, factors such as cryptocurrency market returns, intermediary leverage level, energy prices, and exchange rate variations become relevant in explaining the price decreases of some coins. A common factor that explains both tails is the stablecoin returns, which are influenced by the behavior of most stablecoins and the changes introduced by the Terra collapse.

When considering the directional predictability of the explanatory variables on the top stablecoins, we can disentangle the time series relationship between them and further describe how the stabilization mechanism of each works. We observed that the effects of the high tail of the explanatory variables yield different results when considering each of the tails and their price change distribution. The sensitivity is exceptionally high, and the predictive value is concentrated on the stablecoins and the cryptocurrency market indices. When the markets are in the higher tail (experiencing high price increases), and the stablecoins are in the lower tail, the model predicts a significant price decrease that counters the current loss. They expect high price increases in the higher tail, demonstrating their asymmetrical effects and procyclical nature with the market whenever they are at the top of the distribution. In the lower tail, I demonstrate that liquidity is the most relevant variable in the explanation. Stablecoins correct their price from below, and liquidity enables the currency to sustain a premium above parity.

This work contributes to the literature on the cryptocurrency market, with a specific focus on stablecoin dynamics. I analyze the linear and quantile distribution of stablecoin price variations to gain insights into the relationship between factors influencing their price, including the cryptocurrency market, collateral, and market conditions. Understanding the characteristics of the stablecoin market is crucial for developing optimal algorithms to counteract fundamental values and designing future digital currencies, whether private or central bank digital currencies (CBDCs).

The analyzed time frame in this study is limited, which poses a challenge when comparing the conditional distribution of the tails to market fundamentals. The short duration of extreme episodes restricts the number of data points available for analysis, limiting the findings' precision. Additionally, the market exhibits a high concentration, further impacting the analysis. Future research can address these limitations by expanding the dataset to include more data and events. This would allow for a more comprehensive examination of the dynamic effect of the determinants, analysis of extreme values, and exploration of Tether's role in transmitting shocks to other small and less liquid coins. Additionally, due to the stability mechanism, intraday data can be more informative, and Mixed data sampling (MIDAS) may provide a tool for this.

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Appendix A: Illiquidity Measures

In this section, I will present the two Bid-Ask spread estimators commonly used in the literature to determine the level of liquidity of different assets when there is no access to high-frequency intraday data. The first measure is the methodology proposed by Abdi and Ranaldo (2017) to calculate the Illiquidity measure. They take the high, low, and close values to create an estimator of the Bid-Ask spread from the proxies of the mid-range value such that,

$$mid_t = \frac{High_t - Low_t}{2} \tag{3.9}$$

where $High_t$ and Low_t are the logarithms of the day's highest and lowest prices. From then, we calculate the day corrected Bid-Ask spread as,

$$ARI_t = 2\sqrt{\max\{E(cl_t - mid_t)(cl_t - mid_{t+1}), 0\}} \tag{3.10}$$

where cl_t is the logarithm of the day closing price, and AIR_t is the estimated Bid-Ask spread for the cryptocurrencies. As the mid-range values are estimates of the fundamental values, the relationship between them and the close values can be negative, making the measure follow the same sign. As suggested by Abdi and Ranaldo (2017), the efficient solution is to use zero instead of the negative, as it better approximates the actual value. I use equation 3.10 to calculate the bid-ask spread of each cryptocurrency and stablecoins. I then aggregate each estimated spread by using market capitalization over the market total as a weight for each coin.

Next, to calculate the Corwin and Schultz (2012), we estimate it only using the High and Low prices, compared to the previous ones using the closing prices. They defined the Bid-Ask estimate as

$$\begin{aligned} CSI_t =& \frac{2(e^{\alpha} - 1)}{1 + e^{\alpha}} \\ \alpha =& \frac{\sqrt{2\beta} - \sqrt{\beta}}{3 - 2\sqrt{2}} - \sqrt{\frac{\gamma}{3 - 2\sqrt{2}}} \end{aligned} \tag{3.11}$$

where we have to define the values that both β and γ take as

$$\begin{aligned} \beta =& \sum_{i=0}^{1} \left[\ln \left(\frac{H_{t+i}}{L_{t+i}} \right) \right]^2 \\ \gamma =& \left[\ln \left(\frac{H_{t,t+1}}{L_{t,t+1}} \right) \right]^2 \end{aligned} \tag{3.12}$$

Such that H_t and L_t are the high and low values in period t, while $H_{t,t+1}$ and $L_{t,t+1}$ involve the high and low periods of the current and subsequent period. From it, I calculate the illiquidity measure for each cryptocurrency as the average of both. Finally, I construct the Illiquidity index $ILISTL$ as the capitalization-weighted index of the measures between only the stablecoins. Karnaukh, Ranaldo, and Söderlind (2015) reflects on the importance of liquidity as a source of the FX market fluctuations and shows that low liquidity increases the risk of currencies, especially with the relationship between liquidity and the state of the markets.

Appendix B: Exogenous Variables

The exogenous variables used in the paper come from different sources. I obtained the cryptocurrency data from Coinmarketcap.com, an online database that compiles price information from various Application Programming Interfaces (API) of other Exchanges. Based on the market capitalization of cryptocurrencies with values higher than a million dollars and enough available data for at most a year, I construct a value-weighted for the general cryptocurrencies ($CRYPT$) and others focalized on stablecoins ($STBL$). Because Stablecoins as a cryptocurrency only became popular in recent years, they did not have enough transaction volume and market capitalization to have enough liquidity to be considered. Therefore, I will focus only on January 2017 to December 2022.

Furthermore, Stablecoins are considered substitutes for exchange rates, as they are supposed to provide stability on the value of the transactions that floating exchange rates may not give. As such, variations in the value of the USD will affect the demand for stablecoins; significantly higher devaluations (increases) of the currency against the USD will increase the benefits of using these coins. I construct a foreign exchange index against the USD as the equally weighted exchange rate using ten different exchange rates of developed countries: the Euro (EUR), Japanese Yen (JPY), the UK Pound (GBP), the Canadian Dollar (CAD), Australian Dollar (AUD), the New Zeland Dollar (NZD), the Swiss Franc (CHF), Swedish Krona (SEK), the Danish Krone (DKK), and the Norwegian Krone (NOK). The currencies were downloaded with daily periodicity from Bloomberg.

Intermediaries play an essential role in providing assets to trade and access to the markets to agents and firms. With the increase of restrictions on the leverage of financial institutions and increase in capital requirements, their financial constraints become binding, implying that they embed the risk in the price of the assets. To account for it, I included the variations of the squared leverage of the financial intermediaries ($HKML2$) of He et al. (2017), downloaded from Zhiguo He's webpage. I use the Cambridge Bitcoin Electricity Consumption Index (CBECI) of the Cambridge Digital Assets Programme (CDAP), part of the Cambridge Centre for Alternative Finance, to proxy the effect of electricity consumption. The Index estimates the daily annualized electricity consumption by the Bitcoin network as well as some theoretical bounds of it. I use data on the interest rates in short and long-term maturity to account for collateral value changes. The two most used and liquid assets are the treasury bills and bonds from the Federal Reserve. I collected the data on the constant maturity interest rates for the 3-month Treasury Bill and 10-year Bond from the Board of Governors of the Federal Reserve System webpage.

To complement the possible factors that change the cross-section of stablecoins deviations, I calculate the Corwin and Schultz (2012) and Abdi and Ranaldo (2017) bid-ask spread estimators. Following Karnaukh et al. (2015), I average both to capture the illiquidity of both measures, as they will have a higher level when both coincide rather than just one effect. The general illiquidity index for stablecoins and cryptocurrencies is weighted by market capitalization.

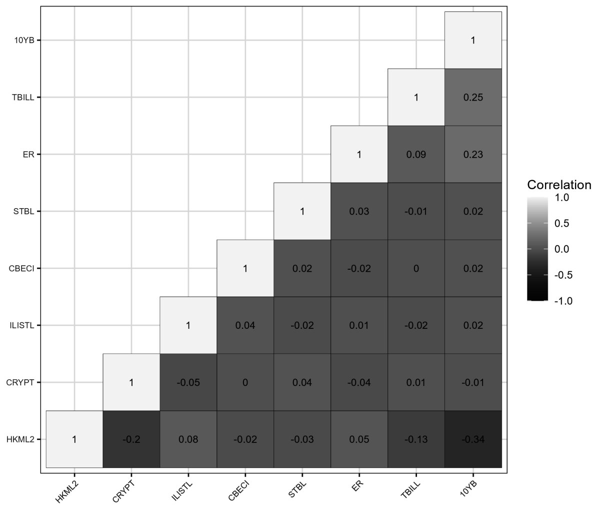
Table B1. Descriptive Statistics of the Exogenous Variables

	Mean	Std. Dev.	MAD	Min	Max	Range	Skew	Kurtosis	ADF
STBL	0.00	0.01	0.00	-0.05	0.06	0.11	0.57	33.09	-33.62
ILISTL	-0.00	0.02	0.00	-0.23	0.31	0.53	2.10	110.27	-40.15
CRYPT	0.00	0.05	0.03	-0.45	0.44	0.89	-0.52	13.19	-26.96
ER	0.00	0.12	0.12	-0.49	0.48	0.97	-0.15	0.95	-27.88
HKML2	0.00	0.03	0.02	-0.23	0.25	0.48	0.57	14.17	-25.27
CBECI	0.00	0.02	0.02	-0.09	0.10	0.19	-0.01	1.64	-19.57
TBILL	0.00	0.03	0.01	-0.23	0.34	0.57	1.00	20.34	-23.07
10YB	0.00	0.05	0.04	-0.30	0.29	0.59	-0.05	3.73	-27.54

Note: The table presents descriptive statistics on the different exogenous variables used in the models. The ADF statistic is the Augmented Dickey-Fuller with Drift test statistic. The critical value for the ADF test is the same for all, -2.86. $STBL$ is the stablecoin value-weighted deviations index, $ILISTL$ is the difference of the illiquidity measure constructed using the bid-ask spread estimators of Corwin and Schultz (2012) and Abdi and Ranaldo (2017), $CRYPT$ is the value-weighted return index of cryptocurrencies, ER is the equal-weighted exchange rate index. For the USD of the ten developed economies, $HKML$ is the difference of square leverage of the intermediaries as calculated by He et al. (2017), $CBECI$ is the logarithmic growth of the annual estimated Bitcoin energy consumption, $TBILL$ is the difference of the interest rates of the 3-month Treasury Bills, and $10YB$ is the difference of the interest rates of the 10-year Treasury Bond. *Sources:* Author's Calculations.

In Table B1, I present the descriptive statistics of the different exogenous variables. As expected, the returns of the stablecoins have lower volatility than cryptocurrencies and exchange rates. Stablecoins offer the promised stability of a fixed exchange rate regime currency but also have a higher probability of a crash or speculative attack without the backing of the central bank. The skewness of STBL compared to the previous indices speaks for the different types of asset stablecoins have a positive skew, which implies that the changes in the prices increase on average more than they fall. Due to possible concerns of simultaneity between the variables, I calculated the correlation matrix in Figure B1. From it, we can see that the variables present a low correlation level; the highest positive is between the 10-year interest rate and the 3-month and exchange rates. Conversely, the negative is between the HKML with 10YB and CRYPT but not between the last. The effect of the intermediaries is consistent with the intermediary asset pricing models that show their importance in the valuation of assets.

Figure B1. Correlation Matrix Exogenous Variables



Notes: The plot presents the correlation matrix between the exogenous variables used on the different models. *Sources:* Author's Calculations

Appendix C: Quantile Regression with Specific Iliquidity

In this section, I present the results of the quantile regressions using the Iliquidity for each of the stablecoins ($ILISTL_i$) rather than just the single index ILISTL used in the Tables 3.7 and 3.8. If we weight by market capitalization, we will have that because Tether (USDT) has the highest market power, the index may reflect more of the liquidity conditions of that coin rather than the market. As such, I use the average between the average of the Corwin and Schultz (2012) and the Abdi and Ranaldo (2017) for each currency to measure the proxy for individual liquidity.

In Table C1, we have the regression of the price change to the factors I used in the model in Table 3.7 for the highest tail of the quantile. We can see that the effect of the illiquidity differs from the previous one, with significance for TUSD, BUSD, and USTC in 95%, while it was significant for the USDT, USDP, USDC, and DAI. The difference in the significance in comparison tells us that because there is no overlap in relevance, that for the last, the liquidity of USDT is meaningful in explaining the variations in their prices. It is not valid for the ones in which the individual liquidity and idiosyncratic shocks are significant rather than the effect of the dominant currency. Concerning the other factors, the stability and significance of the variables did not change.

In the lower tail, for percentiles 5% and 1% of the distribution, we can compare Tables

Table C1. Stablecoin: Quantile Regression Higher Tail

	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity U
	Stablecoins: 95% Percentile									
TERRA	−0.0004***	−0.003***	0.001**	−0.003***	−0.0003	−0.01***	−0.003***	0.21***	−0.005	−0.01
	(0.0001)	(0.0003)	(0.001)	(0.0003)	(0.0004)	(0.001)	(0.001)	(0.03)	(0.003)	(0.003
STBL	1.04***	0.75***	0.77***	0.74***	1.02***	0.45***	1.79*	1.32	22.95***	11.36*
	(0.01)	(0.06)	(0.07)	(0.02)	(0.05)	(0.13)	(1.03)	(0.83)	(3.67)	(4.21
ILISTL	−0.001	0.02***	0.003	0.002	−0.01**	0.01	−0.01	0.09***	0.01	0.01
	(0.001)	(0.004)	(0.01)	(0.003)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01
DILICRYP	0.001***	0.004***	−0.001	0.0002	−0.0005	−0.001	0.003*	0.001	−0.002	0.01*
	(0.0001)	(0.001)	(0.001)	(0.0005)	(0.0003)	(0.002)	(0.002)	(0.001)	(0.003)	(0.01
CRYPT	−0.001	−0.004	0.001	0.0003	0.01***	−0.04**	−0.04***	0.001	−0.03	−0.0
	(0.001)	(0.004)	(0.005)	(0.003)	(0.003)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03
ER	−0.01	0.04	−0.06	−0.12	−0.19	−0.64**	0.65**	0.06	1.11	1.94*
	(0.02)	(0.11)	(0.20)	(0.09)	(0.14)	(0.27)	(0.30)	(0.80)	(0.85)	(0.88
HKML2	0.001	−0.01	0.001	0.004	−0.002	0.03**	−0.03	0.02	−0.08*	−0.0
	(0.001)	(0.01)	(0.01)	(0.004)	(0.004)	(0.01)	(0.02)	(0.04)	(0.04)	(0.03
CBECI	−0.002	−0.01	−0.01	−0.002	−0.01	−0.05*	0.05***	0.05	0.01	−0.0
	(0.002)	(0.01)	(0.01)	(0.005)	(0.01)	(0.02)	(0.02)	(0.04)	(0.05)	(0.06
TBILL	0.0003	−0.002	−0.02**	−0.001	0.001	−0.002	−0.01	−0.05	−0.02	−0.0
	(0.001)	(0.003)	(0.01)	(0.002)	(0.004)	(0.01)	(0.01)	(0.08)	(0.02)	(0.01
10YB	−0.001	0.001	0.001	−0.001	0.0001	−0.0003	−0.001	0.01	0.01	−0.0
	(0.001)	(0.002)	(0.005)	(0.001)	(0.002)	(0.005)	(0.005)	(0.03)	(0.02)	(0.02
TERRA x STBL	−1.12***	−0.62**	−0.43	−0.81***	−1.03***	−0.03	−1.38	40.60***	−23.00***	−11.1
	(0.11)	(0.25)	(0.35)	(0.11)	(0.14)	(0.38)	(1.06)	(5.94)	(3.72)	(4.70
Constant	0.001***	0.004***	0.004***	0.003***	0.002***	0.01***	0.01***	0.01***	0.02***	0.01**
	(0.0000)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.001)	(0.001)	(0.001)	(0.003)	(0.00
	Stablecoins 99% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity U
TERRA	−0.001***	−0.01***	0.005***	−0.01***	−0.002**	−0.01***	−0.01	0.42***	−0.01***	−0.01*
	(0.0001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.004)	(0.01)	(0.03)	(0.004)	(0.003
STBL	1.03***	0.63***	0.78***	0.79***	0.95***	0.17	11.19	−0.05	34.46***	33.00*
	(0.01)	(0.17)	(0.07)	(0.06)	(0.09)	(0.30)	(7.37)	(1.66)	(1.37)	(5.60
ILISTL	0.003**	0.02	0.004**	0.01	−0.01	0.01	−0.02	0.02	0.01	0.003
	(0.001)	(0.02)	(0.002)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01
DILICRYP	0.002***	0.01*	−0.001	−0.0001	−0.0002	−0.004	−0.0002	−0.001	−0.005	0.02**
	(0.0005)	(0.003)	(0.001)	(0.001)	(0.001)	(0.004)	(0.01)	(0.004)	(0.003)	(0.005
CRYPT	−0.002	−0.01	−0.002	−0.01	0.01	−0.05	−0.06	0.02	−0.02	0.13**
	(0.002)	(0.02)	(0.01)	(0.01)	(0.01)	(0.05)	(0.05)	(0.03)	(0.03)	(0.04
ER	0.05	−0.02	−0.18	−0.13	−0.22	−0.79	−1.24	−1.59	1.37	3.42**
	(0.04)	(0.75)	(0.48)	(0.28)	(0.52)	(0.70)	(2.18)	(1.90)	(0.95)	(1.09
HKML2	0.0002	−0.004	−0.005	−0.004	0.01	0.07**	−0.09	0.14	−0.21***	−0.0
	(0.002)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.08)	(0.09)	(0.06)	(0.05
CBECI	−0.003	0.02	−0.01	−0.02	−0.03	−0.06	0.06	0.04	0.05	−0.26
	(0.003)	(0.04)	(0.02)	(0.02)	(0.03)	(0.08)	(0.10)	(0.10)	(0.10)	(0.11
TBILL	0.002	0.02	−0.03*	−0.002	0.002	−0.02	−0.04	0.15	0.01	0.05*
	(0.001)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.19)	(0.04)	(0.03
10YB	−0.001	−0.005	0.003	−0.001	−0.01	−0.004	0.04	0.05	0.03	−0.07
	(0.001)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.07)	(0.04)	(0.03
TERRA x STBL	−1.07***	−0.28	−0.12	−0.92***	−0.87	0.66	−10.42	59.08***	−34.27***	−33.17
	(0.06)	(0.82)	(0.65)	(0.28)	(0.59)	(1.92)	(7.34)	(3.92)	(1.53)	(6.67
Constant	0.001***	0.01***	0.01***	0.01***	0.01***	0.02***	0.02***	0.01***	0.03***	0.03**
	(0.0001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)	(0.00
N	1,434	1,153	1,014	1,008	783	742	481	501	419	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Bar and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with a 1000 replications. Significance is given by *p **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

3.8 and C2. The results show that the individual illiquidity becomes relevant for the BUSD and USTC and remains significant for the USDT for the 5%. While in the lowest percentile, the illiquidity in USDC and USTC becomes relevant, while for TUSD, it is no longer the case. For the other stablecoins, the results remain similar in the significance of the variables as well as the magnitude of the coefficient. The overall results imply that there are factors, like illiquidity, that should be treated as individual factors rather than aggregate on an index that may outweigh the dominant currencies. In the previous case, illiquidity was deemed a factor that affected only the variables in the higher tail. At the same time, there are consistent results that show the significance of illiquidity in explaining both tails for some currencies.

Table C2. Stablecoin: Quantile Regression Lower Tail

	Stablecoins: 5% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	0.0004***	0.002***	−0.001	0.003***	0.001**	0.01***	0.01***	−0.16***	−0.001	0.004***
	(0.0001)	(0.0004)	(0.001)	(0.0003)	(0.0003)	(0.001)	(0.001)	(0.02)	(0.002)	(0.002)
STBL	1.02***	0.62***	0.73***	0.60***	0.97***	0.45***	1.98***	1.02	5.91***	10.87***
	(0.004)	(0.06)	(0.05)	(0.04)	(0.04)	(0.11)	(0.37)	(1.03)	(1.31)	(2.34)
ILISTL	−0.002**	−0.0003	−0.004	−0.003	−0.01***	−0.002	0.002	0.12***	−0.01	0.004
	(0.001)	(0.01)	(0.01)	(0.004)	(0.004)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)
DILICRYP	−0.0001	−0.003**	−0.001	−0.002***	−0.0002	0.003***	−0.0003	0.002	−0.01**	−0.0002
	(0.0001)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.002)	(0.002)	(0.005)	(0.002)
CRYPT	0.002**	0.02***	0.02***	0.01	0.01**	−0.03***	−0.01	0.01	−0.03*	−0.02
	(0.001)	(0.01)	(0.005)	(0.004)	(0.003)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
ER	−0.02	0.24	0.02	0.05	0.21	0.49	0.59	−1.09	−0.02	1.33*
	(0.02)	(0.15)	(0.16)	(0.08)	(0.13)	(0.35)	(0.43)	(1.04)	(0.84)	(0.75)
HKML2	−0.002*	−0.02**	−0.02**	−0.01**	−0.01***	−0.02**	0.04**	0.11	0.07**	−0.04
	(0.001)	(0.01)	(0.01)	(0.003)	(0.003)	(0.01)	(0.02)	(0.07)	(0.03)	(0.04)
CBECI	0.001	−0.004	−0.01	0.001	0.004	0.04*	−0.02	−0.02	−0.19***	0.06
	(0.001)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.06)	(0.06)	(0.05)
TBILL	0.001	−0.004	−0.01	−0.001	−0.0000	0.01	0.01	−0.07	0.003	0.01
	(0.001)	(0.004)	(0.01)	(0.002)	(0.002)	(0.01)	(0.01)	(0.11)	(0.02)	(0.02)
10YB	0.0005	−0.0004	0.002	0.003	−0.004**	0.004	−0.01	0.02	0.001	0.001
	(0.0005)	(0.003)	(0.005)	(0.002)	(0.002)	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)
TERRA x STBL	−1.00***	−0.64**	0.27	−0.37***	−0.78***	−0.36**	−0.35	151.57***	−6.46***	−11.35***
	(0.06)	(0.26)	(0.46)	(0.12)	(0.15)	(0.17)	(1.30)	(19.04)	(1.65)	(2.48)
Constant	−0.001***	−0.004***	−0.004***	−0.004***	−0.002***	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***
	(0.0000)	(0.0004)	(0.0003)	(0.0003)	(0.0002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	Stablecoins 1% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	0.001***	0.01***	0.0000	0.01***	0.001*	0.01	0.01***	−0.30***	−0.002	0.01
	(0.0003)	(0.001)	(0.001)	(0.001)	(0.0005)	(0.01)	(0.001)	(0.003)	(0.01)	(0.01)
STBL	1.01***	0.65***	0.63***	0.50***	0.95***	0.64	2.09***	1.46	−1.73***	21.69***
	(0.02)	(0.08)	(0.07)	(0.04)	(0.04)	(0.46)	(0.30)	(1.06)	(0.53)	(4.10)
ILISTL	−0.01	−0.01	−0.01	−0.01***	−0.02	−0.01	−0.01	0.05***	0.02	−0.02
	(0.003)	(0.02)	(0.005)	(0.002)	(0.01)	(0.01)	(0.01)	(0.004)	(0.01)	(0.02)
DILICRYP	−0.0001	−0.01***	−0.002	−0.01*	0.001	−0.001	−0.002	0.003	−0.03***	0.01
	(0.0004)	(0.002)	(0.002)	(0.01)	(0.001)	(0.01)	(0.002)	(0.002)	(0.01)	(0.01)
CRYPT	0.01***	0.02***	0.02**	0.01**	0.01	−0.08*	−0.04***	0.03*	−0.001	−0.07
	(0.002)	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.01)	(0.02)	(0.06)	(0.06)
ER	−0.05	0.91*	−0.23	−0.25	0.39**	2.08	−0.61	−0.86	4.14**	3.80
	(0.07)	(0.52)	(0.40)	(0.26)	(0.16)	(2.39)	(0.67)	(0.81)	(2.04)	(2.92)
HKML2	−0.0002	0.01	−0.02*	−0.02*	−0.01	0.02	0.11***	0.17***	0.10	−0.04
	(0.003)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.01)	(0.04)	(0.07)	(0.10)
CBECI	0.01***	0.004	0.02	0.04**	0.01	0.10	−0.08***	0.01	−0.32***	−0.03
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.08)	(0.02)	(0.04)	(0.06)	(0.10)
TBILL	0.0001	0.002	−0.003	−0.002	0.01**	−0.01	−0.001	−0.003	0.05	0.04
	(0.004)	(0.01)	(0.02)	(0.01)	(0.005)	(0.03)	(0.01)	(0.03)	(0.03)	(0.05)
10YB	0.004**	0.003	−0.01	0.02**	−0.004	0.01	−0.01	0.06**	−0.02	−0.08
	(0.002)	(0.01)	(0.01)	(0.01)	(0.003)	(0.03)	(0.01)	(0.02)	(0.03)	(0.05)
TERRA x STBL	−0.76***	−1.03	−0.27	0.42	−0.86***	−0.93	0.91	163.07***	−0.31	−22.23***
	(0.26)	(0.76)	(0.72)	(0.75)	(0.17)	(1.33)	(1.11)	(5.42)	(2.25)	(4.31)
Constant	−0.002***	−0.01***	−0.01***	−0.01***	−0.004***	−0.02***	−0.02***	−0.01***	−0.02***	−0.03***
	(0.0001)	(0.001)	(0.0004)	(0.0004)	(0.0004)	(0.003)	(0.0004)	(0.002)	(0.002)	(0.004)
N	1,434	1,153	1,014	1,008	783	742	481	501	419	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Barrodale and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with 1000 replications. Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

Appendix D: Quantile Regression with same sample size

In this section, I will compare the results if we change the sample and reduce it to the minimum to have a balanced panel of stablecoins. The span became smaller as the start of the data went from January 2017 to May 2021, from a total of 1510 data points to 419. If we compare the results from the linear regression, we can see that the results change considerably from Table 3.4 to Table D1. Stablecoin exposure to the market is reduced, where a change of one percent from the Stablecoin market passes from 1.02 to o.64 or Binance from 0.98 to 0.56, a reduction of almost a half. However, this is not the case for Fei and Frax, which increase their sensitivity from 1.74 to 3.89 and 7.59 to 8.45. The change after the Terra crash remains the same. If we compare both fits, we can see that it is considerably reduced compared to the one with the unbalanced panel structure.

Table D1. Stablecoin Regression with Balanced Sample

	Stablecoins									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
α	0.00	−0.00	0.00	−0.00	0.00	−0.00	0.00	0.00	−0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TERRA	−0.00	0.00	0.00	0.00	−0.00	0.00	−0.00	−0.01	0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
STBL	0.64^{***}	0.47^{***}	0.64^{***}	0.63^{***}	0.56^{***}	1.69^{**}	3.89^{***}	−1.26	8.45^{***}	8.13^{***}
	(0.13)	(0.16)	(0.25)	(0.12)	(0.12)	(0.75)	(1.13)	(3.32)	(2.55)	(2.33)
ILISTL	−0.00	0.00^{*}	−0.00	0.00^{***}	0.01^{***}	0.00	-0.02^{***}	0.08	−0.01	-0.01^{*}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.12)	(0.01)	(0.01)
DILICRYP	−0.00	0.00^{*}	0.00	0.00	−0.00	0.00	0.00	−0.01	-0.00^{**}	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
CRYPT	0.00^{*}	−0.00	−0.00	0.00	−0.00	-0.00^{**}	-0.02^{***}	−0.01	-0.02^{***}	-0.03^{***}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.07)	(0.01)	(0.01)
ER	−0.01	0.04^{*}	0.04	0.02^{*}	−0.01	0.15	0.09	−3.79	−0.03	0.24
	(0.01)	(0.02)	(0.06)	(0.01)	(0.04)	(0.10)	(0.20)	(4.28)	(0.24)	(0.29)
HKML2	0.00	−0.00	0.00	−0.00	−0.00	−0.00	-0.02^{*}	0.33	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.24)	(0.01)	(0.02)
CBECI	−0.00	0.00	−0.00	0.00	0.00^{*}	−0.00	0.01	−0.17	0.01	−0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.19)	(0.02)	(0.03)
TBILL	0.00^{*}	−0.00	−0.00	−0.00	−0.00	0.00	−0.01	-0.21^{***}	0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.07)	(0.01)	(0.01)
B10Y	0.00	0.00	−0.00	−0.00	0.00	−0.00	0.01^{*}	0.07	-0.01^{*}	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.05)	(0.00)	(0.01)
TERRA x STBL	-0.70^{***}	-0.44^{***}	-0.46^{*}	-0.62^{***}	-0.54^{***}	-1.60^{**}	-3.61^{***}	69.24^{***}	-8.33^{***}	-8.12^{***}
	(0.13)	(0.16)	(0.25)	(0.12)	(0.13)	(0.76)	(1.15)	(17.40)	(2.56)	(2.31)
R^2	0.37	0.13	0.04	0.35	0.12	0.17	0.10	0.48	0.23	0.15
Adj. R^2	0.35	0.10	0.01	0.33	0.09	0.15	0.07	0.46	0.21	0.13
Num. obs.	397	397	397	397	397	397	397	397	397	397

Note: The model is estimated following Newey and West (1987) with an optimal lag selection of Newey and West (1994). Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

In Table D1, I present the results of the quantile regression model for the higher parts of the tail that correspond to the higher price changes. If we compare the results to Table **??**, we can conclude that, in general, the sensitivity of most of the stablecoins has reduced compared to the different-size samples. For Tether, it goes from a sensibility of 1.04 with respect to the change in the Stablecoin portfolio and is no longer relevant in explaining the Pax Dollar price movements. On the other hand, Frax and Dai are affected by the

Stablecoin index, either becoming relevant or exhibiting a higher elasticity. One specific outcome is that the reduction occurs at the 95th percentile, but the change in the 99th percentile, about the values of the entire sample, is smaller.

In Table D3, we can observe the results for the quantile regression with the homogeneous sample. Comparing these results to those in Table 3.8, we find that the overall results differ in the higher tail. Specifically, Pax Dollar and True USD show no statistical evidence of dependence on the Stablecoin Index, while Tether experiences a significant reduction and Fei USD undergoes a sign change. On the other hand, Binance, Dai, and Frax exhibit increases in their exposure to changes in STBL values in the 1st percentile. These stablecoins demonstrate a high sensitivity to market changes, resulting in price decreases that surpass even more established stablecoins like Tether. This suggests that these newer currencies carry a higher risk premium and are more susceptible to losses in extreme events.

Table D2. Stablecoin: Quantile Regression Higher Tail

	Stablecoins: 95% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	−0.0002***	0.0002*	0.003***	−0.0004***	0.0003**	−0.001**	−0.002**	0.22***	0.003	−0.01**
	(0.0000)	(0.0001)	(0.001)	(0.0001)	(0.0002)	(0.001)	(0.001)	(0.04)	(0.002)	(0.002)
STBL	0.60***	0.56***	−0.13	0.41***	0.63***	2.23**	4.03**	1.67	11.03***	11.25**
	(0.04)	(0.11)	(0.41)	(0.11)	(0.18)	(0.88)	(1.92)	(1.17)	(2.43)	(4.54)
ILISTL	0.003	0.004	−0.01	0.005	0.01*	−0.004*	0.03	−0.01	−0.03	−0.04
	(0.01)	(0.01)	(0.04)	(0.004)	(0.01)	(0.002)	(0.07)	(0.03)	(0.03)	(0.08)
DILICRYP	0.0003*	0.001**	−0.001	0.0000	0.0001	0.001	0.002	0.001	−0.001	0.01
	(0.0002)	(0.001)	(0.001)	(0.0002)	(0.0002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.01)
CRYPT	0.001*	0.0004	−0.003	−0.001**	−0.0002	−0.01	−0.04**	0.01	−0.03***	−0.05*
	(0.0004)	(0.002)	(0.01)	(0.0005)	(0.001)	(0.004)	(0.02)	(0.01)	(0.01)	(0.03)
ER	0.001	0.09	0.32**	0.03	0.12	0.04	0.67*	−1.00*	0.66	1.64**
	(0.02)	(0.05)	(0.16)	(0.03)	(0.07)	(0.12)	(0.34)	(0.60)	(0.53)	(0.67)
HKML2	0.001	−0.003	−0.01	−0.003***	0.002	0.001	−0.02	0.04	−0.04	−0.01
	(0.001)	(0.002)	(0.01)	(0.001)	(0.003)	(0.01)	(0.02)	(0.03)	(0.03)	(0.03)
CBECI	−0.0005	0.001	0.01	−0.002	0.005	−0.005	0.02	−0.002	0.03	−0.07
	(0.001)	(0.004)	(0.01)	(0.002)	(0.003)	(0.01)	(0.03)	(0.03)	(0.03)	(0.05)
TBILL	0.0001	0.001	−0.004	0.0000	0.004**	0.001	−0.02	0.001	−0.02	−0.01
	(0.0003)	(0.002)	(0.01)	(0.001)	(0.002)	(0.003)	(0.01)	(0.04)	(0.02)	(0.02)
10YB	0.001*	−0.0001	−0.004	−0.0000	−0.005**	−0.001	0.0004	0.01	0.004	−0.03
	(0.0003)	(0.001)	(0.005)	(0.0004)	(0.002)	(0.002)	(0.01)	(0.02)	(0.01)	(0.02)
TERRA x STBL	−0.69***	−0.49***	0.49	−0.43***	−0.58***	−2.13**	−3.67*	47.06***	−10.98***	−11.48**
	(0.04)	(0.12)	(0.49)	(0.12)	(0.18)	(0.89)	(2.20)	(5.38)	(2.45)	(4.66)

	Stablecoins 99% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	−0.0003***	0.001*	0.01***	−0.001**	−0.0002	−0.01***	−0.01***	0.45***	0.003	−0.01***
	(0.0001)	(0.0003)	(0.001)	(0.0002)	(0.0003)	(0.001)	(0.004)	(0.04)	(0.003)	(0.004)
STBL	0.61***	0.68**	0.96	0.80***	1.44***	5.04***	18.91***	3.57	18.59***	32.20***
	(0.06)	(0.29)	(2.08)	(0.20)	(0.47)	(0.87)	(3.17)	(2.34)	(2.46)	(6.58)
ILISTL	0.003	−0.002	−0.02	0.005***	0.01	0.01	0.05	−0.02	0.01	0.02
	(0.01)	(0.01)	(0.13)	(0.002)	(0.01)	(0.02)	(0.12)	(0.32)	(0.08)	(0.32)
DILICRYP	0.001**	0.001*	0.01***	0.0002	0.0002	−0.001	0.001	−0.0004	−0.002	0.02**
	(0.0003)	(0.001)	(0.002)	(0.0001)	(0.001)	(0.001)	(0.004)	(0.01)	(0.004)	(0.01)
CRYPT	0.002*	0.0004	−0.002	−0.001***	−0.0003	−0.01	−0.04	0.002	0.03	0.12**
	(0.001)	(0.004)	(0.01)	(0.0003)	(0.002)	(0.01)	(0.04)	(0.03)	(0.04)	(0.05)
ER	−0.09**	0.03	0.44	−0.07	0.10	0.58	−0.17	−1.14	−1.11	3.14**
	(0.04)	(0.11)	(0.65)	(0.12)	(0.15)	(0.43)	(1.41)	(1.12)	(1.56)	(1.54)
HKML2	0.002	−0.004	−0.001	−0.001	−0.0001	−0.02*	−0.04	0.05	−0.12**	−0.10
	(0.002)	(0.004)	(0.02)	(0.003)	(0.005)	(0.01)	(0.06)	(0.07)	(0.06)	(0.08)
CBECI	−0.0001	0.01**	0.07*	0.0003	0.01	−0.01	0.06	0.02	0.04	−0.27*
	(0.002)	(0.01)	(0.03)	(0.001)	(0.01)	(0.02)	(0.06)	(0.08)	(0.10)	(0.14)
TBILL	0.0004	−0.003	−0.02	−0.001	0.004	−0.01	−0.01	0.09	0.02	0.04
	(0.001)	(0.003)	(0.02)	(0.001)	(0.004)	(0.01)	(0.02)	(0.16)	(0.03)	(0.04)
10YB	0.001**	−0.002	−0.0002	0.0003	−0.01***	0.002	0.01	0.02	0.01	−0.06*
	(0.0005)	(0.003)	(0.01)	(0.001)	(0.002)	(0.01)	(0.02)	(0.06)	(0.03)	(0.04)
TERRA x STBL	−0.69***	−0.56*	−0.33	−0.86***	−1.73***	−4.90***	−18.44***	58.01***	−18.38***	−32.39***
	(0.08)	(0.34)	(2.39)	(0.18)	(0.49)	(0.82)	(3.12)	(7.26)	(2.64)	(7.76)
N	397	397	397	397	397	397	397	397	397	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Barrodale and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with 1000 replications. Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

Table D3. Stablecoin: Quantile Regression Lower Tail

	Stablecoins: 5% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	0.0003***	0.0000	−0.002***	0.0003***	0.0000	0.001***	0.002**	−0.14***	−0.002	0.004***
	(0.0001)	(0.0001)	(0.0003)	(0.0001)	(0.0002)	(0.0003)	(0.001)	(0.02)	(0.001)	(0.002)
STBL	0.67***	0.62***	1.03***	0.66***	0.94***	1.50***	3.57***	0.93	8.92***	11.08***
	(0.07)	(0.11)	(0.36)	(0.11)	(0.32)	(0.41)	(1.35)	(0.90)	(1.63)	(1.93)
ILISTL	−0.001	0.004	−0.01	0.004	0.01	0.01	−0.05	0.01	−0.06	−0.07
	(0.002)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.10)	(0.03)	(0.09)	(0.14)
DILICRYP	−0.0003*	−0.0000	0.001	0.0001	0.0001	0.0002	0.001	−0.0005	−0.01**	−0.002
	(0.0002)	(0.0002)	(0.0003)	(0.0001)	(0.0002)	(0.0003)	(0.001)	(0.001)	(0.005)	(0.003)
CRYPT	0.001***	−0.001	−0.002	0.001	−0.001	−0.002	−0.004	0.01	−0.001	−0.04**
	(0.0003)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.01)	(0.01)	(0.01)	(0.02)
ER	−0.001	0.04	−0.32**	0.03	−0.07	0.20*	−0.23	−0.55	−0.56	0.99
	(0.02)	(0.04)	(0.13)	(0.02)	(0.10)	(0.12)	(0.30)	(0.46)	(0.44)	(0.68)
HKML2	0.0004	0.0002	0.01*	0.002*	−0.01	0.005	−0.01	0.04	0.04	−0.06
	(0.001)	(0.002)	(0.01)	(0.001)	(0.004)	(0.004)	(0.02)	(0.03)	(0.02)	(0.04)
CBECI	−0.001	−0.004	−0.01	0.003*	0.004	−0.002	0.02	0.01	−0.01	0.08*
	(0.001)	(0.003)	(0.01)	(0.002)	(0.01)	(0.01)	(0.02)	(0.03)	(0.04)	(0.05)
TBILL	0.0002	−0.001	−0.01**	−0.001	−0.003	0.001	−0.003	−0.02	−0.01	0.01
	(0.0004)	(0.001)	(0.004)	(0.001)	(0.003)	(0.002)	(0.01)	(0.05)	(0.02)	(0.02)
10YB	−0.001	0.0003	0.004	0.0002	−0.0005	−0.002	0.02**	0.01	0.01	0.0001
	(0.0003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.01)	(0.02)	(0.01)	(0.01)
TERRA x STBL	−0.71***	−0.62***	−0.30	−0.59***	−0.82**	−1.45***	−3.50**	142.18***	−9.69***	−11.35***
	(0.07)	(0.12)	(0.45)	(0.11)	(0.34)	(0.44)	(1.43)	(22.09)	(1.91)	(1.99)
	Stablecoins 1% Percentile									
	Tether	TrueUSD	Pax Dollar	USD Coin	Binance USD	Dai	Frax	TerraClassicUSD	Fei USD	Liquity USD
TERRA	−0.0003	0.001***	−0.005***	0.0004***	−0.0004***	0.005***	0.01***	−0.32***	−0.004	0.01
	(0.0004)	(0.0003)	(0.001)	(0.0001)	(0.0001)	(0.001)	(0.002)	(0.02)	(0.004)	(0.01)
STBL	0.59***	0.53	1.01	0.74***	1.24***	4.96***	7.32**	0.87	8.88**	24.66***
	(0.10)	(0.57)	(0.91)	(0.06)	(0.31)	(1.00)	(2.84)	(2.38)	(4.04)	(3.00)
ILISTL	−0.002***	0.01	−0.01	−0.004	−0.01	0.02	0.02	0.01	−0.06	0.06
	(0.001)	(0.004)	(0.03)	(0.01)	(0.02)	(0.02)	(0.11)	(0.18)	(0.12)	(0.22)
DILICRYP	−0.002***	0.0002	−0.0003	−0.0003**	−0.0002	0.002**	0.004**	0.002	−0.03***	0.01
	(0.001)	(0.001)	(0.001)	(0.0001)	(0.0003)	(0.001)	(0.002)	(0.004)	(0.01)	(0.01)
CRYPT	0.002	−0.01*	−0.01	−0.0001	−0.001	−0.0001	−0.01	0.02	−0.05	−0.05
	(0.004)	(0.004)	(0.01)	(0.0004)	(0.003)	(0.01)	(0.03)	(0.04)	(0.04)	(0.06)
ER	0.05	0.08	0.18	−0.08*	−0.36***	0.59**	−0.11	0.44	0.27	3.15
	(0.06)	(0.15)	(0.37)	(0.04)	(0.08)	(0.25)	(0.74)	(1.09)	(1.27)	(2.08)
HKML2	−0.001	0.003	−0.02	−0.003	−0.001	0.005	0.02	0.05	0.06	−0.05
	(0.003)	(0.003)	(0.01)	(0.002)	(0.003)	(0.01)	(0.02)	(0.07)	(0.05)	(0.07)
CBECI	0.001	−0.0000	−0.004	−0.001	−0.01*	−0.001	−0.07*	0.04	−0.09	0.01
	(0.01)	(0.01)	(0.02)	(0.002)	(0.01)	(0.02)	(0.04)	(0.08)	(0.08)	(0.08)
TBILL	0.01	−0.0003	−0.02***	0.001	0.01***	0.004	0.02	−0.01	0.04	0.04
	(0.003)	(0.002)	(0.01)	(0.001)	(0.001)	(0.004)	(0.01)	(0.09)	(0.05)	(0.05)
10YB	−0.001	−0.002	−0.001	−0.0004	−0.0003	−0.003	−0.003	0.02	−0.03	−0.08
	(0.001)	(0.002)	(0.01)	(0.001)	(0.002)	(0.003)	(0.01)	(0.03)	(0.02)	(0.05)
TERRA x STBL	−0.29***	−0.51	−0.92	−0.75***	−0.88**	−4.88***	−7.03***	148.63***	−10.06**	−25.42***
	(0.10)	(0.55)	(0.99)	(0.06)	(0.42)	(0.96)	(2.68)	(18.23)	(4.30)	(3.23)
N	397	397	397	397	397	397	397	397	397	397

Note: The model estimates the Koenker and Bassett (1978)' quantile regression using the Koenker and D'Orey (1987) simplex method based on the algorithm of Barrodale and Roberts (1974). The standard errors are computed using the Wild Bootstrap method of Feng et al. (2011) with 1000 replications. Significance is given by *p<0.1; **p<0.05; ***p<0.01. *Sources:* Author's Calculations.

Appendix E: Directional Predictability Test

In this section, I present the results of the Ljung-Box Q-Statistic test for directional predictability based on the stationary bootstrap of Politis and Romano (1994) as constructed in Han et al. (2016). These results complement the Cross-quantilogram in Section 3.4.3 to determine the lag significance of the four explanative variables: the Stablecoin Market Index (STBL), Cryptocurrency Market Index (CRYPTO), the Intermediary squared leverage of He et al. (2017) (HKML2), and the Iliquidity Index for the Stablecoins (ILIQSTL). It tests the null that

$$H_0 : \rho_\tau(1) = \rho_\tau(2) = ... = \rho_\tau(p) = 0 \tag{3.13}$$

for a lag $p \in T$. Then, the Alternate hypothesis is that for some lag $s \in p$, the relationship described in $\rho_\tau(s) \neq 0$. Then, under the alternative, directional predictability exists up to the lag s. The test uses the Ljung-Box statistic with the Q-statistic in Ljung and Box (1978), given by

$$Q_t(P) = T(T+2) \sum_{s=1}^{p} \frac{\hat{\rho}_\tau^2(s)}{T-s} \tag{3.14}$$

where T is the total number of data points. I will use the Portmanteau sup-version test statistic

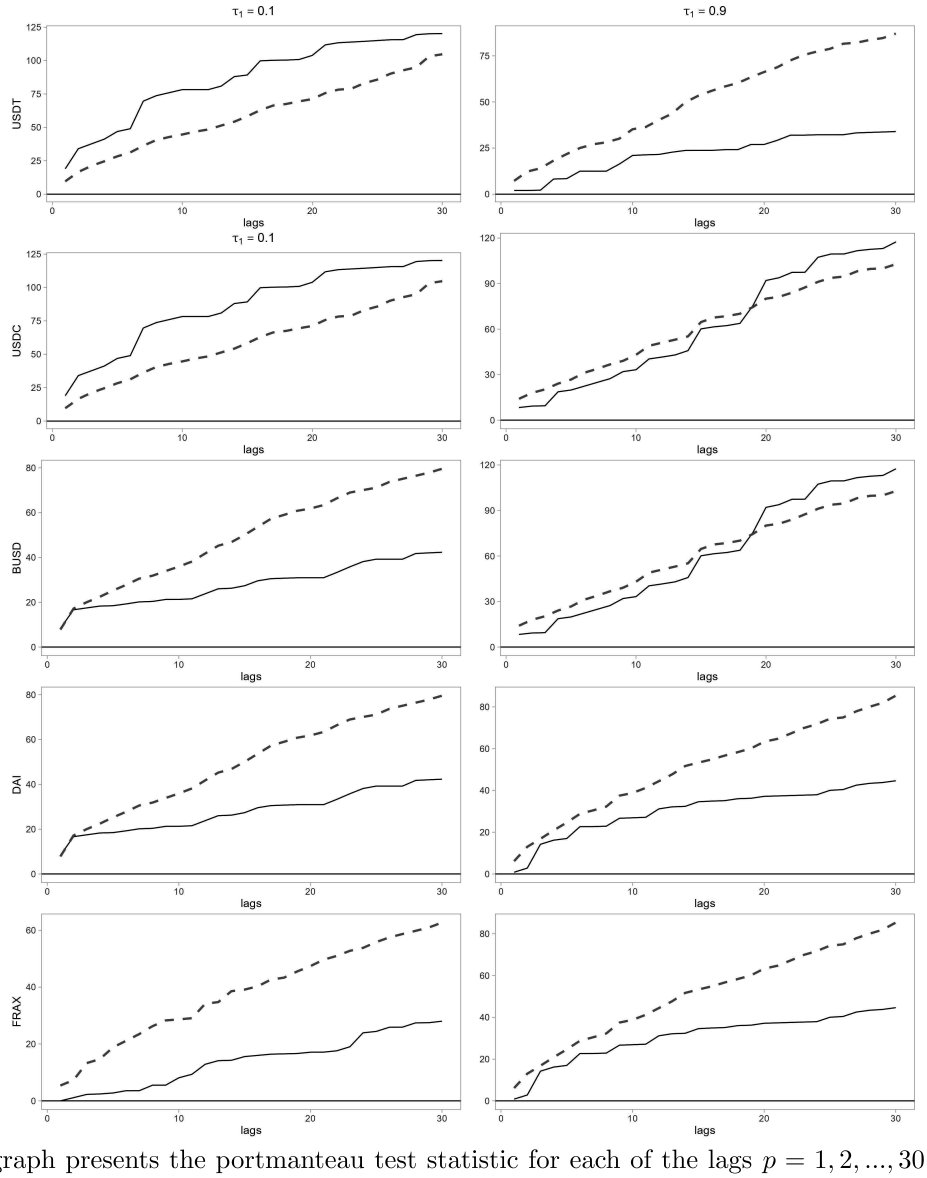
$$\sup_{\tau \in \Im} \hat{Q}_t(P) = \sup_{\tau \in \Im} T \sum_{s=1}^{p} \hat{\rho}_\tau^2(s) \tag{3.15}$$

The bootstrap confidence intervals for not predictability will be calculated using the automatic block-length selection of Politis and White (2004) and Patton et al. (2009).

I present the results of the Ljung-Box test statistics and their corresponding critical values in Figures E1 to E4. The empirical findings reveal insights into the predictive capabilities of various variables related to the higher tail price increments in the selected stablecoins. Notably, the results reject the hypothesis that the variables possess substantial predictive power for such price increases, except for cases involving the stablecoin and cryptocurrency markets variables. Price declines in both markets show statistical significance in explaining price surges in Tether and USD Coin. Strikingly, this predictive influence is more pronounced during the mid and latter segments of the month rather than recent periods. However, for Binance and Dai, the predictive power of the stablecoin market decreases corresponds primarily to the initial past week.

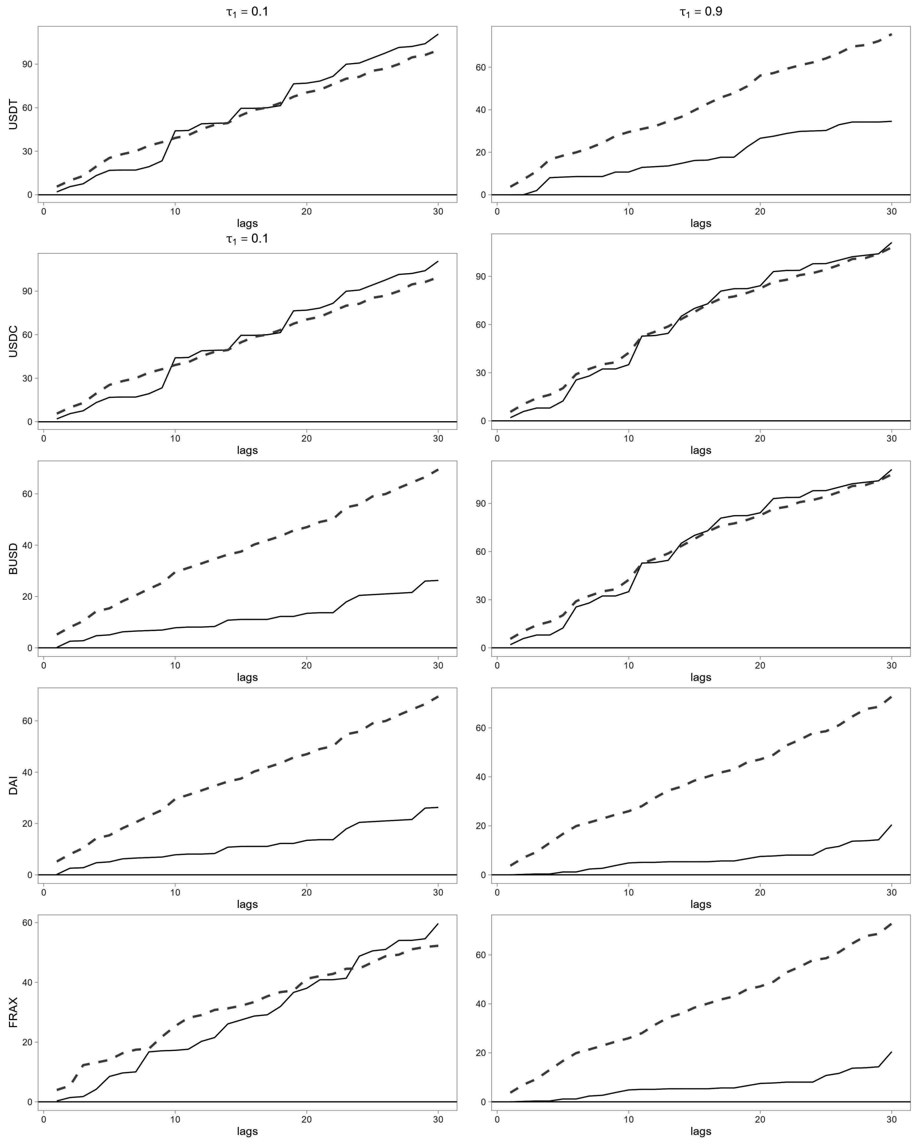
Additionally, the cryptocurrency market dynamics, particularly mid-to-late-month decreases, emerge as meaningful predictors for price upswings in FRAX. Notably, the He et al. (2017) index displays statistical significance solely when explaining heightened returns in Tether, predominantly when considering the upper percentiles of leverage. Surprisingly, the illiquidity measure exhibits limited predictive capacity to explain higher price increases in stablecoins, regardless of the tail distribution.

Figure E1. Directional Predictability Ljung-Box Sup-version test for the High Tail of the Stablecoins from the Stablecoin Market



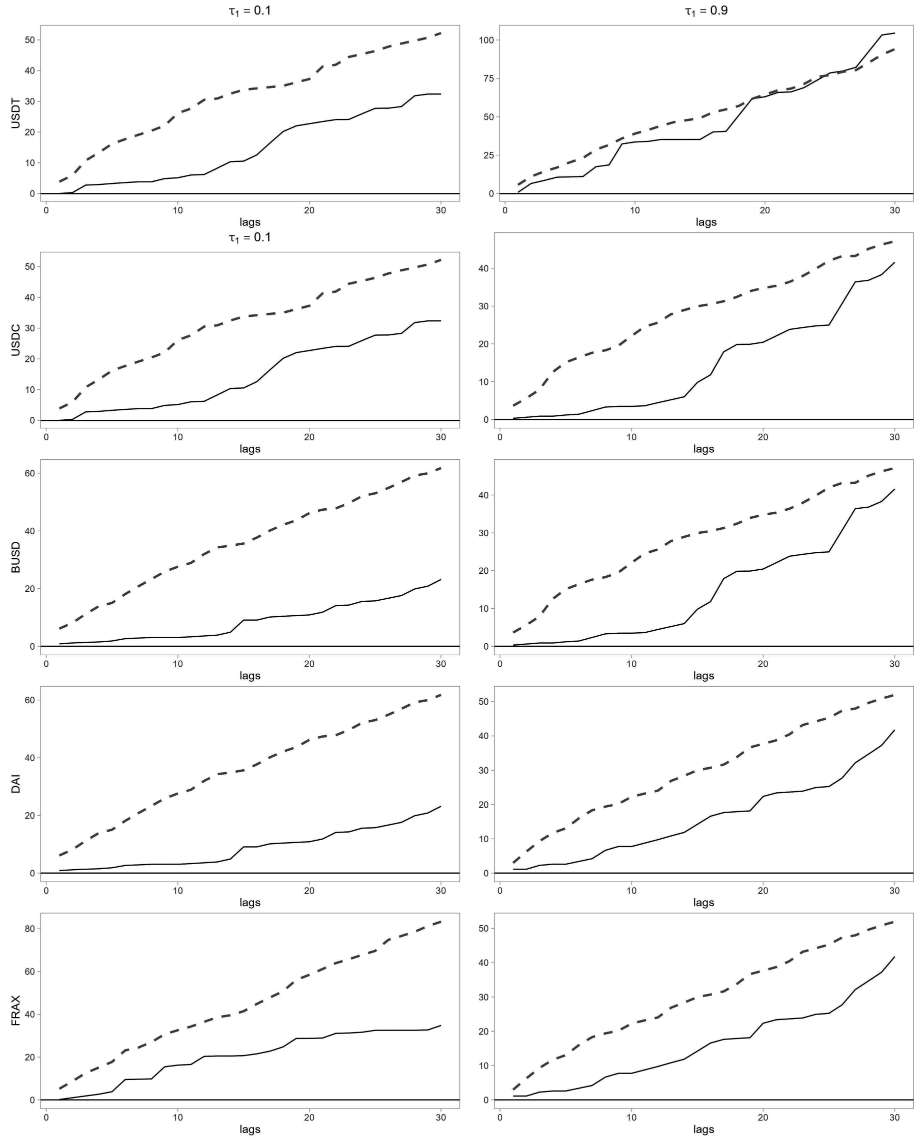
Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Stablecoin Index (STBL) to each of the Stablecoins deviations in the higher tail, such that $\tau_2 = 0.9$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure E2. Directional Predictability Ljung-Box Sup-version test for the high Tail of the Stablecoins from the Cryptocurrency Market



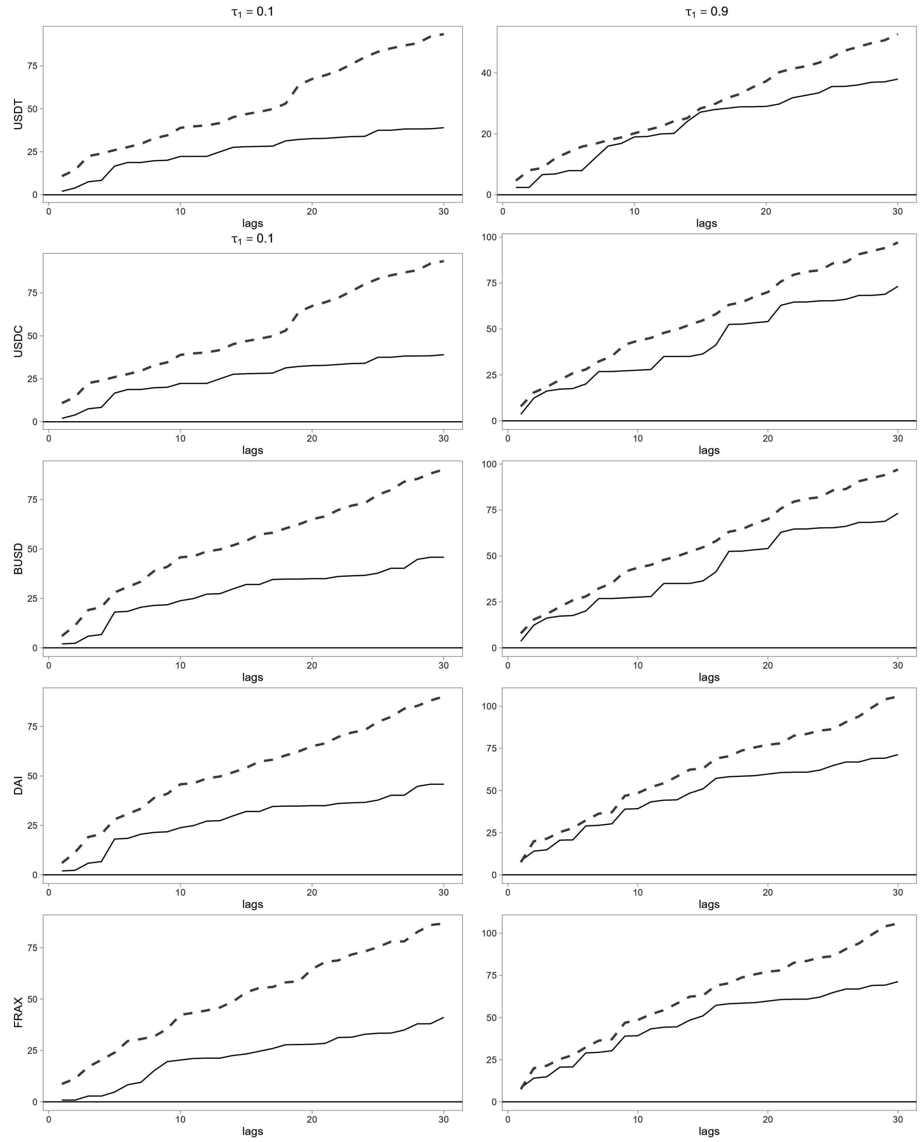
Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Cryptocurrency Index (CRYPT) to each of the Stablecoins deviations in the higher tail, such that $\tau_2 = 0.9$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure E3. Directional Predictability Ljung-Box Sup-version test for the high tail of the Stablecoins from Intermediary Leverage



Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Intermediary squared leverage of He et al. (2017) (HKML2) to each of the Stablecoins deviations in the higher tail, such that $\tau_2 = 0.9$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure E4. Directional Predictability Ljung-Box Sup-version test for the high tail of the Stablecoins from Stablecoins Iliquidity

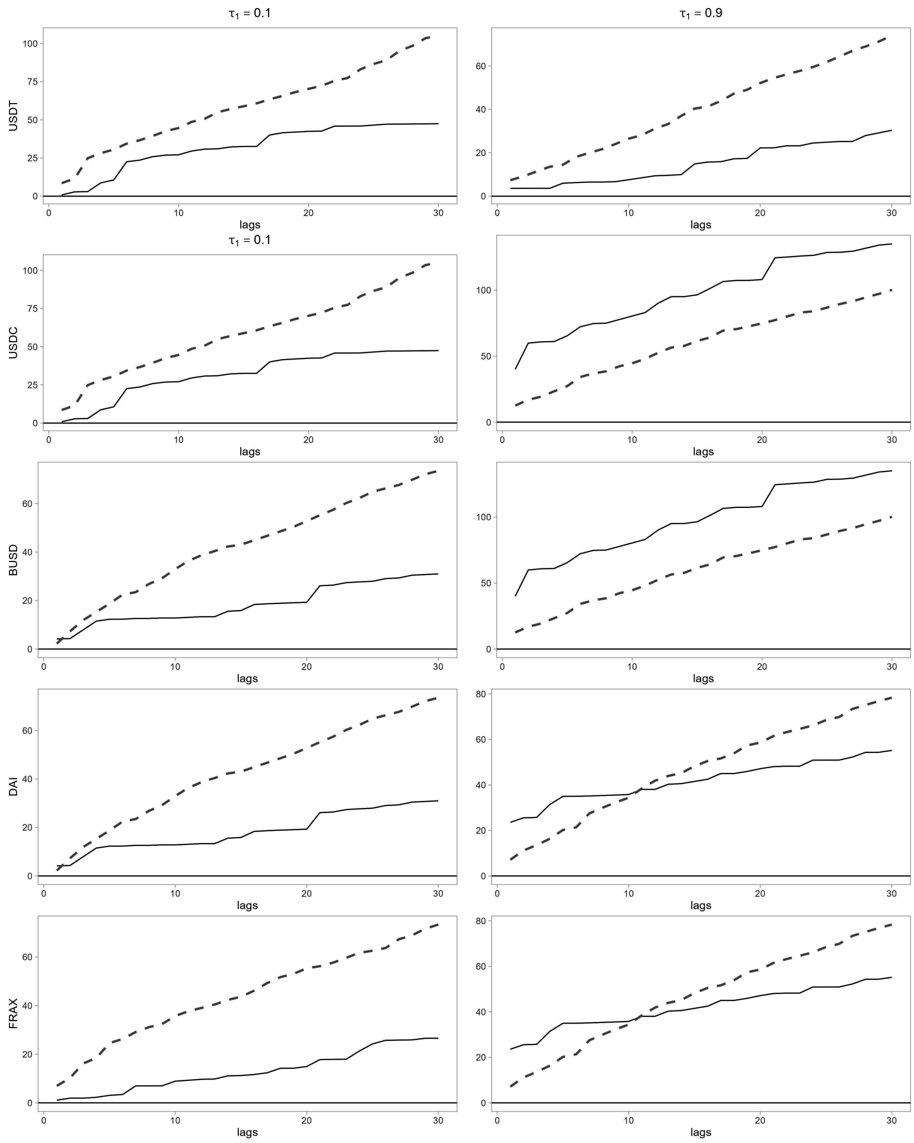


Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Iliquidity Index from the Stablecoins (ILIQSTL) to each of the Stablecoins deviations in the higher tail, such that $\tau_2 = 0.9$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

In the lower tails of the stablecoin distribution, in Figures E5 through E8, we can see a lack of uniformity in the observed effects compared to the higher tails. Notably, significant effects are primarily observed in the higher tails of the Stablecoin Market and the stablecoin illiquidity measure. In the case of the Stablecoin Market, the higher tail with quantile $\tau_1 = 0.9$ exhibits predictive power for increases in both Binance and USD Coin prices, while its influence on DAI and FRAX prices is more pronounced in the most recent days. Conversely, the illiquidity of stablecoins predicts decreases in stablecoin prices in the higher tail, particularly within the first week. Contrary to this, when examining the effects of the Cryptocurrency market index and intermediary leverage, I did not find any statistically significant evidence that suggests they predict changes in the lower tail prices of stablecoins.

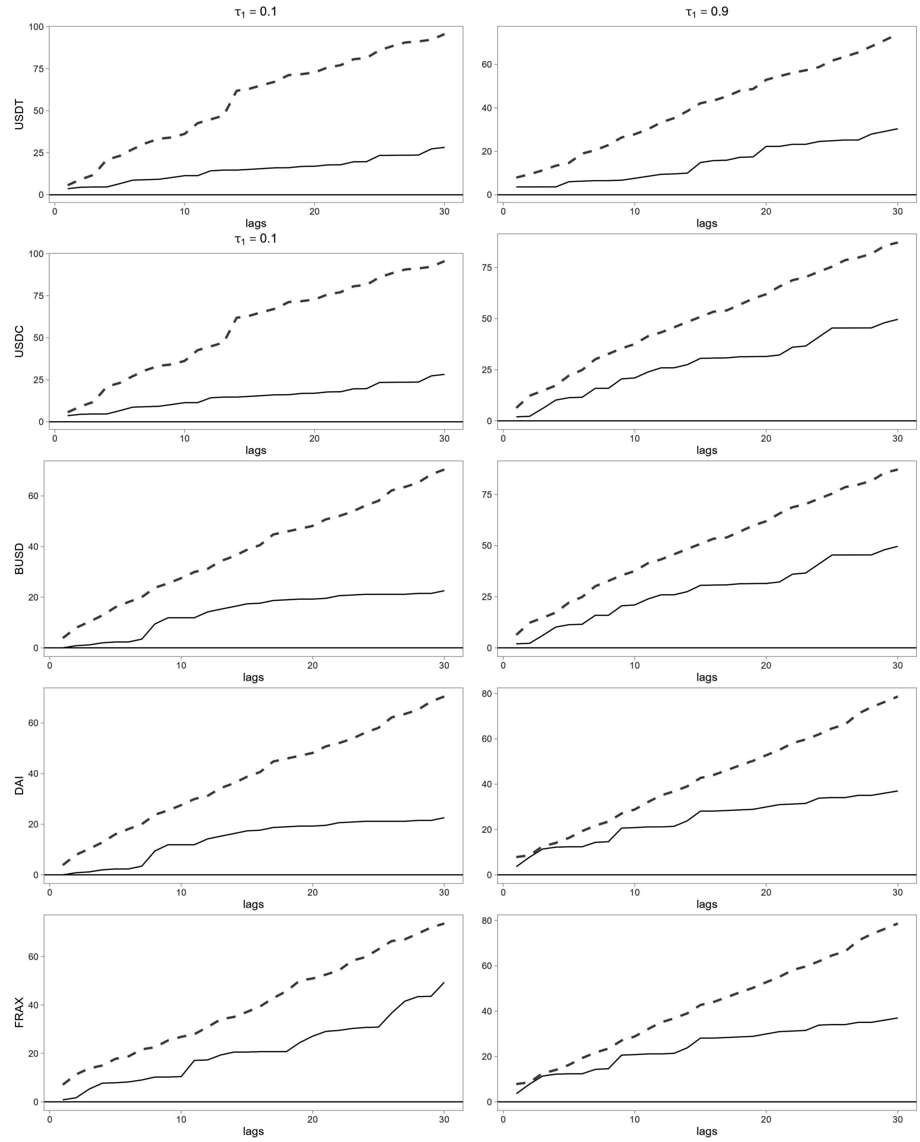
A critical pattern emerges in both tail results and is the inverse relationship between changes in stablecoin prices and their corresponding market indices. This result goes in hand with the mean-reverting behavior of the stabilization mechanism of the coins, designed to uphold parity with the USD. USD Coin exhibits the predictability of price increases of both market tails, while Binance exhibits price increases that correlate with higher increments in both cryptocurrencies and their respective market index. The illiquidity result is coherent with price declines, as a scarcity of available coins diminishes the attractiveness of stablecoins as safe-haven assets.

Figure E5. Directional Predictability Ljung-Box Sup-version test for the Lower Tail of the Stablecoins from the Stablecoin Market



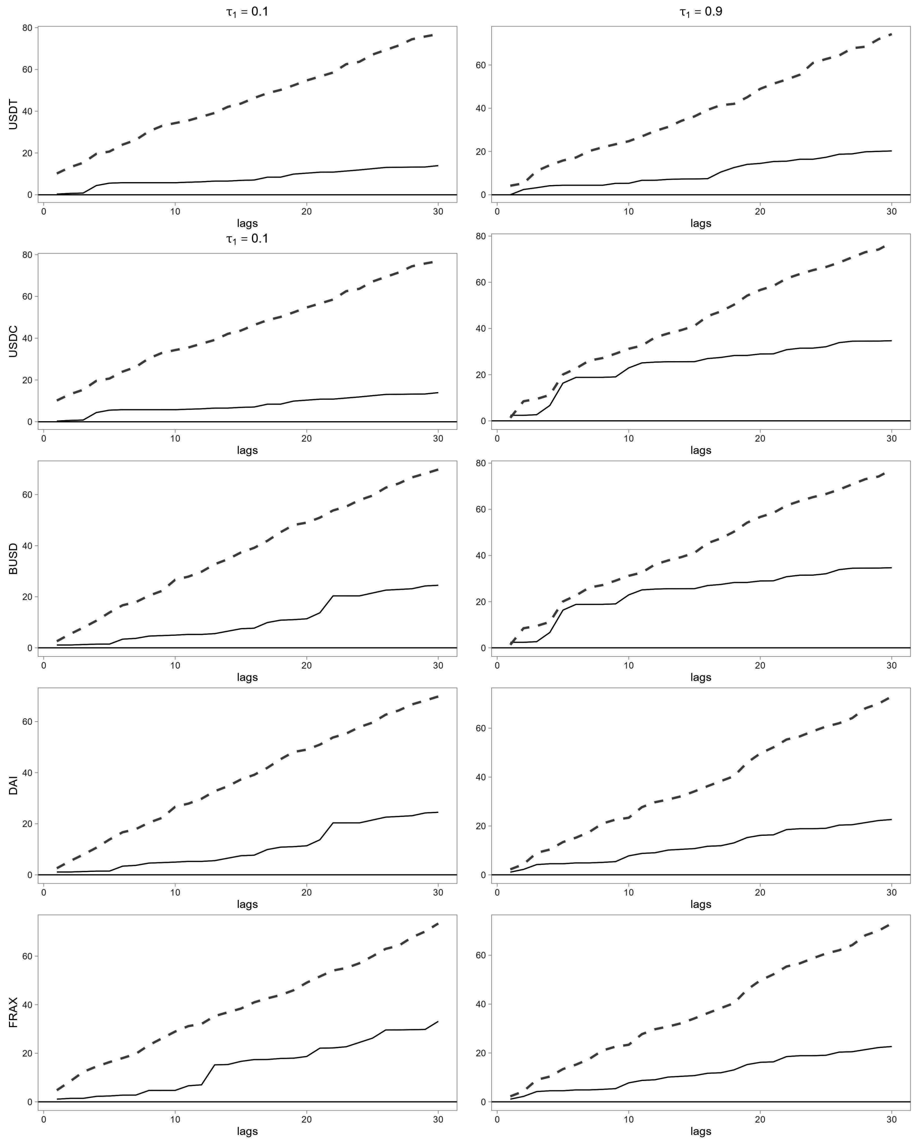
Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Stablecoin Index (STBL) to each of the Stablecoins deviations in the lower tail, such that $\tau_2 = 0.1$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure E6. Directional Predictability Ljung-Box Sup-version test for the Low Tail of the Stablecoins from the Cryptocurrency Market



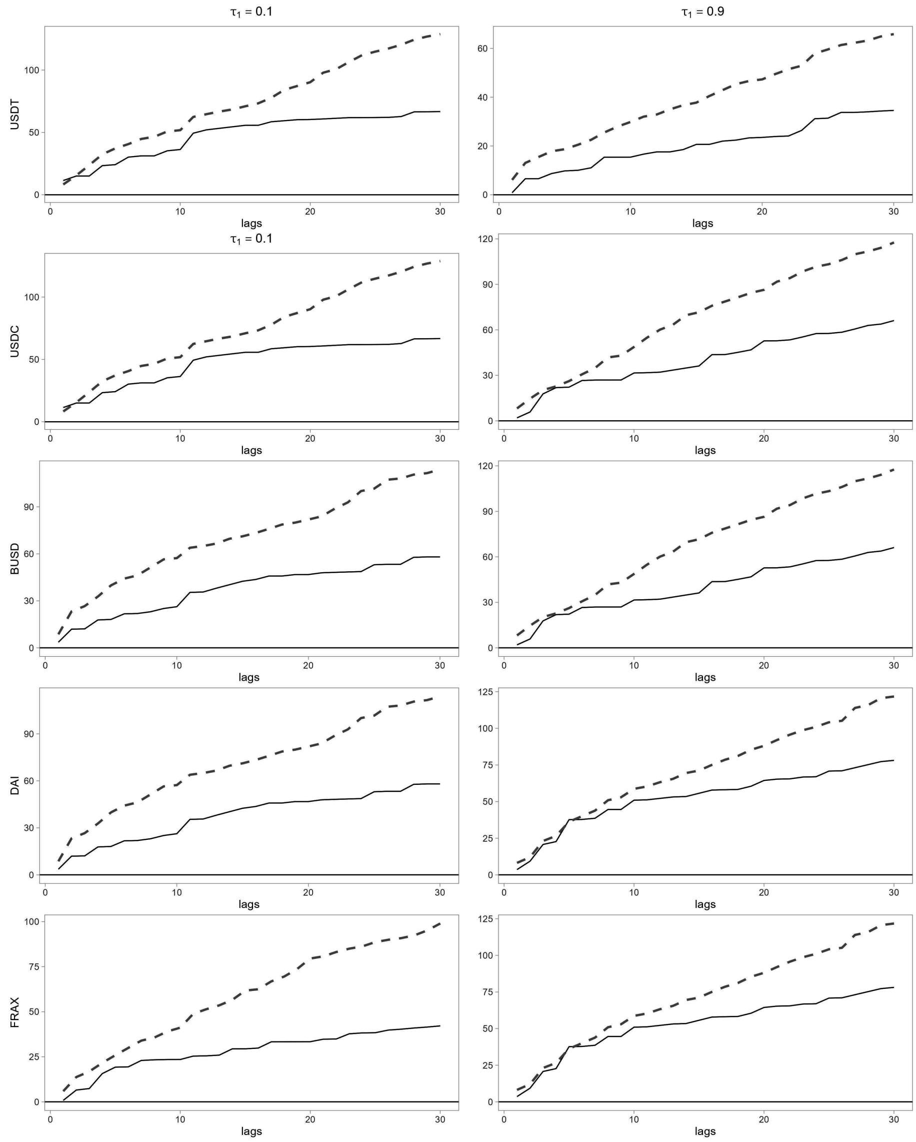
Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Cryptocurrency Index (CRYPT) to each of the Stablecoins deviations in the lower tail, such that $\tau_2 = 0.1$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Figure E7. Directional Predictability Ljung-Box Sup-version test for the Low Tail of the Stablecoins from Intermediary Leverage



Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Intermediary squared Leverage of He et al. (2017) (HKML2) to each of the Stablecoins deviations in the lower tail, such that $\tau_2 = 0.1$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions.
Sources: Author's Calculations

Figure E8. Directional Predictability Ljung-Box Sup-version test for the Low Tail of the Stablecoins from Stablecoins Iliquidity



Notes: The graph presents the portmanteau test statistic for each of the lags $p = 1, 2, ..., 30$ to detect the predictability from the Iliquidity Index from the Stablecoins (ILIQSTL) to each of the Stablecoins deviations in the lower tail, such that $\tau_2 = 0.1$. The red lines are the bootstrapped confidence intervals constructed using the stationary bootstrap method of Politis and Romano (1994) and the automatic block length selection of Politis and White (2004) and Patton et al. (2009) with 1000 bootstrap repetitions. *Sources:* Author's Calculations

Conclusion

In this thesis, I explore foreign exchange rate dynamics, centering on their determinants, fluctuations, and their profound implications for the global economy. The primary objective of this research is to contribute substantively to the expanding body of knowledge within the fields of International Finance and Financial Economics by expanding our understanding of foreign exchange rate dynamics. At its core, my research tries to uncover the complex relationship between exchange rate fluctuations and the world economy through interest rates, capital flows, and transactions through new currencies, such as Stablecoins.

In the first chapter, I propose a novel model for quantifying exchange rate uncertainty by integrating a clustering methodology with factor models, allowing me to construct a world index and define prevalent exchange rate joint dynamics. This index effectively captures daily shocks and variations across currencies, reflecting common underlying factors responsible for exchange market fluctuations and remains robust against unrelated economic variables or events. I find a breakpoint in the common factor of currencies that emerged in July 2007, in line with the literature on the Great Financial Crisis's impact on global markets and the Exchange Rate Reconnect phenomenon. Utilizing this index, I analyze deviations in the Covered Interest Rate Parity puzzle, finding that uncertainty significantly impacts the cross-currency basis for most G10 currencies, except AUD and JPY. The US Dollar influences the Libor but not the Government basis, contrasting previous findings. The exchange rate uncertainty index demonstrates superior goodness of fit and influence compared to traditional volatility indices.

In the second chapter, I analyzed the implications of exchange rate and macroeconomic uncertainties on the United States' Net Foreign Asset (NFA) position. I use a Vector Autoregressive model incorporating diverse restrictions, including sign, narrative, and external instruments, to estimate the effects of these uncertainties. The results reveal that heightened macroeconomic uncertainty diminishes the United States' exorbitant privilege, while shocks to NFA negatively impact both uncertainty types. Moreover, I also show the relationship between uncertainties, where macroeconomic uncertainty amplifies exchange rate uncertainty, while I found the inverse relationship when I see the inverse relationship. Further disaggregation of NFA into inflows and outflows highlights more pronounced effects within each component, offering nuanced insights into capital flows. Additionally, an examination of bond and stock components highlights the differential impact of macroeconomic and exchange rate shocks on foreign demand for safe assets and the Duty it implies. These findings provide valuable parameters for refining uncertainty shock models and inform the development of models considering exchange rate dynamics and differential responses to domestic macroeconomic shocks. Overall, this research underscores the importance of macroprudential models in managing uncertainties through conventional and unconventional monetary instruments.

The last chapter examines the determinants of stablecoin price fluctuations across various quantiles of the price distribution. It employs quantile regression and diverse variables, constructing market capitalization-weighted return indices for stablecoins and cryptocurrencies, along with liquidity measures. The results reveal a dynamic relationship between stablecoin prices and market returns, with evidence suggesting a weakening connection in recent years. The Terra-Luna collapse significantly altered coin behavior, particularly affecting USD assets, algorithmic, and crypto-backed currencies. The study highlights the directional predictability of explanatory variables and provides essential insights into stablecoins' behavior and stabilization mechanisms. This research advances the understanding of stablecoin dynamics, contributing to the cryptocurrency market and financial economics literature, and offers valuable implications for the design of future digital currencies. A limitation is the short time frame analyzed, which restricts the precision of the study's findings, warranting further exploration as data accumulates.

Finally, this academic thesis contributes to different topics of International Finance and Financial Economics, offering a framework for comprehending foreign exchange rate fluctuations and their economic implications. My research findings are useful not only for academics studying the behavior of exchange rates and international markets but also as a guide for policymakers analyzing the effects of policies in which currencies act as a channel and for industry practitioners to optimize their portfolios and account for their exchange rate exposition. Based on recent and advanced econometric methods, my thesis has shown the complex dynamics governing traditional and electronic currencies, revealing their susceptibility to multiple factors. Moreover, I have enriched the discourse surrounding the establishment of efficient stabilization mechanisms within the context of macroprudential policies.

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