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Connections Between Wholesale Funding Markets and Stablecoin Utilization: Implications for Cross-Border Payments and Systemic Financial Risks

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ABSTRACT

This paper examines the relationship between the major stablecoins Tether and USD Coin and the prevailing yields in Treasury bill and commercial paper markets, as well as the utilization of the overnight reverse repurchase facility offered by the Federal Reserve. While previous research identified significant impacts on these assets from digital asset issuance, a 15 basis point shift in Treasury yield and 6 basis points in commercial paper yield was not supported by a two-stage least-squares model instrumented against the minimally reserved Dai stablecoin. However, a meaningful impact from Tether issuance on Treasury bill and commercial paper yield was demonstrated across all instrument tenors when controlling for autocorrelation, and the yield of 6-month and 1-year Treasury bills also demonstrated a causal relationship with respect to the issuance of Tether when controlling for mean reversion. The implications of these results are considered in relation to increasing concern over systemic risks in the macroeconomic environment, and the impact that movements in wholesale funding markets could have on retail-level users of digital assets in jurisdictions with less well-developed financial regulatory regimes.

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INTRODUCTION & BACKGROUND

The global banking system and lending environment has long relied on U.S. dollar-denominated instruments to serve as collateral in both domestic and cross-border transactions, at the wholesale level. Dollar transactions dominate global trade, with 60% of transactions as of 2020 denominated in USD, regardless of whether citizens in the nations of either counterparty use the dollar to transact at a retail level. This is due to the USD's position as the world's reserve currency, wherein it is viewed as the least risky medium of exchange. The price-specie-flow paradigm of global trade would imply that this attitude toward the dollar is due to the superior depth of liquidity in gold – traditionally held by the U.S. government, the issuer of the dollar. However, this understanding of USD trade fails to explain many market anomalies which have been amplified since the breakdown of the USD-gold peg in 1971, and which have arguably contributed to the 1997 Asian Financial Crisis, Great Financial Crisis of 2008, and interest rate irregularities observed in collateralized asset markets in the past several years.

The Crisis of 2008 constituted a fundamental shift in risk attitudes by bank managers around the world, and eventually resulted in the implementation of the Basel II and III accords, as well as additional U.S.-specific regulations, which sought to constrain risk-taking behavior by global systemically important banks (GSIBs)[1]. These include requirements to maintain reserve ratios above 6% for the share of assets held in "Tier I" capital, which consists of short-term U.S. Treasury bills and low-risk money market instruments. As the issuance of Treasuries occurs through their exchange for bank reserves at the wholesale level by commercial banks, and their subsequent sale to retail and institutional investors, the combination of a risk-off investment environment and low

[1] For more information, see https://www.bis.org/bcbs/basel3.htm

federal funds rate following the GFC resulted in a relative shortage of Treasury collateral that could be held by banks to develop, further depressing yields and decreasing the volume of loan issuance in most developed countries relative to GDP.

In tandem with these changes in the global lending environment, the invention of bitcoin by the pseudonymous Satoshi Nakamoto in 2009 spawned a new asset class of digitally native money, and eventually led to the development of over 20,000 cryptocurrency assets into which investors could move funds, in hopes of a high-risk, high-reward bet paying off. The first several years of bitcoin's adoption were largely limited to cryptography enthusiasts, and few on-ramps existed between the traditional banking system and cryptocurrency. In 2014, BitUSD was created as the first stablecoin – a digital asset which is pegged to a government-issued currency. While BitUSD is no longer used, major stablecoins like Tether (USDT) and USD Coin (USDC) currently sport multi-billion-dollar market caps, and serve several functions for retail and institutional market participants around the globe, such as a bridge from traditional banking to crypto-native trading platforms, management of savings to earn an attractive yield, and low-friction international transactions in a non-volatile currency.

Generally speaking, stablecoins can be either reserve-backed or algorithmic, with USDT and USDC being examples of the former. Reserve-backed stablecoins hold most or all of the funds equivalent to those issued in cash or cash equivalents denominated in the asset to which they are pegged, or other assets that allow a yield to be offered to holders of the token. Market prices for these coins are generally set based on perceptions of the reserve assets' stability, and the net issuance patterns for the token. By contrast, algorithmic stablecoins use a programmed set of judgements on market volatility to control the supply, and thus the price, of the token. Such stablecoins can be based either on a rebasing or a seigniorage algorithm – the former will execute millions of trades every day to maintain a peg to the underlying, while the latter will utilize a complex set of multiple assets to maintain the intended price – creating and destroying the tokens as needed. Unfortunately, algorithmic stablecoins have become unfavorable over the last year, particularly with the collapse of the Terra-Luna ecosystem, at the time the largest seigniorage-based algorithmic stablecoin traded. Such events have also cast greater scrutiny on reserve practices of tokens like USDT and USDC, which have been manually adapted based on broader market conditions by the issuing entities and have been detailed in regulatory disclosures.

Tether is the most widely-utilized stablecoin worldwide, partially due to the domicile of its issuer in the Cayman Islands, allowing buyers of the tokens to avoid anti-money-laundering scrutiny that would be present with a U.S. issuer, and which makes the asset more easily traded in practice by American and international market participants on offshore exchanges as well. However, several legal cases have been brought against the company throughout its history for improper use of customer funds, and the cryptocurrency bear market and subsequent depegging of USDT in late 2021 resulting in the issuer releasing new disclosures of their reserve asset composition. While the company claimed at the time that tokens issued were backed 1:1 with the firm's USD-denominated reserves, it was revealed that these reserves were not solely composed of cash and cash equivalents. As of the end of 2021, around 31% of Tether's reserves were composed of commercial paper notes, with an average rating and tenor of A-2 and 80 days, respectively (A-2 is a risk classification that falls in the middle of potential risk tiers). Given that commercial paper has generally declined as a preferred corporate financing source since 2008, and because most CP notes mature in 2-3 weeks, Tether was criticized for taking excessive risk with their reserve base.

Coincidentally, with the rise in rates offered on Treasury bills since Q1 2022, and the contraction of the risk premium commanded by risky debt instruments during this period, Tether has since shifted their reserve composition much more towards Treasuries. As of the end of 2022, close to 59% of Tether's total reserves were held in Treasuries, and their CP holdings had been completely abandoned. The topical relevance of this change is underscored by the very recent distress in the commercial banking sector, thus far having resulted in the implosion of Credit Suisse and Silicon Valley Bank, as well as the widening of credit default swap spreads on most large financial institutions. The banking sector is a large component of outstanding commercial paper issuance, and most financial institutions will likely increase their demand for Treasury bills in order to shore up their balance sheets. However, the Federal Reserve's ongoing quantitative tightening program has led to a decline of about 8% in the total volume of Treasuries outstanding, since a peak of approximately $5.8 trillion in Q2 2022. As a result of these strains on the availability of "pristine collateral when it is most needed, market anomalies have begun to appear recently which belie the utilities of U.S. government securities in the wholesale markets for purposes other than their yield-bearing nature. In particular, the delta between the yield quoted on 4-week Treasury bills and the secured overnight rate offered by the Federal Reserve's reverse repurchase facility has widened to 65 basis points – 4.15% vs. 4.80%, respectively. Additionally, results of recent competitive auctions of 4-week and 8-week Treasuries show that tranches were purchased by some commercial banks at a 0% yield. These data points emphasize the strained supply of Treasury collateral to banks' balance sheets, given that these buyers have been willing to forgo a higher yield on an overnight agreement, or to forgo any return at all.

In this paper, I will specifically explore the interplay of the tightening of global financial conditions since Q1 2022 with the issuance and price behavior of the largest stablecoin, USDT. This will include an analysis of relationships between these stablecoins and common collateral assets and wholesale funding instruments. Additionally, I will speculate on the potential effect such relationships may have on the continued viability of stablecoins – and cryptocurrencies more broadly – in promoting forms of low-friction cross-border payments and more secure means of savings in developing countries.

PRIOR RELATED WORK

Given the cotemporal nature of downside volatility in asset classes like cryptocurrencies that are far out on the risk curve, and the tightening of financial conditions in traditional asset markets, it is important to gauge the impact of such changes on stablecoin supply dynamics. Academic and public policy researchers have conducted studies on the supply and demand dynamics impacting stablecoins for as long as such assets have been significant market constituents, with Tether being one of the most prominently featured assets in the literature. Many papers focus on policy implications of stablecoin adoption and price volatility, particularly from quasi-governmental entities like the Federal Reserve System, and the Bank for International Settlements (BIS), a Switzerland-based group of global central bankers who often set the stage for upcoming monetary innovations. Of particular interest to such policy groups in recent years has been the potential interplay between stablecoins and the creation of central bank digital currencies (CBDCs), which aim to achieve real-time retail funds transfers using a centralized ledger, and the impact of cryptocurrency assets on financial inclusion in developing countries. Here, I will review such research dating back to 2015, from both academic and policy-related standpoints.

In 2015, the BIS released a working paper titled “Digital Currencies,” in which they discussed the implications that stablecoin adoption globally could have on the effectiveness of central bank policy and on the integrity and mandates of traditional financial institutions. While this was one of the first such pieces of literature to discuss these topics, Tether was only launched a year prior, and thus many broad generalizations were made in this paper about the ways in which stablecoin adoption may unfold. Specifically, the paper was authored by the BIS’s Committee on Payments and Market Infrastructures, and the authors discussed the possibility of traditional financial intermediaries like central banks becoming less necessary over time if stablecoins are adopted widely for retail payments. In most developed countries, interbank transfers are regulated by the respective nations' central banks and can often take several days to clear, and in developing markets, stablecoins can serve as a low- or zero-fee alternative for retail transfers, and act as a store hold of savings in a currency that holds its value against real goods and services locally. Most notably, however, the discussion of market implications of stablecoins at this time was limited to general speculation on financial intermediaries becoming obsolete, with specific institutions mentioned including those that engage in maturity transformation and gatekeeping of credit access. Since this authorship of this paper, these functions have been adopted by decentralized finance (DeFi) entities, which act similarly to banks, but without regulatory requirements, jurisdictional restrictions on their customer base in most cases, and the personnel overhead traditionally required to facilitate lending and borrowing. While DeFi does not necessarily need to be conducted with stablecoins as the financial medium, market forces often produce a premium on stablecoin lending in DeFi algorithms in the form of high interest rates paid to the lender, the destination and contractual terms of whose funds are determined by an algorithm that aims to eliminate bias, geographical, and "check size" restrictions. However, in relation to the subject of this paper, the 2015 BIS report does not speculate on any connection between USD-denominated reserve asset markets and the supply-demand dynamics of USD-denominated stablecoins.

Updates to the BIS's view on the stablecoin ecosystem have been published since, notably in the 2019 report, "Investigating the Impact of Global Stablecoins," which was drawn up among representatives from the central banks of G7 nations (the United States, European Union, Canada, United Kingdom, France, Germany, Italy, and Japan met at a summit earlier that year). This report provided more color on the specific functions of the traditional financial infrastructures that could be impacted by stablecoins, such as those concerned with settlement, compliance with taxation regulations, and the elimination of terrorism and other illicit financing. The most germane part of this report discusses how central bank monetary policy may be nullified in smaller markets whose government-issued currencies are not widely used as a reserve asset in international trade. If a stablecoin enters wholesale usage in such countries, they argue it may displace the use of the local state currency and render such countries' own central bank monetary policy, such as interest rates and monetary supply management, ineffectual. However, this report does not provide specific figures on the extent to such local state currencies are used in trade, and does not meaningfully acknowledge the extent to which different forms of the U.S. dollar have already been widely used in some countries at the retail level in the informal economy. Additionally, since the reserve composition of major stablecoins like Tether were not as topical at this time, the report did not approach the topic of the relationship between assets like U.S. Treasury bills and these tokens, even though the former are often used as collateral in Eurodollar lending operations and international trade settlement. Nonetheless, this point of the effectiveness of monetary policy transmission in nations with currencies not widely used in international trade was underscored in Li and Shen (2021), where the authors posit that this is the case based on a theoretical construction established by economist Irving Fisher in the early 20th century. While considering this question over a timeline which included the global market and monetary shocks felt during the COVID-19 pandemic, during which many developing financial markets were disproportionately affected, it is also important to have an empirical basis for such relationships between the traditional financial system and stablecoins. One issue with Fisher's equation, which equates the product of the money supply size and its velocity (the number of times in which new currency units lent into existence are circulated through the economy before a loan is repaid) with the gross domestic product, is that most USD loans are made abroad as Eurodollars and are not countable in monetary statistics like the Federal Reserve's M2 supply statistic, even though they affect and are affected by U.S. monetary policy. While it is not clear what share of stablecoin transactions globally could be classified as retail, the transferring of value between U.S. dollars abroad and stablecoin tokens would further obscure the source of any impacts that stablecoin supply and demand may cause to the Eurodollar lending market.

While the research above provides some idea of principles which may underlie stablecoin and U.S. dollar market patterns, the methodology of this paper will be centered more closely on the domains addressed in two more recent publications on the empirical relationship, or lack thereof, between the issuance of stablecoins and the issuance and yield of debt instruments which are held as reserves backing them. First, Barthelemy et al. (2022) sought to unearth correlations that existed between the issuance volume and yield of commercial paper, and the issuance of USDT and USDC. This study determined that there was a significant relationship between the volume of commercial paper issued and the supply of both stablecoins. Specifically, an increase of 0.08 standard deviations in the commercial paper volume resulted in a full standard deviation move in stablecoin issuance. However, the authors of this study determined that there was no relationship between the interest rates offered on such commercial paper instruments and stablecoin issuance volumes, suggesting that such entities could be indiscriminate buyers of commercial paper in some time frames. While according to audit disclosures of USDC by independent accounting firms, this issuer no longer invests in commercial paper, this was the largest single constituent of USDT reserves through Q3 2021 (the latter has since abandoned this strategy as well, at least for the time being). This is important because the total volume of the commercial paper market has declined over time as financial institutions sought to mitigate systemic risks after the GFC. When looking at when types of tranches are most affected by this relationship, Barthelemy et al. found that commercial paper notes with maturities of no more than four days, and those with the highest rating of AA from non-financial issuers, were most closely connected to the stablecoin markets. Roughly 35% and 45% of the correlation between commercial paper and stablecoin issuance volumes was explained by the causal relationship identified, for these two commercial paper types respectively. This study examined the relationship over the period from Q1 2019 through Q2 2022. While neither issuer released disclosures containing a tenor breakdown of their commercial paper investments, this relationship identified suggests that commercial paper notes held were predominantly very short-term.

The above paper was originally published in 2021, and later updated with roughly another year of data analysis. Building on the methods used there, Kim (2022) again explores the relationship between commercial paper issuance volume and yield, as well as yields on U.S. Treasury bills, and stablecoin issuance. Barthelemy et al. identified that there was no causal relationship from USDC-to-CP (with respect to issuances), and only a USDT-to-CP issuance causality when considering AA CP notes from financial institutions. Kim uses similar methods of statistical analysis to Barthelemy et al., but this paper differed in its methodology in two significant ways. First, Kim chose to add together the changes in issuance of both USDT and USDC. This makes for a simpler analysis, and when put together, these two stablecoins currently constitute about 77% of the total global market cap of all stablecoins. However, while the difference in their reserve composition has been narrowed more recently, as Tether has shifted away from commercial paper and more into U.S. Treasuries, the combination of time series for the two stablecoins may confound separate relationships that each may or may not have with the market actions of their backing assets. Indeed, USDT has experienced less severe price deviations in Q1 2023 than USDC, as it was viewed by market participants to be less exposed to contagion risk from the collapse of

Signature Bank and Silicon Valley Bank. Conversely, USDC was much more stable than Tether around its price peg in late 2021, when the latter came under scrutiny for making risky bets with customers' reserved funds and fell significantly below its $1.00 peg. Besides this data analysis strategy, Kim also excluded data from a part of his analysis from prior to April 2020, due to the downside shock in prevailing interest rates, and thus T-bill rates, that occurred in March. He notes that a statistically significant relationship can be identified either way, but that the effect size is larger for the data set that excludes March 2020. In this latter case, a causal stablecoin-to-reserve asset relationship was identified – an increase of one standard deviation in the daily issuance of USDT and USDC combined resulted in an increase in CP issuance quantity of 11%, and a CP yield decline of 18 basis points (taken as a share of the magnitude of the yield for the weighted average of CP notes on the prior day). Similarly, a decrease of 15 basis points in T-bill yields was also identified. The strongest relationships were identified for asset-backed (secured) CP and non-financial issuer CP notes with overnight maturities – in these cases, the coefficient of daily stablecoin issuance was found to be 0.237 and 0.180, with respective p-values of 0.0214 and 0.0202. These coefficients refer to the effect size of one standard deviation changes in stablecoin issuance on CP yields. Similar relationships were unearthed between stablecoin issuance and Treasury yields, and with a slight increase in the explanatory power at each increasing tenor of Treasury (p=0.0190 for 1-month T-bill and 0.0168 for 1-year T-bill). While the directionality of the relationship was fixed in this study to focus on the impact of stablecoin issuance on day t on the behaviors of the reserve assets on day *t+1*, in my view, this is a more methodologically-sound analysis than Barthelemy et al., since "traditional" assets like commercial paper and Treasuries are limited to transaction during business hours, even if the stablecoins being studied are being constantly created and destroyed based on 24/7 global trading relationships.

Finally, I chose to review a few articles that discuss the potential implications of broad stablecoin adoption on the developing world. While it is an interesting academic discussion to explore the relationships between stablecoins and traditional asset markets, the transmission of monetary policy between the domestic U.S. dollar and foreign wholesale funding operations, and the effects on monetary stability in smaller countries, can have many implications in the real economy. In a book chapter on the outlook for emerging markets with respect to digital currency innovations,

Feyen et al. (2021) discusses how many developing economies are likely to have the effectiveness of their monetary policy preempted by widespread retail adoption of stablecoins and other cryptocurrencies. Furthermore, should such adoption occur broadly, it is likely to initiate a positive feedback loop with the supply factors driving stablecoins in such economies – if emerging market participants increasingly use stablecoins as an alternative to their local state currencies, the authority of those local governments will be increasingly undermined, and could encourage them to respond with rash and draconian policies.

Kulkarni et al. (2019) notes an example where such action has already played out at an early stage – Facebook Libra currency (later rebranded to Diem before being scrapped entirely) had opposition voiced by many political and legislative bodies around the world, and language has since been incorporated into white papers and policy reports on private, corporation-issued digital currencies by authorities like the BIS and International Monetary Fund. Thus, policymakers have tended to resist the idea of the widespread adoption of private digital currency, even in cases where it would ostensibly help those who do not have access to traditional financial services. Even in jurisdictions where financial industry regulation is not as extensive as in North America and Western Europe, companies providing business functions similar to those of banks can fall under scrutiny. For example, the early-stage development of the Everex platform, detailed by Norta et al. (2019), has already set out to focus in part on micro-lending via low-friction funds transfer mechanisms, including stablecoins and other cryptocurrencies. However, such ambitions may also thwart the rollout of this and similar technologies, even when at their core they primarily focus on funds transfers for the payment for goods and services, as well as low-cost remittances. Overall, it is still unclear how various market and regulatory crosswinds will end up impacting the use of stablecoins and other digital currencies in the developing world.

Finally, a relatively new resource that has been instrumental in building and understanding of global wholesale dollar funding markets, ideas around which are incorporated into this paper, is the "Eurodollar University" YouTube channel and accompanying website. Here, fund manager Jeffrey Snider provides great detail on the often-unseen impacts that eurodollars (USD currency instruments issued and transacted entirely separate from the purview of the Federal Reserve and U.S. Treasury) have on debt market volatility, and indirectly on equity and currency markets as well. The development of some methodologies in this paper have made use of the recognition of financial ecosystems like this outside the United States, many of which interact quite closely with the cryptocurrency and stablecoin markets.

METHODOLOGY

Following on the statistical methods used by Barthelemy et al. and Kim, this study primarily makes use of a two-stage least-squares (2SLS) model of daily net issuance of stablecoins, in relation to the issuance and yield – where appropriate – of traditional reserve assets underlying stablecoins. Prior to conducting this analysis, an examination of the rolling correlations between net daily stablecoin issuance and ensuing yield and volume variance in the asset markets studied was made. This was to determine an intuitive picture of how closely the moves in the markets for each traditional asset corresponded with moves in the digital assets, and to isolate periods of interest and compare them to fundamental analysis of market-moving events in both markets. The correlation formula used as such is generalized below.

$$r_{dSC:RRP} = \frac{\sum_{t=1}^{n}(Stablecoin\ Issuance_t - \overline{Stablecoin\ Issuance})(RRP\ Volume_{t+1} - \overline{RRP\ Volume})}{\sqrt{\sum_{t=1}^{n}(Stablecoin\ Issuance_t - \overline{Stablecoin\ Issuance})^2}\sqrt{\sum_{t=1}^{n}(RRP\ Volume_{t+1} - \overline{RRP\ Volume})^2}}$$

This paper made use of several classes of USD-denominated debt instruments that constitute significant portions of the reserve makeup for Tether and USD Coin, or did at some point in the past. Specifically, assets studied include the yield of asset-backed, non-financial, and financial commercial paper of overnight and 7-day tenors, yield of Treasury bills of 1, 2, 3, 6, and 12-month tenors, and the quantity of aggregate reverse repurchase agreements with the Federal Reserve. The generalized equation below represents the second stage of calculations in the case of each asset characteristic (dependent variables), regressed against the daily net issuance of Tether and USD Coin.

$$Dependent\ Asset_{t+1} = \alpha\ +\ \beta(\widehat{Stablecoin\ Issuance_t})$$

While Tether's past and current reserve composition includes other assets such as cash deposits, holdings in money market funds, and holdings in precious metals, and USD Coin had also continuously held some amount of cash in their reserves, the measurement ability, liquidity depth, or multitude of other drivers behind these markets would make them less suitable for uncovering volume and yield relationships with stablecoins, as has been evidenced by their lack of inclusion in similar work such as the studies above. I also follow on Kim in using net daily issuance of the stablecoin Dai as an explanatory variable in these analyses. This is because Dai is a well-established algorithmic stablecoin that is also pegged to the U.S. dollar, with the third-largest market cap of all stablecoins, currently at around $5.4 billion. As an algorithmic token, Dai does not rely on a reserve treasury of dollar-denominated assets to maintain its peg. Rather, it uses a trading scheme based largely on cryptocurrencies like bitcoin and ether, as well as other stablecoins, to hold stability. Thus, there is no direct connection that could be foreseen between Dai issuance and volume or yield patterns in the reserve assets mentioned above. However, unlike Kim, Dai issuance is taken here at face value as an explanatory factor, since the Terra-Luna ecosystem previously analyzed against Dai has since ceased trading in a meaningfully similar way, and because its shorter history prior to the collapse already made it a shakier basis for comparison. The formula below represents the first step of the analysis, where daily net issuance of the stablecoins is instrumented against daily net issuance of Dai over the same period.

$$Stablecoin\ Issuance_{t+1} = \alpha\ +\ \beta(Dai\ \widehat{Issuance_t})$$

Building upon previous work, this paper also includes adjusted analyses from the plain-vanilla 2SLS that aim to model the price behaviors of the stablecoins more closely, and those of all financial assets, in incorporating assumptions of autocorrelation and heteroskedasticity into the models. Autocorrelation is often addressed in econometrics using an exponentially weighted moving average (EWMA) in place of raw datasets. In this case, a rolling 10-day EWMA is incorporated into the datasets for all assets, with the stablecoin sets having been trimmed throughout to remove data from non-trading days, while keeping day-to-day net change metrics in line with natural calendar days. Given that some datasets analyzed in Barthelemy et al. and Kim yielded large residuals (high root-mean-square errors), this paper makes use of an EWMA construction with a lambda, or decay factor, or 0.965, which has been found to be optimal for shorter-term money market instruments based on back-testing in J.P. Morgan's RiskMetrics model. This figure determines how much recent observations are weighed against those further from the present, and serves to smooth the model. EWMA is typically used to forecast volatility of daily returns, and is used here with the daily net stablecoin issuances and changes in wholesale funding instrument yields and volumes likewise. The following formula shows how EWMA is used for these datasets.

$$Dependent\ Asset_t = \sum_{t-10}^{t-1} \sqrt{\lambda(Stablecoin\ Issuance_{t-i})^2 \ + \ (1-\lambda)(Stablecoin\ Issuance_{t-i} - \overline{Stablecoin\ Issuance_{t-10 \to t-1}})^2}$$

Finally, previous work in the area was extended through use of an additional model to account for mean reversion of volatility in certain portions of the time series. Commonly referred to as heteroskedasticity, the clustering of volatility in daily data points was observed in all datasets, particularly USDT's daily net issuance. The generalized autoregressive conditional heteroskedasticity (GARCH) model is often used in such cases to approximate a local linear relationship concerning volatility where a global measurement of such a relationship would yield statistically insignificant results, due to results from intervening "quiet" periods. The model draws upon the same form as an EWMA model of residue smoothing, but adds an additional term and coefficient. The α and β coefficients used in this model are drawn from Salamat et al. (2020), using a weighted average of the market caps for the cryptocurrencies studied in the paper as of March 31, 2023, based on the assumption that USDT and USDC are most often used as a bridge to speculation in a basket of cryptocurrencies, thus adopting their volatility characteristics (this β term is equivalent to the λ in the EWMA model); the λ coefficient is simply the difference of 1 and the other two coefficients. The following formula represents the relationship used here.

$$Dependent\ Asset_t = \alpha(Stablecoin\ Issuance_{t-1}) + \beta(Stablecoin\ Issuance_{t-2}) + \lambda(\overline{Stablecoin\ Issuance_{0 \to t}})$$

RESULTS

In order to build on the corpus of prior related literature, this study utilized datasets for Dai, Tether, USD Coin, Treasury bill yields, commercial paper yields, and reverse repurchase agreement statistics from January 21, 2020 through March 31, 2023. Due to the greater period elapsed since the COVID-19 market shock in March 2020, all data were analyzed over this period as a continuous whole. As mentioned previously, dates for which data was not available for one or more assets was excluded, owing for example to the non-trading day exclusions for traditional financial assets, as well as other unavailable days for the stablecoin time series. Data for Dai, USDT, and USDC was taken from CoinMarketCap.com, T-bill yields and CP yields from Bloomberg, and RRP contract volumes from the Federal Reserve's FRED Economic Database. Reliable data available for Dai was the limiting factor on the length of all the series, resulting in the chosen period of study.

By repeating methods similar to those used by Kim and Barthelemy et al. for the 2SLS analyses, insufficient evidence was found to support a causal relationship or lasting correlation between net stablecoin issuance and Treasury bill yields. The *p*-values calculated here ranged from 0.3822 for the relationship to the 1-month T-bill yield with Tether as the endogenous variable, to 0.7344 for the 6-month yield in the same scenario. In the former case, the observed impact on the yield according to the model was an increase of 15.37 basis points for an increase of 1 standard deviation in the Tether supply (roughly $6.29 million); however, these and the other results should not be regarded as significant under a 95% confidence interval.

Among the classes of commercial paper for which the yields were analyzed, similarly insignificant results were obtained. While CP yields were only tested against net issuance of Tether – as USD Coin never used CP notes in its reserve basket – *p*-values obtained under this model ranged from

0.1640 for A2 P2-rated notes from nonfinancial issuers with an overnight maturity, to 0.9719 for similar notes carrying an AA rating. As the least insignificant result might fall close to consideration under a wider confidence interval, the implied result may hold minor weight. This model connected a decrease of 5.92 basis points in the CP yield for a standard deviation increase in net daily Tether issuance. However, none of the other CP analysis results approach meaningfulness for robust conclusions.

Finally, the 2SLS model was used to draw potential conclusions about the response of the total outstanding volume of overnight reverse repurchase agreements with the Federal Reserve to net stablecoin issuance. For one, the activity in this facility is closely connected to Treasury bills, which make up the lion's share of collateral in such arrangements. Additionally, debt instruments traded as derivatives of these agreements have been used as a reserve asset for Tether (and possibly USD Coin as well), once making up its single largest instrument held in the issuer's reserves. However, utilization of this facility remained relatively low until Q2 2021, where it began to increase steadily, and reached a sustained level of over $2 trillion by Q3 2022. While the dramatic changes in utilization of the facility and high volatility during the entire time series inherently make it a less suitable variable for study, I chose to retain the entire date range used when analyzing the other assets mentioned above. The results of the regression for this data series yielded effect sizes of -29.44% and -75.32% on the outstanding volume of the facility when analyzed against a one standard deviation increase in the net issuance of USDT and USDC, respectively (in the latter case, about $3.7 million). Both of these results are statistically insignificant, however, with respective *p*-values of 0.7446 and 0.7542. Therefore, it is safe to reject the hypothesis that reverse repo volumes are connected to the stablecoin market in any material way.

Next, an exponentially weighted moving average was constructed with a rolling 10-day calculation periods for all of the same asset pairs explored above. The purpose of this model was to extend the simple linear regression to account for possible autocorrelation, as the volatility of most financial assets has been shown to more closely follow the directional pattern of the recent past on a short-term scale (i.e. a pattern of up or down movements is more likely to continue into the near future than for a "random walk" to take over immediately). Under this model, the causal relationship between net Tether issuance and Treasury bill yields of all tenors studied was shown to be robust, with $p<0.0003$ in all cases examined. However, this was not the case when modeling T-bill yields against USDC – despite this token having a sizeable market cap and consistent history of Treasuries in their reserve basket, this model demonstrated signs of overfitting when applied to USDC, with extraordinarily small p-values and high t-statistics. This suggests that noise from residuals crept into the model and did not accurately identify that there was not a significant relationship between this token and T-bill yields. Despite these findings, when this model was extended to all eight classes of commercial paper tested under the 2SLS model, p ranged from 0.0003 to 0.0017, for the midgrade (A2 P2) nonfinancial-issuer notes with a 7-day tenor, and the one-day AA-grade financial notes, respectively. This suggests that there may be a meaningful relationship between Tether issuance and both T-bill and CP yields, but that these relationships are obscured by autocorrelation in the USDT dataset, and the low p with relatively high t-statistics for these Treasury rates and certain CP rates would warrant caution due to potential overfitting before the model were to be unconditionally applied to broader data. Additionally, this model was tested against overnight reverse repo volumes, but was shown to be insignificant in the case of Tether, and overfitted when tested against USDC issuance.

Finally, a modified GARCH model was constructed to take the inputs of net daily stablecoin issuance in place of the traditional volatility values, in order to test the likely case of long-term reversion to the mean that could impact the utility of models like the Tether EWMA if used on future market data. The purpose of this model was to control for heteroskedasticity, or volatility clustering, in the datasets. The results obtained showed that the assumptions of volatility mean reversion were highly predictive for Tether's impact on certain T-bill yields; interestingly, this model's robustness increased with greater Treasury tenors, with *p*-values ranging from 0.1761 for the 1-month T-bill, to 0.0022 for the 1-year. Similar to the EWMA analysis, however, the GARCH model displayed signs of overfitting on all Treasury tenors and RRP volume when dependent on USDC, and yielded insignificant results when tested upon CP yields (lowest *p* of 0.1155 when measured for 7-day nonfinancial A2 P2 CP) and RRP volume dependent on Tether.

Further detail is available in Appendices 1-3 on the results of the 2SLS tests, with specific linear slope coefficients demonstrated in each case that point to the predicted change in the dependent variables. Additionally, Appendix 4 contains summary statistics for the EWMA analyses, and Appendix 5 for the GARCH models.

IMPLICATIONS & FURTHER WORK

In this paper, the results of several statistical models fitted to data on the market behavior of three stablecoins, and their potential impact on U.S. dollar-denominated debt instruments widely used in wholesale funding markets was examined. Here, I will briefly discuss the potential impacts of these findings on the global regulatory environment surrounding digital assets, and potential avenues of further research that should be explored.

One of the most surprising findings was the lack of utility that USD Coin's net issuance data provided over the measurement period as a causal variable for other financial assets. As discussed above, USDC's reserve management strategy has always prioritized overcollateralization and the maintenance of a clean reputation from a regulatory perspective. While it was not always clear during the period studied here which debt instruments composed USDC's reserves at any given time, the company managing the issuance of the token now discloses all Treasury tranches in which they are invested – currently with 1-, 2-, and 3-months tenors only. This points to the possible conclusion that worldwide investors in the Treasury market have already priced in the likely purchases USDC will make each quarter, based on the relatively unchanged financial position they can observe in the recent past. It is also possible, however, that since USDC is significantly smaller in market cap than Tether, and those effects which the latter has on T-bill yields when taking into account autocorrelation and volatility mean reversion are more muted, and thus not detectable in statistically significant ways.

If the hypothesis on USD Coin's Treasury-buying actions being anticipated well in advance of their participation in auctions, it is possible that this would also apply to the case of Tether, and explain the low confidence of the 2SLS results generated. As the general positioning of global economic participants has shifted towards a more risk-off stance over the past year, it is possible that investors' concerns spurred the increased disclosure from, and scrutiny of, Tether Holdings, and began to more accurately price in potential liquidity risks more than in the pre-2020 era.

Additionally, as Tether is often the low-friction token of choice for cross-border funds transfers and wealth accumulation by retail market participants, it is possible that the company's executives are seeking to avoid a "bank run" scenario of a redemption cascade if and when emerging and developing markets seek to strengthen the regulatory framework around cryptocurrencies and stablecoins for those who transact from within their borders. This could also lead to confounding variables and the obscuring of relationships to underlying reserve assets through a more efficient market.

Finally, while not the case for USDC, a sizeable portion of Tether's reserve basket still lies in less traditional, less liquid asset classes – namely, corporate bonds, other cryptocurrencies, and precious metals. Since the market cap (and thus the net issuance or redemptions) can often fluctuate in excess of 0.5% in a single day, significant price moves in reserve assets such as these can lead to margin calls and other consequences for a bank-like entity like Tether Holdings, which is likely operating on a delicate net margin. In future research, it might be beneficial to construct models which incorporate prices and yields (where applicable) of assets such as these as variables dependent on stablecoin issuance.

Furthermore, while this paper made use of the same instrumental variable as Kim in the Dai stablecoin, this token's declining market share and recent reserve strategy pivot away from primarily investing in other high-risk cryptocurrencies on an algorithmic basis might mean that it is no longer suitable as such. Unless and until other minimally reserved stablecoins become well-established in the cryptocurrency market, a study that examines the relationship between stablecoin issuance and the market characteristics of the "non-traditional" assets mentioned above could incorporate the net issuance of USDC as an instrumental variable. This would allow the effects of Treasury, commercial paper, and reverse repo market fluctuations to be isolated from those of other assets such as those.

APPENDIX 1 – Effect of Net Daily USDT and USDC Issuance on Treasury Yields

1-Month T-Bill (USDT)		1-Month T-Bill (USDC)	
n	771	n	771
Standardized y	**15.37 bps**	**Standardized y**	**19.48 bps**
Coefficient (β)	6.8352	Coefficient (β)	8.5856
p(β)	0.3822	p(β)	0.4040
Intercept (α)	-0.0006	Intercept (α)	-0.0076
p(α)	0.9831	p(α)	0.8361
σ(β)	0.023	σ(β)	0.024
First-Stage T-Value	2.070	First-Stage T-Value	1.523

2-Month T-Bill (USDT)		2-Month T-Bill (USDC)	
n	779	n	779
Standardized y	**-1.92 bps**	**Standardized y**	**-3.3 bps**
Coefficient (β)	-1.9326	Coefficient (β)	-2.3833
p(β)	0.6934	p(β)	0.6988
Intercept (α)	0.0245	Intercept (α)	0.0263
p(α)	0.196	p(α)	0.2321
σ(β)	0.022	σ(β)	0.024
First-Stage T-Value	2.064	First-Stage T-Value	1.546

3-Month T-Bill (USDT)		3-Month T-Bill (USDC)	
n	779	n	779
Standardized y	**10.21 bps**	**Standardized y**	**13.02 bps**
Coefficient (β)	3.8090	Coefficient (β)	4.6844
p(β)	0.4880	p(β)	0.4707
Intercept (α)	0.0068	Intercept (α)	0.0031
p(α)	0.7274	p(α)	0.8954
σ(β)	0.022	σ(β)	0.024
First-Stage T-Value	2.065	First-Stage T-Value	1.551

6-Month T-Bill (USDT)		6-Month T-Bill (USDC)	
n	781	n	781
Standardized y	**5.31 bps**	**Standardized y**	**6.6 bps**
Coefficient (β)	1.5679	Coefficient (β)	1.9224
p(β)	0.7344	p(β)	0.7336
Intercept (α)	0.0072	Intercept (α)	0.0057
p(α)	0.6605	p(α)	0.7803
σ(β)	0.022	σ(β)	0.024
First-Stage T-Value	2.076	First-Stage T-Value	1.558

1-Year T-Bill (USDT)		1-Year T-Bill (USDC)	
n	781	n	781
Standardized y	**-1.25 bps**	**Standardized y**	**-1.93 bps**
Coefficient (β)	-0.7647	Coefficient (β)	-0.9412
p(β)	0.6916	p(β)	0.6997
Intercept (α)	0.0076	Intercept (α)	0.0083
p(α)	0.2705	p(α)	0.3455
σ(β)	0.022	σ(β)	0.024
First-Stage T-Value	2.076	First-Stage T-Value	1.558

APPENDIX 2 – Effect of Net Daily USDT Issuance on Commercial Paper Yields

Overnight Financial AA CP		7-Day Financial AA CP	
n	780	n	519
Standardized y	**7.23 bps**	**Standardized y**	**38.51 bps**
Coefficient (β)	3.3419	Coefficient (β)	20.2247
p(β)	0.4235	p(β)	0.2213
Intercept (α)	0.0005	Intercept (α)	-0.0209
p(α)	0.9719	p(α)	0.6402
σ(β)	0.022	σ(β)	0.018
First-Stage T-Value	2.075	First-Stage T-Value	1.225

Overnight Nonfinancial AA CP		7-Day Nonfinancial AA CP	
n	768	n	499
Standardized *y*	**3.13 bps**	**Standardized *y***	**9.36 bps**
Coefficient (β)	0.2294	Coefficient (β)	2.1794
p(β)	0.9719	p(β)	0.7639
Intercept (α)	0.0278	Intercept (α)	0.0362
p(α)	0.231	p(α)	0.2347
σ(β)	0.023	σ(β)	0.028
First-Stage T-Value	2.065	First-Stage T-Value	1.618

Overnight Nonfinancial A2 P2 CP		7-Day Nonfinancial A2 P2 CP	
n	780	n	778
Standardized *y*	**-5.92 bps**	**Standardized *y***	**-6.14 bps**
Coefficient (β)	-2.8273	Coefficient (β)	-3.1664
p(β)	0.164	p(β)	0.3069
Intercept (α)	0.0126	Intercept (α)	0.0192
p(α)	0.0803	p(α)	0.0813
σ(β)	0.022	σ(β)	0.022
First-Stage T-Value	2.075	First-Stage T-Value	2.066

Overnight Asset-Backed AA CP		7-Day Asset-Backed AA CP	
n	780	n	780
Standardized *y*	**-1.3 bps**	**Standardized *y***	**-0.26 bps**
Coefficient (β)	-0.9277	Coefficient (β)	-0.5793
p(β)	0.6593	p(β)	0.8277
Intercept (α)	0.0079	Intercept (α)	0.0103
p(α)	0.294	p(α)	0.2768
σ(β)	0.022	σ(β)	0.022
First-Stage T-Value	2.075	First-Stage T-Value	2.075

APPENDIX 3 – Effect of Net Daily USDT and USDC Issuance on Federal Reserve Overnight Reverse Repurchase Agreement Volumes

Overnight RRP Volume (USDT)	
n	669
Standardized y	**-29.44%**
Coefficient (β)	-2708.2808
p(β)	0.7446
Intercept (α)	35.5563
p(α)	0.2344
σ(β)	0.024
First-Stage T-Value	2.170

Overnight RRP Volume (USDC)	
n	669
Standardized y	**-75.32%**
Coefficient (β)	-4679.7071
p(β)	0.7542
Intercept (α)	41.6729
p(α)	0.3911
σ(β)	0.025
First-Stage T-Value	-0.313

APPENDIX 4 – Results of EWMA Model Regressions for Asset Pairs

1-Month T-Bill (USDT)		**1-Month T-Bill (USDC)**	
n	773	n	773
p(β)	0.0001	p(β)	4.86×10^{-22}
T-Statistic	-3.8604	T-Statistic	9.9534

2-Month T-Bill (USDT)		**2-Month T-Bill (USDC)**	
n	773	n	773
p(β)	0.0001	p(β)	3.42×10^{-23}
T-Statistic	-3.8253	T-Statistic	10.2481

3-Month T-Bill (USDT)		**3-Month T-Bill (USDC)**	
n	773	n	773
p(β)	0.0002	p(β)	1.56×10^{-24}
T-Statistic	-3.7806	T-Statistic	10.5836

6-Month T-Bill (USDT)		**6-Month T-Bill (USDC)**	
n	773	n	773
p(β)	0.0002	p(β)	1.02×10^{-25}
T-Statistic	-3.7796	T-Statistic	10.8728

1-Year T-Bill (USDT)		**1-Year T-Bill (USDC)**	
n	773	n	773
p(β)	0.0001	p(β)	8.08×10^{-27}
T-Statistic	-3.8235	T-Statistic	11.1375

Overnight Financial AA CP		7-Day Financial AA CP	
n	773	n	773
p(β)	0.0017	p(β)	0.0011
T-Statistic	-3.1512	T-Statistic	-3.2833
Overnight Nonfinancial AA CP		**7-Day Nonfinancial AA CP**	
n	773	n	773
p(β)	0.0013	p(β)	0.0008
T-Statistic	-3.2314	T-Statistic	-3.366
Overnight Nonfinancial A2 P2 CP		**7-Day Nonfinancial A2 P2 CP**	
n	773	n	773
p(β)	0.0006	p(β)	0.0003
T-Statistic	-3.4512	T-Statistic	-3.6189
Overnight Asset-Backed AA CP		**7-Day Asset-Backed AA CP**	
n	773	n	773
p(β)	0.0012	p(β)	0.0005
T-Statistic	-3.2422	T-Statistic	-3.4901

Overnight RRP Volume (USDT)		Overnight RRP Volume (USDC)	
n	773	n	773
p(β)	0.1608	p(β)	3.25×10^{-53}
T-Statistic	-1.4036	T-Statistic	16.6140

APPENDIX 5 – Results of GARCH Model Regressions for Asset Pairs

1-Month T-Bill (USDT)		**1-Month T-Bill (USDC)**	
n	781	n	781
p(β)	0.1761	p(β)	<0.0001
T-Statistic	-1.3540	T-Statistic	-5.5245

2-Month T-Bill (USDT)		**2-Month T-Bill (USDC)**	
n	781	n	781
p(β)	0.0961	p(β)	<0.0001
T-Statistic	-1.6662	T-Statistic	-5.6249

3-Month T-Bill (USDT)		**3-Month T-Bill (USDC)**	
n	781	n	781
p(β)	0.0724	p(β)	<0.0001
T-Statistic	-1.7992	T-Statistic	-5.7043

6-Month T-Bill (USDT)		**6-Month T-Bill (USDC)**	
n	781	n	781
p(β)	0.0159	p(β)	<0.0001
T-Statistic	-2.4170	T-Statistic	-5.6758

1-Year T-Bill (USDT)		**1-Year T-Bill (USDC)**	
n	781	n	781
p(β)	0.0022	p(β)	<0.0001
T-Statistic	-3.0664	T-Statistic	-5.5184

Overnight Financial AA CP		7-Day Financial AA CP	
n	781	n	781
p(β)	0.1609	p(β)	0.1513
T-Statistic	-1.4035	T-Statistic	-1.4365

Overnight Nonfinancial AA CP		7-Day Nonfinancial AA CP	
n	781	n	781
p(β)	0.1447	p(β)	0.1323
T-Statistic	-1.4599	T-Statistic	-1.5065

Overnight Nonfinancial A2 P2 CP		7-Day Nonfinancial A2 P2 CP	
n	781	n	781
p(β)	0.1361	p(β)	0.1155
T-Statistic	-1.4921	T-Statistic	-1.5757

Overnight Asset-Backed AA CP		7-Day Asset-Backed AA CP	
n	781	n	781
p(β)	0.1270	p(β)	0.1334
T-Statistic	-1.5278	T-Statistic	-1.5023

Overnight RRP Volume (USDT)		Overnight RRP Volume (USDC)	
n	781	n	781
p(β)	<0.0001	p(β)	0.0002
T-Statistic	-4.4948	T-Statistic	-3.7622

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Lehmann Group **Princeton, NJ**

Corporate Finance Summer Analyst **May 2022 – August 2022**

- Assisted in market research on potential clients in healthcare, technology, and industrial sectors in lower-middle market, and initiated outreach to company contacts
- Conducted initial outreach via email and LinkedIn to business prospects, and helped to identify suitable candidates for further progress in company pipeline
- Worked with firm principals to develop new ideas for increasing visibility among potential clients targeted, and ways to best represent firm's mission to such companies

Everberg Capital **New York, NY**

Private Credit Summer Analyst **June 2021 – August 2021**

- Performed background research on industries suited to the firm's investment thesis, and arranged research into slide decks to be distributed and presented both internally and externally, serving as primary research sources in future deals
- Worked with analysts and associates to prepare deal screening memoranda and introductory presentations, including through the arrangement of comparable company data, consolidating financial analyses, and assisting with due diligence
- Assisted the partners of the firm in building out tracking tools for sponsors, lenders, limited partners, and other contact interactions, and updating quarterly financial reports from portfolio companies for distribution to the firm's co-investors

LEADERSHIP EXPERIENCE

Leveraged Lion Capital **University Park, PA**

Director of Portfolio Analytics **December 2021 – May 2022**

- Coordinated weekly and monthly benchmarking of the performance of ~30 positions across eight sectors of the LLC portfolio, comparing price movements of holdings to Bloomberg Barclays High Yield Bond Index and LSTA 100 Index
- Worked with the Chief Investment Officer to rebalance positions to target weights and recommend timing of trades

Lead Analyst | Healthcare Sector **April 2021 – December 2021**

- Supervised two Associate Analysts to determine the optimal sector strategy for next semester using quantitative risk-return assessments of individual bonds and loans and a broader thesis on the credit performance of constituent industries

Associate Analyst | Healthcare Sector **November 2020 – April 2021**

- Interviewed and was selected to join the first student-run high-yield bond and syndicated leveraged loan portfolio
- Analyzed prospective fixed-income investments in medical device, managed care, and pharmaceutical companies by performing bottom-up credit analyses and building financial models, using Bloomberg Terminal data and company filings
- Prepared reports on price movements and sector news on a weekly basis for presentation to the entire organization

EXTRACURRICULAR ACTIVITES

- Penn State Crew Club
- Penn State Fixed Income Association
- Penn State Investment Association