The Impact of Chinese Capital Outflows on Bitcoin vs. Yuan Relationships: A Multi-Period Analysis

Michael Williams, Mucahit Kochan, and David Green

Abstract

We examine the relationships among Bitcoin (BTC), the Chinese Yuan (CNY), and Chinese capital outflows between 2014-2021. We find that BTC returns strongly comove with CNY returns after 2018Q1, while no significant BTC/CNY relationship exists before 2018Q1. Further, the strength of the BTC/CNY relationship increases throughout 2018 to the present date. Yet, this relationship strength cannot be explained by periods of ascending BTC prices, changes in crypto mining location, nor changes in the use of BTC "mining pools". Instead, we find that the strength of the BTC/CNY relationship is strongly and directly related to Chinese capital outflows. We find no similar relationship with a "bogey" currency, the Euro, implying that the capital outflows -to-BTC/CNY relationship is unique to China and its capital outflow environment. In total, our novel results suggest that BTC is used as part of a process to move economically significant amounts of capital from mainland China.

Keywords: Bitcoin, BTC, cryptocurrency, Chinese Yuan, CNY, capital outflows

I. Introduction

Decentralized cryptocurrencies allow individuals to conduct business and transfer digital coins without binding government interference. As such, one of the most recognized cryptocurrencies, Bitcoin (BTC), has a significant potential to be used as a channel of global capital outflows and to bypass capital controls. As seen in the 2019 Global Digital Asset AML Research Report, published by blockchain security firm Peckshield, capital flight from China via BTC and other cryptocurrencies amounted to around $11.4 billion in 2019, alone (Redman, 2020). These facts raise the important question as to whether BTC and countries' "home currencies" are related to those countries' capital outflows. Our paper provides compelling evidence that this is, indeed, the case: periods of enhanced capital outflows are associated with stronger contemporaneous movements between BTC and the Chinese Yuan (CNY).

Although BTC *networks* are generally decentralized and anyone willing to devote computer power can mine BTC, BTC *mining* is predominantly centralized in China. According to the Cambridge Bitcoin Electricity Consumption Index and Stoll et al. (2019), China accounted for more than 75.5 percent of global BTC mining in late-2019. Further, while any set of mining participants may pool their mining efforts in order to enhance their expected mining profits, the majority of BTC mining pools are managed by individuals or organizations located in China. Mining pool concentration has been of such a concern to Chinese authorities that Vice Premier Liu He recently warned financial officials of a "clamp down on Bitcoin mining and trading activity" to ensure financial stability.

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Capital outflows and capital control evasion is an especially strong concern for Chinese monetary policy makers, whose multi-decade battle with these issues is well known. These concerns have lead to decades of strong regulatory- and market- based interventions. In particular, China uses various restrictions to limit the depletion of Chinese foreign currency reserves while keeping the value of the Chinese Renminbi, also known as the Yuan, low. For example, regulators at the People's Bank of China (PBOC) and the State Administration of Foreign Exchange (SAFE) have put tight restrictions on Chinese citizens from participating in international markets; Chinese citizens are not allowed to move more than $50,000 per year out of the country. Further, the PBOC has routinely intervened in the exchange markets to hold CNY exchange rates low, with several U.S. Policymakers calling these interventions "currency manipulation" (Staiger and Sykes, 2010).

Speaking directly of PBOC/SAFE intervention in cryptocurrencies, the PBOC banned financial institutions from handling BTC transactions in 2013 and even shut down local cryptocurrency exchanges in 2017 (Library of Congress, 2018). This intervention has slowly but consistently continued to the present date where, in June, 2021, several bitcoin mining companies halted their operations including BTC.TOP which accounts more than 18 percent of China's hash rate (Campbell, 2021). As a result of these interventions, many BTC investors have moved to neighboring countries and a non-trivial number of BTC mining pools have sprouted up in the European Union. These effects are significant enough to create cross-country premiums in BTC. For example, Choi et al. (2020) report that BTC held in Korea demanded a 4.73% premium over BTC held in the U.S., something known as the "Kimchi Premium".

Yet, despite the capital controls, the regulatory burdens, and the movement of some BTC investors offshore, BTC mining and mining pools are nevertheless uniquely concentrated in China; a concentration that has been and is remarkably consistent over time. Just as there is a "Kimchi Premium" due to BTC investor location, it is not unreasonable to hypothesize that there is also a BTC pricing effect induced by the considerable concentration of BTC production in China. Further, it is also not unreasonable to hypothesize that a BTC vs. CNY relationship should covary with changes in Chinese capital outflows; outflows that may have, in part, been facilitated by BTC's transaction-obscuring power.

We examine these hypotheses in this paper wherein BTC, CNY, and Chinese capital outflows are compared and linked. Specifically, we find that BTC and CNY exhibit significant comovement behavior at daily intervals. This cross-rate comovement, however, only appears in the latter half of our sample; a time marked by increasing Chinese capital outflows. We further test BTC/CNY comovement against Chinese capital outflows using a rolling-regression approach. Both by visual inspection as well as through rigorous econometric modeling, we find that the strength of BTC/CNY comovement increases with stronger Chinese capital outflows. Note that we do not find a similar set of relationships when using a "bogey" currency (i.e. the European Union Euro) or capital outflow data (i.e. from the European Union).

Thus, our results describe and provide evidence towards Chinese capital outflows impacting the strength of cross-price movements between BTC and CNY. These results have implications for BTC and CNY market participants, central bank regulators, and everyday cryptocurrency users. We continue in Section 2 with a review of the existing literature, explain our methodological approach in Section 3, present our results in Section 4, and then provide concluding remarks in Section 5.

II. Literature Review

Since Bitcoin's (BTC) 2009 introduction as the world's first cryptocurrency, the aggregate market value of all cryptocurrencies exceeded $2 trillion in April, 2021 (Kharpal, 2021). Due to cryptocurrencies' popularity, there is a growing interest in research related to cryptocurrencies, especially BTC. Many papers in the extant literature cover such topics as market efficiency from both the transactions-processing and informational perspectives (e.g. see Kim, 2017; Tiwari et al., 2018; Urquhart, 2016; Wei, 2018); pricing dynamics during extreme market fluctuations, an aspect that's almost synonymous with BTC (e.g. see Corbet et al., 2018; Fry and Cheah, 2016; Fry, 2018); volatility dynamics, clustering, and causes (e.g. see Katsiampa, 2019; Urquhart, 2017; Aalborg et al., 2019); news announcement effects (e.g. see Corbet et al., 2020; Vidal-Tomása and Ibañez, 2018; Feng et al., 2018); diversification, hedging, and risk reduction for use in both traditional-asset portfolios as well as within cryptocurrency portfolios (e.g. see Bouri et el, 2017a; Baur et al., 2018; Urquhart and Zhang, 2019); regulation and the impact of regulatory regimes (e.g. see Ju et al., 2016; Viglione et al., 2015; Luther and Salter, 2017); and more (e.g. see Corbet et al., 2019 for a comprehensive overview of cryptocurrency literature).

Limited portions of the prior literature argue against the existence of interactions between cryptocurrencies and home currencies. For example, Yermack (2015) finds no correlation between BTC and fiat currency rates during economic announcements between July, 2010 and March, 2014. Similarly, Bouri et al. (2017b) analyze BTC's ability to act as a "safe haven" for the United States Dollar (USD), among other assets. While their results do suggest that BTC can act as a limited diversifier, BTC would not be considered as a "safe haven" for USD fluctuations.

Yet, the majority of existing literature finds that BTC prices co-move and, at times bi-causally impact, home currency exchange rates. For example, but using relatively low frequency data, Carrick (2016) compares the correlation of BTC and emerging market currency returns from January, 2011 to December, 2015. Carrick finds statistically significant correlations among BTC and the various exchange rates. Of particular note is that the BTC vs. Chinese Yuan (CNY) correlation is positive while the non-BTC/CNY correlations are negative. Pieters (2016) uses daily data to show that BTC price changes can be used to estimate countries' exchange rate changes and that sub-daily data frequencies may not capture BTC vs. home currency interactions.

In addition to existing at daily intervals, BTC vs. home currency effects also detectable at higher frequencies. For instance, Urquhart and Zhang (2019) use hourly BTC and exchange-rate data to analyze BTC's properties as a hedge or safe-haven. Here, the authors find that BTC can act as a safe haven for four exchange rates and a diversifier for three others. Sensoy (2019) tests the weak form efficiency of BTC vs. a variety of home currencies. Sensoy finds that different exchange rates have different cross-rate dynamics but that market efficiency has increased over time for Euro- and USD- based BTC prices. Further, as inefficiency increases with data frequency, Sensoy provides evidence that there is a time delay to efficiency. Finally, Sensoy shows that differences in different countries' exchange rates, alone, do not govern BTC vs. exchange rate dynamics. For example, liquidity increases cross-price efficiency whereas volatility decreases this efficiency.

To be sure, the extent of BTC vs. home currency interactions are not economically trivial. For example, Kim (2017) finds the potential for cross-rate arbitrage profits across 16 different exchange rates. Further, these profits primarily derive from BTC's surprisingly-smaller average bid-ask spreads, relative to the home currencies. Not only does Kim show that BTC vs. home currency relationships exist and the fact that these relationships are economically significant, but also that traders can efficiently use BTC as a means of currency conversion.

With respect to the general issue of capital controls, flows, and flight, more-traditional studies examine capital outflows via bond issuances, foreign direct investment, and trade of goods (e.g. see Bruno and Shin, 2015; Feyen et al., 2015; Avdjiev et al., 2014; Wang and Wang, 2015; Aizenman, 2004; Lin and Ye 2018 while still others specifically focus on Chinese capital outflows (e.g. see Gunter, 2004; Ljungwall and Wang, 2008; Cheung and Qian, 2010).

While the literature on general capital flows is vast, the prior literature regarding the interaction among BTC, home currencies, and capital flows is more limited and indirect. For example, Cheng and Dai (2020) show the potential for using BTC to facilitate CNY/USD carry trade using BTC and where this relationship strengthens during heightened PBOC restrictions on BTC. No such relationship was found for currencies with relatively unrestricted capital flows. In net, the authors' results suggest that BTC transactions can be used to bypass regulations and capital controls. Pieters (2016) finds similar results wherein BTC may be a means for bypassing capital controls. Makarov and Schoar (2020) more directly link BTC usage with capital outflows in that cross-rate arbitrage opportunities arise from either the slow-moving of capital (Duffie, 2010) or binding capital controls.

Looking at the literature showing a more-direct link between BTC usage and capital outflows, Ju et al. (2016) examine capital outflows via BTC transactions from the CNY to the USD. The authors find evidence of capital flight shortly before the PBOC's December 5, 2013 announcement prohibiting BTC transactions for financial institutions and intermediaries. Ju et al.'s results are reinforced by Yu and Zhang (2018) who document that economic uncertainties induce heightened cryptocurrency demand. Yu and Zhang assist Ju et al. in that we would expect an intuitive relationship between economic uncertainty and the desire to shield wealth from this uncertainty (read: capital outflows).

Another relevant study is Griffin and Shams (2020) who investigate whether Tether influenced BTC during BTC's rapid price appreciation during its 2017 boom. This study is relevant in that Tether is a stablecoin whose value is pegged to the USD and is frequently used as a transaction facilitator among various means of exchange. In other words, Tether's relationship with BTC is an exchange rate equivalent of BTC's relationship with a home currency. Here, the authors find that Tether transaction flows explain BTC prices, indicating that cryptocurrencies may act as decentralized and partially-anonymizing financial intermediary in the capital outflow process.

Where the current paper fits into and expands the existing literature is that our empirical methodology allows for a *direct* examination of the BTC, home currency, and capital outflow relationship. Our modeling approach relies on little hand waiving or indirect inference and is, instead, a direct statistical test on this triad of relationships. Also, our paper bridges the gap between a.) Ju et al. (2016) who show a linkage between BTC *transactions* and capital outflows and b.) Griffen and Shams (2020) who show a relationship between BTC *prices* and capital outflows; we examine how capital outflows drive BTC vs. home currency price dynamics, thus examining both mechanisms simultaneously.

III. Methodology

This study employs two methodological approaches to understand Bitcoin (BTC) vs. "home currency" interactions and, especially, how these interactions may be shaped by capital outflows. While each approach is, ultimately, focused on the Chinese Yuan (CNY) vs. BTC relationship, we employ a "bogey" home currency, the Euro (European Union; EUR) to help clarify the relationship among CNY, BTC, and Chinese capital outflows.

The first methodological approach focuses on uncovering the presence and extent of BTC vs. home currency relationships. Here, daily BTC prices are collected from CoinMarketCap and merged with daily, directly-quoted currency data for the CNY and EUR from Yahoo! Finance. This process leads to a merged dataset spanning September, 2014 to March, 2021. Note that March, 2021 was designated as the sample end date as, past this time, a myriad of potentially confounding central bank and regulatory interventions were enacted. Returns for the various BTC and currency rates are calculated as follows:

$$r_X = \frac{\left(P_t - P_{t-1}\right)}{P_{t-1}}$$

and was chosen over alternative return definitions (e.g. "log normal returns") to preserve the full extent of tail behavior in all series.

From there, the following two regression models are estimated using Ordinary Least Squares (OLS) with Newey-West (1987) heteroskedasticity- and autocorrelation- corrected standard errors:

$$r_{BTC,t} = \alpha_0 + \sum_{j=1}^{5} \beta_j \, r_{BTC,t-j} + \sum_{j=1}^{5} \gamma_j \, r_{CNY,t-j} + \lambda_{CNY} \, r_{CNY,t} + \varepsilon_t \qquad \text{(Eq. 1A)}$$

$$r_{BTC,t} = \alpha_0 + \sum_{j=1}^{5} \beta_j \, r_{BTC,t-j} + \sum_{j=1}^{5} \gamma_j \, r_{EUR,t-j} + \lambda_{EUR} \, r_{EUR,t} + \varepsilon_t \qquad \text{(Eq. 1B)}$$

Here, BTC returns are modeled as a function of lagged own-returns to account for own-autocorrelation effects, lagged home currency returns to account for cross-autocorrelation effects (e.g. inefficient spillovers between BTC and a given currency), as well as a contemporaneous home currency return variable that reflects the direction and strength of BTC vs. home currency comovement.

As seen in Figure 1, BTC has experienced tremendous price appreciation over its life and, especially, during 2020-2021. To ensure that our results are robust to potential breakdates, and to extend the richness of our results, each estimation is performed under four separate time regimes: a Full sample extending from September, 2014 to March, 2021; an Early sample spanning September, 2014 to April, 2018; a Late sample extending from May, 2018 to March, 2021; and a separate, Bubble sample spanning March, 2020 to March, 2021. The breakdate for the Early and Late samples is chosen using a Chow Breakpoint Test (Chow, 1960) while the beginning of the Bubble sample was based on the lowest BTC price in 2020 (i.e. March 12th, 2020).

Three Wald Coefficient Restriction tests are employed against Equations 1A/B, for each BTC/currency pair, and for all four samples:

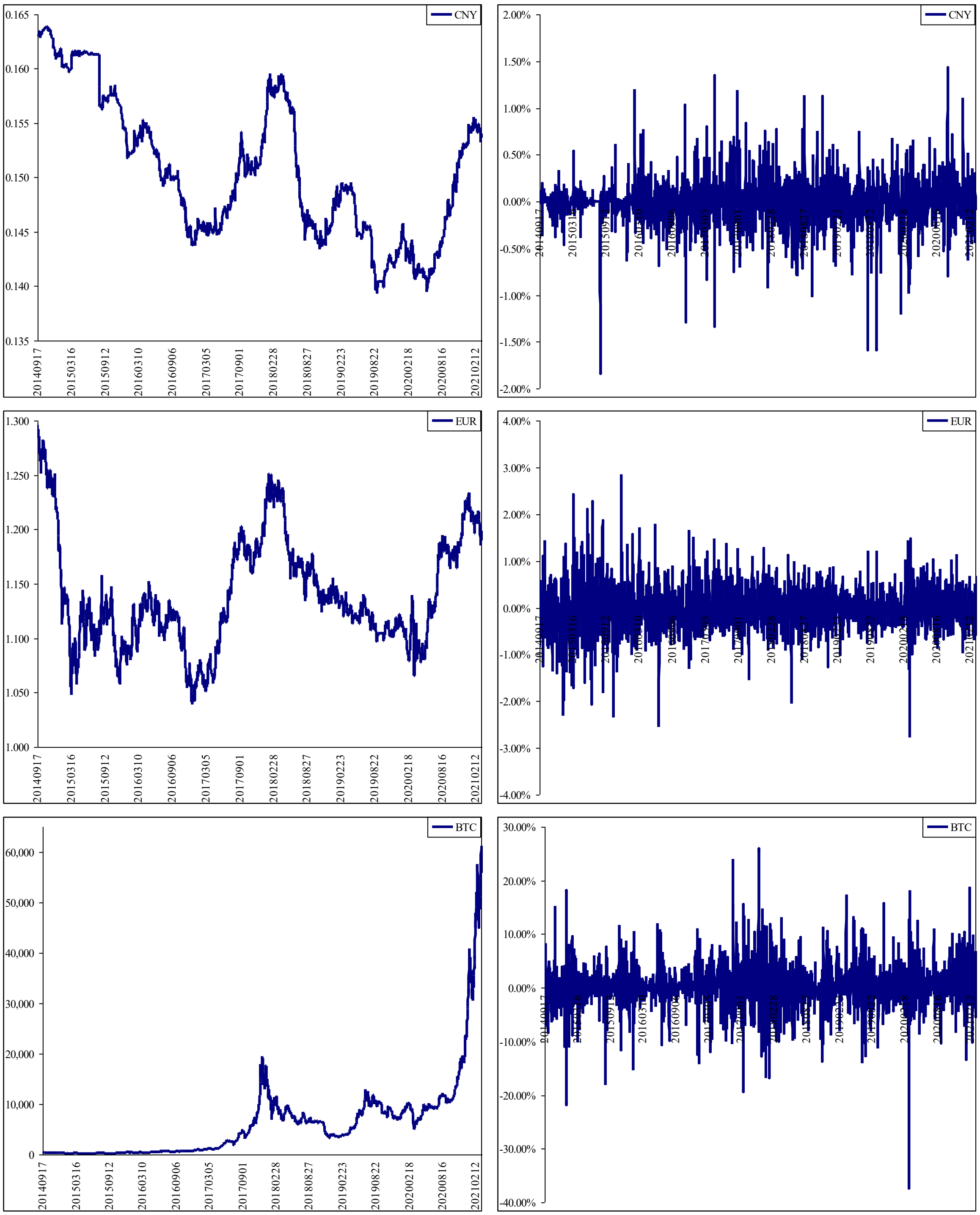
$$\gamma_1 = .. = \gamma_5 = 0 \qquad \text{(W1)}$$

$$\gamma_1 + .. + \gamma_5 = 0 \qquad \text{(W2)}$$

$$\lambda_{Currency} = 0 \qquad \text{(W3)}$$

Figure 1 Price Data

The following figures report the levels (left) and returns (right) of Chinese Yuan (CNY), European Union Euro (EUR), and Bitcoin (BTC) exchange rates, all relative to the United States Dollar (USD), and across the September, 2014 to March, 2021 time periods.



W1 tests if the collection of (cross-autoregressive) currency-to-BTC impacts are jointly significant. W2 tests a slightly more stringent form of W1 wherein currency-to-BTC impacts may be cumulatively (and jointly) significant. W3 tests whether the currency-vs.-BTC relationship exists on a contemporaneous basis, hence measuring currency vs. BTC comovement after own- and cross- autoregressive effects have been accounted for. Note that, through our use of the Newey West correction in each of our estimations, results from the above restriction tests should be free from auto-regressive and heteroskedastic interference. Also note that we've selected five own- and cross- autoregressive terms for use in Equation 1 A/B to explicitly model up to one, full week's worth of trading activity.

As is seen in the Literature Review and elsewhere, we believe that there is a strong case for BTC being used, in part, for capital outflows in countries with binding capital controls. It follows, then, that any use of BTC for capital outflows should have a contemporaneous impact on BTC vs. home currency relationships. That is: capital outflow demand via BTC should induce capital outflow participants to exchange their home currency with BTC, thus leading to discernable BTC vs. home currency effects. Further, this BTC vs. home currency relationship should be positively-related to capital outflows such that increases (decreases) in capital outflows should be associated with stronger BTC vs. home currency relationships.

To test the above hypothesis, we model the strength of BTC vs. home currency relationships (i.e. the estimated parameter from Equation 1 A/B; $\lambda_{Currency,t}$; CNY and EUR) as a function of capital outflows ($Value_{Country}$; China and EU; FXEmpire.com), linear (T) and quadratic (T^2) trend variables to account for autonomous changes in the BTC vs. home currency relationship over time, and a binary Outlier variable equal to one when capital outflows for a given country is greater than one standard deviation away from the historical mean:

$$\hat{\lambda}_{Currency,t} = \alpha_0 + \psi_{Country}\, Value_{Country,t} + \theta_1 T_t + \theta_2 T_t^2 + \theta_3\, Outlier_t + \omega_t \qquad \text{(Eq. 2)}$$

We operationalize the above approach by, first, parsing the Full (daily) dataset into quarterly segments. Then, we estimate Equation 1A (1B) for CNY (EUR) and for each quarterly time period, separately. With each quarterly estimate, we capture a quarterly measure of BTC vs. home currency strength, $\lambda_{Currency,t}$, and compare it against each country's quarterly-reported level of capital outflows. Here, we use the inverse of each country's capital account as a proxy, broad measure of capital outflows; see Schneider (2003) for different definitions of capital outflows used in the literature. Note that we use the level value for each country's capital outflows as, both visually and via regression estimates, flight is mean reverting and is not unitary persistent (i.e. a unit root process).

If capital outflows are, indeed, related to a given currency's contemporaneous relationship with BTC, we should see that the following hypothesis test (W3) is rejected at a sample-appropriate level of significance:

$$\hat{\lambda}_{Currency,t} = 0$$

IV. Results

We begin our analysis with Figure 1 which plots the Chinese Yuan (CNY), European Union Euro (EUR), and Bitcoin (BTC) level and returns series. Here, we note that all series exhibit various trend regimes and, most prominently, with BTC experiencing a massive appreciation in value, starting in early-2020. Also, while CNY and EUR returns are constrained within modest bounds, BTC has experienced significant price shocks over time; some these extending ± 30%. Thus, throughout our analysis, we pay particular attention to ensuring robustness against data-, structural break-, and model instability- issues. Also, while this study does not explicitly model own- or cross- volatility dynamics, we do employ the Newey-West (1987) heteroskedasticity- and autocorrelation- correction to each estimation.

Table 1 reports the estimation results for Equations 1A and 1B across the four sample periods. In total, these results are consistent with strong (weak), time-varying BTC vs. CNY (BTC vs. EUR) relationships. Specifically, across the Early sample and using a 5% significance level, we fail to reject both the causal- (i.e. W1 and W2) and coincident- (W3) restriction tests; this applies to both CNY and EUR. While these findings do not completely rule out BTC vs. home currency relationships at the intraday frequency during the Early period (e.g. see Chan at el., 2011), our results do suggest that BTC is not impacted by home countries' exchange rate movements at the daily -to- weekly time scales from September, 2014 to April, 2018.

Table 1 Returns Comovement

The following tables report regression results for the Bitcoin (BTC) vs. Chinese Yuan (CNY) relationship (Table 1A; Eq. 1A) and the Bitcoin (BTC) vs. European Union Euro (EUR) relationship (Table 1B; Eq. 1B) across four samples: Full (September, 2014 to March, 2021), Early (September, 2014 to April, 2018), Late (May, 2018 to March, 2021), and Bubble (March, 2020 to March, 2021). Note that "Wald Zero p-Value" and "Wald Sum p-Value" refer to the p-Values calculated from Wald coefficient equality- (W1) and summed- (W2) restriction tests, respectively, on each model's causality parameters. Further, "Comovement p-Value" and "Comovement Coef." represent each model's coincident parameter restriction test (W3) p-Value and estimated coefficient, respectively. Please see the Methodology section regarding Equation 1 for more details on the econometric modeling.

Table 1A BTC vs. CNY

	Full	Early	Late	Bubble
Wald Zero p-Value	0.678	0.825	0.702	0.035
Wald Sum p-Value	0.644	0.345	0.687	0.665
Comovement p-Value	0.026	0.352	0.020	0.008
Comovement Coef.	-0.882	-0.546	-1.223	-2.924

Table 1B BTC vs. EUR

	Full	Early	Late	Bubble
Wald Zero p-Value	0.886	0.988	0.517	0.152
Wald Sum p-Value	0.430	0.884	0.068	0.013
Comovement p-Value	0.622	0.805	0.536	0.361
Comovement Coef.	-0.089	-0.054	-0.220	0.530

Yet, during the Late sample period, we find that BTC vs. home currency relationships do emerge and especially so as the sample nears the present date. Specifically, we find that BTC co-moves contemporaneously with CNY in both the Late (p-Value: 0.020) and Bubble samples (p-

Value: 0.008). Further, the magnitude of the BTC/CNY relationship increases by more than 2.39 times in the Bubble sample, relative to the Late sample. These narrowly-focused results indicate that the BTC relationship with CNY is time-varying and increased substantially during BTC's recent price bubble. Note that, in addition to the strong contemporaneous relationship, we find limited evidence of causality in the BTC/CNY relationship during the Bubble sample. While this finding may indicate that the BTC/CNY relationship is prone to extended inefficiencies during extraordinary market conditions, nevertheless, the contemporaneous relationship remains.

Contrasting with the above BTC/CNY results, we find that the BTC vs. EUR relationship is never significant at the contemporaneous level and across any of the four sample periods. Further, while we find limited evidence of EUR-to-BTC causality in the Bubble sample (p-Value of Wald Sum test: 0.013), the lack of contemporaneous BTC/EUR relationships may suggest that Bubble sample BTC/EUR causality is transitory; perhaps related more to market-induced inefficiencies than a consistent, economic phenomena.

For robustness purposes and in unreported results (available upon request), we extend Equations 1A and 1B by adding five return lags of a multi-cryptocurrency index variable (i.e. the CMC Crypto 200 Index; CoinMarketCap) to account for systematic crypto currency effects. We find that the BTC/CNY results described above still hold despite the addition of this systematic variable. However, when employing these same index returns to Equation 1A, we do not find evidence of BTC/EUR relationships, causal or coincident, and for any sub-period. This provides further evidence that the limited and weak EUR-to-BTC causality noted above is not likely a bona fide and consistent economic phenomena. BTC/EUR causality is, instead, likely a result of temporary market inefficiencies or the influencing effects of systematic crypto market conditions.

As noted in the Methodology section, we are using a split sample design to not only gain a richer understanding of BTC vs. home currency effects, but also as BTC has experienced significant volatility and price trends over its life. A related concern of this volatility is the possibility that the above results are biased by additional, unaddressed model instability. To test for this, we perform recursive -residual and -coefficient analyses on each Full sample (i.e. Equation 1A and 1B) estimation. We find that, with the exception of a few minor disturbances, the results in Table-1 A/B are robust to potential model-, data-, and relationship- instability; results available upon request. Additionally, as some in the prior literature opt for Quantile Regression approaches (as opposed to OLS; e.g. see Bouri et al., 2017 and Balcilar et al., 2017) in order to account for volatile BTC price swings and tail behavior, we have similarly employed Quantile approaches for robustness purposes. We find that our results in Table-1 A/B are qualitatively unchanged when extending from an "averaging" OLS approach to a more tail-oriented, Quantile approach; results available upon request.

Thus, from Figure-1 and Table-1 A/B, a picture of BTC vs. CNY relationships emerges wherein BTC and CNY interact, mostly on a contemporaneous basis, and especially so during the recent rise in BTC prices. Yet, the question remains as to "what influences BTC vs. CNY comovement at daily intervals?" and, relatedly, "why do we not see this same effect for BTC vs. EUR?".

A potential explanation, as seen in much of the prior literature, is hedging. That is: in addition to the hedging plain vanilla portfolio risk, traders may wish to also hedge home currency movements with BTC, and vice versa (e.g. see Urquhart and Zhang, 2019). Yet, while intuitively appealing, this potential explanation is not supported by our findings of a.) strong BTC/CNY relationships in the face of b.) weak BTC/EUR relationships. If hedging currency risk was a suitable explanation for our results, we should see similarly strong BTC vs. home currency effects in both the CNY and EUR. The currency hedging hypothesis is further refuted by our findings (above) that the (expected-value oriented) OLS regression results are qualitatively similar to the (tail-value oriented) Quantile regression results. If currency hedging was a suitable hypothesis, we should see that the OLS-based BTC/CNY and BTC/EUR relationships were also captured, and equally so, in the Quantile-based results; they were not.

Beyond the currency hedging hypothesis, other explanations may also intuitively seem to hold. For example, it may be possible that the solid (weak) BTC/CNY (BTC/EUR) relationship is a result of coin-mining location and, in particular, China's dominance of the BTC mining space. Here, we know from prior literature (e.g. see Romiti et al., 2019) and from empirical data obtained from “btc.com”, that China’s mining market power has not fallen below 50 percent. In fact, China is and has been for some time the dominant location for BTC mining. Yet, China's relatively consistent mining market power cannot explain our findings that BTC/CNY relationships increased over the latter half of the sample; particularly so during the massive price appreciation that began in mid-2020. We see a similar argument against crypto "mining pools" being behind BTC/CNY relationships as a.) China's abundant use of BTC mining pools hasn't significantly changed over time whereas b.) the BTC/CNY relationship has changed over time. Further, attempts at linking the changing BTC vs. home currency relationship with periods of BTC price appreciation also fail. If BTC price appreciation was to blame for BTC vs. home currency effects, both BTC/CNY and BTC/EUR relationships should behave similarly (but do not).

Thus, it seems a bit of a paradox that BTC/CNY relationships exist and seem to be related to phenomena occurring predominantly after 2018, despite the lack of change in mining dominance and other possible explanations. One explanation receiving only sparse attention in the prior literature rests in the evading of capital controls and capital outflows. As summarized in Ocampo (2017): the People's Bank of China (PBOC) has enacted several capital control regimes over the past decade, sometimes proactively and sometimes reactively. This contrasts with the European Central Bank's relatively lax capital control policies (e.g. see Honohan, 2020). Could it be that Chinese capital outflow demand mixed with the resulting failure of binding capital controls, is related-to and possibly an explanation-for BTC/CNY relationships?

To test for this possibility, we begin by plotting quarterly-aggregated capital outflows for both China and the EU in Figure 2. Additionally, we co-plot the quarterly-estimated "BTC vs. home currency strength" coefficient ($\lambda_{Currency,t}$; see Methodology for more estimation details). Here, we see that Chinese capital outflows have experienced wild swings throughout time, starting quite strong in 2014 to 2015 when the PBOC was attempting a series of liberalizations, dually oriented at preventing so-called "hot money flows" (e.g. see Ding et. al, 2014). From about 2015 to 2018, Chinese capital outflows began to fluctuate, decline, and then escalate significantly in early-2020. This contrasts with EU capital outflows which, while volatile, do not surpass Chinese capital flight in magnitude and does not experience a clear, early-2020 acceleration.

What's more is that, when we plot the quarterly-estimated "relationship strength" coefficient against capital outflows in Figure 2, an interesting pattern emerges. Specifically, Chinese capital outflows vary in remarkably similar ways to BTC/CNY strength but does not vary contemporaneously with EU capital outflows. Also, visually speaking, EU (Chinese) capital outflows are loosely (not) related to the BTC/EUR relationship strength coefficient. This differential behavior is in line with our estimation results in Table 1. Further, these findings provide initial evidence that Chinese BTC participants, whether they be miners, traders, or others, evade quasi-binding PBOC capital controls through the use of BTC.

To test this capital outflow hypothesis more formally, we estimate Equation 2 for the 2x2 combination of capital outflows (Chinese and EU) and relationship strength (BTC/CNY and

Figure 2 Capital Outflow & Relationship Strength

The following figures plot quarterly Chinese (Figure 2A) and European Union (Figure 2B) capital outflows (solid black lines) from 2014Q4 to 2020Q4 and where positive (negative) values represent capital outflows (inflows) from (to) a given country. Also, quarterly-estimated comovement parameters (see Methodology section; light grey dotted line) for the Bitcoin/Yuan (left) and Bitcoin/Euro (right) relationships are plotted. All individual-level figure scales have been matched for illustrative purposes.

Figure 2A Chinese Capital Outflows

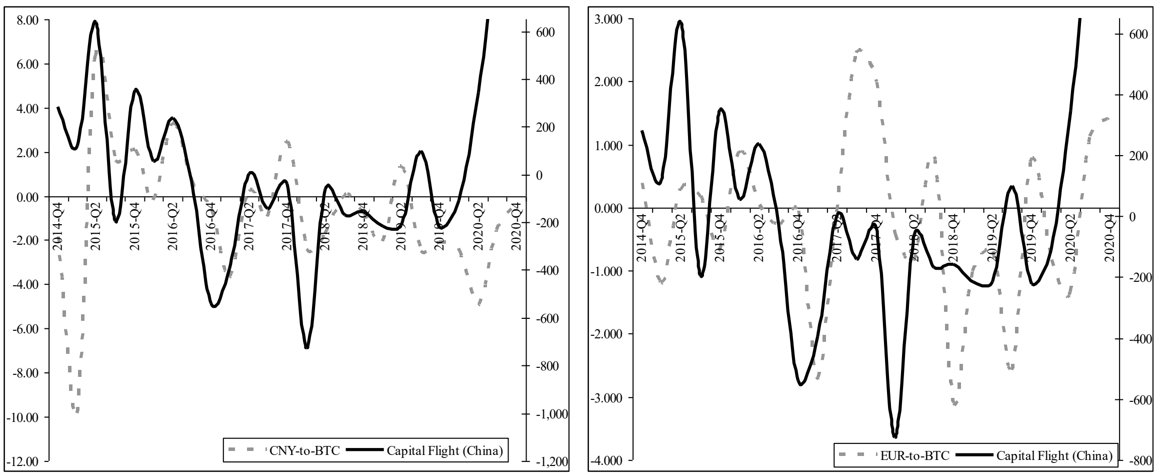
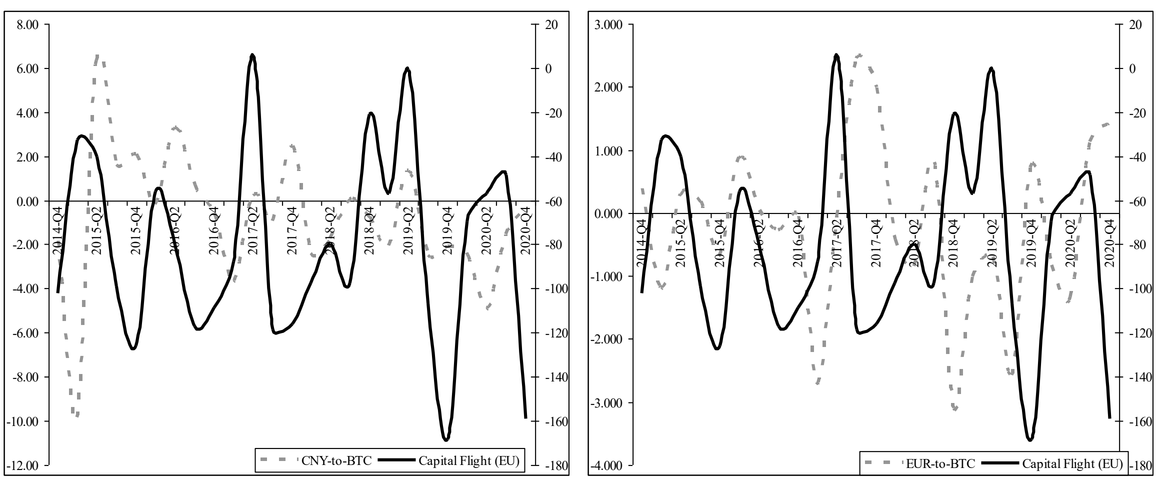


Figure 2B European Union Capital Outflows



BTC/EUR). As reported in Table 2A and using a 10% significance level due to sample considerations, both the BTC/CNY and BTC/EUR relationships are significantly- and positively-related to contemporaneous changes in Chinese capital outflows. Further, the relationship between Chinese capital outflows and the BTC/CNY relationship is remarkably stronger than the BTC/EUR relationship; the impact parameter (*Value*) for the BTC/CNY relationship is more than

3.51 times that of the BTC/EUR relationship; the BTC/EUR-focused estimation also has an effectively-zero adjusted R^2.

Table 2 Capital Outflows & Relationship Regressions

The following tables report the regression estimation results for Chinese capital outflows (Table 2A) and European Union capital outflows (Table 2B) against a quarterly-estimated coincident parameter for the Chinese Yuan (CNY) vs. Bitcoin (BTC) relationship (left panels) and EU Euro (EUR) vs. Bitcoin (BTC) relationship (right panels). Within each table, Alpha refers to each model's intercept, Value represents the capital outflow impact variable, T1 (T2) represents a linear (quadratic) trend variable, and Outlier is a binary variable equal to one when a given region's capital outflows are greater or less than one standard deviation from the mean. Please see the Methodology section regarding Equation 1 (for time-varying coincident parameter modeling) and Equation 2 (for the estimation results reported in the tables below).

Table 2A Chinese Capital Outflows

	CNY vs. BTC		EUR vs. BTC	
	Coef	p-Value	Coef	p-Value
Alpha	-5.025	0.111	-0.774	0.315
Value	0.005	0.008	0.001	0.066
T1	1.118	0.045	0.154	0.474
T2	-0.048	0.024	-0.007	0.410
Outlier	0.520	0.675	0.062	0.914
Adj R2	0.209		≈ 0.000	

Table 2B European Union Capital Outflows

	CNY vs. BTC		EUR vs. BTC	
	Coef	p-Value	Coef	p-Value
Alpha	-1.458	0.613	-0.502	0.456
Value	-0.006	0.592	-0.011	0.038
T1	0.226	0.546	-0.094	0.523
T2	-0.012	0.323	0.003	0.613
Outlier	-0.330	0.859	-0.278	0.637
Adj R2	≈ 0.000		≈ 0.000	

Note that, in separate, unreported results (available upon request), we re-estimate Equation 2 where the *difference* in comovement coefficients (i.e. $\lambda_{China,t}$ - $\lambda_{EU,t}$) serves as the dependent variable. Based on this analysis, the comovement differential variable is positive and statistically significant at the 10% level (p-Value of 0.051) meaning that the qualitative difference seen in Table 2A (i.e. 3.51 times) is significant, both statistically and economically. Also, for robustness purposes, we applied different forms of the BTC vs. home currency coefficient as Equation 2's dependent variable (i.e. using the estimated t-Stats, as opposed to raw, estimated coefficients) and found that our results are quantitatively unchanged. Thus, the above findings that the BTC/CNY relationship is positively related to Chinese capital outflows (and more so than the BTC/EUR relationship) are robust to statistical noise and dependent variable specifications.

Contrasting with the Chinese capital outflow results found in Table 2A, the results in Table 2B examine how BTC/CNY and BTC/EUR co-vary with EU capital outflows. Here, we find that the BTC/CNY relationship is not at all related to EU capital outflows and has an effectively-zero adjusted R^2. The results of the BTC/EUR relationship with EU capital outflows are just as underwhelming as the estimated adjusted R^2 is, also, effectively zero. Additionally, the estimated coefficient for *Value* is negative (-0.011). These results either imply a nonsensical economic outcome or that EU capital outflows are achieved in ways unrelated to BTC and cryptocurrencies. Thus, while there is some evidence that the BTC/EUR relationship is related to EU capital outflows, the results are weak statistically, weak economically, and collectively suggest that BTC/EUR is more related to EU capital inflows than outflows.

In net, our results indicate that BTC and CNY have formed a statistically- and economically-significant contemporaneous relationship over time and especially after early-2020. The BTC/CNY relationship is remarkably similar of and statistically related to the patterns and strength of Chinese capital outflows. Conversely, BTC and EUR share inconsistent relationships with one another and have little to do with either Chinese or EU capital outflows. Thus, we provide evidence that Chinese market participants are (or are attempting) evading quasi-binding PBOC capital controls through the use of BTC. This evasive behavior causes an efficient, contemporaneous relationship between BTC and CNY to form and to strengthen as more evasion occurs. We do not find similar behavior for the EU, suggesting that EU market participants do not consistently evade, nor would they really need to evade, EU capital controls through the use of BTC.

V. Conclusion

The prior literature generally shows that Bitcoin (BTC) interacts with home currency exchange rates and, according to a smaller sampling of this literature, these interactions are potentially the byproduct of capital outflows. We build on and expand the extant literature by directly testing whether capital outflows significantly impact BTC's relationship with home currencies. Unlike prior studies our novel empirical approach allows us to directly measure capital outflow impacts on BTC/rate dynamics and to do so in a way that respects the time-varying nature of adaptive markets.

Using daily data spanning 2014 to 2021, we find that BTC is statistically correlated to the Chinese Yuan (CNY) and, to a much lower degree, the European Union Euro (EUR). Specifically, CNY and BTC positively comove, even after accounting for own- and cross- autoregressive effects. This comovement is time varying and is particularly strong after 2018Q1. Thus, CNY and BTC are correlated and this relationship has increased over time.

Unfortunately, factors such as BTC mining location, mining pool location, price bubbles, price crashes, and more fail to adequately explain the heightened BTC/CNY relationship over time. Yet, what can explain the heightened BTC/CNY relationship is capital outflows. Specifically, we find through both visual inspection and rigorous econometric analysis that Chinese capital outflows are positively and directly linked to the strength of the BTC/CNY relationship. That is, higher levels of Chinese capital outflows are concurrently associated with stronger correlations (read: strength) between BTC/CNY. We find much more limited evidence that Chinese capital outflows impact the BTC/EUR (European Union Euro; EUR) relationship, possibly due to the co-ownership of Chinese and European BTC mining pools. We find no evidence, however, that European Union capital outflows are associated with either BTC/CNY or BTC/EUR relationships. Our results have implications for individual traders, speculative investors, money managers, as well as financial regulatory bodies: capital outflows, exchange rate usage, and exchange rate impacts are co-determinative and must be simultaneously addressed to ensure optimal policy outcomes.

Thus, we find that BTC/home currency relationships can be driven by capital outflows, but not always. Looking towards future research: China's unique capital outflow situation, especially after 2018, may simply be an outlier. Alternatively, it may also be the case that China's extreme capital outflows have inadvertently-revealed behavior that is systematically replicated during other countries' periods of strong capital outflows. In addition to questions of the uniqueness or ubiquity of capital outflow induced BTC/rate effects, there is also the confounding impact of the US/China trade war which, coincidentally, began in early-2018. Did the trade war exacerbate the need for alternative currencies while, unrelatedly, increasing capital outflows? Or, was the US/China trade war a coincident but unrelated factor in the increased demand for Chinese capital outflows and BTC transactions? These questions, along with the impact of Central Bank interventions on BTC/rates, merit examination in future research.

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