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Inflation and cryptocurrencies revisited: A time-scale analysis

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ABSTRACT

This letter revisits the time-series relation between cryptocurrency prices and forward inflation expectations. Using wavelet time-scale techniques, a positive link between cryptocurrencies and forward inflation rates is identified, focused on a brief period surrounding the onset of the COVID-19 pandemic. This coincides with a rapid and synchronized decrease in cryptocurrency prices and forward inflation expectations, followed by a swift recovery to pre-crisis levels. Outside of the crisis period, we find no clear evidence of any inflation hedging capacity of Bitcoin or Ethereum during times of increasing forward inflation expectations.

1. Introduction

In the wake of the COVID-19 crisis, many countries have resorted to aggressive fiscal and monetary stimulus in an attempt to support their economies. Along with supply shortages in key areas, conditions have given rise to heightened inflation expectations, exacerbated by stagnant and falling wages due to substantial pandemic-driven changes in international working conditions. Such expectations have also been quite volatile due to uncertainty relating to the increased supply of money resulting from unconventional monetary policy operations. Investors seek safe haven assets to shelter and diversify from the effects of inflation on their purchasing power. In this paper, we use a dynamic framework to re-examine the potential of cryptocurrencies as a viable diversification mechanism. Persistence of unconventional monetary policy expansions appears aligned with simultaneous broad asset price increases, inclusive of cryptocurrencies. Increased inflation expectations have been linked to cryptocurrency price appreciation (Blau et al., 2021). The use of quantitative easing, zero and negative interest rate policies, and continued signalling of government supports appears to have underpinned inflation expectations. This has given rise to a topical and unresolved research question, as to whether cryptocurrencies can play a role as an inflation hedging mechanism. While gold has been a popular inflation hedge during previous periods of high realized inflation, Bitcoin has been suggested to have many similar properties, and is often referred to in the media as "digital gold". This research sets out to revisit the analysis of Blau et al. (2021), using wavelet time-scale analysis to establish the dynamic relationship between forward inflation expectations and cryptocurrencies, specifically Bitcoin and Ethereum.

In designing an ideal global digital currency, Balvers and McDonald (2021) propose price stability, namely, pegging the currency to a measure of inflation, as a key feature. In practice, Bitcoin and Ethereum, the major cryptocurrencies examined in this study, do not appear to meet the criteria expected of an inflation hedge. Cryptocurrency prices have high associated volatility (Shen et al., 2020) and are exposed to similar macroeconomic factors as traditional assets, reducing their effectiveness as a hedge (Conlon and McGee, 2020; Conlon et al., 2020), although retaining some currency hedging capacity (Urquhart and Zhang, 2019). The ease through which cryptocurrencies are traded and stored can be identified as one key reason why they can act as a more efficient inflation hedge than gold. For Bitcoin, the technological limit to supply may also underpin any ability to provide a store of value. This technological limit is not shared by Ethereum, which does not have a defined issuance limit, motivating our analysis of the second largest cryptocurrency.

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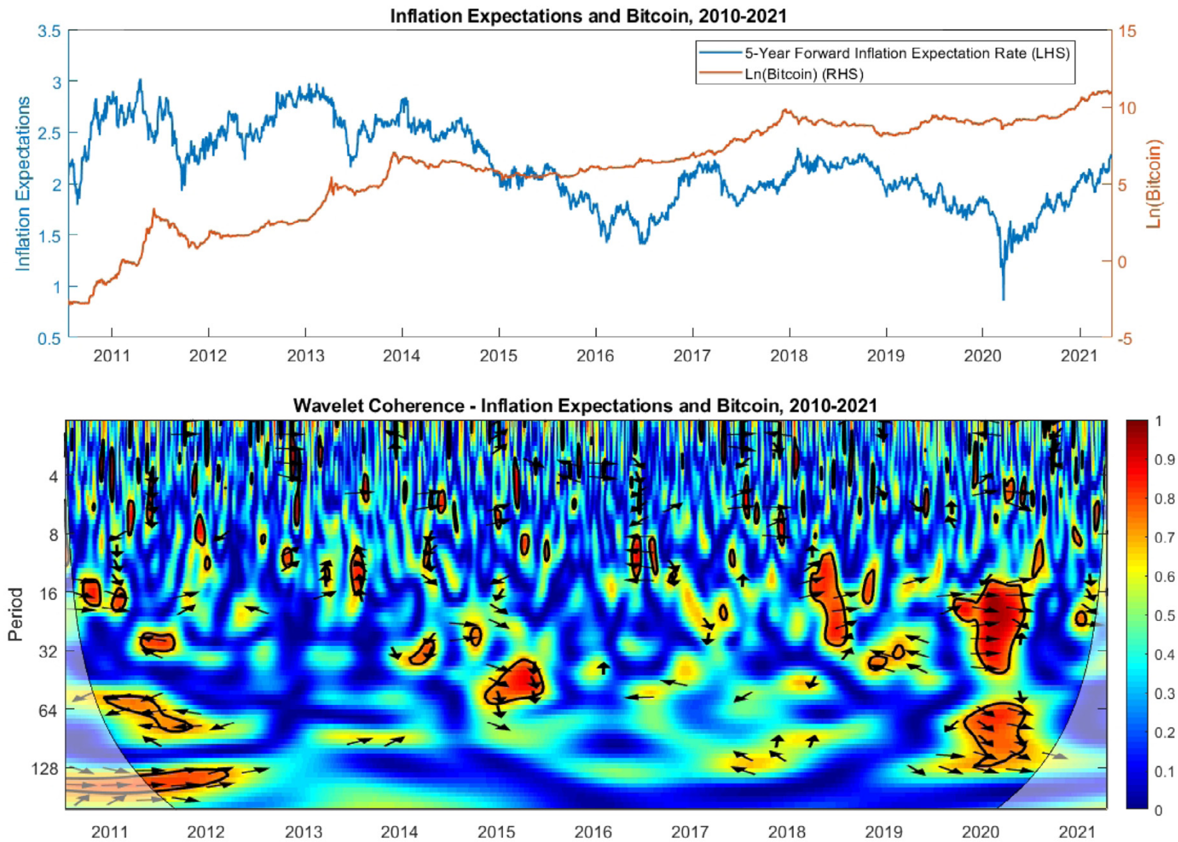

Fig. 1. **Wavelet Coherency Analysis of Bitcoin and Inflation.**
The regions of differing coherency are represented using a heat map, which ranges from blue (low coherency) to red (high coherency). East (west) facing arrows represent in- (out-of-) phase, while north (south) facing arrows indicate that inflation leads (lags) Bitcoin. A north-east (south-east) facing arrow symbolizes that the series are in-phase but that inflation (Bitcoin) leads Bitcoin (inflation). A northwest (south-west) facing arrow signifies that the series are out-of-phase but that Bitcoin (inflation) leads inflation (Bitcoin). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Forward expectations in earnings growth of stocks act as a good hedge against anticipated inflation (Bodie, 1982), while other assets, such as commodities are based on supply and demand dynamics offering strong hedging benefits (Zaremba et al., 2019). Cryptocurrencies, while also influenced by supply and demand factors, obtain price relevant information from several more opaque sources, many of which are not related to expected inflation, and provide diversification benefits when aggregate demand exceeds aggregate supply (Urquhart, 2018). A further consideration with Bitcoin and Ethereum is the persistent issues with regards to energy usage (Corbet et al., 2021).

In light of these discrepant theoretical links between cryptocurrencies and inflation, we rely on empirical evidence over the period 2010–2021 to reveal any hedging capacity. While we confirm the finding of Blau et al. (2021) that there is a link between both Bitcoin and Ethereum and expected inflation, we find that any relationships are predominantly associated with a single point in time. Specifically, a positive link is evident coinciding with the rapid and synchronized *decrease* in both forward inflation expectations and the price of cryptocurrencies at the onset of the COVID pandemic. Except for the sharp reversion in forward inflation expectations after the onset of COVID-19 to pre-crisis levels, we find no evidence of any positive links between inflation and either Bitcoin or Ethereum during times of increasing forward inflation expectations. This raises significant doubts over the ability of cryptocurrencies to hedge expected inflation in the short- or long-run. Our findings highlight the importance of accounting for the dynamic relationship between inflation and cryptocurrencies, in keeping with previous results for gold (Conlon et al., 2018; Bampinas and Panagiotidis, 2015). This builds upon the unconditional findings of Blau et al. (2021), where changes in Bitcoin Granger cause changes in the forward inflation rate, indicating that Bitcoin might act as a hedge against forward inflation expectations. Our findings support the existence of a relationship between Bitcoin and forward inflation expectations, but show that such hedging potential is limited outside of the crisis period. Our examination of Ethereum also provides a new perspective, with comparable limitations to its hedging capacity, however, intrinsic differences in issuance limits relative to Bitcoin.

The transitory positive link found between cryptocurrencies and forward inflation expectations from the start of the COVID-19 pandemic may be understood from different viewpoints. From the perspective of Baur et al. (2018), Bitcoin can be considered a speculative asset, dropping in value alongside other speculative assets as the pandemic began (Conlon and McGee, 2020). Coinciding with this, forward inflation expectations fell rapidly, influenced by a change in the outlook arising from lockdown restrictions. The subsequent sharp concurrent recovery in both cryptocurrencies and forward inflation expectations may have followed from the initial announcements regarding unconventional monetary policy to support the economy. An interesting question, not addressed in this research, is why this relationship did not persist during the persistent subsequent episodes of quantitative easing.

2. Methodology

In this paper, we employ the continuous wavelet transform (CWT) to quantify the magnitude, direction and any lead–lag effects between Bitcoin and forward inflation expectations in calendar time. Relative to the vector autoregressive (VAR) model adopted by Blau et al. (2021) in their study of the links between Bitcoin and forward inflation expectations, our approach provides a number of advantages. First, the CWT facilitates an understanding of the dynamic relationships between cryptocurrencies and forward inflation expectations, allowing us to identify the specific points in time at which links are evident, and map to periods of increasing inflation expectations. Second, using the CWT we can identify any changes in the direction of the relationship over time. Finally, the CWT is a multi-scale analysis tool, providing information about the relationships between cryptocurrencies and forward inflation expectations simultaneously at different horizons. This is of particular importance for investors seeking to understand hedging capacity for long-term inflation risks.

The CWT framework employed is based on Torrence (1998), using a "small wave" or wavelet, $\psi(t)$, which is a function of a time parameter t. The wavelet coefficients, $W(\tau, \epsilon)$, associated with a time series $f(t)$ are calculated as:

$$W(\tau, \epsilon) = \sum_{t=1}^{N} f(t)\, \psi^* \left[\frac{t-\tau}{\epsilon} \right]. \tag{1}$$

ψ^* is the complex conjugate of the wavelet, $\epsilon > 0$ is the scale associated with the transformation and $[-\alpha < \tau < \alpha]$ the location of the window. $\frac{1}{\epsilon}$ is a normalization factor.

Due to its strong localization properties, we follow Grinsted et al. (2004) and select the Morlet wavelet with wave number $\omega_0 = 6$ for this study. Formally, this is given by:

$$\psi(t) = \pi^{\frac{1}{4}} e^{i\omega_0 t} e^{\frac{-t^2}{2}}. \tag{2}$$

The cross-wavelet power spectrum represents the common variation between two time series over time and scale. This metric is simply the product of the wavelet coefficients $W_{\epsilon,\tau}(r,s) = W_{\epsilon,\tau}(r) * W_{\epsilon,\tau}(s)$, where $*$ is a complex conjugate. Similar to the estimation of covariance between time series, the cross-wavelet spectrum is influenced by the magnitude of the variation of the two time series. Analogous to correlation, the wavelet squared coherency is defined by normalizing the smoothed cross-wavelet power spectrum by the smoothed wavelet power spectrum associated with the individual time series and given by:

$$\rho^2_{\epsilon,\tau} = \frac{\left|Q\left(\epsilon^{-1} W_{\epsilon,\tau}(r,s)\right)\right|^2}{\left|Q\left(\epsilon^{-1} W_{\epsilon,\tau}(r)\right)\right|^2 \left|Q\left(\epsilon^{-1} W_{\epsilon,\tau}(s)\right)\right|^2}. \tag{3}$$

Q is the smoothing operator in both time and scale (Torrence, 1998). Squared coherency, $0 \leq \rho^2_{\epsilon,\tau} \leq 1$, implies no comovement when $\rho^2_{\epsilon,\tau} = 0$ and perfect comovement when $\rho^2_{\epsilon,\tau} = 1$. Regions of statistically significant squared coherency are determined using Monte-Carlo methods (Aguiar-Conraria and Soares, 2014; Torrence, 1998). The continuous wavelet transformation can also be used to isolate the direction of the relationship between two time series and to uncover any lead–lag effects. The wavelet multiscale phase between two time series $f(t)$ and $g(t)$ is given by:

$$\theta_{\epsilon,\tau}(f,g) = tan^{-1}\left(\frac{\Im\{Q\left(\epsilon^{-1} W_{\epsilon,\tau}(f,g)\right)\}}{\Re\{Q\left(\epsilon^{-1} W_{\epsilon,\tau}(f,g)\right)\}} \right). \tag{4}$$

Q is the smoothing parameter, while $\Re$ and $\Im$ and correspond to the real and imaginary components of the wavelet coefficients. Phase arrows are employed in wavelet coherency plots to represent both the direction of co-movement and lead–lag effects. East (west) facing arrows stand for in- (out-of-) phase, while north (south) facing arrows indicate that time series two leads (lags) time series one. The two time series are in-phase, but time series two (time series one) leads time series one (time series two) when the phase arrow faces in a north-east (south-east) direction. Contrasting results are given for north-west and south-west facing arrows. See Conlon et al. (2018) for a detailed interpretation of phase arrows in the context of the continuous wavelet transformation.

3. Data

Cryptocurrency data are obtained from Coinmetrics, using the CM reference rates. These are formed using a methodology that adheres to the International Organisation of Securities Commissions (IOSCO) framework of principles for financial market benchmarks. Five-year forward inflation expectations are obtained from the St. Louis Federal Reserve Bank, using their 5-Year Forward Inflation Expectation Rate (T5Y1FR). Bitcoin data are from 18th July 2010 through 30th April 2021. Ethereum data are from 8th August 2015 through 30th April 2021. Logarithmic real returns are calculated and matched with changes in forward inflation expectations.

4. Empirical findings

Using a portfolio setting, Bodie (1982) demonstrate that the hedging demand for an asset is a function of the correlation between inflation and the real returns on the asset. In the present study, wavelet coherency is employed as a localized measure of the correlation between inflation and the real returns on cryptocurrencies. Positive coherency is indicative of hedging potential, but care must be taken in the interpretation of results if the investor is predominantly concerned about increases in forward inflation expectations. In other words, in the analysis below, we discern between times of increasing and decreasing forward inflation expectations.

Wavelet coherency between Bitcoin and 5-year forward expected inflation is examined in Fig. 1. Periods of high coherency are shown in warm colours (red) while cool colours (blue) correspond to low coherency. For Bitcoin to provide a hedge against inflation in the sense of Bodie (1982), we are seeking a positive interrelationship with expected inflation, indicated by right-facing arrows.

On average, since the introduction of Bitcoin, it has demonstrated only a limited interrelationship with inflation, as indicated by blue colouring. The primary exception is at horizons greater than 16 days from early 2020. This corresponds to the onset of the COVID-19 pandemic and illustrates that changes in the price of Bitcoin and changes in forward inflation expectations moved in lock-step at this point. Between January 31st 2020 and March 19th 2020, forward inflation expectations fell by 68%, while Bitcoin simultaneously dropped by 41%. Forward inflation expectations recovered to the January level by 31st July 2020, by which time Bitcoin had increased by 60% from the levels seen in mid-March. These findings indicate that, while positive coherency between Bitcoin and inflation expectations is associated with hedging capacity, this is primarily driven by the substantial decrease in forward inflation expectations surrounding the onset of the pandemic followed by the rapid coinciding recovery in both inflation and Bitcoin. Any increase in forward inflation expectations following this is not found to be related to the change in the price of Bitcoin, indicating no hedging potential at this time.

Several other bands of high coherency are evident. One begins in 2018, at periods of between 10 and 32 days, with northeast-facing arrows indicating that inflation leads Bitcoin. Another band is evident in 2015 at horizons between 40 and 64 days. South and south-east facing arrows indicate that inflation lags Bitcoin. Finally, there are several brief bands in 2011 and 2012 at long horizons. None of these bands is associated with increasing

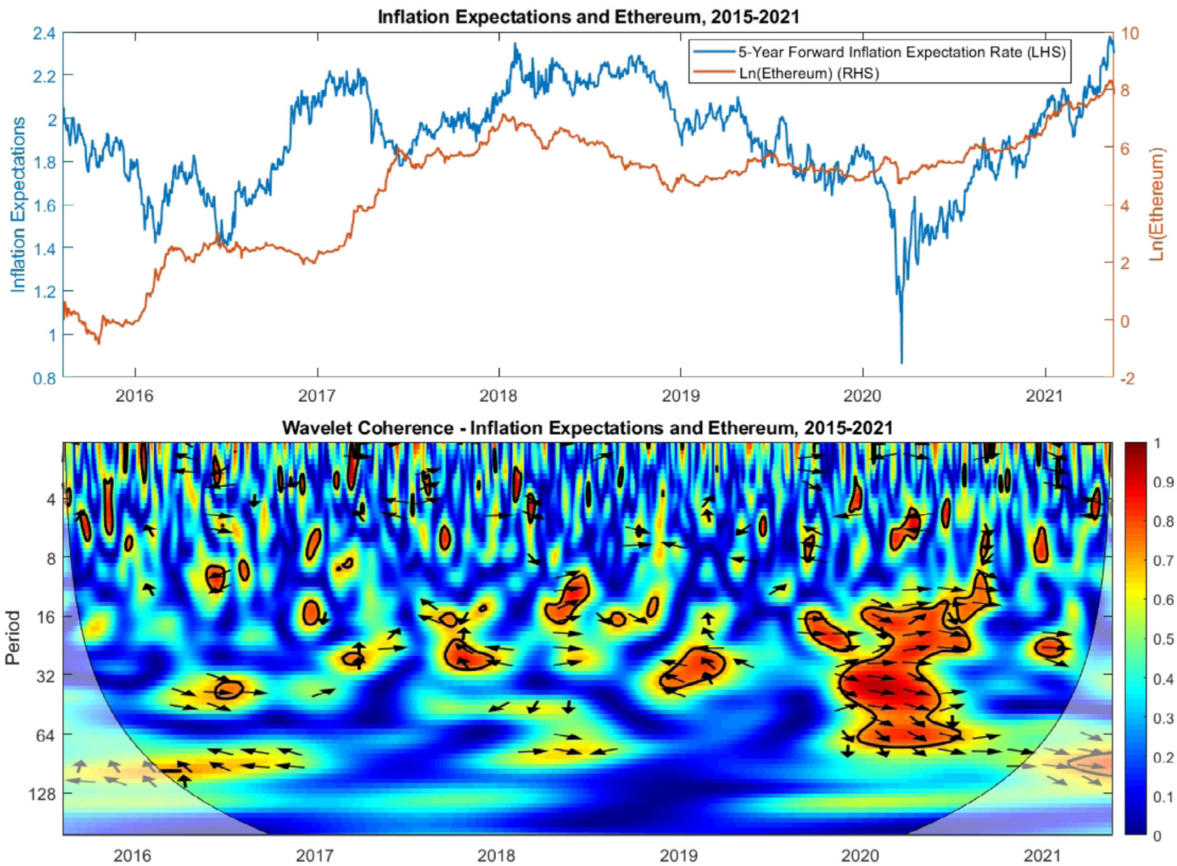

Fig. 2. Wavelet Coherency Analysis of Ethereum and Inflation.
The regions of differing coherency are represented using a heat map, which ranges from blue (low coherency) to red (high coherency). East (west) facing arrows represent in- (out-of-) phase, while north (south) facing arrows indicate that inflation leads (lags) Ethereum. A north-east (south-east) facing arrow symbolizes that the series are in-phase but that inflation (Ethereum) leads Ethereum(inflation). A northwest (south-west) facing arrow signifies that the series are out-of-phase but that Ethereum (inflation) leads to inflation (Ethereum). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

forward inflation expectations. For example, in 2018 forward inflation expectations decreased by 7.6%, while Bitcoin holders encountered steep losses. Along with the findings surrounding the COVID-19 pandemic, this indicates that any historical interrelationships between Bitcoin and expected inflation are associated with periods of decreasing inflation, highlighting the importance of accounting dynamically for positive and negative changes in expected inflation.

As indicated earlier, one of the motivators for Bitcoin as an inflation hedge is the scarcity in supply. In contrast, Ethereum has no technological issuance limit and might be expected to present a different relationship with expected inflation. The wavelet coherency between Ethereum and 5-year forward inflation expectations, as shown in Fig. 2, invalidates this idea.

Results are akin to those found for Bitcoin. Across most of the price history of Ethereum, there is only very limited evidence of a relationship with forward inflation expectations. The major exception is 2020 when a coinciding rapid decrease in forward inflation expectations and the price of Ethereum is followed by a reversion in both. After mid-2020, the evidence of positive coherency is expunged during a period when forward inflation expectations increased steadily. Any other evident bands of high coherency are associated with stagnant or decreasing forward inflation expectations. These findings indicate that, while there is a relationship between Ethereum and inflation, it is mostly driven by the drop and rapid recovery in forward inflation expectations at the start of the pandemic, rather than by simply an increase in forward inflation expectations above trend.

Our empirical findings suggest that Bitcoin and Ethereum cannot be considered a hedge for forward inflation expectations. Evidence for hedging capacity is primarily associated with a single event, the COVID-19 pandemic, at medium- to long-run horizons and does not extend throughout the history of these cryptocurrencies.

5. Conclusion

During previous occasions of high inflation, investors attempted to preserve their purchasing power by investing in assets such as gold, property and stocks. The recent addition of cryptocurrencies as an investment option has added a possible new alternative inflation hedge. In this paper, we assess the capacity of Bitcoin and Ethereum to act as a hedge for forward inflation expectations.

Our empirical findings indicate a brief positive relationship between forward inflation expectations and both Bitcoin and Ethereum, coinciding with the initial stages of the COVID-19 crisis. Outside of this period, we find only very limited evidence that cryptocurrencies act as a hedge during periods of increasing forward inflation expectations. These findings suggest that cryptocurrencies do not hedge against increases in forward inflation expectations, but instead may derive price-related information from factors common to forward inflation expectations during times of crisis.

These findings add to the mounting questions over the role of cryptocurrencies as a financial asset. While a transitory link between cryptocurrencies and forward inflation expectations is evident, the absence of consistent hedging properties may be a cause for alarm as investors attempt to find storage of value outside of traditional mechanisms. Such desperation to maintain wealth within ultra-risky assets ripe with criminality will be of concern for policy-makers and regulators alike.

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