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Testing for asymmetric nonlinear short- and long-run relationships between bitcoin, aggregate commodity and gold prices☆

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ABSTRACT

Unlike prior studies, this study examines the nonlinear, asymmetric and quantile effects of aggregate commodity index and gold prices on the price of Bitcoin. Using daily data from July 17, 2010 to February 2, 2017, we employed several advanced autoregressive distributed lag (ARDL) models. The nonlinear ARDL approach was applied to uncover short- and long-run asymmetries, whereas the quantile ARDL was applied to account for a second type of asymmetry, known as the distributional asymmetry according to the position of a dependent variable within its own distribution. Moreover, we extended the nonlinear ARDL to a quantile framework, leading to a richer new model, which allows testing for distributional asymmetry while accounting for short- and long-run asymmetries. Overall, our results indicate the possibility to predict Bitcoin price movements based on price information from the aggregate commodity index and gold prices. Importantly, we report the nuanced result that most often the relations between bitcoin and aggregate commodity, on the one hand, and between bitcoin and gold, on the other, are asymmetric, nonlinear, and quantiles-dependent, suggesting the need to apply non-standard cointegration models to uncover the complexity and hidden relations between Bitcoin and asset classes.

1. Introduction

After being proposed by Nakamoto (2008) in a paper entitled "Bitcoin: A Peer-to-Peer Electronic Cash System", Bitcoin was implemented on January 3, 2009 as an alternative payment system independent of any central authorities or central banks. However, Bitcoin emerged later as an investment asset (Polasik et al., 2015), given the tradability of its unit of value. Importantly, Bitcoin combines features from commodities (i.e. gold) and sovereign currencies, and thus can be considered as synthetic commodity money (Selgin, 2015). In fact, Bitcoin is regulated as a commodity in the US. Interestingly, in April 2017 the Bitcoin price for the first time exceeded the price of an ounce of gold, and numerous press articles emerged comparing Bitcoin and the yellow metal. Numerous studies have examined the relations between Bitcoin and asset classes such as stocks, bonds, and currencies and highlighted the hedging ability of Bitcoin (see, among others, Dyhrberg, 2016a, 2016b; Baur et al., 2015; Brière et al., 2015; Ji et al., 2017; Bouri et al., 2017a, 2017b, 2017c). However, it remains unclear what relation exists between Bitcoin and commodities in general, and between Bitcoin and gold in particular, especially in terms of asymmetry, non-linearity, and quantiles variability.

Bouri et al. (2017c) report evidence of the ability of Bitcoin to diversify movements in conventional assets, commodities, and energy commodities. Ji et al. (2017), who used a directed acyclic graph approach and focused on the integration of the Bitcoin market within the global financial system, reveal a very weak relation between Bitcoin and commodity markets, including the gold market. Bouri et al. (2017b, 2017c) relied on quantile dummies within a dynamic conditional correlation framework to assess the safe haven property of Bitcoin against commodities, but the authors do not account for the cointegration relationship across the quantiles. Although Bouri et al. (2017a) employed a quantile-based approach, they focused only on the relation between Bitcoin and global uncertainty. Balcilar et al. (2017) employed a non-parametric causality-in-quantile test to unveil the causal relationship between trading volume and Bitcoin returns and volatility. They highlight the importance of considering a quantile nonlinear approach to detect causality in different quantiles. Against this background, in this study we examined the nonlinear, asymmetric, and quantile effect of aggregate commodity and gold prices on the Bitcoin price, using advanced autoregressive distributed lag (ADRL) models, namely the

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nonlinear ARDL (NARDL) model of Shin et al. (2014) and the quantile ARDL (QARDL) model of Cho et al. (2015). We also applied a combination of these two models, called the Quantile Nonlinear Autoregressive Distributed Lag (QNARDL) model. In addition to the novel contribution presented in this paper, by allowing for asymmetric behavior between the examined variables (i.e. by applying the hidden cointegration analysis), we offer another novelty. This entails accounting for a second type of asymmetry, known as distributional asymmetry according to the position of the dependent variable within its own distribution. Such a combination of nuanced integration approaches has not been used in the literature to date. The proposed QNARDL model allows testing for distributional asymmetry, while accounting for long- and short-run asymmetries. When applied to the relation between Bitcoin and aggregate commodity (gold) prices, these models allow us to provide a clear view of the relation, which is useful to market participants. The latter are keen to understand non-linearity, asymmetry, and variability across the quantiles, which ultimately would help them generate better trading and investment strategies. In our empirical analysis, we used the aggregate commodity index and gold prices separately as the main dependent variables, and Bitcoin as the dependent variable. We also included several explanatory variables stemming from the literature. Accordingly, our analysis covers a large number of assets that includes not only conventional assets such as equities, bonds, and currencies, but also commodities. In examining commodities, and in addition to a general commodity index, we focused on gold, as many press and scholarly articles refer to Bitcoin as a "digital" commodity, or "digital" gold. We also focused on the dollar index, given the wide acceptance and use of Bitcoin as a digital currency, although no consensus exists on whether Bitcoin is a currency, commodity, or both (a hybrid asset).

Our results indicate a significant relation between Bitcoin and the commodity index, as well as between Bitcoin and gold, which is not always symmetric. Furthermore, the results indicate that the relation differs between the short and long runs and across the different quantiles.

The rest of the paper is divided into three sections: Section 2 reviews the related literature; Section 3 describes the data and methodology; Section 4 presents the empirical results; and Section 5 concludes.

2. Literature review

Derived from mathematical cryptography, and based on peer-to-peer networking, Bitcoin was the first, and is the most popular digital currency to come into existence. Unlike conventional sovereign currencies, it operates without the need for any intermediary, and is not a liability on any balance sheet. Its decentralized and pseudo-anonymous attributes make it appealing to users, thanks to two key innovations: The first is the public-distributed ledger, called 'blockchain' where all Bitcoin transactions are digitally recorded. The second is the consensus mechanism, called 'proof of work', which is used to solve the double-spend problem. Notably, the accessibility aspect of Bitcoin as an investment has been enhanced by the inception of trading platforms where Bitcoin is bought and sold using traditional currencies. Accordingly, many market participants have arisen to profit from movements in the Bitcoin price. In a seven-year period, the Bitcoin price has increased exponentially from less than one USD in April 2011–1347.96 USD at the end of April 2017.

Scholars were first interested in the technical, safety, ethical, and legal aspects of Bitcoin; then the economics and financial aspects became the subject of interest. Fry and Cheah (2016) provide evidence on the Bubble in the Bitcoin market, and similar results are reported by Cheung et al. (2015), who indicate that Bitcoin has no fundamental value, but instead a mostly speculative value. Quite similar results are shown by Baek and Elbeck (2015), who indicate that Bitcoin is 26 times more volatile than the S&P 500 Index and that Bitcoin returns are not influenced by fundamental economic factors, but rather by buyers and sellers. Given that Bitcoin does not have identifiable cash flows, some studies have raised the difficulty in determining its fundamental value and suggest instead empirical models to identify the determinants of the Bitcoin price. For instance, Bouoiyour and Selmi (2015) show that in the short term, the Bitcoin price is appositively affected by investors' attraction and the exchange-trade ratio. Kristoufek (2015) employed a wavelet coherence approach and indicates that the Bitcoin price is not affected by economic and financial variables. Further examination of price formation in the Bitcoin market points toward the importance of market forces, Bitcoin's attractiveness, and the insignificance of macro-financial developments (Ciaian et al., 2016). However, Li and Wang (2017) indicate that, in the long term, Bitcoin's price is more sensitive to economic fundamentals and less sensitive to technological factors. Yelowitz and Wilson (2015) reveal that computer programming enthusiasts and illegal activity have driven interest in Bitcoin but found no support for political and investment motives. Ober et al. (2013) stress the important role of user anonymity in the Bitcoin market.

Bitcoin is often seen as a basic form of movement against capitalism, free trade, and globalization (Cohen, 2016), and is part of an alternative 'peer-to-peer' economy (Bouri et al., 2017c). That Bitcoin emerged in 2009, the year that followed the global financial crisis, during which an environment of weak trust in the global financial system had spread, points toward the potential role of Bitcoin not only as an alternative to cash (Evans-Pughe, 2012), but also as the panacea to replace financial institutions. In this sense, Bitcoin has been appreciated by practitioners and users, especially during the numerous financial and economic crises that have coincided with its short history. Notably, during the European sovereign debt crisis of 2010–2013 and the Cypriot banking crisis of 2012–2013, Bitcoin was seen as an alternative currency to those of conventional economies and a shelter from sovereign and systematic risk (Bouri et al., 2017b). Luther and Salter (2017) show that interest in Bitcoin amplified considerably after Cyprus announced it would accept a bailout. Bitcoin has been seen by many as an alternative to traditional stores of value, such as gold, and has been named the digital gold (Popper, 2015). Several articles refer to a flight from conventional currencies to Bitcoin, a feature that is often associated with gold. Dyhrberg (2016a) locates the hedging capability of Bitcoin somewhere near to that of gold. However, there is no consensus among scholars about whether Bitcoin is a currency or commodity, or both (Lo and Wang, 2014). Yermack argues that Bitcoin does not fulfil the functions of money, whereas Polasik et al. (2015) show that it acts as a medium of exchange. Recently, Blau (2017) shows that Bitcoin is a currency rather than a speculative investment.

Baur et al. (2015) show that Bitcoin is an investment, and highlight its role as a useful diversifier (i.e. uncorrelated with traditional assets). Brière et al. (2015) used weekly data from 2010 to 2013 and highlight the low correlation of Bitcoin with both traditional assets (worldwide stocks, bonds, hard currencies) and alternative investments (commodities, hedge funds, real estate), and point toward the significant diversification benefits of Bitcoin, despite its extremely high average return and volatility. They also show that adding a small proportion of bitcoins (3%) can enhance the risk-return trade-off of well-diversified portfolios. Dyhrberg (2016b) indicates that Bitcoin is a hedge for UK currency and equities. Ji et al. (2017) argue that Bitcoin is isolated from the global financial system, suggesting a valuable role in portfolio diversification. Bouri et al. (2017a) point to the hedging ability of Bitcoin against global uncertainty. Ender et al. (2018) find a negative association between Bitcoin returns and economic policy uncertainty, suggesting a hedging property of Bitcoin. Bouri et al. (2017c) show that Bitcoin is an effective diversifier for major world equities, bonds, oil, gold, the general commodity index, and the US dollar index.

Several studies have focused on price discovery in the Bitcoin market (Bouoiyour and Selmi, 2015; Ciaian et al., 2016; Li and Wang, 2017) via the application of an ARDL and, and mixed findings have emerged. Ciaian et al. (2016) show that the Bitcoin price is not sensitive to macro-financial developments in the long run. Li and Wang (2017)