When bitcoin is high: cryptocurrency value, illicit markets and US marijuana bills.

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When Bitcoin is high:

Cryptocurrency value, illicit markets, and US marijuana bills

Savva Shanaev[a], Efan Johnson[a], Mikhail Vasenin[a], Humnath Panta[b] and Binam Ghimire[c*]

[a]University of Northumbria at Newcastle, Newcastle-upon-Tyne, NE1 8ST, United Kingdom
[b]School of Business, SH 126, Cal Poly Humboldt, 1 Harpst St, Arcata, CA 95519
[c]Robert Gordon University, Garthdee House, Garthdee Road, Aberdeen, AB10 7QB, Scotland, UK
*corresponding author: b.ghimire@rgu.ac.uk

Abstract

Design/methodology/approach

This study utilises a dataset of 58 state-level marijuana decriminalisation and legalisation bills and referenda in the United States in 2010-2022.

Purpose

The main purpose of this paper is to estimate the implications of illicit market use for the value of Bitcoin in an event studies framework.

Findings

Decriminalisation is associated with a strong and consistent positive Bitcoin price response around the event, recreational legalisation induces a more ambiguous reaction, and medical legalisation is found to have a negative albeit small impact on Bitcoin value. This suggests decriminalisation enhances shadow economy use value of Bitcoin, while recreational and medical legalisation are not consistently reducing illicit drug cryptomarket activity. The effects are robust to various estimation windows, in subsamples, and also when outliers, heavy tails, conditional heteroskedasticity, and state size are accounted for.

Originality/value

New to the literature, the choice of US marijuana bills, specifically as sample events, is based on both theoretical and empirical grounds.

Keywords: Bitcoin; cannabis; illicit market; shadow economy; event study

JEL codes: G14, G18, K42

Introduction and Literature Review

It has been widely documented that cryptocurrencies are extensively used on illicit markets (Dolliver, 2015; Foley et al., 2019), which has been extensively cited as a major concern for cryptocurrency regulation in early (Yeoh, 2017) and more recent literature (Huang, 2021; Benson et al., 2023) alike. Foley et al. (2019) estimate that 46% of Bitcoin transactions occur in the shadow economy. Illicit drug markets are one of the most common venues such transactions take place (Dolliver et al., 2018; Foley et al., 2019; Hiramoto and Tsuchiya, 2023), and cannabis is the substance most often purchased via cryptocurrencies (Aldridge and Decary-Hetu, 2016; Norbutas, 2018). As such, Aldridge and Decary-Hetu (2016) report that cannabis is the most traded drug on illicit cryptomarkets, while Norbutas (2018) shows it comprises 32% of dollar value traded on illegal online platforms. Hardy and Norgaard (2016) and Cerveny and van Ours (2019) document that Bitcoin is the dominant cryptocurrency used to purchase cannabis on the Dark Web marketplaces. This implies that up to 15% of all Bitcoin might be spent on cannabis alone. Therefore, lack of research on this potential channel of cryptocurrency value formation represents a notable literature gap this study seeks to address.

Research on illicit cryptomarkets agrees that the pseudonymous nature of Bitcoin facilitates its use as a medium of exchange for illegal goods, lowering risks associated with detection while still allowing sellers to build reputation (Hardy and Norgaard, 2016) and reach a wider customer base (Dolliver, 2015), consistent with convenience theory of crime for the use of cryptocurrencies (Nolasco Braaten and Vaughn, 2021). Hiramoto and Tsuchiya (2023) further demonstrate how drug sales are a crucial factor in the growth of illicit online cryptomarkets. Jardine and Lindner (2020) demonstrate the relevance of illegal online platforms for drug use in the United States, with interest in Dark Web positively correlated with self-reported cannabis consumption geographically and the connection stronger in state jurisdictions where recreational marijuana is legalised, hinting towards a link between cannabis

policy reforms and Bitcoin use value as a medium of exchange on illicit markets. This study therefore additionally aims at providing financial market-based evidence regarding the relationship between drug policy and illicit market activity.

Further supporting the sentiment-oriented and financial relationships between cannabis and cryptocurrencies, several marijuana-themed coins have recently emerged, including PotCoin, DopeCoin, HempCoin, and CannabisCoin, with their returns and volatilities exhibiting especially strong positive linkages with Bitcoin (Kyriazis, 2021). However, little to no research has considered the impact of shadow economy usability on cryptocurrency value, with the only study investigating this issue to date is Almaqableh et al. (2022a) who show cryptocurrency prices negatively react to drug busts[1]. Another study, has examined the case of Federal Reserve and its services to legally eligible banks regarding payment mechanism (Hill, 2023) but it does not deal with the intersection of cryptocurrency and drug policy reforms. Our study is especially relevant given the shift to speculative and investment-oriented use of Bitcoin (Foley et al., 2019) and growing concern shown by regulators in line with cryptocurrency use in money laundering and terrorist financing (Shanaev et al., 2020; Auer et al., 2022). Whether cryptocurrencies derive a substantial part of their market values from the access to the shadow economy they facilitate is therefore a relevant issue for both investors and policymakers. This study seeks to address this gap in the literature by exploiting a series of events exogeneous to Bitcoin network but directly relevant to its illicit market use – a series of state-level marijuana decriminalisation and legalisation bills and referenda in the United States in 2010-2022[2].

Policy initiatives aimed at decriminalising and legalising medical or recreational use of marijuana have been gaining momentum since the start of the 21st century (Kapp, 2003;

[1] The abnormal returns Almaqableh et al. (2022a) report, however, are consistently significant only in 90-day adjustment windows. This study seeks to establish a more direct link between drug policy and Bitcoin value that is less sensitive to confounding events.

[2] It becomes especially relevant given the recent actions taken by the Biden administration to reform the federal policy stance on marijuana, with pardons issued regarding prior federal offences for simple possession and plans announced to review the legal classification of marijuana as a substance (The White House, 2022).

Webster, 2018), with Uruguay, Canada, and Thailand fully legalising recreational marijuana sales, while Luxembourg and Germany decriminalised cannabis in 2023 and 2024, respectively. In the United States and Canada, both regional and federal reforms have spurred the development of a sizeable cannabis industry, with financial market properties of cannabis stocks (Weisskopf, 2020; Cox and Cheng, 2021a, b) and real estate (Guttery and Poe, 2018) investigated in prior research. Cox and Cheng (2021a, b) demonstrate that Canadian and US cannabis stocks outperform market indices and can be attractive for portfolio diversification purposes. While Canadian stocks have extremely high market betas (Cox and Cheng, 2021a), their US counterparts enjoy moderately negative betas, highlighting their defensive properties (Cox and Cheng, 2021b). Weisskopf (2020) studies the performance of a portfolio formed of all listed cannabis equities and finds positive yet insignificant abnormal returns in asset-pricing models and no correlation with Bitcoin. Cannabis stocks are shown to be small growth stocks with relatively low operating profitability that reinvest their earnings aggressively (Weisskopf, 2020). This corresponds to the concerns surrounding the speculative nature of cannabis industry investing (Scheuer, 2020; Cornell and Damodaran, 2020) particularly in the context of policy risk they are exposed to, especially in the United States (Guttery and Poe, 2018; Weisskopf, 2020). Afik et al. (2022) reinforce the prominence of bubbles in this financial market segment by showing that firms announcing cannabis-related ventures enjoy substantial stock price appreciation, even if their involvement in the industry is purely declarative, which is similar to the effects of corporate blockchain and cryptocurrency-related announcements investigated in earlier literature (Corbet et al., 2020). Karim et al. (2022) classify cannabis equities as sin stocks and highlight their relatively unattractive risk-return properties when compared to ethical investments. Chen et al. (2021) demonstrate that while cannabis stocks positively react to news surrounding legalisation, they do not outperform the market in the long-term. Andrikopoulos et al. (2021) show that the impact of policy initiatives on cannabis

equities is conditional on investor mood. Given little to no connection between cannabis stocks and cryptocurrencies identified in the existing literature (Weisskopf, 2020), and that the only piece of research on shadow economy use and Bitcoin value focuses on drug busts and not formal policy initiatives (Almaqableh et al., 2022a), investigating the impact of marijuana decriminalisation and legalisation on Bitcoin value is undoubtedly warranted.

The rest of the paper is structured as follows. First, the data collection and estimation strategies are outlined, and the sample choice of the study is justified. Next, the findings are presented alongside relevant robustness checks. The final section concludes with key theoretical and practical implications.

Data and Methodology

This paper resorts to event study methodology to generate inferences with regards to illicit market use implications for Bitcoin value. Event studies have been extensively and fruitfully utilised in cryptocurrency empirical finance[3]. Political risk and uncertainty considerations for Bitcoin price dynamics have also been thoroughly studied in the context of geopolitical risk (Aysan et al., 2019; Nouir and Hamida, 2023), trade policy uncertainty (Gozgor et al., 2019), economic policy uncertainty (Wang et al., 2020; Nouir and Hamida, 2023), COVID-19 (Conlon and McGee, 2020; Huang et al., 2021), environmental concerns (Wang et al., 2022; Jin and Yu, 2023), blockchain policy uncertainty (Lucey et al., 2022), and the Russia-Ukraine war (Khalfaoui et al., 2022), with the cryptocurrency market generally found to be very responsive to uncertainty innovations and policy shocks. This study therefore contributes to this growing body of literature by incorporating drug policy in the form of state-level marijuana decriminalisation and legalisation initiatives.

[3] Event study applications to cryptocurrency markets include investigations of drug bust (Almaqableh et al., 2022a), terrorist attack (Almaqableh et al., 2022b), altcoin (Nguyen et al., 2019) and stablecoin (Saggu, 2022) issuance, blockchain attack (Shanaev et al., 2019), and regulation (Shanaev et al., 2020) impact on coin prices, as well as on coin liquidity (Yue et al., 2021).

The choice of United States marijuana bills specifically as sample events is based on both theoretical and empirical grounds. First, the heterogeneity of cannabis legality across states, a high level of drug policy uncertainty both federally and regionally (Weisskopf, 2020), and the timing of bills and referenda allows to treat these events as natural experiments for the purposes of Bitcoin price dynamics. This arguably allows to recognise event study inferences from state-level decriminalisation as causal, whereas using country-level data naturally limits the sample size and therefore presents more severe confounding event concerns, while also potentially suffering from endogeneity, as countries that legalise or decriminalise marijuana might also issue cryptocurrency-friendly legislation. Conversely, in the United States, while regulatory initiatives for cryptocurrencies have been predominantly associated with national authorities and agencies such as SEC, CFTC, and the Federal Reserve (Shanaev et al., 2020), cannabis-related policies have been recently concentrated at the state level due to its removal from the list of federally controlled substances (Patton, 2020), which presents an ideal setting for this study's estimation strategy. Second, existing research on illicit online marketplaces facilitating cannabis purchases with Bitcoin shows that Dark Web transactions in the US, unlike in Europe, are locally concentrated (Dolliver et al., 2018; Norbutas, 2018; Jardine and Lindner, 2020) and therefore domestic policy can be more impactful to shadow economy use value of Bitcoin. Finally, United States are a prominent location for Bitcoin trading, representing a substantial share of transactions and hosting large cryptocurrency exchanges such as Coinbase and Gemini that are among the most influential and informationally relevant (Ji et al., 2021; Kristoufek and Bouri, 2022).

This study collects daily Bitcoin prices from 18th July 2010 until 30th September 2022. Mt. Gox (Coinmarketcap) data is utilised for the period before (starting from) 29th April 2013

due to data availability[4]. Bitcoin daily log-returns are then mapped to the announcement dates of exhaustive list of 58 US state-level marijuana bills and referenda signed into law during the sample period collected from official state House and Senate websites as well as reputable news sources such as Bloomberg and Reuters (see Table 1 below). These events are classified as either decriminalisations (D), recreational legalisations (R), or medical legalisations (M). Overall, there have been 14, 21, and 23 such events, respectively, in the sample period[5].

Table 1. Sample events.

State	Marijuana bill type	Announced	Went into effect	Source
Alabama	Medical legalisation	17/05/2021	17/05/2021	Senate Bill 46
Alaska	Recreational legalisation	04/11/2014	24/02/2015	Measure 2
Arizona	Medical legalisation	14/11/2010	14/11/2010	Proposition 203
Arizona	Recreational legalisation	03/11/2020	22/01/2021	Proposition 207
Arkansas	Medical legalisation	08/11/2016	08/11/2016	Issue 6
California	Recreational legalisation	08/11/2016	01/01/2018	Proposition 64
Colorado	Recreational legalisation	06/11/2012	01/01/2014	Amendment 64
Connecticut	Decriminalisation	07/06/2011	07/06/2011	Senate Bill 1014
Connecticut	Medical legalisation	05/05/2012	07/06/2012	Public Act 12-55
Connecticut	Recreational legalisation	22/06/2021	01/07/2021	Senate Bill 1201
Delaware	Decriminalisation	18/06/2015	18/12/2015	House Bill 39
District of Columbia	Decriminalisation	04/03/2014	17/07/2014	Bill 20-0409
District of Columbia	Recreational legalisation	04/11/2014	26/02/2015	Initiative 71
Florida	Medical legalisation	08/11/2016	03/01/2017	Amendment 2
Georgia	Medical legalisation	16/04/2015	16/04/2015	House Bill 1
Hawaii	Decriminalisation	25/06/2019	11/01/2020	House Bill 1383
Illinois	Medical legalisation	01/08/2013	01/01/2014	House Bill 1
Illinois	Recreational legalisation	31/05/2019	01/01/2020	House Bill 1438
Louisiana	Medical legalisation	30/06/2015	06/08/2019	House Bill 149
Louisiana	Decriminalisation	15/06/2021	01/08/2021	House Bill 652
Maine	Recreational legalisation	08/11/2016	09/10/2020	Question 1
Maryland	Medical legalisation	14/04/2014	01/10/2014	House Bill 881
Maryland	Decriminalisation	14/04/2014	01/10/2014	Senate Bill 364
Massachusetts	Medical legalisation	06/11/2012	01/01/2013	Question 3
Massachusetts	Recreational legalisation	08/11/2016	15/12/2016	Question 4
Michigan	Recreational legalisation	06/11/2018	06/12/2018	Proposal 1
Minnesota	Medical legalisation	06/05/2014	01/07/2015	Senate Bill 1641
Mississippi	Medical legalisation	03/11/2020	overturned 14/05/2021	Initiative 65
Missouri	Decriminalisation	13/05/2014	01/01/2017	Senate Bill 491
Missouri	Medical legalisation	06/11/2018	17/10/2020	Amendment 2
Montana	Recreational legalisation	03/11/2020	01/01/2021	Initiative 190
Nevada	Medical legalisation	12/06/2013	12/06/2013	Senate Bill 374
Nevada	Recreational legalisation	08/11/2016	01/01/2017	Question 2
New Hampshire	Medical legalisation	23/07/2013	23/07/2013	House Bill 573
New Hampshire	Decriminalisation	18/07/2017	16/09/2013	House Bill 640
New Jersey	Recreational legalisation	03/11/2020	22/02/2021	Public Question 1
New Mexico	Decriminalisation	04/04/2019	01/07/2019	Senate Bill 323
New Mexico	Recreational legalisation	12/04/2021	29/06/2021	House Bill 2
New York	Medical legalisation	19/06/2014	14/07/2014	Senate Bill 7923
New York	Decriminalisation	20/06/2019	29/07/2019	Senate Bill 6579
New York	Recreational legalisation	30/03/2021	31/03/2021	Senate Bill 854A

[4] Despite earlier concerns surrounding quality of cryptocurrency price quotes provided by Coinmarketcap (Alexander and Dakos, 2020), more recent research has confirmed their usability for empirical finance studies (Vidal-Tomas, 2022).

[5] Two policy initiatives – medical legalisation in Mississippi and recreational legalisation in South Dakota – were subsequently overturned, although Mississippi eventually legalised medical marijuana via a different bill (Senate Bill 2095) on 26th January 2022 which is not included in the final sample to prevent double-counting. Excluding overturned marijuana bills from the sample does not materially affect the results.

North Dakota	Medical legalisation	08/11/2016	07/10/2018	Measure 5
North Dakota	Decriminalisation	10/05/2019	10/05/2019	House Bill 1050
Ohio	Medical legalisation	08/06/2016	01/09/2018	House Bill 523
Oklahoma	Medical legalisation	26/06/2018	26/06/2018	Question 788
Oregon	Recreational legalisation	04/11/2014	01/07/2015	Measure 91
Pennsylvania	Medical legalisation	17/04/2016	15/02/2018	Senate Bill 3
Rhode Island	Decriminalisation	13/06/2012	13/06/2012	Senate Bill 2253
Rhode Island	Recreational legalisation	25/05/2022	25/05/2022	Senate Bill 2430
South Dakota	Medical legalisation	03/11/2020	01/07/2021	Measure 26
South Dakota	Recreational legalisation	03/11/2020	overturned 08/02/2021	Amendment A
Utah	Medical legalisation	21/03/2018	21/03/2018	House Bill 195
Vermont	Decriminalisation	06/06/2013	06/06/2013	House Bill 200
Vermont	Recreational legalisation	04/01/2018	07/10/2020	House Bill 511
Virginia	Decriminalisation	12/04/2020	01/07/2020	House Bill 972
Virginia	Recreational legalisation	07/04/2021	01/07/2021	Senate Bill 1406
Washington	Recreational legalisation	06/12/2012	01/12/2013	Initiative 502
West Virginia	Medical legalisation	19/04/2017	01/07/2018	Senate Bill 386

Notes: sample marijuana bills comprise all state-level cannabis decriminalisations or legalisations for recreational or medical use between 18th July 2010 and 30th September 2022 collected manually from Bloomberg, Reuters, and official state House and Senate websites.

This study then utilises dummy variable regressions with Newey-West (1987) heteroskedasticity and autocorrelation consistent standard errors to generate inferences regarding drug policy relevance for Bitcoin value and calculating average abnormal returns for [-1; 1], [-3; 3], [-5; 5], [-7; 7], [-7; -1], [0; 0], and [1; 7] windows. Reflecting market efficiency considerations, it is chosen to report results based on announcement dates rather than dates the legislation went into effect. While it is possible that some informed trading based on the anticipation of the legislative change even before seven days prior to the announcement, which constitutes a necessary limitation of event study methodology, longer estimation windows are avoided to prevent confounding events from affecting the results.

The main hypothesis of this study is associated with the differential impact of marijuana bills on average abnormal returns. Subject to decriminalisation, risks of purchasing marijuana on illicit cryptomarkets via Bitcoin substantially reduces, while opportunities to buy cannabis outside of the shadow economy remain unchanged, which in turn can increase the demand for Bitcoin to facilitate cryptomarket transactions and therefore its exchange value – this can be especially relevant for agents with higher risk aversion that might not have chosen to utilise illicit drug cryptomarkets prior to decriminalisation given the risk of criminal prosecution which has been found a salient factor in motivations of such market participants (Martin et al.,

2020). This leads this study to hypothesise that if illicit market use is indeed material for the market dynamics of Bitcoin, decriminalisations will be associated with high positive abnormal returns around such policy announcements, while the impact of recreational and medical legalisation can be more nuanced. As such, if legalisation successfully reduces illegal cannabis consumption, negative abnormal returns for Bitcoin can be hypothesised as its shadow economy use value theoretically goes down. For medical marijuana, this negative Bitcoin market value implications are arguably the strongest, as people resorting to cannabis for its medicinal properties could then fully satisfy their demand via legal venues. Indirectly supporting this assumption, Jardine and Lindner (2020) document weaker connection between Dark Web interest and self-reported cannabis use in jurisdictions that implemented medical legalisation. Contrastingly, as Jardine and Lindner (2020) and Noonan (2021) show illicit markets for marijuana are still prominent after recreational use of marijuana is legalised, this study expects to still find positive abnormal returns for recreational legalisation, albeit of much smaller magnitude than that of decriminalisation. Additionally, Martin et al. (2020) present interview-based evidence that while illicit drug cryptomarket participants are responsive to financial and legal risks and rewards, which additionally motivates the hypothesis of positive Bitcoin price response to cannabis decriminalisations, there is a cultural and behavioural aspect to online drug marketplaces which might not be fully substituted by legal availability of recreational or medical marijuana. If the latter considerations are material, the impact of medical and recreational legalisations on Bitcoin illicit market use and therefore value can be negligible.

Testing whether the results are robust to outliers, heavy tails, and autoregressive conditional heteroskedasticity, the [-1; 1] average abnormal returns are also estimated in quantile regression conditional median framework and in GARCH models with Gaussian, Student's T, and generalised error distributions. To investigate the consistency of the effects

given gradual maturing of the cryptocurrency markets and the closures of Dark Web marketplaces (Foley et al., 2019), the sample is further split into before and after the shutdown of Silk Road 2.0 (6th November 2014), into 2010-2017 and 2018-2022 subperiods, as well as into bull, bear, and sideways markets based on relative position of the Bitcoin price to its retrospective all-time high, testing whether the identified effects are driven by sentiment rather than illicit market use of Bitcoin.

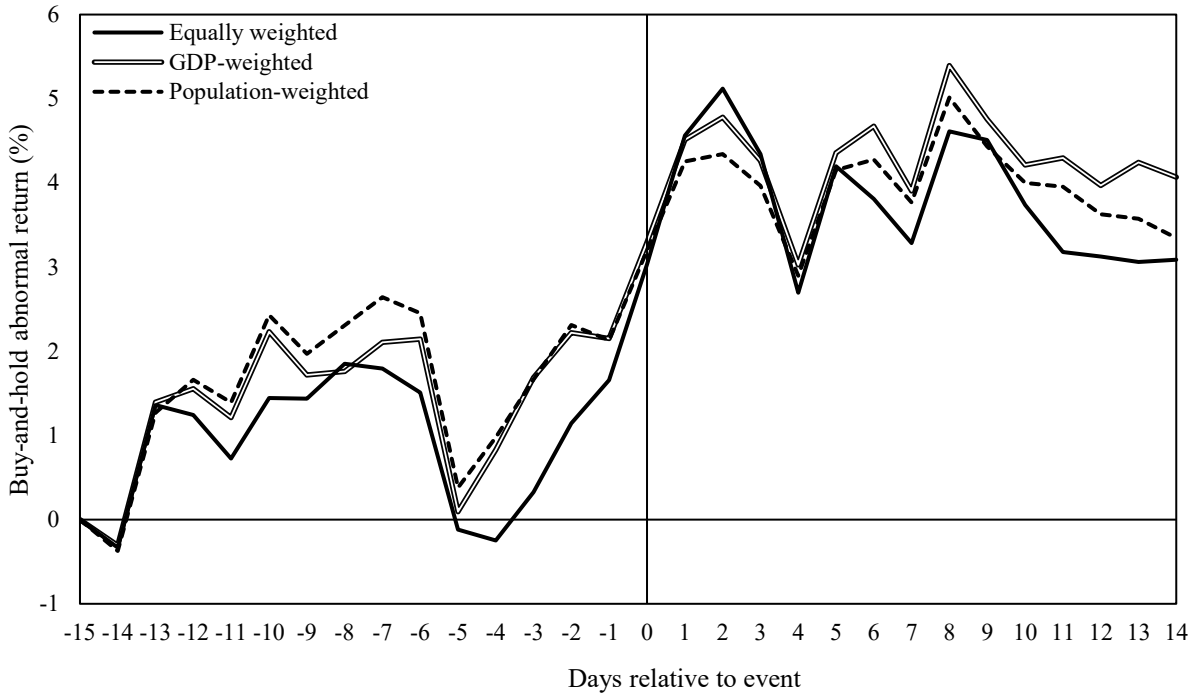
Accounting for relative economic importance of cannabis decriminalisation and legalisation in various states, this study also weighs the estimations by state GDP and population in all models, with data obtained from Bureau of Economic Analysis and census.gov, respectively. Further, to control for links between cryptocurrency and conventional markets, such as stocks, bonds, and gold (Kwon, 2020; Nguyen, 2022), the regressions are additionally estimated on daily and weekly frequencies with Bitcoin price and policy initiative data corresponding to relevant US-specific trading days or weeks (Friday-to-Friday), and S&P 500, US 20-year government bond, and gold total return indices obtained from Bloomberg.

Findings and Discussion

Figures 1-4 below present the buy-and-hold abnormal return dynamics around marijuana bills. While there is a sizeable (around 5%) upward price movement in the full sample, the effect is notably heterogeneous across marijuana bill types. As such, the abnormal returns around decriminalisations are much higher (15%-30%) and are more strongly anticipated. The effects are visibly stronger in GDP-weighted and population-weighted quasi-portfolios, reinforcing the relative importance of decriminalisation in larger states and providing some early evidence for the non-spurious nature of the results. Recreational legalisations are associated with more ambiguous results, and some negative anticipation to medical legalisations is notable approximately one week before the event. Therefore, whereas early results regarding

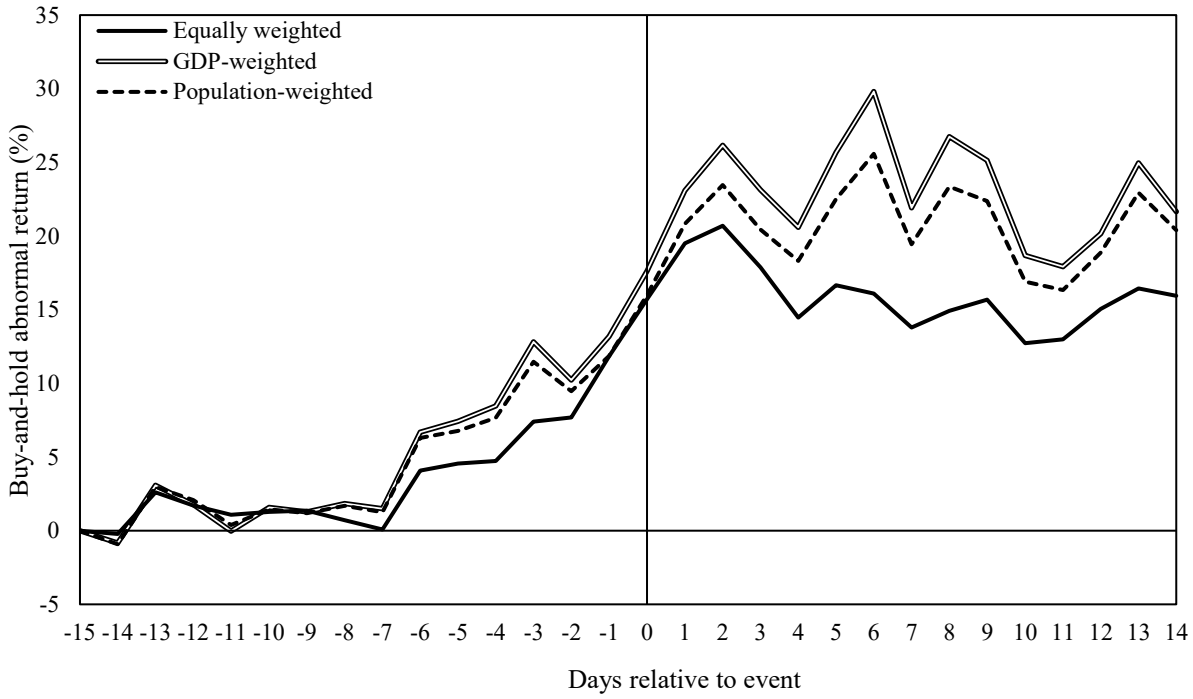
decriminalisation are fully consistent with the developed hypotheses and showcase an increase in Bitcoin use value as the legal deterrents for using illicit cryptomarkets weaken, the findings for recreational and medical legalisation are less straightforward, suggesting these policy initiatives might not reduce Bitcoin use as a facilitator of illicit market transactions.

Figure 1. Bitcoin buy-and-hold abnormal return around all marijuana bills.



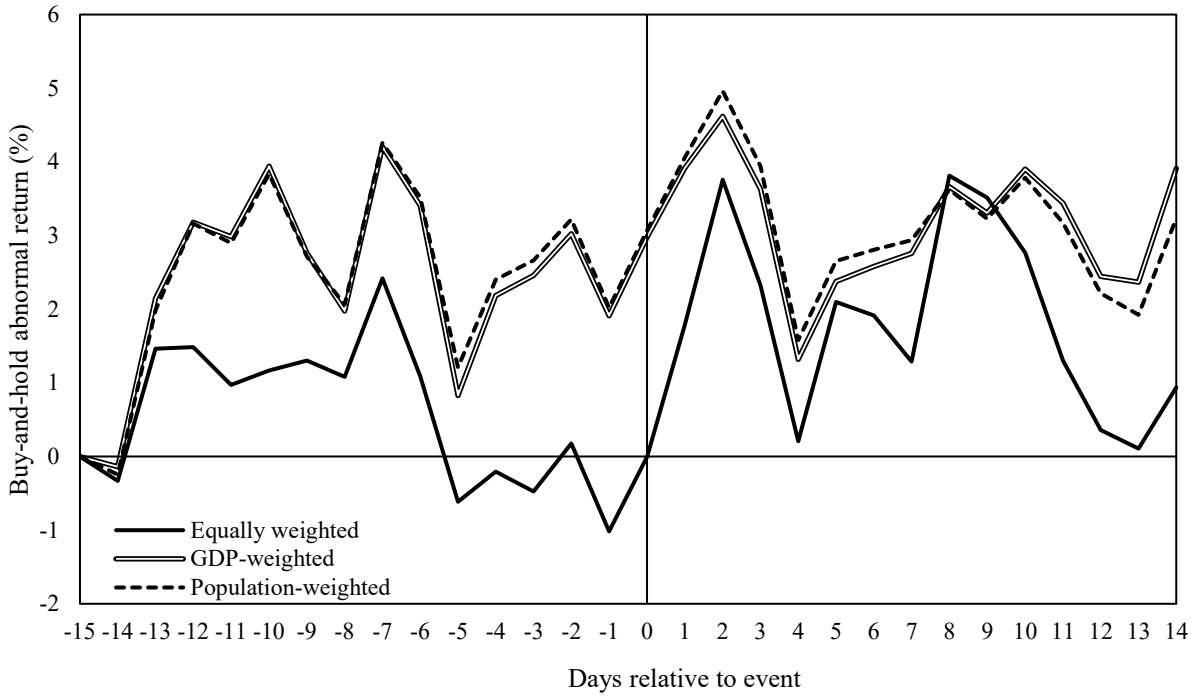
Notes: Buy-and-hold abnormal returns around all marijuana bills ($n = 58$) calculated using equally weighted, state GDP-weighted, and state population-weighted quasi-portfolios and the constant return model.

Figure 2. Bitcoin buy-and-hold abnormal return around marijuana decriminalisations.



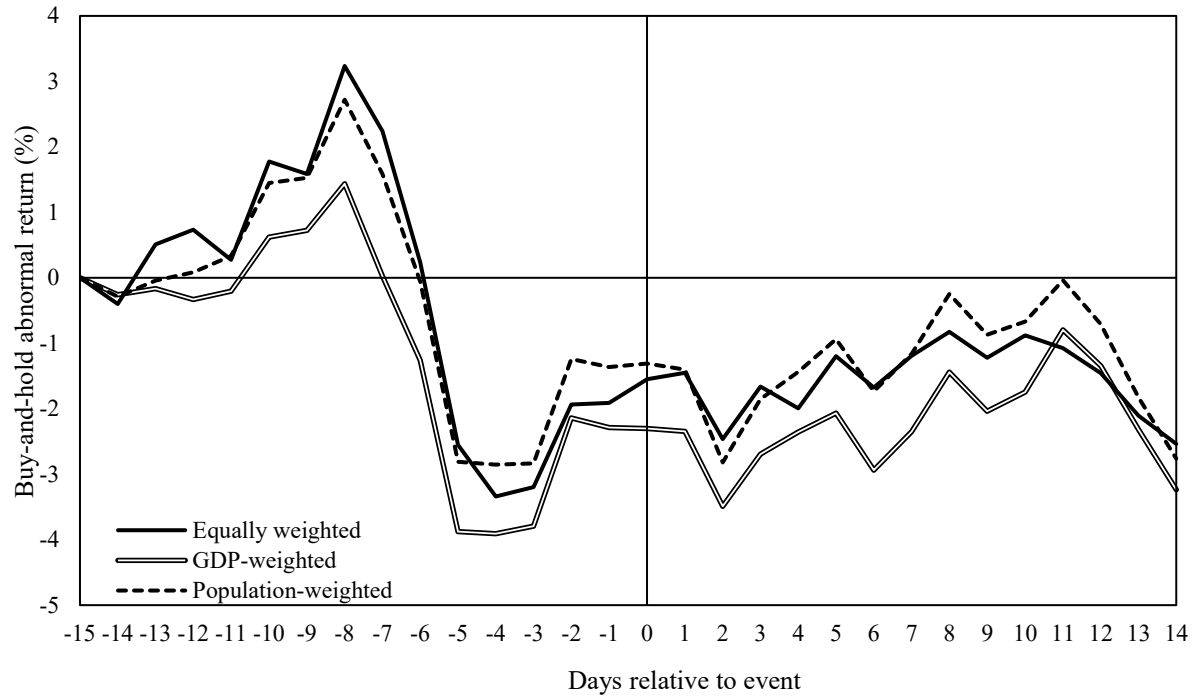
Notes: Buy-and-hold abnormal returns around decriminalisation bills ($n = 14$) calculated using equally weighted, state GDP-weighted, and state population-weighted quasi-portfolios and the constant return model.

Figure 3. Bitcoin buy-and-hold abnormal return around recreational marijuana legalisations.



Notes: Buy-and-hold abnormal returns around recreational legalisation bills ($n = 21$) calculated using equally weighted, state GDP-weighted, and state population-weighted quasi-portfolios and the constant return model.

Figure 4. Bitcoin buy-and-hold abnormal return around medical marijuana legalisations.



Notes: Buy-and-hold abnormal returns around medical legalisation bills ($n = 23$) calculated using equally weighted, state GDP-weighted, and state population-weighted quasi-portfolios and the constant return model.

Table 2 below highlights the heterogeneity of market reactions to decriminalisations, recreational legalisations, and medical legalisations, especially for the anticipation period, and justifies treating these events separately for further estimation purposes.

Table 2. Heterogeneity test for Bitcoin price response to different policy initiatives.

Estimation window	[-1; 1]	[-3; 3]	[-5; 5]	[-7; 7]	[0; 0]	[1; 7]	[-7; -1]
Restricted F-statistic	6.4959***	3.2236**	2.5883*	3.7340**	2.2355	0.0384	6.6135***
p-value	*0.0015*	*0.0399*	*0.0753*	*0.0240*	*0.1071*	*0.9623*	*0.0014*

Notes: Restricted F-statistic calculated using a redundant variable F-test for the joint versus separate treatment of decriminalisation, recreational legalisation, and medical legalisation events. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

Table 3 presents the average abnormal return estimation results. Bitcoin substantially appreciates (10%-12%) around a decriminalisation announcement with the results overwhelmingly significant. Decriminalisation in jurisdictions constituting 1% of global GDP (1% of US population) corresponds to statistically and economically significant price reaction of 10%-16% (3%-5%). There are small positive announcement (negative anticipation) effects for recreational (medical) legalisation, however these are not consistently significant. The findings are overall supportive of the theory that Bitcoin illicit market use contributes to its price formation, with decriminalisation lowering the risks of involvement with online cryptomarkets and medical legalisation slightly reducing the shadow economy use value of Bitcoin, whereas the impact of recreational legalisation is mixed. Therefore, while decriminalisation increases the shadow economy use value of Bitcoin due to lower risk of involvement with illicit marketplaces, recreational legalisation is not reducing Bitcoin value, hinting towards imperfect substitutability of drugs obtained through Dark Web platforms and legal and regulated alternatives, reflecting cultural attitudes and behavioural preferences of their participants (Martin et al., 2020) and possibly interactions between cannabis and other drug market dynamics and respective Bitcoin usability. Price reactions are consistent with market efficiency, with little to no adjustment effects after respective announcements. This contrasts with findings on drug busts (Almaqableh, 2022a) and cryptocurrency regulation

(Shanaev et al., 2020), implying that Bitcoin investors monitor marijuana policy development more closely which further supports its importance[6].

Table 3. Baseline estimations: Bitcoin average abnormal returns around marijuana bills.

Estimation window	Baseline			GDP-weighted			Population-weighted		
	D	R	M	D	R	M	D	R	M
[-1; 1]	3.5421***	0.5602	-0.1402	3.4245*	0.1834	-0.2995	1.0656**	0.0668	-0.0920
	(1.3674)	(0.4686)	(0.3126)	(1.7962)	(0.1527)	(0.3344)	(0.5143)	(0.0520)	(0.0945)
	0.0096	*0.2320*	*0.6539*	*0.0566*	*0.2297*	*0.3705*	*0.0383*	*0.1992*	*0.3306*
[-3; 3]	1.6911**	0.1576	0.0760	1.6432**	0.0503	0.0862	0.5028**	0.0217	0.0074
	(0.7298)	(0.3239)	(0.2950)	(0.7313)	(0.1373)	(0.2635)	(0.2380)	(0.0523)	(0.0828)
	0.0205	*0.6266*	*0.7968*	*0.0247*	*0.7144*	*0.7437*	*0.0347*	*0.6785*	*0.9285*
[-5; 5]	1.0008*	-0.0002	-0.2351	1.3250***	-0.0138	-0.1210	0.3966**	0.0019	-0.0382
	(0.5568)	(0.2358)	(0.2798)	(0.5068)	(0.1230)	(0.2488)	(0.1649)	(0.0459)	(0.0826)
	0.0723	*0.9992*	*0.4007*	*0.0090*	*0.9108*	*0.6268*	*0.0162*	*0.9666*	*0.6439*
[-7; 7]	0.8646*	-0.0708	-0.5188*	1.0852**	0.1013	-0.3772	0.3349**	0.0461	-0.1180
	(0.5048)	(0.2758)	(0.2996)	(0.4314)	(0.0910)	(0.2635)	(0.1389)	(0.0384)	(0.0885)
	0.0868	*0.7975*	*0.0834*	*0.0119*	*0.2657*	*0.1524*	*0.016*	*0.2295*	*0.1827*
[0; 0]	3.4405**	0.8039	-0.1923	3.5206	0.5386*	-0.5149	1.1596	0.1898*	-0.1662
	(1.6432)	(0.5385)	(0.6024)	(2.4220)	(0.2899)	(0.6139)	(0.7295)	(0.1037)	(0.1826)
	0.0363	*0.1355*	*0.7496*	*0.1461*	*0.0633*	*0.4016*	*0.1120*	*0.0673*	*0.3626*
[1; 7]	-0.2572	-0.1012	-0.0148	0.4410	-0.0168	-0.0539	0.1151	-0.0076	-0.0063
	(0.5294)	(0.3517)	(0.2963)	(0.7425)	(0.1202)	(0.2941)	(0.2401)	(0.0499)	(0.0937)
	0.6270	*0.7735*	*0.9603*	*0.5526*	*0.8890*	*0.8545*	*0.6318*	*0.8795*	*0.9461*
[-7; -1]	1.4829**	-0.0835	-0.9460**	1.3613*	0.1635	-0.6940	0.4266*	0.0827	-0.2288
	(0.6927)	(0.3874)	(0.4676)	(0.7660)	(0.1641)	(0.4897)	(0.2354)	(0.0686)	(0.1581)
	0.0323	*0.8293*	*0.0431*	*0.0756*	*0.3191*	*0.1565*	*0.0700*	*0.2283*	*0.1479*

Notes: Average daily abnormal returns are estimated in a regression framework with dummy variables. D, R, and M stand for decriminalisation, recreational legalisation, and medical legalisation, respectively. Standard errors in parentheses and p-values in italics. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

Table 4 investigates the effects in subsamples. While decreasing over time, they remain statistically significant after the closure of Silk Road 2.0 and since 2018. This reduction can be naturally attributed to growing market maturity. Decriminalisation abnormal returns are robust in bull, bear, and sideways market periods, reinforcing that the result is associated with Bitcoin shadow economy use and not cryptocurrency sentiment.

Table 4. Robustness check: [-1; 1] average abnormal returns in subsamples.

Subsample	Baseline			GDP-weighted			Population-weighted		
	D	R	M	D	R	M	D	R	M
2010-2017	4.1221*	0.2831	-0.1403	19.0770**	0.2400**	-0.7706**	4.1261*	0.0866*	-0.1846*
	(2.1930)	(0.3084)	(0.3396)	(8.7777)	(0.1192)	(0.3155)	(2.3782)	(0.0493)	(0.0952)
	0.0603	*0.3586*	*0.6796*	*0.0298*	*0.0442*	*0.0146*	*0.0829*	*0.0787*	*0.0526*

[6] Unreported estimations show the effects are smaller and statistically insignificant for dates policy initiatives went into effect, contrastingly to announcement dates, thus additionally confirming market efficiency and highlighting the informational rather than pure sentiment content of drug policy impact on Bitcoin market value.

2018-2022	2.8092**	0.9591	-0.5394	1.7355***	0.6291*	-1.6359	0.5527***	0.2010*	-0.4552
	(1.1949)	(0.7049)	(0.6582)	(0.2948)	(0.3280)	(2.2126)	(0.1309)	(0.1093)	(0.4670)
	0.0188	*0.1738*	*0.4126*	*0.0000*	*0.0552*	*0.4598*	*0.0000*	*0.0662*	*0.3298*
Silk road	4.8206*	0.3844	-0.3733	18.8854**	0.6484	-0.9432**	4.0263*	0.1797	-0.2538*
	(2.7793)	(0.3638)	(0.5190)	(9.0226)	(0.6680)	(0.4338)	(2.4375)	(0.1913)	(0.1446)
	0.0830	*0.2909*	*0.4721*	*0.0365*	*0.3318*	*0.0298*	*0.0988*	*0.3477*	*0.0795*
Post Silk road	2.5620**	0.6967	-0.1535	1.7375***	0.2521	-0.4647	0.5603***	0.0867	-0.1197
	(1.0817)	(0.6164)	(0.3889)	(0.3138)	(0.1892)	(0.4497)	(0.1371)	(0.0627)	(0.1117)
	0.0179	*0.2585*	*0.6932*	*0.0000*	*0.1828*	*0.3016*	*0.0000*	*0.1673*	*0.2842*
Bull market	10.7548**	0.6893	-0.4879	50.0097***	0.1223	-2.5352	15.0987***	0.0397	-0.4586
	(4.6090)	(0.9290)	(0.4735)	(4.8938)	(0.3312)	(3.0642)	(1.7224)	(0.1202)	(0.5516)
	0.0198	*0.4582*	*0.3030*	*0.0000*	*0.7121*	*0.4082*	*0.0000*	*0.7408*	*0.4060*
Sideways market	2.9327**	-0.1811	0.2069	2.4449***	0.0048	0.0821	0.7461***	-0.0016	0.0224
	(1.2660)	(0.4825)	(0.4517)	(0.8057)	(0.1648)	(0.4479)	(0.2419)	(0.0643)	(0.1264)
	0.0206	*0.7075*	*0.6469*	*0.0024*	*0.9769*	*0.8546*	*0.0021*	*0.9801*	*0.8591*
Bear market	1.5205**	1.0819*	0.4168	13.6541*	1.7909	0.9146	3.0542**	0.3385	0.2267
	(0.7404)	(0.6033)	(0.3962)	(7.5822)	(1.1185)	(0.7945)	(1.4937)	(0.3213)	(0.1895)
	0.0402	*0.0732*	*0.2931*	*0.0720*	*0.1096*	*0.2499*	*0.0411*	*0.2923*	*0.2317*

Notes: Average daily abnormal returns are estimated in a regression framework with dummy variables. D, R, and M stand for decriminalisation, recreational legalisation, and medical legalisation, respectively. Standard errors in parentheses and p-values in italics. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

Robustness check results are presented below in Tables 5 and 6. The effects persist when outliers, heavy tails, conditional heteroskedasticity, and relationships with conventional financial markets such as stocks, bonds, and gold are accounted for. Overall, this study has found overwhelming support for its main hypothesis, successfully linking Bitcoin value formation to its use as the medium of exchange on illicit cryptomarkets.

Table 5. Robustness checks: [-1; 1] average abnormal returns in alternative specifications.

Model	Baseline			GDP-weighted			Population-weighted		
	D	R	M	D	R	M	D	R	M
Quantile regression	1.1922***	0.9622**	-0.3604	1.2331*	0.2665	-0.4294	0.4224**	0.1121	-0.1469
	(0.4213)	(0.4497)	(0.3638)	(0.6631)	(0.3040)	(0.5014)	(0.2093)	(0.0982)	(0.1376)
	0.0047	*0.0324*	*0.3219*	*0.0630*	*0.3807*	*0.3918*	*0.0436*	*0.2534*	*0.2860*
GARCH (Gaussian)	0.9872	0.2574	-0.0173	1.7860***	0.1686	-0.3398	0.4990***	0.0541	-0.0824
	(0.6085)	(0.4327)	(0.2578)	(0.3893)	(0.1747)	(0.2153)	(0.1428)	(0.0613)	(0.0681)
	0.1047	*0.5520*	*0.9464*	*0.0000*	*0.3343*	*0.1145*	*0.0005*	*0.3771*	*0.2262*
GARCH (Student T)	1.2041***	0.5210	-0.1632	1.5776**	0.2984	-0.3953	0.4784**	0.1024	-0.1071
	(0.3891)	(0.3719)	(0.2828)	(0.6453)	(0.2769)	(0.4175)	(0.2199)	(0.0816)	(0.1045)
	0.0020	*0.1613*	*0.5639*	*0.0145*	*0.2813*	*0.3438*	*0.0296*	*0.2093*	*0.3057*
GARCH (GED)	0.7447**	0.7015**	-0.2502	1.2516**	0.2687	-0.4108	0.4285***	0.1115*	-0.1407**
	(0.3672)	(0.2986)	(0.2214)	(0.5281)	(0.2207)	(0.3124)	(0.1622)	(0.0637)	(0.0677)
	0.0426	*0.0188*	*0.2584*	*0.0178*	*0.2233*	*0.1885*	*0.0082*	*0.0799*	*0.0375*

Notes: Average daily abnormal returns are estimated in a regression framework with dummy variables. D, R, and M stand for decriminalisation, recreational legalisation, and medical legalisation, respectively. Quantile regressions are estimated at conditional medians. Standard errors in parentheses and p-values in italics. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

Table 6. Robustness checks: average abnormal returns controlled for other markets.

Frequency	Baseline	GDP-weighted	Population-weighted

	D	R	M	D	R	M	D	R	M
Daily	3.5849***	0.2924	-0.5960	3.1053**	0.1302	-0.6193	0.9343**	0.0594	-0.2008
	(0.9192)	(0.9808)	(0.7934)	(1.4549)	(0.6669)	(1.0999)	(0.4593)	(0.2153)	(0.3020)
	0.0001	*0.7656*	*0.4526*	*0.0329*	*0.8452*	*0.5734*	*0.0420*	*0.7826*	*0.5061*
Weekly	10.1690**	0.8061	-1.3301	9.1453*	1.2144*	-1.6558	2.9084**	0.4510*	-0.5604
	(3.9721)	(2.1262)	(1.9477)	(4.7592)	(0.6321)	(1.5189)	(1.3841)	(0.2347)	(0.5157)
	0.0107	*0.7047*	*0.4949*	*0.0551*	*0.0552*	*0.2761*	*0.0360*	*0.0551*	*0.2776*

Notes: Average daily abnormal returns are estimated in a regression framework with dummy variables. D, R, and M stand for decriminalisation, recreational legalisation, and medical legalisation, respectively. Standard errors in parentheses and p-values in italics. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

Conclusion

This study has demonstrated the importance of illicit market use for cryptocurrency value by utilising an exhaustive sample of 58 US state-level marijuana bills across 2010-2022 in an event study framework for Bitcoin prices. Marijuana decriminalisation leads to substantial Bitcoin price appreciations showing corresponding increases in demand for illicit cryptomarket transactions it facilitates, and small negative price reaction is found in anticipation to medical legalisation, supportive of the main hypothesis of this study that shadow economy use positively contributes to the value of Bitcoin. However, recreational legalisation does not reduce Bitcoin prices and even substantially increases them in some estimations which implies continued use of illicit online marketplaces subject to establishment of legal and regulated alternatives. The results are consistent across event windows, in subsamples, and when outliers, heavy tails, and conventional financial market exposures are accounted for. The Bitcoin market is generally efficient in incorporating marijuana policy information.

The results have clear implications for investors and policymakers. First, a previously undocumented link between cryptocurrencies and the cannabis sector has been discovered which establish a fundamental source of cryptocurrency value which is theoretically grounded yet has been previously overlooked in empirical research. Second, given future possibility of marijuana decriminalisation in a wide range of jurisdictions, material increases in both Bitcoin price and its illicit market use are expected which can inform both speculative investing and strategic drug policy decisions. Third, this study has provided some indirect evidence

suggesting recreational and medical marijuana legalisations do not substantially reduce the use of illicit online cryptomarkets which might be due to cultural and behavioural attitudes of existing participants of such platforms. Finally, as Bitcoin value is at least partially driven by its shadow economy usability, this contributes to its political and ESG risk profile for the purposes of positive and negative screening and augments existing environmentally driven concerns surrounding the ethics of cryptocurrency investing. Socially conscious investors could test for similar drug policy exposures of cryptoassets to inform their perception of their social risk profile and therefore asset allocation decisions. The assembled marijuana bill dataset can also be used in future event study research for blockchain fundamentals, as well as for other financial markets.

The limitations of this study are mainly associated with its US focus and its use of event study methodology – however the exhaustive sample size and the chosen event windows do substantially mitigate potential confounding event effects. Further research could investigate the impact of cannabis policy on the on-chain processes of Bitcoin such as transactions, scrutinise the impact of global drug policy events on cryptocurrency markets, as well as utilise the event dataset this study gathered in application to various cryptoassets or cannabis stocks.

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