Is Bitcoin really more than a diversifier? A pre- and post-COVID-19 analysis

Abstract

We examine whether Bitcoin can act as a safe haven against adverse movements of stock and bond assets in five major economies during the COVID-19 bear market. The empirical analyses are conducted using a Bayesian panel VAR method that captures potential interaction and heterogeneity across country/region-segmented markets. We find that Bitcoin in each given economy contributes to diversification benefits and/or risk mitigation both within and across borders, while its role against traditional assets varies. We also show that the COVID-19 outbreak alters the role of Bitcoin in our target segmented markets except for the US.

Keywords: Bitcoin; Safe Haven; Diversifier; COVID-19; Bayesian panel VAR method

JEL Classifications: C33; G15

Highlights

- We examine the safe haven role of Bitcoin across economies in COVID-19 bear market.
- A Bayesian PVAR is employed to model the cross-border interaction and heterogeneity.
- Bitcoin plays different roles for stock and bond in individually-segmented markets.
- It offers diversification benefits and/or risk reductions within and across borders.
- COVID-19 outbreak alters the Bitcoin's role in various economies except for the US.

1. Introduction

The unprecedented COVID-19 epidemic has not only incurred tremendous cost in lives, but also profoundly penetrated trajectories of economic growth like none other, in the form of persistent uncertainties, and weakening investors' sentiments at a gigantic scale. Given the fact that investor loss aversion implies a greater sensitivity to severe losses than gains (Tversky and Kahneman, 1991), the significant financial turmoil associated with the epidemic would lead to adjustments in optimal portfolio selections (Berkelaar et al., 2004). It therefore prompts investors to seek 'shelter', i.e. a safe haven, one that is of great importance for mitigation of investment risks (Conlon and McGee, 2020).[1] In this paper, we identify the ability of Bitcoin in each target country/region for effective diversification benefits and/or risk reductions against adverse movements of stock and bond assets within and across borders.[2] The acute market losses associated with the ongoing epidemic, i.e. the COVID-19 bear market, serves as a critical test-bed for the role of Bitcoin against stock and bond investments. Specifically, we capture the potential interaction and heterogeneity cross individually-segmented markets of Bitcoin and traditional assets through a panel VAR model with Bayesian stochastic search (i.e., Bayesian panel VAR method) proposed by Koop and Korobilis (2016). The dynamics of the Bitcoin's role among target countries/regions is also uncovered via a comparison before and after the COVID-19 outbreak.[3]

Traditionally, though gold is often associated with a safe haven against stock and bond (Baur and Lucey, 2010; Conlon et al., 2018), its position has been increasingly questioned when facing the zero-bound interest rate and the intensified financialization of gold invest-

[1] According to Baur and Lucey (2010); Bouri et al. (2017a), an asset having no correlation (a negative correlation) with another asset on average and during severe market stress is respectively defined as a weak (strong) hedge and a weak (strong) safe haven; an asset having a positive correlation (but not perfect) with another asset on average is defined as a diversifier.

[2] In terms of the global Bitcoin trading, Makarov and Schoar (2020) suggest Bitcoin market segmentation by the base currency against which Bitcoin is traded. They find that most Bitcoin investors only use one fiat currency, i.e. their home currency, in Bitcoin trading, supporting the argument of segmented markets by country/region.

[3] The five countries/regions include Australia, Canada, Europe, the UK, and the US. Their markets cover more than 80% trading volumes of the global Bitcoin transactions (Gillaizeau et al., 2019).

ment after the global financial crisis (Shahzad et al., 2019). Recently, the role of Bitcoin as an investment shelter during a market crash has been recognized in academia (Luther and Salter, 2017). Bitcoin can possess a safe haven ability mainly due to its weak correlation with traditional financial assets, its function as a store of value, and its independence with monetary policies (Conlon and McGee, 2020; Shahzad et al., 2019). However, hedging and safe haven properties of Bitcoin are not consistently supported by the extant literature. Baur et al. (2018) point out the strong speculative nature of Bitcoin-related investment, leading to the selling pressure of Bitcoin and its weakened role as a store of value during extreme market stress. Moreover, the safe haven ability could be relatively weak compared to the traditional safe haven like gold due to its higher volatility, less liquidity, and greater transaction costs (Smales, 2019). Existing empirical findings regarding the role of Bitcoin are summarized in Table A.1 in Appendix A, demonstrating that a consensus on whether Bitcoin is really more than a diversifier for traditional assets has yet to be established.

Moreover, while the global Bitcoin trading depicts a high degree of market segmentation implying potential cross-border investment and arbitrage opportunities (Makarov and Schoar, 2020), existing findings on the role of Bitcoin are nevertheless drawn based on a single/aggregate Bitcoin price series. Indeed, since Bitcoin (traded in various currencies across countries/regions) depicts a strong volatility connectedness (Gillaizeau et al., 2019), a serious informational loss about the Bitcoin's role would occur unless we capture the interaction and heterogeneity across country/region-segmented markets. In addition, existing empirical tests for the safe haven role of Bitcoin has long been devoid of a critical test-bed, i.e. severe financial turbulence (Conlon et al., 2020; Ji et al., 2020).

Our paper adds to the extant literature in the following ways. First, we capture the nature of the Bitcoin market segmentation in individual countries/regions. Second, our employed Bayesian panel VAR method can well consider underlying interaction and heterogeneity across segmented markets. The Bayesian paradigm improves the estimation precision within a more flexible and informative environment than a classical mean-based estimation using panel data. Third, we are among the first to uncover the role of Bitcoin as a safe haven and/or diversifier against traditional assets among different countries/regions during the COVID-19 bear market, while comparing its dynamic role in pre- and post-COVID-19 periods. Overall, we find that the role of Bitcoin across countries/regions alters due to the COVID-19 outbreak except for the US where Bitcoin remains a constant role both within and across borders in pre- and post-COVID-19 periods. Our results possess important implications that investors should acknowledge the interaction and heterogeneity across individually-segmented markets when seeking for Bitcoin as an effective shelter in financial turbulence.

2. Data and Preliminary Analysis

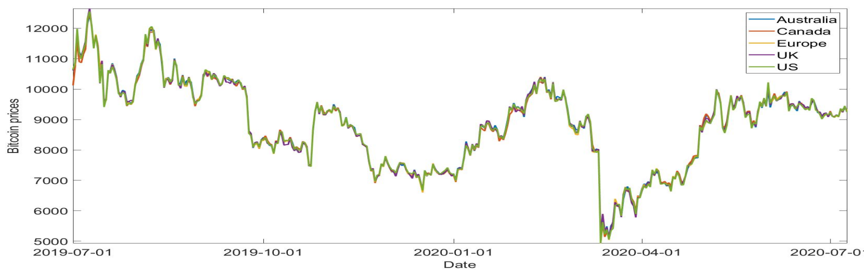
We collect a panel dataset including the price series of Bitcoin, stock, and bond covering the five major countries/regions with a daily frequency. Specifically, Bitcoin closing price data are from Bitcoin Charts (bitcoincharts.com); stock prices are represented by the stock price index and from Investing (Investing.com); bond prices are proxied by the bond index with maturity over 10 years and from S&P Dow Jones Indices database.[4] The whole year data spanning from 01 JUL 2019 to 09 JUL 2020 are used to form the research context characterized by significant financial turmoil (Conlon and McGee, 2020; Conlon et al., 2020; Ji et al., 2020).[5] While we mainly focus on the ability of Bitcoin for wealth preservation in the COVID-19 bear market, in the light of Corbet et al. (2020), the one-year data are further split on 31 DEC 2019, i.e. the outbreak of COVID-19, to examine the dynamics of the Bitcoin's ability in pre- and post-COVID-19 periods, respectively.

Dynamic movements of prices of Bitcoin, stock, and bond in each segmented market are presented in Figure 1. It shows that while the five Bitcoin price series generally experiences a co-movement pattern, they demonstrate obvious local differences overtime, providing intu-

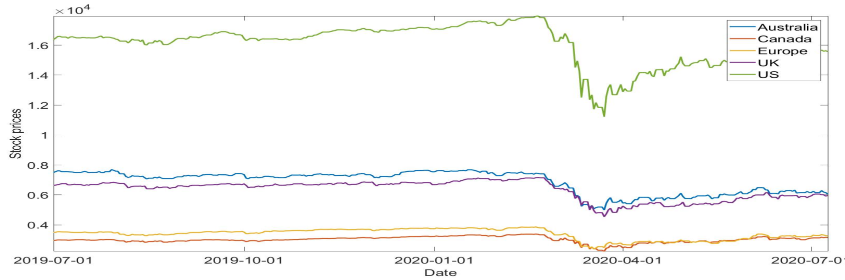
[4]The stock index of each of the five countries/regions used in the paper is S&P ASX200, S&P TSX, STOXX, FTSE100, and S&P500, respectively. The effect of local currencies on empirical results is eliminated by converting them to US dollars.

[5]This is motivated by the extant related literature that a more than 20% downward move in financial markets is sufficient to provide strong evidence for any safe haven properties (Conlon et al., 2020).

(a) *Bitcoin price series*



(b) *Stock price series*



(c) *Bond price series*

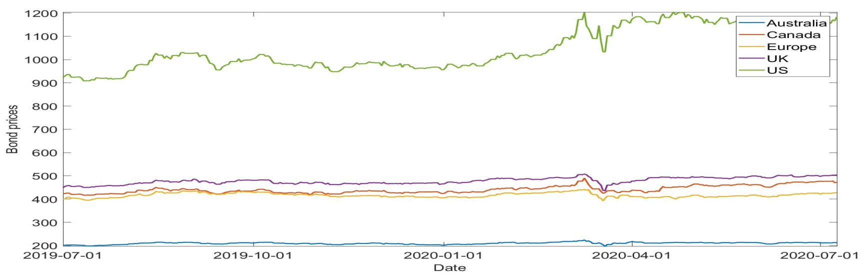


Figure 1: ***Dynamic movements of target series***

itive and strong evidence of country segmentation nature. Both stock and bond price indices also depict obvious differences across countries/regions. Moreover, the three price series in each segmented market witnessed a marked drop in Mar 2020, which is consistent with the first announcement of COVID-19 as a pandemic by the WHO on 11 Mar 2020.[6] For each price series, we calculate its return as the first difference of the logarithm of prices between the current day and last day times 100. Table 1 shows summary statistics of the return transformed series for target variables in the five countries/regions during the COVID-19 period. Briefly, Bitcoin is found to possess negative and much small mean value with the highest stadard deviation (namely volatility) compared to both stock and bond. Most of the return series of target variables in the five countries/regions are negatively skewed and lep-

[6]See details about key dates of COVID-19 announced by the WHO at https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline.

tokurtic, coinciding with empirical evidence from Bouri et al. (2017a); Conlon et al. (2020); Corbet et al. (2020).

Table 1: *Summary statistics of the target series*

	Mean	Std. Dev.	Minimum	Maximum	Skewness	Kurtosis
Panel A: Bitcoin						
Australia	-0.0357	4.0778	-42.6288	13.8575	-2.9085	31.7352
Canada	-0.0226	4.1979	-47.4008	15.0501	-3.6134	43.2821
Europe	-0.0365	4.3734	-47.7436	15.8145	-3.1521	38.0389
UK	-0.0363	4.2218	-43.5036	14.7730	-2.7034	30.0836
US	-0.0374	4.3709	-48.0904	15.2301	-3.3129	38.9110
Panel B: Stock						
Austratlia	-0.0294	1.5082	-10.2030	6.7665	-1.4682	12.0432
Canada	-0.0136	1.6870	-13.1761	11.2945	-1.7607	26.1305
Europe	-0.0187	1.5949	-13.2405	8.8343	-1.8282	18.0385
UK	-0.0574	1.4496	-11.5124	8.6668	-1.5589	16.4276
US	0.0164	1.7526	-12.7652	8.9683	-1.0483	15.5536
Panel C: Bond						
Austratlia	0.0144	0.6535	-3.5506	4.0895	-0.2448	9.4707
Canada	0.0291	0.6870	-2.9401	2.8705	-0.1451	4.1136
Europe	0.0187	0.6150	-3.4028	2.6987	-0.7309	7.4585
UK	0.0307	0.6680	-5.1559	5.3560	-0.2118	20.6055
US	0.0666	1.0411	-6.0565	6.4995	0.3420	10.8476

3. Methodology

3.1. Panel VAR model

The panel VAR model is a highly recognized method for quantification of the relationship between target variables in multiple countries/regions (Canova and Ciccarelli, 2009). It can not only ameliorate the endogeneity issue of simultaneity, but also consider the potential interaction and heterogeneity across countries/regions to meet the increasingly integrated global economy in recent years. In this sense, we employ the panel VAR model to gauge the relation between Bitcoin and traditional financial assets in the five countries/regions, and the model is constructed following Koop and Korobilis (2016).

Let R_{jt} be a return vector of $Z = 3$ financial assets for country/region j ($j = A, C, E, G$ and U) at period t ($t = 1, \ldots, T$), i.e. $R_{jt} = (Bitcoin'_{jt}, Stock'_{jt}, Bond'_{jt})'$, where A, C, E, G

and U represent $J = 5$ countries/regions that involve Australia, Canada, Europe, the UK, and the US, respectively. The panel VAR model is then formulated as:

$$R_{jt} = B_{jA}R_{At-1} + B_{jC}R_{Ct-1} + B_{jE}R_{Et-1} + B_{jG}R_{Gt-1} + B_{jU}R_{Ut-1} + \varepsilon_{jt}, \tag{1}$$

where $B_{jA}, \ldots, B_{jU}$ denote $Z \times Z$ coefficient matrices of $R_{At-1}, \ldots, R_{Ut-1}$ and ε_{jt} is the error term following a normal distribution, i.e. $\varepsilon_{jt} \sim N(0, \Sigma_{jj})$, with Σ_{jj} as a covariance matrix.[7]

Particularly in our case, key coefficient vectors (i.e. B^{12} and B^{13}) that represent the correlation of Bitcoin with stock and bond across countries/regions are[8]

$$B^{12} = (\beta^{12}_{AA}, \ldots, \beta^{12}_{AU}, \beta^{12}_{CA}, \ldots, \beta^{12}_{CU}, \beta^{12}_{EA}, \ldots, \beta^{12}_{EU}, \beta^{12}_{GA}, \ldots, \beta^{12}_{GU}, \beta^{12}_{UA}, \ldots, \beta^{12}_{UU}), \tag{2}$$

$$B^{13} = (\beta^{13}_{AA}, \ldots, \beta^{13}_{AU}, \beta^{13}_{CA}, \ldots, \beta^{13}_{CU}, \beta^{13}_{EA}, \ldots, \beta^{13}_{EU}, \beta^{13}_{GA}, \ldots, \beta^{13}_{GU}, \beta^{13}_{UA}, \ldots, \beta^{13}_{UU}), \tag{3}$$

where β^{mn}_{kl} refers to the coefficient of financial asset n of country/region l, which appears on the equation of financial asset m of country/region k.

3.2. Restriction selection and Bayesian stochastic search

The panel VAR estimation often suffers from the issue of over-parametrization especially when multiple countries are taken into account. When it occurs, the observed data are not sufficient for the coefficient estimates, leading to the application of mean-based estimation technique and therefore a failure to capture the country/region-specific information. Thus, to balance between parameter identification and micro-level information, we follow George et al. (2008); Koop and Korobilis (2016) and conduct coefficient restrictions on dynamic and static interdependencies across countries/regions.

The dynamic interdependency occurs when coefficients of the panel VAR model between two target countries/regions are interdependent. If there is no dynamic interdependency from country/region l to k, we can define a restriction by imposing $B_{kl} = 0$ for $k \neq l$.

[7] Without loss of generality, our panel VAR model considers the one-lag case and does not include intercept term or exogenous variables. These can be easily generalized in the formulae.

[8] A full model specification regarding variable dimension and coefficients of the panel VAR model is detailed in Appendix B.

Considering that each country/region has a dynamic interdependency with any of the rest $(J-1)$ ones, which results in a total of $J \times (J-1)$ restrictions.

The static interdependency concerning with the covariance matrix of the panel VAR model further represents linkages between two target countries/regions. The restriction specified by setting $\Sigma_{kl} = 0$ for $k \neq l$ indicates that there is no statistic interdependency between country/region l and k. Due to the symmetry of the covariance matrix ($\Sigma_{kl} = \Sigma_{lk}$), the number of restrictions regarding statistic interdependency is $\frac{(J\times(J-1))}{2}$.

To jointly estimate model parameters and select their associated restrictions, we employ a Bayesian stochastic search for restrictions using hierarchical priors and Markov Chain Monte Carlo (MCMC) methods that extends the VAR model selection methods such as George et al. (2008), and is similar with the Stochastic Search Specification Selection (S^4) for the panel VAR model proposed by Koop and Korobilis (2016). It eases the selection procedure by applying restrictions to a whole block of parameters rather than each single one. We define the selection indicator of φ that comprises $J \times (J-1)$ vector of φ^{DI} and $\frac{(J\times(J-1))}{2}$ vector of φ^{SI} to separately restrict dynamic and static interdependencies, where each element in φ is a dummy variable that satisfies $\varphi_{kl} \in \{0, 1\}$ and needs to be estimated from the data. A detailed discussion of the Bayesian stochastic search process is in Appendix C.

4. Empirical Results

4.1. Model restrictions and coefficient estimation

This section reports results of the panel VAR model specified in Equation (1) through Bayesian stochastic search for restriction selection.[9] Table 2 lists the results whether restrictions on dynamic and static interdependencies are imposed or not. A restriction is held if the probability that the corresponding element in φ has a value of zero is greater than 50% (Koop and Korobilis, 2016). As shown in Panel A of Table 2, all the restrictions on

[9]We took 54,000 MCMC draws for our model with the first 4,000 chains discarded as burn-in. Every 10th draw of the remaining 50,000 chains is collected to estimate the model parameters.

dynamic interdependency are not held, indicating the existence of interaction (regarding the coefficient matrix) across the five countries/regions. Panel B of Table 2 reports that many static interdependencies between countries/regions do not exist. For example, restrictions on the US static interdependency with Australia, Canada, and Europe are held, indicating the high stability of the US in the face of external shocks (in the covariance matrix).

Table 2: *Imposed restrictions on dynamic and static interdependencies during the COVID-19 period*

Panel A: Restrictions on Dynamic Interdependencies							
No.	To	From	Hold / Not Hold	No.	To	From	Hold / Not Hold
1	Australia	Canada	Not Hold	11	Europe	UK	Not Hold
2	Australia	Europe	Not Hold	12	Europe	US	Not Hold
3	Australia	UK	Not Hold	13	UK	Australia	Not Hold
4	Australia	US	Not Hold	14	UK	Canada	Not Hold
5	Canada	Australia	Not Hold	15	UK	Europe	Not Hold
6	Canada	Europe	Not Hold	16	UK	US	Not Hold
7	Canada	UK	Not Hold	17	US	Australia	Not Hold
8	Canada	US	Not Hold	18	US	Canada	Not Hold
9	Europe	Australia	Not Hold	19	US	Europe	Not Hold
10	Europe	Canada	Not Hold	20	US	UK	Not Hold
Panel B: Restrictions on Static Interdependencies							
No.	To	From	Hold / Not Hold	No.	To	From	Hold / Not Hold
1	Australia	Canada	Not Hold	6	Canada	UK	Hold
2	Australia	Europe	Not Hold	7	Canada	US	Hold
3	Australia	UK	Hold	8	Europe	UK	Not Hold
4	Australia	US	Hold	9	Europe	US	Hold
5	Canada	Europe	Not Hold	10	UK	US	Not Hold

Accordingly, we impose aforementioned model restrictions and proceed with coefficient estimates. Estimation results that reflect the relation of Bitcoin with stock and bond in the five segmented markets are reported in Table 3. These results possess important implications on the identification of the role of Bitcoin against stock and bond investments in individual countries/regions to be explained in the next subsection.

4.2. Examining the role of Bitcoin during the COVID-19 period

To identify the role of Bitcoin for stock and bond assets, in the light of Baur and Lucey (2010); Bouri et al. (2017a), Bitcoin can be a diversifier against stock and/or bond if the element in coefficient vectors of B^{12} and/or B^{13} is significantly positive while less than one.

Particularly in financial turmoil, Bitcoin can be a weak safe haven against stock and/or bond if the element in coefficient vectors of B^{12} and/or B^{13} is not significantly different from zero; a strong safe haven if the coefficient vectors are significantly negative. Thus, we conduct the Bayesian panel VAR estimation with estimates of B^{12} and B^{13} reported in Table 3. Accordingly, the role of Bitcoin during the COVID-19 epidemic is summarized in Table 4.

Table 3: *Bayesian panel VAR estimates during the COVID-19 period*

	Australia		Canada		Europe		UK		US
	Mean (Std. Dev.)		Mean (Std. Dev.)		Mean (Std. Dev.)		Mean (Std. Dev.)		Mean (Std. Dev.)
Panel A: Stock									
β^{12}_{AA}	**0.9131**	β^{12}_{CA}	-0.1468	β^{12}_{EA}	-0.3333	β^{12}_{GA}	**0.5546**	β^{12}_{UA}	**-1.7068**
	(0.4471)		(0.5059)		(0.3662)		(0.3298)		(0.6162)
β^{12}_{AC}	**0.8239**	β^{12}_{CC}	-0.0901	β^{12}_{EC}	-0.0932	β^{12}_{GC}	**0.3533**	β^{12}_{UC}	**-1.6916**
	(0.4695)		(0.5297)		(0.3849)		(0.3466)		(0.6448)
β^{12}_{AE}	-0.1206	β^{12}_{CE}	0.0780	β^{12}_{EE}	0.0035	β^{12}_{GE}	0.1177	β^{12}_{UE}	**-0.8052**
	(0.2284)		(0.2617)		(0.1926)		(0.1703)		(0.3199)
β^{12}_{AG}	0.0028	β^{12}_{CG}	0.0410	β^{12}_{EG}	**0.3367**	β^{12}_{GG}	**-0.1896**	β^{12}_{UG}	**0.3283**
	(0.0641)		(0.0762)		(0.0563)		(0.0487)		(0.0923)
β^{12}_{AU}	-0.0337	β^{12}_{CU}	0.0084	β^{12}_{EU}	**0.2561**	β^{12}_{GU}	**-0.1524**	β^{12}_{UU}	**0.2383**
	(0.0745)		(0.0861)		(0.0632)		(0.0542)		(0.1050)
Panel B: Bond									
β^{13}_{AA}	**0.8298**	β^{13}_{CA}	-0.1183	β^{13}_{EA}	-0.3208	β^{13}_{GA}	**0.4777**	β^{13}_{UA}	**-1.8606**
	(0.4676)		(0.5266)		(0.3823)		(0.3444)		(0.6398)
β^{13}_{AC}	0.1584	β^{13}_{CC}	0.0657	β^{13}_{EC}	**0.2373**	β^{13}_{GC}	0.0927	β^{13}_{UC}	**-1.1201**
	(0.2001)		(0.2335)		(0.1682)		(0.1466)		(0.2797)
β^{13}_{AE}	-0.0167	β^{13}_{CE}	0.1848	β^{13}_{EE}	0.0625	β^{13}_{GE}	0.1490	β^{13}_{UE}	**-1.0125**
	(0.1978)		(0.2284)		(0.1682)		(0.1490)		(0.2799)
β^{13}_{AG}	0.0647	β^{13}_{CG}	0.0267	β^{13}_{EG}	**0.1962**	β^{13}_{GG}	-0.0053	β^{13}_{UG}	**0.2060**
	(0.0830)		(0.0982)		(0.0710)		(0.0618)		(0.1173)
β^{13}_{AU}	-0.0297	β^{13}_{CU}	0.1191	β^{13}_{EU}	**0.4132**	β^{13}_{GU}	**-0.1277**	β^{13}_{UU}	**0.5577**
	(0.1294)		(0.1531)		(0.1114)		(0.0975)		(0.1859)

Notes: coefficients in bold are significant in 95% confidence interval. Standard errors are in parentheses.

Overall, Bitcoin in each country/region-segmented market demonstrates heterogeneous roles against the stock in different markets. Specifically, Bitcoin in Australia is no more than an effective diversifier for stocks in the same country and Canada; it is a weak safe haven in Europe, the UK, and the US, suggesting a preference for investors in these countries/regions to hedge their equity portfolios using Bitcoin in Australia. In parallel, Bitcoin in the UK behaves similar roles as that in Australia, while the former demonstrates a relatively stronger ability of risk reductions for stock assets in the UK and the US. Bitcoins in both Europe and the US offer diversification benefits against stocks in the UK and the US; they also respectively demonstrate weak and strong abilities of risk reductions for equity investments in Australia, Canada, and Europe. It is worth noting that Bitcoin in Canada equally acts as a weak safe haven for stock investments in various countries/regions. As for the bond, Bitcoin generally behaves as the same role to that for the stock except in certain cases such as the role of Bitcoin in the UK as a weak safe haven against the stock versus a diversifier against the bond in Canada. Thus, Bitcoin in individually-segmented markets can help in diversification and/or risk reduction for stock and bond assets both within and across borders.

Table 4: *The role of Bitcoin for the traditional assets during the COVID-19 period*

Bitcoin	Australia	Canada	Europe	UK	US
Panel A: Stock					
Australia	Diversifier	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven
Canada	Diversifier	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven
Europe	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven
UK	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven	Diversifier
US	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven	Diversifier
Panel B: Bond					
Australia	Diversifier	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven
Canada	Weak Safe Haven	Weak Safe Haven	Diversifier	Weak Safe Haven	Strong Safe Haven
Europe	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven
UK	Weak Safe Haven	Weak Safe Haven	Diversifier	Weak Safe Haven	Diversifier
US	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven	Diversifier

4.3. The dynamic role of Bitcoin pre- and post-COVID-19 outbreak

How does the role of Bitcoin against stock and bond investments evolve before and after the COVID-19 outbreak? To answer this question, we further identify the role of Bitcoin in each country/region-segmented market before the outbreak from 01 Jul 2019 to 30 Dec 2019 as shown in Table 5;[10] then its dynamic role over pre- and post-epidemic samples is uncovered

[10]Corresponding results of model restrictions and coefficient estimates are reported in Appendix D.

by comparing between Tables 4 and 5.

The comparison shows that Bitcoin in the US possesses a consistent role for stock and bond investments in different segmented markets before and after the COVID-19 outbreak; its role for both assets under study keeps highly stable. In contrast, the role of Bitcoin in the UK experiences relatively marked alteration over the two samples except constantly a weak safe haven against the stock and bond in Europe and a strong safe haven against the stock in the US. Bitcoin in Europe also demonstrates a dynamic role against extreme movements in the assets under study; for example, it is a weak safe haven against the stock in the US and the bond in Canada before the COVID-19 outbreak, while its role is altered to be a diversifier for both assets afterwards. Moreover, Bitcoin in Canada can consistently reduce risks for equity and bond portfolios over time, while after the COVID-19 outbreak its role as a safe haven is weakened for its own stock and bond assets as well as the stock in Australia. Similarly, the risk reduction ability of Bitcoin in Australia for its own stock and bond as well as the stock in Canada is dampened when the epidemic comes, while being constant elsewhere. Overall, the role of Bitcoin in individually-segmented markets generally experiences obvious changes in the face of the COVID-19 outbreak except for the high stability in the US.

Table 5: *The role of Bitcoin for the traditional assets before the COVID-19 outbreak*

Bitcoin	Australia	Canada	Europe	UK	US
Panel A: Stock					
Australia	Weak Safe Haven	Strong Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven
Canada	Strong Safe Heaven	Strong Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven
Europe	Weak Safe Haven	Weak Safe Haven	Diversifier	Weak Safe Haven	Strong Safe Haven
UK	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven	Diversifier	Diversifier
US	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven	Diversifier
Panel B: Bond					
Australia	Weak Safe Haven	Strong Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven
Canada	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven
Europe	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Weak Safe Haven	Strong Safe Haven
UK	Weak Safe Haven	Weak Safe Haven	Diversifier	Strong Safe Haven	Diversifier
US	Weak Safe Haven	Weak Safe Haven	Diversifier	Weak Safe Haven	Diversifier

5. Conclusion

The COVID-19 bear market offers a critical testing ground for the safe haven role of Bitcoin against stock and bond investments. Considering the potential interaction and heterogeneity across country/region-segmented markets, our results indicate that Bitcoin in each economy can contribute to effective diversification and/or risk mitigation against not only its own traditional assets, but also that outside borders. We find that the role of Bitcoin in various economies experiences obvious variations following the COVID-19 outbreak except for the US where Bitcoin keeps a constant position over time. Our results shed new light on whether Bitcoin can be treated as an effective shelter among target segmented markets during severe downturns related to the ongoing epidemic. Country/region specific investment strategy, as rolled out in our results, should be of interest to investors.

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Appendix A. Summary of the Key Literature regarding the Role of Bitcoin

Table A.1: *Summary of the key literature regarding the role of Bitcoin*

Authors	Method	Period	COVID-19 Context	The role of Bitcoin against adverse movements of traditional assets	
				Stock	Bond
Briere et al. (2015)	The mean-variance spanning test	2010.07.23-2013.12.27	No	Bitcoin return behaves a fairly low correlation with stock and bond investments; Bitcoin offers marked diversification benefits	
Bouri et al. (2017a)	DCC-GARCH	2011.07.18-2015.12.22	No	Bitcoin can serve as a diversifier for both stock and bond in most cases; a strong haven against extreme downside changes in Asian stocks in a weekly data horizon	
Corbet et al. (2018)	Generalized variance decomposition method	2013.04.29-2014.02.07; 2014.02.10-2017.04.30	No	Bitcoin behaves disconnected with mainstream assets and could offer diversification benefits for investors with short-investment horizons	
Wang et al. (2019)	VAR-GARCH-BEKK	2013.01.17-2017.09.29	No	Bitcoin demonstrates a hedging role in both stock and bond markets;	
Dyhrberg (2016)	Threshold GARCH	2010.07.19-2015.05.22	No	Bitcoin behaves as a hedge against stock and can reduce risk of stock investments	—
Bouri et al. (2017b)	Wavelet-based quantile-in-quantile method	2011.03.17-2016.10.07	No	Bitcoin serves as a hedge for stock at extreme ends of the Bitcoin market at shorter investment horizons	—
Klein et al. (2018)	BEKK-GARCH	2011.07.01-2017.12.31	No	Bitcoin does not serve as a safe-heaven; it offers diversification benefits to the portfolio	—
Kliber et al. (2019)	DCC	2014-2017	No	Bitcoin acts as a weak hedge in target international markets when considering investments in US dollars; it acts as a safe haven in Venezuela	—
Guesmi et al. (2019)	DCC-GJR-GARCH	2012.01.01-2018.01.05	No	A short position of Bitcoin has a hedging potential for stock; a hedging strategy involving Bitcoin can effectively reduce the portfolio risk	—
Shahzad et al. (2019)	Cross-quantilogram approach	2010.07.20-2018.02.22	No	Bitcoin serves as a weak-form save haven for both global and individual Chinese stock market	—
Conlon et al. (2020)	Portfolio value at risk (VaR); conditional VaR	2019.04.11-2020.04.09	Yes	Bitcoin does not act as a safe haven for most target international equity markets except its modest downside risk benefits to the Chinese CSI 300 stock index	—
Conlon and McGee (2020)	Portfolio value at risk (VaR); conditional VaR	2019.03.21-2020.03.20	Yes	Is not a safe haven; Bitcoin and stock returns are significantly positively correlated.	—
Corbet et al. (2020)	DCC-GARCH	2019.03.11-2019.12.30; 2019.12.31-2020.03.10	Yes	Bitcoin does not act as a hedge or safe haven; but rather amplifies portfolio risk	—
Ji et al. (2020)	Cross-quantilogram approach	2019.12.01-2020.03.31	Yes	The safe haven ability of Bitcoin is weak	—

Appendix B. The Model Specification of Panel VAR in Matrix Form

We can write the matrix form of our panel VAR model based on equation (1), which is

$$\begin{bmatrix} r_{At} \\ r_{Ct} \\ r_{Et} \\ r_{Gt} \\ r_{Ut} \end{bmatrix} = \begin{bmatrix} B_{AA} & B_{AC} & B_{AE} & B_{AG} & B_{AU} \\ B_{CA} & B_{CC} & B_{CE} & B_{CG} & B_{CU} \\ B_{EA} & B_{EC} & B_{EE} & B_{EG} & B_{EU} \\ B_{EA} & B_{EC} & B_{EE} & B_{EG} & B_{EU} \\ B_{UA} & B_{UC} & B_{UE} & B_{UG} & B_{UU} \end{bmatrix} \begin{bmatrix} r_{At-1} \\ r_{Ct-1} \\ r_{Et-1} \\ r_{Gt-1} \\ r_{Ut-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{At} \\ \varepsilon_{Ct} \\ \varepsilon_{Et} \\ \varepsilon_{Gt} \\ \varepsilon_{Ut} \end{bmatrix}. \tag{B.1}$$

When we unfold the variable dimension, each block of coefficient matrix can be specified in the following form:

$$B_{kl} = \begin{bmatrix} \beta_{kl}^{11} & \beta_{kl}^{12} & \beta_{kl}^{13} \\ \beta_{kl}^{21} & \beta_{kl}^{22} & \beta_{kl}^{23} \\ \beta_{kl}^{31} & \beta_{kl}^{32} & \beta_{kl}^{33} \end{bmatrix} \quad \text{for } \forall\ k, l = A, C, E, G, \text{ and } U, \tag{B.2}$$

where 1, 2, and 3 denote the Bitcoin, stock, and bond. Therefore, the correlation of Bitcoin with other financial assets (i.e. stock and bond) between country k and country l is denoted by β_{kl}^{12} and β_{kl}^{13}, respectively.

Appendix C. Bayesian Stochastic Search Process

Our Bayesian Stochastic Search is based on hierarchical priors and the MCMC algorithm to impose restrictions for the model. The prior for restriction on dynamic interdependency is

$$vec(B_{kl}) \sim (1-\varphi_{kl}^{DI})N(0,\kappa_{kl}^2 \times c_{DI} \times I) + \varphi_{kl}^{DI}N(0,\kappa_{kl}^2 \times I) \text{ for } k \neq l, \tag{C.1}$$

where $\kappa_{kl}^2 \sim Gamma(1, \tau^{DI})$ with $\tau^{DI} = 50$, and $c^{DI} = 10^{-6}$. The hypper prior for the selection indicator of φ_{kl}^{DI} is given by

$$\varphi_{kl}^{DI} \sim Bernoulli(\theta_{kl}^{DI}) \text{ for } k \neq l, \tag{C.2}$$

where $\theta_{kl}^{DI} \sim Beta(1, \rho)$ with $\rho = 1$.

To specify the statistic interdependency restriction, we denote the covariance matrix of full error term in the panel VAR model as Σ, and define its upper triangular matrix by setting $\Sigma = \Phi^{-1'}\Phi^{-1}$, which can be partitioned into $Z \times Z$ matrix of Φ_{kl} for Σ_{kl}. Then, the prior for restriction on statistic interdependency is

$$vec(\Phi_{kl}) \sim (1-\varphi_{kl}^{SI})N(0,\delta_{kl}^2 \times c_{SI} \times I) + \varphi_{kl}^{SI}N(0,\delta_{kl}^2 \times I) \text{ for } k > l, \tag{C.3}$$

where $\delta_{kl}^2 \sim Gamma(1, \tau^{SI})$ with $\tau^{SI} = 60$, and $c^{SI} = 10^{-5}$. The hypper prior for the selection indicator of φ_{kl}^{SI} is given by

$$\varphi_{kl}^{SI} \sim Bernoulli(\theta_{kl}^{SI}) \text{ for } k > l, \tag{C.4}$$

where $\theta_{kl}^{SI} \sim Beta(1, \rho)$ with $\rho = 1$.

Next, we conduct the MCMC algorithm. The Gibbs sampler is used to implement the estimation by recursively generating draws from the conditional distributions of all model parameters, and the procedures are as follows:

1. Generate B

The $ZJ \times ZJ$ matrix of B that involves all the coefficients in the panel VAR model is drawn from the Normal distribution, which is

$$vec(B) \sim N(\mu, \Omega), \tag{C.5}$$

where $\mu = \Omega\left(\left(\Sigma^{-1} \otimes R'_{t-1}R_{t-1}\right)B_{ols}\right)$ with B_{ols} being the OLS estimate of B, $\Omega = (\Sigma^{-1} \otimes R'_{t-1}R_{t-1} + (W'W)^{-1})^{-1}$ with R_{t-1} comprising all returns in the last period and W being a diagnoal matrix that its Z^2 diagonal elements in the corresponding block equal to $\kappa^2_{kl} \times c_{DI} \times \mathbf{1}$ if $\varphi^{DI}_{kl} = 0$ and $\kappa^2_{kl} \times \mathbf{1}$ if $\varphi^{DI}_{kl} = 1$, with $\mathbf{1}$ being a vector of ones with dimension $Z^2 \times 1$. κ^2_{kl} in W can be drawn from the Gamma distribution:

$$\kappa^2_{kl} \sim Gamma\left(1 + \frac{1}{2}Z, \tau^{DI} + \frac{1}{2}\sum_{z=1}^{Z}\frac{\left(vec(B_{kl})_z\right)^2}{(c^{DI})^{1-\varphi^{DI}_{kl}}}\right). \tag{C.6}$$

2. Generate φ^{DI}_{kl}

We draw the selection indicator of φ^{DI}_{kl} from the Bernoulli distribution, which is

$$\varphi^{DI}_{kl} \sim Bernoulli\left(\frac{w_{2,kl}}{w_{1,kl} + w_{2,kl}}\right), \tag{C.7}$$

where $w_{1,kl} = \phi\left(vec\left(B_{kl}\right), \kappa^2_{kl} \times I\right)$ and $w_{2,kl} = \phi\left(vec\left(B_{kl}\right), \kappa^2_{kl} \times I\right)\left(1 - \theta^{DI}_{kl}\right)$ with $\phi(\cdot)$ being the probability density function of the Normal distribution. We draw θ^{DI}_{kl} in $w_{2,kl}$ from the Beta distribution:

$$\theta^{DI}_{kl} \sim Beta(1 + \sum \varphi^{DI}_{kl}, \rho + \sum (1 - \varphi^{DI}_{kl}). \tag{C.8}$$

3. Generate Φ_{kl}

The draw of upper triangular matrix of covariance matrix Φ_{kl} is generated from the Normal distribution, which is

$$vec(\Phi_{kl}) \sim N\left(\mu_{kl}, \Omega_{kl}\right), \tag{C.9}$$

where $\mu_{kl} = \Phi^{ii}_{kl}\Omega_{kl}S^{ols}_{kl}$ with Φ^{ii}_{kl} being the diagonal elements of Φ_{kl}, and S^{ols}_{kl} derived from the corresponding elements of $(R_t - B_{ols}R_{t-1})'(R_t - B_{ols}R_{t-1})$, $\Omega_{kl} = \left(S_{kl} + (V_{kl}V_{kl})^{-1}\right)^{-1}$ with S_{kl} derived from the corresponding elements of $(R_t - BR_{t-1})'(R_t - BR_{t-1})$ and V_{kl} being a diagonal matrix that its Z^2 diagonal elements equal to $\delta^2_{kl} \times c_{SI} \times \mathbf{1}$ if $\varphi^{SI}_{kl} = 0$ and $\delta^2_{kl} \times \mathbf{1}$ if $\varphi^{SI}_{kl} = 1$, with $\mathbf{1}$ being a vector of ones with dimension $Z^2 \times 1$. δ^2_{kl} in V_{kl} can be drawn from the Gamma distribution:

$$\delta_{kl}^2 \sim Gamma\left(1+\frac{1}{2}Z, \tau^{SI}+\frac{1}{2}\sum_{z=1}^{Z}\frac{(vec(\Phi_{kl})_z)^2}{(c^{SI})^{1-\varphi_{kl}^{SI}}}\right). \tag{C.10}$$

4. Generate φ_{kl}^{SI}

Similar with the draw of φ_{kl}^{DI}, the selection indicator of φ_{kl}^{SI} is drawn from the Bernoulli distribution, which is

$$\varphi_{kl}^{SI} \sim Bernoulli\left(\frac{v_{2,kl}}{v_{1,kl}+v_{2,kl}}\right), \tag{C.11}$$

where $v_{1,kl} = \phi\left(vec\left(\Phi_{kl}\right), \delta_{kl}^2 \times I\right)$ and $v_{2,kl} = \phi\left(vec\left(\Phi_{kl}\right), \delta_{kl}^2 \times I\right)\left(1-\theta_{kl}^{SI}\right)$ with $\phi(\cdot)$ being the probability density function of the Normal distribution. We draw θ_{kl}^{SI} in $v_{2,kl}$ from the Beta distribution:

$$\theta_{kl}^{SI} \sim Beta(1+\sum\varphi_{kl}^{SI}, \rho+\sum(1-\varphi_{kl}^{SI}). \tag{C.12}$$

Appendix D. Model Restrictions and Coefficient Estimates before the COVID-19 Outbreak

The results whether restrictions on dynamic and static interdependencies are held or not before the COVID-19 outbreak are displayed in Table D.1. We find that seven restrictions on dynamic interdependency and two restrictions on static interdependency are detected. For example, Australia and Canada are not dynamically interdependent with Europe, the UK, and the US, respectively; there is no static interdependency between the UK and Australia, as well as between the UK and Canada.

With both the dynamic and static interdependency restrictions imposed, i.e. zero coefficients in the panel VAR model indicating no correlation between the restricted assets as already defined in Table D.1, the coefficient estimates using the sample before the COVID-19 outbreak are reported in Table D.2.

Table D.1: *Imposed restrictions on dynamic and static interdependencies before the COVID-19 outbreak*

Panel A: Restrictions on Dynamic Interdependencies							
No.	To	From	Hold / Not Hold	No.	To	From	Hold / Not Hold
1	Australia	Canada	Not Hold	11	Europe	UK	Hold
2	Australia	Europe	Not Hold	12	Europe	US	Not Hold
3	Australia	UK	Not Hold	13	UK	Australia	Hold
4	Australia	US	Not Hold	14	UK	Canada	Hold
5	Canada	Australia	Not Hold	15	UK	Europe	Not Hold
6	Canada	Europe	Not Hold	16	UK	US	Not Hold
7	Canada	UK	Not Hold	17	US	Australia	Hold
8	Canada	US	Not Hold	18	US	Canada	Hold
9	Europe	Australia	Hold	19	US	Europe	Not Hold
10	Europe	Canada	Hold	20	US	UK	Not Hold
Panel B: Restrictions on Static Interdependencies							
No.	To	From	Hold / Not Hold	No.	To	From	Hold / Not Hold
1	Australia	Canada	Not Hold	6	Canada	UK	Hold
2	Australia	Europe	Not Hold	7	Canada	US	Not Hold
3	Australia	UK	Hold	8	Europe	UK	Not Hold
4	Australia	US	Not Hold	9	Europe	US	Not Hold
5	Canada	Europe	Not Hold	10	UK	US	Not Hold

Table D.2: *Bayesian panel VAR estimates before the COVID-19 outbreak*

	Australia		Canada		Europe		UK		US
	Mean (Std. Dev.)		Mean (Std. Dev.)		Mean (Std. Dev.)		Mean (Std. Dev.)		Mean (Std. Dev.)
Panel A: Stock									
β_{AA}^{12}	-0.3478	β_{CA}^{12}	**-0.7288**	β_{EA}^{12}	-0.6189	β_{GA}^{12}	-0.1662	β_{UA}^{12}	-0.8331
	(0.4052)		(0.4257)		(0.7401)		(0.5381)		(0.6869)
β_{AC}^{12}	**-0.4302**	β_{CC}^{12}	**-0.6709**	β_{EC}^{12}	-0.5140	β_{GC}^{12}	-0.3246	β_{UC}^{12}	-0.6352
	(0.4158)		(0.4380)		(0.7515)		(0.5473)		(0.7008)
β_{AE}^{12}	0.0000	β_{CE}^{12}	0.0000	β_{EE}^{12}	**0.2396**	β_{GE}^{12}	0.0000	β_{UE}^{12}	**0.4694**
	(0.0000)		(0.0000)		(0.2090)		(0.0000)		(0.1693)
β_{AG}^{12}	0.0000	β_{CG}^{12}	0.0000	β_{EG}^{12}	**-0.1761**	β_{GG}^{12}	**0.1172**	β_{UG}^{12}	**0.1060**
	(0.0000)		(0.0000)		(0.1286)		(0.0832)		(0.0993)
β_{AU}^{12}	0.0000	β_{CU}^{12}	0.0000	β_{EU}^{12}	0.0047	β_{GU}^{12}	0.0772	β_{UU}^{12}	-0.1119
	(0.0000)		(0.0000)		(0.1742)		(0.1099)		(0.1403)
Panel B: Bond									
β_{AA}^{13}	-0.3486	β_{CA}^{13}	**-0.6440**	β_{EA}^{13}	-0.4048	β_{GA}^{13}	-0.3441	β_{UA}^{13}	**-0.7850**
	(0.4129)		(0.4340)		(0.7514)		(0.5457)		(0.7008)
β_{AC}^{13}	0.0863	β_{CC}^{13}	-0.0367	β_{EC}^{13}	-0.0229	β_{GC}^{13}	**0.3649**	β_{UC}^{13}	**0.2828**
	(0.0631)		(0.0693)		(0.1649)		(0.1076)		(0.1354)
β_{AE}^{13}	0.0000	β_{CE}^{13}	0.0000	β_{EE}^{13}	0.0662	β_{GE}^{13}	0.0000	β_{UE}^{13}	**0.4407**
	(0.0000)		(0.0000)		(0.1966)		(0.0000)		(0.1608)
β_{AG}^{13}	0.0000	β_{CG}^{13}	0.0000	β_{EG}^{13}	**0.3355**	β_{GG}^{13}	**-0.1581**	β_{UG}^{13}	0.0226
	(0.0000)		(0.0000)		(0.1771)		(0.1113)		(0.1397)
β_{AU}^{13}	0.0000	β_{CU}^{13}	0.0000	β_{EU}^{13}	**0.2489**	β_{GU}^{13}	-0.0703	β_{UU}^{13}	-0.0143
	(0.0000)		(0.0000)		(0.2281)		(0.1427)		(0.1835)

Notes: coefficients in bold are significant in 95% confidence interval. Standard errors are in parentheses.