The Relationship and Spillover Effects of Agriculture-Related Cryptocurrencies Before and During COVID-19

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Abstract

In this paper, using time-varying econometrical modelling, we investigate the impact of COVID-19 on the major cryptocurrencies related to agriculture. In this context, we examine the relationship and spillover effects between these cryptocurrencies before and during the pandemic. Based on our findings, before the pandemic, a positive relationship and positive spillover effects were present, whereas, during the COVID-19 pandemic, this relationship and the spillover effects became negative. The results show that the COVID-19 pandemic affected the relationship and the spillover effects between the cryptocurrencies related to agriculture.
Keywords: COVID-19; cryptocurrencies; agriculture; spillover effects; time-varying modelling

Introduction

The 21st century is known as the century of technological evolution in many fields, including biology, medicine, economy and even finance. With the emergence of cryptocurrencies, the financial system has undergone significant changes, which have paved the way to a decentralised financial system.

Agriculture is known as the backbone of nations worldwide, and it is an important sector for the survival of humans (Kamalakshi, 2022). Blockchain technology has already transformed many industries, namely, transactions, finance, real estate, health resources and regulations (Biswas et al., 2021). As stated by Kamalakshi (2022), blockchain can transform the agriculture and food sectors, but little research and study have taken place regarding this important subject (Biswas et al., 2021).

The most well-known cryptocurrencies related to agriculture are Herbalist, Carbon Coin and Blocery. All of them have a specific function and can be utilised in the field of agriculture. To begin with, based on its white paper, on the Herbalist platform, users can buy and sell products securely and reliably, ultimately building their reputation through review points. Moreover, consumers can merit lower prices and better quality of products, whereas sellers can provide pictures or videos proving the superior quality of their products. In this way, the platform provides protection for both parties (Herbalist token, 2018).

The other important crypto asset related to the field of agriculture is Carbon Coin. Carbon Coin and similar cryptocurrencies aim to track and reward the decrease in CO_2 emissions worldwide from specific agents (Taylor, 2021). Carbon cryptocurrencies are important for the environment and for reversing the pollution effect (Saraji & Borowczak, 2021). We should note that these cryptocurrencies may have implications for the cryptocurrency network, as the

mining process in the ecosystem of certain cryptocurrencies increase CO_2 emissions (Kononova & Dek, 2020).
Finally, Blocery utilises distributed ledger data, allowing participating producers, settlement and service providers, distributors and consumers to be connected in a transparent and reliable network without the need for intermediaries (Blocery, 2018).
Although there are no adequate studies regarding cryptocurrencies, some researchers have highlighted the importance of a probable relationship and spillover effects among assets in the field of finance, but there is a total absence of agricultural cryptocurrencies investigation. The present paper fills this gap in the literature by examining the change in the relationship and the spillover effects between the agriculture-related cryptocurrencies due to COVID-19, unveiling the importance of external shocks.
The remaining paper is structured as follows: Section 2 presents the literature review, Section 3 states the methodology followed, Section 4 presents the data and variables and the results of the present paper, and, finally, Section 5 concludes the paper.

Literature Review

The COVID-19 pandemic affected the financial system severely (Alexakis et al., 2021). Cryptocurrencies, linked with various other assets, were also impacted in many ways. For example, González et al. (2021) argued that a positive link between the gold price and cryptocurrency returns was observed during the COVID-19 pandemic.
Furthermore, evidence has shown that cryptocurrencies experienced a change in their long-run dependence during the COVID-19 pandemic, with a persistent downward trend (Assaf et al., 2022). Similarly, an important structural change in the relationship between cryptocurrencies was seen during the outbreak of the pandemic (Kumar et al., 2022). Moreover, the pandemic also impacted the cryptocurrencies' volatility (Apergis, 2022).
Spillover analysis has been used many times previously, especially during crises such as the COVID-19 pandemic. For instance, scholars have stated that the COVID-19 pandemic has had a significant effect on many commodities, stocks and other financial assets, resulting in spillover effects on the financial system (Ben Amar et al., 2020). The interconnection and the spillover effects of cryptocurrencies are also found to be affected by COVID-19 with many pandemic-driven contagion channels (Akhtaruzzaman et al., 2022), and COVID-19 is found to cause spillover connectedness among cryptocurrencies (Raza et al., 2022).
Regarding the field of agriculture, Laborde et al. (2020) highlighted that social and economic measures, lockdown and other implications led to an important change in food prices, thus affecting producers and consumers (Laborde et al., 2020). Furthermore, Daglis et al. (2020) used spillover analysis to examine the effect of COVID-19 on future food prices, unveiling a channel of spillover transmission.
Moreover, Mensi et al. (2021) examined the spillover effects among the most well-known cryptocurrencies, and based on their results, these specific cryptocurrencies exhibit spillover effects, with short-term spillover effects being more important than the medium and long-term spillover effects (Mensi et al., 2021).
Similarly, Morates (2021) showed that the financial system exhibits significant spillovers among the 30 largest cryptocurrencies and that crude oil prices drive Bitcoin's spillovers. Similarly, Xu et al. (2021) investigated the tail-risk interdependence among the major cryptocurrencies, showing that significant risk spillovers exist among cryptocurrencies.

Finally, Fousekis and Tzaferi (2021) argue that a significant asymmetric spillover exists between the return and volume of crypto markets, with spillovers transmitted from returns to volume being stronger than the opposite in the long run.
Despite its great importance, no study has examined the effect of COVID-19 on the relationship and spillover effects among the major agricultural cryptocurrencies. The present paper aims to fill this gap in the literature.

Methodology

The present paper follows a time-varying framework to test the coefficients of a probable relationship and the spillover effects among the major cryptocurrencies related to agriculture. We also test the change in this relationship and the spillover effects due to the COVID-19 pandemic. Following this, we present the methodology employed in this work.

Time-Varying Parameter Modelling

In this paper, we implement time-varying parameter modelling for two periods, before and during the COVID-19 pandemic. As cryptocurrencies are assets known to interact, we structure a time-varying parameter vector autoregressive (TVP-VAR) model based on (Primiceri, 2005). The structure of a TVP-VAR is as follows:

$$Y_t = c_t + B_{1,t}Y_{t-1} + \cdots + B_{k,t}Y_{t-k} + {A_t}^{-1}\,\Sigma_t\varepsilon_t \quad (3.1)$$

Here, Y_t is an Nx1 vector of endogenous variables, c_t is a vector of time-varying intercepts, $B_{i,t}$, I = 1,2,…,k are the matrices of the time-varying coefficients, A_t is the lower triangular matrix with ones on the main diagonal and time-varying coefficients below it, Σ_t is a diagonal matrix of the time-varying standard deviations, and finally, ε_t is a Nx1 vector of unobservable shocks with variance equal to the identity matrix (Primiceri, 2005).
Alternatively, we may rewrite Equation 3.1 by stacking a vector B_t, the right-hand side (RHS) coefficients:

$$y_t = X_t'B_t + {A_t}^{-1}\,\Sigma_t\varepsilon_t \quad (3.2)$$

$$X_t' = I_n \otimes [1, y_{t-1}', \dots, y_{t-k}'] \quad (3.3)$$

Here, $\otimes$ symbolises the Kronecker product.
Finally, through this time-varying specification, we may derive the impulse responses that also have a time-varying character. We may then capture the average so that we may depict how this shock changes over time.

Result Analysis

Data and Variables

In this work, we divide the examination period into the pre-COVID-19 period and the COVID-19 era. In this context, we utilise all available data from the pre-COVID-19 period and the COVID-19 pandemic period. The cryptocurrencies used in the present work are Herbalist (HERB) and Carbon Coin (CARBON) because data before and during the pandemic were available for these two. The pre-COVID-19 period is considered from 21 December 2018 to

21 January 2020 due to data availability. Similarly, the COVID-19 period starts on 22 January 2020 and ends on 21 January 2022 because data are available for both the stringency index and confirmed cases from this start date. The financial data are derived from Yahoo Finance on a daily frequency.

We should mention that agriculture-related cryptocurrencies[1] are those with operations and functions that can be utilised in this field. To be more precise, there are many cryptocurrencies with various functions and utilities, the most well-known being transaction properties, smart contracts, information encryption, information retrieval from many users simultaneously and many others. The cryptocurrencies investigated in the present paper are related to agriculture in many ways. Herbalist Token aims to bring farmers and consumers into contact, bypassing intermediaries (Herbalist, 2018). Carbon Coin is a cryptocurrency that aims for pollution reduction by rewarding companies' and organisations' efforts to cause less pollution. These cryptocurrencies are unique and closely related to agriculture, displaying functions and properties applied in this field. In this way, they differ from most well-known cryptocurrencies.

As for the COVID-19 period, we included confirmed COVID-19 cases, downloaded from the Johns Hopkins database. Moreover, we also used an average of the lockdown stringency index of the G7 countries downloaded from Our World in Data. These two time-series are the exogenous variables in our analysis. The descriptive statistics of the data are presented in Table 1.

Tab. 1. *Descriptive Statistics of the Time-Series*

Variable	HERB	CARBON	Confirmed	Lockdown Stringency index
Mean	6.782E-06	1.141E-04	1.113E+08	5.951E+01
Standard Deviation	7.647E-06	1.637E-04	9.757E+07	1.397E+01
Min	1.000E-06	4.000E-06	5.570E+02	1.986E+00
Max	1.040E-04	6.760E-04	3.465E+08	7.685E+01

Results

We first examine the relationship and spillover effects between the cryptocurrencies for the pre-COVID-19 period. Then, we examine whether this relationship and the spillover effects changed due to COVID-19. We first present the results related to the pre-COVID-19 period. Table 2 depicts the coefficients of the TVP-VAR before the COVID-19 pandemic.

[1] https://cryptoslate.com/cryptos/agriculture/

Tab. 2. *Coefficient Summaries for the Pre-COVID-19 Period*

HERB (equation)	HERB.l1	CARBON.l1	(Intercept)
Min	9.260E-01	8.142E-03	3.347E-07
1st Qu.	9.261E-01	8.145E-03	3.348E-07
Median	9.261E-01	8.149E-03	3.349E-07
Mean	9.261E-01	8.149E-03	3.349E-07
3rd Qu.	9.261E-01	8.152E-03	3.350E-07
Max	9.261E-01	8.156E-03	3.351E-07
CARBON (equation)	HERB.l1	CARBON.l1	(Intercept)
Min	4.057E-02	7.305E-01	3.962E-06
1st Qu.	5.303E-02	7.423E-01	4.196E-06
Median	6.277E-02	7.501E-01	4.480E-06
Mean	5.985E-02	7.471E-01	4.557E-06
3rd Qu.	6.797E-02	7.529E-01	4.871E-06
Max	6.883E-02	7.538E-01	5.492E-06

The results indicate that cryptocurrencies' lagged values affect cryptocurrencies' contemporaneous values positively. Based on the coefficients, a positive relationship is observed.

For the next step of our analysis, we capture the spillover effects between the cryptocurrencies for the same period. The results are depicted in Figure 1.

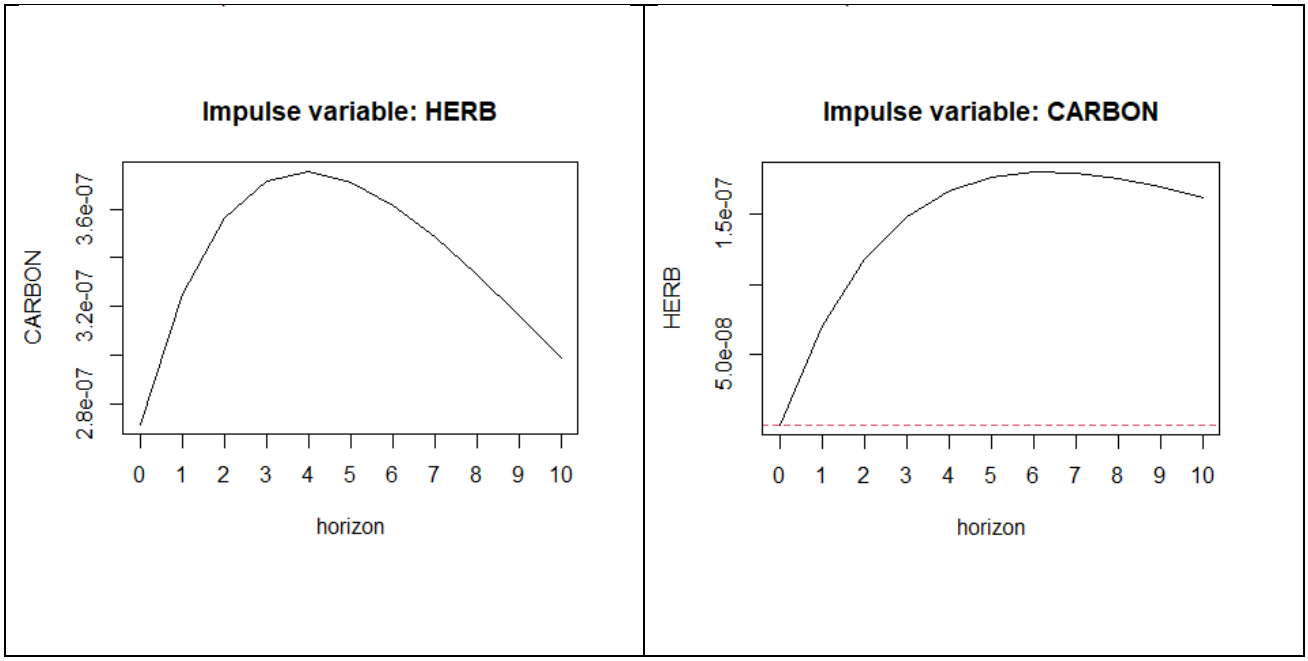


Fig.1. *Impulse–Response Functions between the Cryptocurrencies for the Pre-COVID-19 Period*

The results show that the average shock, transmitted from each cryptocurrency to the other, has a positive sign, with the effect decreasing in magnitude, after some point, over time.
The spillover analysis and the coefficients of the model employed indicate that the relationship between the cryptocurrencies before COVID-19 was positive. This may be attributed to many factors, an important one being the financial system itself. As both cryptocurrencies are related to a specific sector, namely, agriculture and the natural environment, they may have had more asset value for investors and less functional importance. If investors were interested in agricultural cryptocurrencies, the increase in the price of one of them rendered the sector more attractive and, in turn, increased the price of the other cryptocurrency.
The same methodological framework is structured for the COVID-19 era. In this period, exogenous variables, namely, the confirmed COVID-19 cases and the lockdown stringency index, are available, so we utilise them in our analysis. We present the coefficients of the model for the COVID-19 period in Table 3.

Tab. 3. *Coefficient summary for the COVID-19 period*

HERB (equation)	HERB.l1	CARBON.l1	(Intercept)	Confirmed	Lockdown stringency index
Min	5.543E-01	-2.521E-03	3.960E-07	9.185E-15	3.148E-08
1st Qu.	5.544E-01	-2.521E-03	3.971E-07	9.191E-15	3.153E-08
Median	5.545E-01	-2.521E-03	3.982E-07	9.197E-15	3.157E-08
Mean	5.545E-01	-2.521E-03	3.982E-07	9.197E-15	3.157E-08
3rd Qu.	5.546E-01	-2.520E-03	3.993E-07	9.203E-15	3.161E-08
Max	5.546E-01	-2.520E-03	4.004E-07	9.210E-15	3.165E-08

CARBON (equation)	HERB.l1	CARBON.l1	(Intercept)	Confirmed	Lockdown stringency index
Min	-3.093E +01	-3.665E-01	-8.195E-03	-9.701E-12	-9.942E-05
1st Qu.	-2.073E+00	1.941E-01	-7.700E-05	-9.867E-13	-4.974E-06
Median	-2.593E-03	4.856E-01	5.000E-06	2.139E-14	-6.433E-08
Mean	-9.902E-01	4.404E-01	2.900E-04	1.720E-12	-5.669E-06
3rd Qu.	2.109E-01	6.932E-01	7.090E-04	1.952E-12	1.192E-06
Max	1.508E+01	1.999E+00	6.598E-03	3.622E-11	4.186E-05

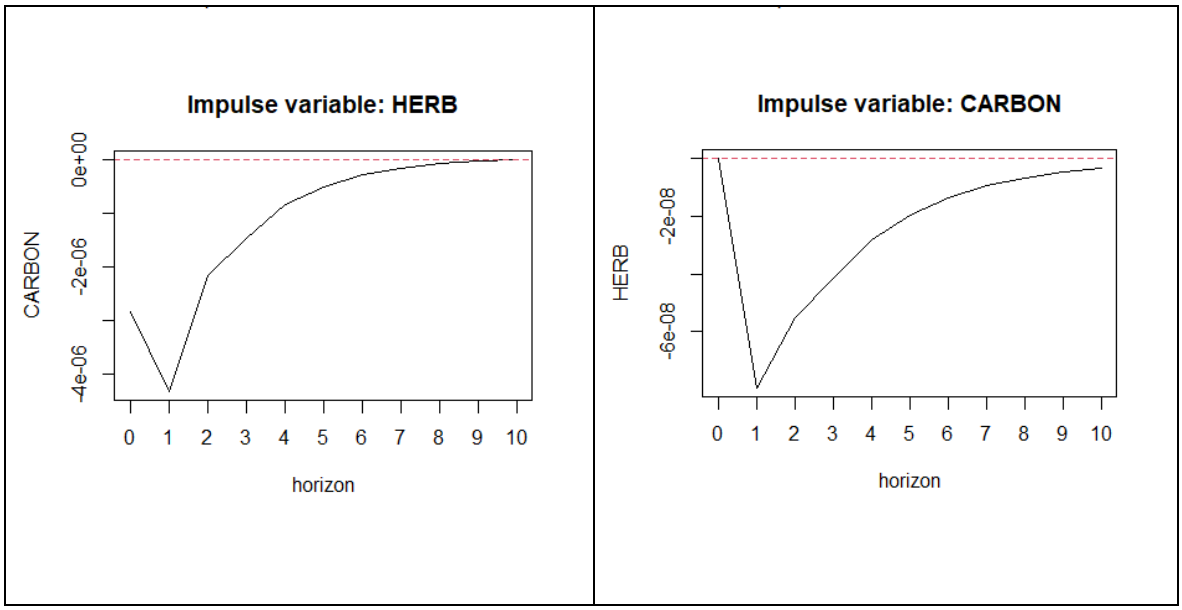
Based on the results, the lagged values of each cryptocurrency affect its contemporaneous values positively, whereas the contemporaneous values of the other cryptocurrency are affected mainly[2] negatively. This shows that the two cryptocurrencies during the COVID-19 era affected each other negatively.

Moreover, the number of confirmed COVID-19 cases affected both cryptocurrencies mainly positively, whereas the lockdown stringency index affected HERB positively and CARBON negatively. This means that the pandemic itself affected HERB positively, which may be because the pandemic made more and more individuals and companies utilise logistic operations, which the HERB cryptocurrency demonstrates. Thus, the pandemic positively affected this cryptocurrency's performance. Similarly, while the pandemic affected CARBON (with some deviations) positively, the lockdown affected it negatively. The COVID-19 pandemic unveiled the extent of human pollution, a reason for many individuals and companies to turn to CARBON. Thus, the positive effect of the pandemic is not surprising. On the other hand, the negative effect of the lockdown may have caused many companies to suspend their activity due to their inability to fund or invest in assets such as the aforementioned cryptocurrency.

We capture the spillover effects between the cryptocurrencies for the same period. The results are depicted in Figure 2.

[2] Note that in the time-varying parameter modelling, we capture the summary of the coefficients, with the mean and median indicating the general tendency of each coefficient.

Fig.2. *Impulse–Response Functions between the Cryptocurrencies for the COVID-19 Period*



The results show that the average shock transmitted from each cryptocurrency to the other has a negative sign, with the effect decreasing in magnitude (in absolute value) over time. Summing up our results, the COVID-19 pandemic changed the dynamic relationship between these two cryptocurrencies.

Conclusion

The present paper examines the effect of COVID-19 in the major cryptocurrencies related to agriculture through the time-varying parameter modelling and spillover effects approach. To do so, we constructed a time-varying parameter vector autoregressive model, examining the spillover effects before COVID-19 and during the pandemic.

The results, and more precisely, the coefficients of the model employed and the spillover analysis indicate that the relationship between the cryptocurrencies before COVID-19 was positive. This may be attributed mainly to the financial system itself, as both cryptocurrencies are related to agriculture, and if investors turn to one of these cryptocurrencies, this renders the sector attractive, affecting, in the same way, the price of the other cryptocurrency. Contrariwise, during the COVID-19 pandemic, the relationship between the cryptocurrencies changed, with the cryptocurrencies affecting each other negatively and the spillover effects being also negative.

During the COVID-19 period, the results changed because these cryptocurrencies may have been adopted during the pandemic due to their utilities and features. The pandemic positively affected the HERB cryptocurrency, which may be because individuals and companies increased their utilisation of the features that HERB has. On the other hand, during the pandemic, we all came to a realisation regarding the amount of human pollution, as the environment seemed cleaner during this period due to the suspension of human activity. Thus, many individuals and stakeholders turned to CARBON, leading to an increase in its price. Simultaneously, the lockdown measures impacted this specific cryptocurrency negatively,

probably due to the suspension of many companies' activity, impacting their revenues and investments and, in turn, affecting CARBON cryptocurrency's price.

Moreover, we should mention that the change in the relationship between these cryptocurrencies during the pandemic may be partially attributed to their rival features. For instance, many cryptocurrencies' performance, mining, and so on require large amounts of energy, increasing the CO_2 emissions, whereas CARBON promotes a decrease in the CO_2 emissions for the revival of the environment.

Furthermore, the present paper's results are consistent with the literature. It has already been stated that the major cryptocurrencies experienced a change in their long-run dependence during the COVID-19 pandemic, with a persistent downward trend (Assaf et al., 2022). Additionally, an important structural change in the relationship of cryptocurrencies was observed during the outbreak of the pandemic (Kumar et al., 2022). Regarding the interconnection and the spillover effects of cryptocurrencies, they are found to be affected by COVID-19 with many pandemic-driven contagion channels (Akhtaruzzaman et al., 2022). Finally, COVID-19 is found to impact the cryptocurrencies' volatility (Apergis, 2022), with Raza et al. (2022) arguing that COVID-19 causes the spillover connectedness among them. Our work draws conclusions similar to the ones derived from the literature on other cryptocurrencies; our findings indicate that COVID-19 affected and changed the relationship between the two agricultural cryptocurrencies examined.

These results are important, as they show that agricultural cryptocurrencies may be interrelated in different ways during specific periods, and external shocks such as COVID-19 can affect them. Even though the cryptocurrencies are known to be decentralised and regarded to perform autonomously, the present paper's results indicate that despite their decentralised character, the examined cryptocurrencies associated with the field of agriculture are affected by external shocks, such as the COVID-19 outbreak, and they can also impact one another.

The implications of the findings of this paper can be examined in future works, for instance, whether a relationship between the classical financial system (stocks, commodities, futures, etc.) and agriculture-related cryptocurrencies exists and whether this relationship (if it exists) is changing over time. Furthermore, as data regarding Blocery (Blocery, 2018) start from August 2020, they could not be utilised in our work. However, data on this cryptocurrency could also be obtained and studied in a probable future work.

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