Cryptocurrency and Monetary Policy Implications

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May 2021

Abstract

This paper explores the topic of cryptocurrencies, with a special focus on Central Bank Digital Currency (CBDC) and its impact on the Monetary Policy transmission. The literature on the impact of technological innovations on the future of the Central Bank remains inconclusive. This is mainly because cryptocurrencies are a fairly new addition to the financial system. The Jorda local Projection approach is used to show whether or not there are significant effects of the cryptocurrency variable on the right-hand side variables. The impulse response functions of the cryptocurrency shock on the response to the right-hand side variables are represented by significant bumpiness, indicating that it is difficult to deduce there are material consequences of the cryptocurrency shock on the right-hand side variables of the model, and hence Monetary Policy itself.

Keywords: Cryptocurrency, Monetary Policy, CBDC

1 Introduction

Although there is a continuing debate about the concise definition of money, there is a general agreement among economists that money is characterized by the following: i) it serves as a medium of exchange; ii) it is a unit of account; and 3) it stores its value (Niepelt, 2018). But how did this valuable piece of paper in today's age emerge? There is evidence that money is as old as civilization itself. It started with barter trade where goods were used as a medium of exchange. As specialization emerged in medieval times

coordinating trade became unfeasible, thus societies started minting coins from metals, in quest for a more standardized medium of exchange (Ritter, 1995). Only by the beginning of twentieth century an international system based on gold emerged. The gold standard was followed by The Bretton Woods System during which time the dollar was defined as 35 dollars per one ounce of gold until Bretton Woods demise in 1971, after which countries moved to a system of floating exchange rates (Eichengreen, 2008). From commodity money there was an easier transition to paper money convertible to commodity. This currency money was fiduciary based, thus the regime transition from barter to fiat had to be accompanied by a high level of credibility that the issuer of the paper or fiat money, that is the government, would not issue more money for benefits of seigniorage (Ritter, 1995). This physical medium of exchange was already a graduation from the old barter trade days, since it helped people quantify the value of goods and allowed them to save for future consumption without fearing the depreciation of the good. Risk-averse individuals need to be ensured they could have an immediate access to a globally accepted means of payment in case of emergency or conditions of political or economic difficulties.[1]

Much has changed in the past 20 years for bankers and policy makers with emerging financial technology innovations such as mobile payments and digital currencies, where some of them have established their own unit of account independent of Central Bank.[2] These financial technologies are still at a novice stage and pose little threat to the current financial structures. This is mainly due to their limitations such as volatility, risk, lack of scalability and legal barriers, but with further technological developments these challenges can be overcome. This has made it inevitable for Central Banks around the world to seek out ways in which they can establish their own sovereign currencies. Just like physical currency, the CBDC [3] would be universally accessible for public and private transactions. That is, the Central Bank reserves would no longer be the sole prerogative of the financial banking sector, but would extend to private individuals and the non-financial sector as well (Niepelt , 2018). CBDC would be publicly issued through a legal tender and would not exhibit the rapid fluctuations that many digital currencies have exhibited (Levin and

[1] "Reports of the Death of Cash Are Greatly Exaggerated." Federal Reserve Bank of San Francisco. SF Fed Blog, November 20, 2017 (https://www.frbsf.org/).

[2] An exploration of fintech and the consumer interest. Consumers International, 2017. (https://www.consumersinternational.org/).

[3] Central Bank Digital Currency, or digital currency issued by the Central Bank

Bordo, 2017). The thrust for adoption of digital currencies by central banks could be driven by the fear that a cashless society might deem monetary policy irrelevant. As a preventative measure for this, Central Banks quest ways to influence the economy by trying to adapt to these technological evolutions. This paper studies the role of financial technological innovations on the monetary policy and central bank landscape. There is a growing literature on this topic, given its economic relevance in today's financial system and economy. However, findings drawn from these papers remain inconclusive. This is because, regardless of their popularity, digital currencies, as well as many other newly developed financial technologies (fintech) remain aliens to traditional ways of conducting peer-to-peer transactions, with coins and bank notes still in place.

2 Will Central Bank's authority be jeopardized?

Historically, states have exhibited a comparative advantage in building confidence over bank notes and coins, which in and of themselves have no value and are merely fiduciary based. This is due to the ability of the state to internalize any issues related to the debasement[4] of the currency through regulation and public authority. This idea can be extended to the CBDC. Since issuing currency is accompanied by an interest income earned by the issuer (seigniorage), there exists some scope for the issuer to abuse the authority by printing an excessive amount of currency. That is, people fear that the authority issuing the money may act opportunistically by creating an overabundance of currency, triggering hyperinflation and thus causing the currency to lose value (Camera, 2017). However, if such authority is only granted to the Central Bank, the states agree that the creation of trust and credibility, although costly in the short-run, due to foregone seigniorage opportunities and loss in terms of employment, has mid- to long-term benefits associated with it.

Private entities are thought to be motivated by short-run objectives and, hence, have the incentive to misuse their authority and manipulate the currency so as to extract short-run benefits to the society's long-term detriment. Since currency systems are con-

[4]Debasement is the phenomena associated to a (tangible) currency depreciation or an intangible currency depreciation in the case of virtual currencies whenever a Central authority to currency makes the decision to increase the supply of money.

sidered to be public goods, the private sector has the tendency to ignore the externalities associated with the oversupply of the currency (Camera, 2017). Public entities such as the Central Bank, on the other hand, are compelled to internalize these effects due to reputational concerns.[5]. As such, a public currency system independent of political authorities is thought to suffer a lot less from problems related to public confidence than a private currency system. So, the former has a comparative advantage to the latter in providing such good (Ritter, 1995). According to one school of thought, private cryptocurrencies do not successfully satisfy the three basic functions of money, which are: i) medium of exchange; ii) unit of account; and 3) store of value (Pichler and summer, 2018). The reasoning is the following: cryptocurrencies, such as bitcoin, are generally not accepted as a medium of exchange in the market as it is extremely rare that a bitcoin can be used in paying for goods and services. When this rare event occurs, it is usually firms that are concerned with their marketing, and thus decide to accept bitcoin for this reason (Pichler and summer, 2018). Moreover, it is unconventional and unlikely that prices of products and services are presented in cryptocurrencies. As such, there is not enough evidence to conclude that private digital tokens such as bitcoin can be considered as a unit of account. Last but not least, cryptocurrencies are not a store of value precisely due to their inherent volatile nature, so in the eyes of the public they are perceived as very unattractive to use as a means of payment (Pichler and summer, 2018). As such, with the current privately issued money designs we cannot expect the private sector to replace the public currency system, and the advantages of the Central Bank having monopoly power over the currency system remains indisputable.

[5]According to Barro and Gordon model, the Central Bank might be able to breach its promise once by creating more inflation than the expected level. However, given that people are rational, they would not do so the second time around. Subsequently, the latter would set their inflationary expectations at a higher level, thus causing the equilibrium level to worsen. This, hence, serves as an explanation to why the interest of keeping a credible commitment aligns between individuals and the Central Bank.

3 A glimpse into the potential structure of CBDCs

3.1 Tokens

Among many suggested possibilities the two most popular structures of the CBDCs are accounts and tokens. If the Central Bank agrees to issue CBDC tokens, the latter would work similar to bitcoin in the sense that the former would need to use some form of Distributed Ledger Technology (DLT)[6] to verify the ownership of tokens and distribute payment transactions independent of any Central Bank or clearinghouse intervention (Pichler and Summer, 2018). Transactions using DLT are thought to have a substantially reduced "double-spending" incentive, which refers to the incentive to alter the records and take advantage of someone else's assets. Such incentives for fraud are mitigated by the creation of a closed pool of participants that oversee the transaction occurring, a process enabled by blockchain.[7] Hence, this group of coequals may serve as a substitute to a trusted central counter-party (Prasad, Eswar, 2018). As such, this technology could be programmed such that fraudulent transactions are essentially impossible. In other words, the process of validation is thought to be computationally challenging and requires that a straight majority of the system users acknowledge the transaction as valid (Camera, 2017). Another philosophy suggested by Bordo and Levin (2018), however, suggests that a token-based system is slow in making transactions and thus the verification step is time-consuming. Additionally, opposing the previous argument, the two authors claim that the scope for fraud would be significantly higher under such system, thus hackers could potentially blackmail and undermine trust and efficiency in the payment sphere. Same as with bank notes, with tokens people would be able to have a stored inventory of CBDC in a way that no Central Bank transaction approval is required. Whoever wants to then use CBDC can do so without having to register with an account and reveal their identity (Koning, 2018). Despite many advantages thought to be associated with DLT, such as speed of transactions, increase of security and lower probability of manipulation due to

[6]Digital Ledger Technology refers to digital records or transactions that occur in multiple places at the same time. It is characterized by a decentralized method of making transactions and ensures for the immutability of records. (Prasad, 2018). Such blockchains are made with veracity in a chronological order, a process enabled by cryptography. (Boel, 2016).

[7]Rosic, Ameer. "What is Blockchain Technology? A Step-by-Step Guide for Beginners". Blockgeeks, 2016. (https://blockgeeks.com/).

easier record track keeping as well as lower probability of cyberattacks due to a more transparent payment system, this system presents some challenges. One of the crucial problems with DLT is that this technology is generally immature and very little trust and confidence is accorded to it by the general population. Besides, they are considered highly volatile instruments due to their value not being tied to a sovereign currency (Norges Bank, 2018).

3.2 Accounts

With accounts individuals as well as firms would be able to electronically hold funds directly with the Central Bank. At the present, such a right resides only with commercial bank. The public, such as households and non-financial institutions, cannot have a direct interaction with the Central Bank. This is due to the current lack of trust on abstract means of payments that use DLT. People prefer to leave the monopoly power of currency to a central authority such as the Central Bank. In order to verify that a party is not blackmailing the other party in transaction by falsifying ledger records, an intermediate party, such as a commercial bank is needed to intervene (Camera, 2017). The account-based method is thought to allow the storage of assets in the Central Bank's database, and the former would be accessible through software (i.e. smart phone and online banking) as well as hardware (cards and watches).[8]As such, a vital difference between today's functioning ways of payment and CBDC is that the latter would allow account holders to perform transactions immediately with the payee, a method compared to two customers of a bank today transacting between one-another from the same bank (Norges Bank, 2018). The Central Bank would be able to interact directly with the non-financial sector, and if everyone in the society gets endowed with such accounts, the Central Bank's balance sheet would be boosted substantially and the overall role of the Central Bank in the society would in fact potentially increase (Gnan and Masciandaro, 2018). Accounts are thought to allow the Central Bank to truly foster price stability in the economy for as long as the former are interest-bearing. Central Banking without any coins and bank notes in circulation would imply liquidity that never abandons this system (Camera,

[8]Central bank digital currencies. Norges Bank Papers, 2018. ISBN 978-82-8379-042-9. (https://static.norges-bank.no/).

2017). Additionally, since printing paper currency due to its low level of durability is costly, Central Bank's profits from this currency are reduced. Although the Central Bank would give up some of its seigniorage in terms of interest payments it would have to make on CBDC, seigniorage would increase in terms of savings of holding cash, thereby compensating and possibly even increasing the Central Bank's overall monopoly profits (Gnan, Masciandaro, 2018). All this brings us to the supposition that with CBDC accounts, the Central Bank would be able to retain its power, and possibly even increase its relevance in the economy. With CBDC tokens, on the other hand, the Central Bank could very possibly lose its power, and remain as an entity that only intervenes during economic or financial system downturns. One could also think of a hybrid technology between tokens and accounts where for the sake of supervision to eliminate the loss of confidence concerns, DLT can be centrally managed by the Central Bank. Additionally, one could also think of creating a DLT system such that the anonymity of the user is preserved. Moreover, because DLT enables money to be exchanged more securely and be tracked more easily, with a Central Bank involved, the distributed ledger technology could, in fact, further reinforce trust and confidence in the monetary system (Smets, 2016). CBDC in a form of DLT could then potentially allow for the expansion of the Central Bank's balance sheet by creating access to the general public beyond commercial banks. As of today, such a payment system does not exist and is entirely imaginary. However, as Central Banks explore ways in which they want to tackle the opportunity of issuing a CBDC, it is something that they might be interested to consider.

4 Can cash and digital currencies coexist?

Many studies suggest that cash and CBDC adopted by Central Banks could coexist as long as the transaction costs of holding CBDC are low enough. This implies that the interest rate set on the CBDC cannot be set at negative levels. Otherwise people would immediately substitute CBDC for physical bank notes and coins that are by construction, non-interest bearing (Meaning and Dyson, 2018). This is the case in which the CBDC does not perfectly substitute cash. CBDC may not have the same level of trust by citizens to take the place of fiat currency, but it might do so eventually as the technology matures

and trust is built. When the two coexist, agents that have lower transaction needs may use cash, while those with higher transaction needs turn to CBDC. For instance, businesses that are small or medium sized still need cash in order to pay back customers who offer coins and banks notes as a means of payment (Delnevo, 2018). Paying positive rates on CBDC would increase the costs for the Central Bank and therefore reduce its seigniorage profits, but it would incentivise people to switch from bank notes and in turn increase the demand for CBDC. The larger the spread between interest earned on CBDC relative to the interest earned on bank notes and coins, the larger would the demand for CBDC be by the general public. On the other hand, if this spread were to be negative, given that cash is still available in the economy, people would shift their holdings of CBDC to holdings of bank notes and coins (Engert and Fung, 2018). Therefore, although cash and CBDC could theoretically coexist, such cohabitation would make it inconvenient and possibly unfeasible for the Central Bank to operate in the economy. If drawbacks, such as loss of anonymity related to CBDC are somehow able to be overcome, and cash is successfully eradicated by countries, then CBDC might become a perfect substitute for cash and even replace the latter due to its ability to carry out transactions much more quickly and effectively. If cash ceases to exist and the only means of payment people use are electronic wallets, with negative interest-bearing CBDC, the Central Bank would essentially be able to perform a similar task to quantitative easing through manipulating the level of interest rates rather than the supply of money (Davoodalhosseini, 2018). Only if currency gets filled in entirely for electronic money may there no longer be any long-run shrinkage in money demand followed by negative interest rates, allowing the Central Bank to retain its authority it enjoys today (Boel, 2016). With negative interest rates, not only would domestic agents be able to borrow more, but domestic citizens would also have more money into their digital account, enabling them to spend more. If, on the other hand, attempts to eliminate cash in the economy fail, an alternative solution for the Central Bank to discourage the immediate convertibility of CBDC into paper currency after the introduction of negative interest rates is to suspend the par convertibility between the two. Alternatively, the Central Bank might want to try to at least partially suspend bank notes with respect to CBDC, such that the substitution between the two is less than perfect (Engert and Fung, 2018). Whether the introduction

of CBDC as a substitute or complement to physical cash would be effective also greatly depends on the reason why these countries use cash and whether they would prefer to use cash even in the presence of CBDC or not (Gnan-Masciandaro, 2018). For instance, a study conducted in Italy shows that around 1.8 million households do not hold any bank accounts mainly for reasons such as account maintenance costs and physical distance from a bank branch. A socio-demographic study of these same individual households conducted presented that a majority of them were also low-income and low-education households. While CBDC is thought to substantially mitigate these transaction costs of conducting banking activities for people, as far as we are concerned with education, the introduction of the CBDC would make little to no difference in this regard (Panetta, 2018).

5 Money Supply as a Central Bank tool

For many decades, Central Banks around the world have used Money Supply as their main tool to combat financial difficulties, such as recessions. During economic downturns the Central Bank would print money to create inflationary pressures. The 2008 financial crisis is one such example (Dalebrant, 2016). The panic embedded as well as the loss of trust in the economy, made people to hold back their money to save more and consume less. During this crisis, the Central Bank stood to purchase government as well as other market securities to lower interest rates charged in the economy and induce economic activity through increased inflation. That is, as the major economies experienced a long-lasting underperformance in the demand side of the economy, in order to attempt at bringing the economy back at its potential output level, they lowered the level of interest rate (Engert and Fung, 2018). The inflation created by the increase in Money Supply is believed to have incentivized lending and increased liquidity in the economy (Meaning and Dyson, 2018). Hence, whether wide integration of CBDC would have an impact on monetary policy depends on the extent to which the Central Bank is using money supply as a tool for conducting monetary policy.

Recent evidence shows that there has been a decreasing trend of Central Banks using money supply as a tool across countries, switching to an alternative scheme of influencing

the short-term level of interest rates instead. As such, the decrease in demand for money is thought to have very little effect on the transitioning mechanism of monetary policy (Dalebrant, 2016). From this doctrine, CBDC would enable the Central Bank to no longer have to perform traditional quantitative easing to stimulate the economy because it could directly increase the balances of the CBDC account holders through helicopter drops[9](Barker, David and Ryland, 2017). Another philosophical system suggested by Engert and Fung (2018) suggests that a direct transfer from the Central Bank to the market participants, such as individuals and firms, could be made without the need of introducing CBDC, but they admit that such action would induce larger administrative costs than a Central Bank digital currency potentially would.

6 Data Methodology: A local projection approach

The local projection method is flexible enough to accommodate the shape of the impulse response functions without constraining their shape, and still providing results that are more robust to any misspecifications. For this reason, a less rigorous approach of the local projection method is used to see the effect of the cryptocurrency shock on the cryptocurrency response, demand deposits held with banks in the US, the level of GDP, M1 over GDP, M2 over GDP, interest rate as well as the unemployment rate for years 2012 to 2020. In order to perform this analysis the quarterly time trend as well as the lagged values of the independent variables, excluding the target variable of the unemployment rate, are regressed by the cryptocurrency variable. The residuals from the regression are created to then construct the shocks to this model. This is performed with stationary time series variables after the variables have been differenced to achieve this goal. The analysis is followed by scaling the series by 100 so as to ease their interpretation. Then a loop over the cryptocurrency shock and the difference in the right-hand side variables is created to quietly generate the coefficient for the shock variable as well as the 95 percent confidence interval for latter plotting. The specification of the time horizon for the impulse response function is created as a time-1. This lag length and the impulse response horizon impose

[9]The term Helicopter Money refers to lumpsum transfers the Central Bank could directly make to individuals and firms in support of quantitative easing (Gnan and Masciandaro, 2018).

the degrees-of-freedom constraints given the small sample of 36 quarters. The Jorda local projection method then estimates the regression of the dependent variable at the pre-specified horizon on the shock in period t and uses the coefficient on the shock as the impulse response estimate. A loop over consecutive values from 0 to the fourth quarter is created in order to loop over the variables in this model. A regression of Newey standard errors is performed on the lagged values of each independent variable from 0 to 3. The coefficient as well as the standard error of the cryptocurrency shock variable are generated, and the coefficient is quietly replaced to take into account the horizon and the creation of 95 percent confidence intervals. Each individual independent variable is replaced by a value equal to zero whenever the horizon is set to equal zero. Individual impulse response functions to the external cryptocurrency shock are created. The result looks as follows:

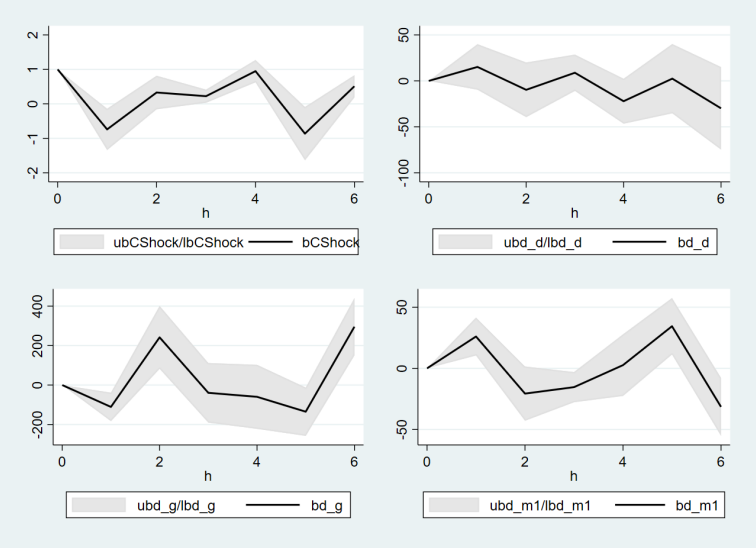

Figure 1: Impulse Reponse Function

It can be seen from the graph that the response of the cryptocurrency variable to the cryptocurrency shock is such that the former declines during the first quarter, but then increases in the second, stabilizes in the third and then repeats the first quarter's performance. For the demand deposit response, on the other hand, the cryptocurrency shock causes the former to increase slightly on the first quarter and then decrease on the next. This trend of bumpiness continues throughout the 6 quarters. Although slow, it is evident that there is a decreasing trend of demand deposits from the cryptocurrency shock. GDP

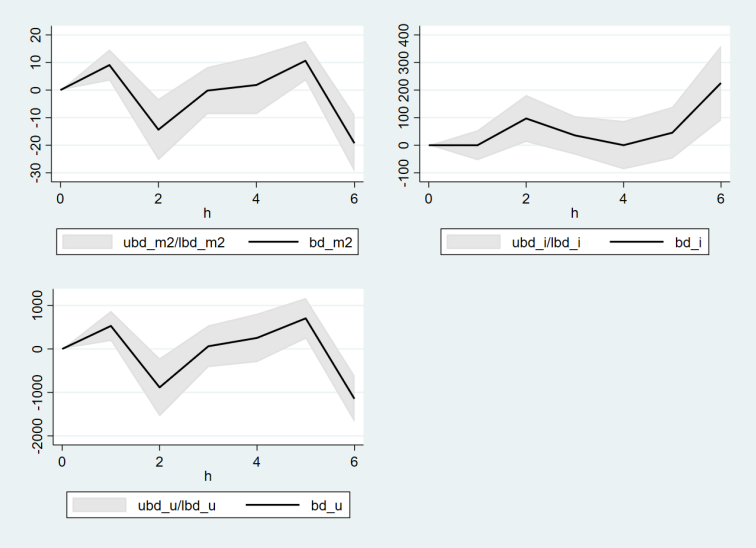

Figure 2: Impulse Reponse Function

eventually shows an increase after the fifth quarter, and the bumpiness is slighlty smaller than on the other response variables. There is no clear effect of unemployment, M1 and M2 over GDP from the cryptocurrency shock. On the other hand, these is an increasing trend on the interest rate. This can possibly be explained by the intuition that banks increase the interest rate in order to incentivize demand deposit holders. Although it can be observed that the impulse response functions somewhat follow the economic intuition as to what we would expect from an exogenous cryptocurrency shock, for the results to be robust to any potential biases a much larger data set is needed.

7 Conclusion

The extent to which societies decide to trust frontier financial technologies for everyday transactions, hold their money and own their data, the traditional banking ecosystem can eventually become redundant. Whether the Central Bank can maintain itself as the main institution of trust that combats economic instability remains to be witnessed. However, a good number of current studies suggest that there exist multiple advantages Central Bank has in remaining the central authority over the currency. That is, the private sector focuses its attention towards its own private benefits and would likely provide an overabundance of the currency. The Central Bank would internalize such negative externality effects. The adoption of financial technologies and the transition to a cashless

financial system is not in the very far vicinity. There are tangible problems such as loss of anonymity, regulation, and fraudulent activities associated with digital currencies. These challenges still help the Central Bank maintain its role as a crucial actor in the payment space and in setting monetary policy, but its traditional role is presumably limited in comparison to what it would have been under CBDC. Hence, without major shifts of how the private sector functions, and the creation of more public confidence, the Central Bank is thought to remain central. If the latter can keep up with these technological evolutions, then the Central Bank and its tools for controlling monetary policy would likely enhance. This would happen if the former introduces the CBDC in replacement of, or as a compliment to physical cash. CBDC and cash would likely be able to coexist as means of payments as long as the former does not charge negative-interest rates. With such rates, people would prefer to hold cash, which is by nature non-interest bearing. Even if challenges, such as lack of trust, related to private digital currencies are overcome and the private sector takes over the traditional monopoly power of the Central Bank, there is still room for the Central Bank to remain an integral part of the financial system.

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8 Appendix

Equation	Excluded	F	df	df_r	Prob > F
d_c	d_d	.85005	3	10	0.4977
d_c	d_g	1.4292	3	10	0.2916
d_c	d_i	1.2185	3	10	0.3531
d_c	d_u	.5112	3	10	0.6835
d_c	d_m1	.42185	3	10	0.7415
d_c	d_m2	1.5445	3	10	0.2632
d_c	ALL	2.1427	18	10	0.1096
d_d	d_c	6.9452	3	10	0.0083
d_d	d_g	4.2338	3	10	0.0357
d_d	d_i	1.1279	3	10	0.3838
d_d	d_u	3.6673	3	10	0.0514
d_d	d_m1	.715	3	10	0.5652
d_d	d_m2	6.2876	3	10	0.0114
d_d	ALL	16.184	18	10	0.0000
d_g	d_c	4.3542	3	10	0.0331
d_g	d_d	2.6311	3	10	0.1076
d_g	d_i	.73056	3	10	0.5569
d_g	d_u	.39229	3	10	0.7613
d_g	d_m1	2.0769	3	10	0.1670
d_g	d_m2	.86112	3	10	0.4925
d_g	ALL	7.4175	18	10	0.0013
d_i	d_c	1.2783	3	10	0.3343
d_i	d_d	1.2919	3	10	0.3302
d_i	d_g	.23772	3	10	0.8681
d_i	d_u	.16044	3	10	0.9205
d_i	d_m1	.92099	3	10	0.4656
d_i	d_m2	.53408	3	10	0.6693
d_i	ALL	3.767	18	10	0.0185
d_u	d_c	6.2531	3	10	0.0116
d_u	d_d	2.5156	3	10	0.1176
d_u	d_g	1.1084	3	10	0.3908
d_u	d_i	.3476	3	10	0.7918
d_u	d_m1	1.3742	3	10	0.3064
d_u	d_m2	.86018	3	10	0.4929
d_u	ALL	6.2388	18	10	0.0027
d_m1	d_c	6.4173	3	10	0.0107
d_m1	d_d	2.6876	3	10	0.1031
d_m1	d_g	1.0747	3	10	0.4032
d_m1	d_i	.45242	3	10	0.7213
d_m1	d_u	.54689	3	10	0.6614
d_m1	d_m2	.71948	3	10	0.5628
d_m1	ALL	6.5478	18	10	0.0022
d_m2	d_c	6.5943	3	10	0.0098
d_m2	d_d	3.3733	3	10	0.0627
d_m2	d_g	1.0775	3	10	0.4022
d_m2	d_i	1.0925	3	10	0.3967
d_m2	d_u	.44935	3	10	0.7233
d_m2	d_m1	1.8328	3	10	0.2049
d_m2	ALL	8.7679	18	10	0.0006

Figure 3: Granger Causality Wald Test

The equations are differentiated by their dependent variable. For each equation, vargranger tests for the Granger causality of each variable individually, then tests for the Granger causality of all added variables jointly. Consider the Granger causality tests for the cryptocurrency equation. The row with "GDP excluded" tests the null hypothesis that all coefficients on lags of the GDP in the cryptocurrency wallet holders equation are equal to zero, against the alternative that at least one is not equal to zero. The p-value of 0.2916 does not fall below the typical statistical significance threshold of 0.05 or even 0.1. As such, the null hypothesis that lags of the GDP do not affect the cryptocurrency variable cannot be rejected. With this model and these data, the GDP variable does not Granger-cause cryptocurrency. Similarly, in the GDP equation, lags of none of the other

right-hand side variable are statistically significant. Hence, it cannot be said that they Granger-cause GDP. On the other hand, the cryptocurrency variable Granger-causes GDP because its p-value is 0.0331. This value falls below any traditional significance levels. As such, we can reject the null hypothesis that the cryptocurrency variable does not Granger-cause GDP. From the Granger Causality Wald Test we also see that the right-hand side variables do not have a significant effect on the left-hand side variable of cryptocurrency wallet holders. This makes the cryptocurrency variable exogenous to the model. On the other hand, the cryptocurrency shock has a significant effect on the demand deposit holders, GDP, unemployment rate, M1 over GDP, M2 over GDP as well as M2. It does not have a significant effect on the interest rate variable, however. This is a potential symptom that cryptocurrencies are a fairly new addition to the financial system. This leads to another shortcoming to the model which is the fact that the data set is fairly short.

```
*********************************
************ Project ***************
*********************************
clear
** Setting directories
cd "C:\Users\Fjolla\Desktop\Time Series Project"

global data "C:\Users\Fjolla\Desktop\Time Series Project"

global workfiles "C:\Users\Fjolla\Desktop\Time Series Project"

use "crypto_demand_deposits.dta"

gen t=_n

tsset t
*********************************
```

```
**********************************
generate d_c=d.cryptocurrency
generate d_i=d.irate
generate d_u=d.unrate
generate d_d=d.deposit
generate d_g=d.gdp
generate m1=m1_gdp
generate m2=m2_gdp
generate d_m1=d.m1
generate d_m2=d.m2
reg d_c t L.d_g L.d_i L.d_d L.d_m1 L.d_m2
predict CShock, residuals
**********************************

quietly var d_c d_d d_g d_i d_u d_m1 d_m2 , lags(1/3) dfk small
vargranger

matlist e(Sigma)
****************************JORDA PROJECTION*************************************
replace d_d = 100*d_d
replace d_m1=100*d_m1
replace d_m2=100*d_m2
replace d_g = 100*d_g
replace d_i=100*d_i
replace d_u=100*d_u
/*******************************************************************************
**  SET UP FOR LATER IRF PLOTTING
*******************************************************************************/
foreach var in CShock d_d d_g d_i d_u d_m1 d_m2  {
  quietly gen b‘var’ = .
  quietly gen ub‘var’ = .
```

```
  quietly gen lb‘var’ = .
}

//Use the cryptocurrency shock
*************************************************************************;
* ESTIMATE USING JORDA PROCEDURE AND GRAPH THE IRFS;
*************************************************************************;
gen h = t-1 // h is the horizon for the irfs */

*The lag length and the IR horizon impose
degree-of-freedom constraints for very small samples

*The  Jordà  method  estimates regressions of the
dependent variable at horizon t + h on the shock
in period t and uses the coefficient on the shock
as the impulse response estimate.

forvalues i = 0/6{

   foreach var in CShock d_d d_g d_i d_u d_m1 d_m2  {

      newey F‘i’.‘var’ L(0/1).CShock  L(0/1).d_d L(0/1).d_g
      L(0/1).d_i L(0/1).d_u L(0/1).d_m1 L(0/1).d_m2 ,
      lag(‘=‘i’ + 1’)

  gen b‘var’h‘i’ = _b[CShock]

      gen se‘var’h‘i’ = _se[CShock]

  quietly replace b‘var’ = b‘var’h‘i’ if h==‘i’
      quietly replace ub‘var’ = b‘var’h‘i’ + 1.96*se‘var’h‘i’ if h==‘i’
```

```
  quietly replace lb‘var’ = b‘var’h‘i’ - 1.96*se‘var’h‘i’ if h==‘i’
  }
}
*******************************************************************************;
**** Commment these commands out when q = 1;
replace d_d = 0 if h==0
replace d_g = 0 if h==0
replace d_i=0 if h==0
replace d_u=0 if h==0
replace f = 0 if h==0
replace d_m1=0 if h==0
replace d_m2=0 if h==0
*******************************************************************************;
foreach var in CShock d_d d_g d_i d_u d_m1 d_m2  {
tw (rarea ub‘var’ lb‘var’ h, bcolor(gs14)
clw(medthin medthin)) ///
(scatter b‘var’ h, c(l) clp(l) ms(i)
clc(black) mc(black) clw(medthick))if h<=6,
saving(varromer_‘var’.gph,replace)
}

graph combine varromer_CShock.gph varromer_d_d.gph
varromer_d_g.gph varromer_d_m1.gph

graph combine varromer_d_m2.gph varromer_d_i.gph
varromer_d_u.gph
```