



UNIVERSITY *of* NICOSIA

MSc in Digital Currency

Cryptocurrency and Central Banking

DFIN-511

Introduction to Digital Currencies

Session 8: Cryptocurrency and Central Banking



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Session Objectives

- ▼ Understand the basic functions of Central Banks (at a very high level)
- ▼ Examine how digital currencies/cryptocurrencies replicate (or do not replicate) the functions of Central Banks and advantages/disadvantages this creates
- ▼ Understand the public positions of the Federal Reserve and the ECB towards digital currencies

Agenda Session 8

- ▼ Central Banks and their characteristics
- ▼ Comparison of what DCs and CBs do differently
- ▼ The ECB and the Fed on Bitcoin and DCs
- ▼ State Owned Cryptocurrencies
- ▼ Conclusions
- ▼ Further Reading



Central Banks and their characteristics

Some definitions

- ▼ **Central** banks are financial entities that are established in all countries to define and support the monetary system of their nation:
 - ▼ They create the rules and regulations under which national banks should function
 - ▼ They are responsible for monitoring the stability of inflation rates, of the price of money and regulation of the debit and credit framework of the nation
 - ▼ They control money issuance and control of money supply
 - ▼ They act as “*the lender of last resort*” for banks or other eligible institutions.

- ▼ The Bank of International Settlements (BIS) is the Central Bank of Central Banks. Its mission is “to serve central banks in their pursuit of monetary and financial stability, to foster international cooperation in those areas and to act as a bank for central banks.”

Central Banks and their characteristics

The most common functions handled by Central Banks are Monetary Stability, Financial Stability/Regulation, Policy Operations Management and Financial Infrastructure Provisioning

▼ **Monetary Stability**

- ▼ Formulating, conducting, implementing and monitoring the proper functionality of the national monetary policy
- ▼ Balancing and managing (to their best of their ability) inflation, interest rates, exchange rates, while being supportive of economic growth.
- ▼ Managing the money supply of a currency

▼ **Financial Stability/Regulatory Functions**

- ▼ Regulating the banking sector
- ▼ Ensuring a stable financial system for the country they operate
- ▼ Undertaking the role of the lender of last resort

▼ **Policy Operations Management**

- ▼ Currency intervention
- ▼ Liquidity Management
- ▼ Lender of Last Resort (The provision of liquidity to the banking system to counteract shocks and prevent bank runs from spreading from one institution to another. In a fiat currency system, Central Banks cannot “run out of liquidity”)

▼ **Financial Infrastructure**

- ▼ Payment and settlement systems
- ▼ Currency Provisions

Functions of Central Banks (BIS Survey 2008)

- ▼ The tables in the next two pages highlight the functions of central banks across the globe. Source of this information is a BIS Survey conducted in 2009, as published in the [report](#) of BIS regarding the roles of modern central banks.
- ▼ Colors represent the degree of responsibility that the central bank of each country has undertaken for each respective function and goal (white refers to no responsibility, light orange to partial or shared activity and dark orange refers to full responsibility).
- ▼ The survey results show that all central banks take responsibilities when it comes to tasks like monetary and financial stability, regulation and policy operations, and provision of financial infrastructure, whereas they take less action on debt and asset management, research and consumer needs' identification.

Functions of Central Banks (BIS Survey 2008)

		AR	AU	BR	BG	CA	CL	HR	CZ	HK	Eurosystem									
		ECB	BE	FI	FR	DE	IT	NL	PT	SK	ES									
1. Monetary stability functions	Monetary policy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Exchange rate policy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2. Financial stability & regulatory functions	Prudential policy development	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Supervision/oversight	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3. Policy operation functions	FX intervention	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	FX reserves	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Liquidity management	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lender of last resort	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4. Financial infrastructure provision functions	Currency provision	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Banking/account management services	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Payment system (inter-bank)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Settlement system for central bank money	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Other settlement systems	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Registry provision	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5. Other public good functions	Debt management	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Asset management	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Development functions	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Research (other than for functions above)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Statistics	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Consumer services	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6. Other functions		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Functions of central banks and their coverage in different countries, as defined in the BIS Study, 2008

Functions of Central Banks (BIS Survey 2008)

		HU	IS	IN	IL	JP	MY	MX	NZ	NO	PL	RU	SG	ZA	SE	CH	TH	TR	UK	US
1. Monetary stability functions	Monetary policy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Exchange rate policy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Financial stability & regulatory functions	Prudential policy development	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Supervision/oversight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Policy operation functions	FX intervention	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FX reserves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Liquidity management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lender of last resort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Financial infrastructure provision functions	Currency provision	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Banking/account management services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Payment system (inter-bank)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Settlement system for central bank money	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other settlement systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Registry provision	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Other public good functions	Debt management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Asset management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Development functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Research (other than for functions above)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Statistics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Consumer services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Other functions		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Functions of central banks and their coverage in different countries, as defined in the BIS Study, 2008

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Comparison: Traditional Central Banks and cryptocurrencies

Central Bank Functions vs. Cryptocurrencies

Central Bank General Functions	Central Bank Detailed Functions	Cryptocurrencies
Monetary Stability Functions	Monetary Policy	Yes. Monetary policy fixed at inception, but can be changed by majority of miners. In the case of Bitcoin, it is mildly inflationary (expansionary) money supply but with the rate of increase dropping rapidly over time
	Exchange Rate Policy	No
Financial Stability & Regulatory Functions	Prudential Policy Supervision	No
	Supervision/Oversight	No
Policy Operation Functions	FX Intervention	No
	FX Reserves	No
	Liquidity Management	No
	Lender of Last Resort	No
	Currency Provision	Yes, through block rewards
Financial Infrastructure and Provision Functions	Banking/account management services	No
	Payment system (inter-bank)	Yes. Cryptocurrencies have a built in payment system that, from one point of view, merges a variety of traditional payment and settlement systems
	Settlement system of central bank money	
	Other settlement systems	
	Registry Provision	No
Other Public Good Functions	Debt Management	No
	Asset Management	No
	Development Functions	No
	Research (other for the functions above)	No
	Statistics	All data produced by the system is publicly available
	Consumer Services	No

Note

▼ Note for previous table:

Overall, cryptocurrencies provide a very light set of Central Banking functions relative to traditional Central Banks, primarily setting monetary policy, payment/transfer services and issuance/distribution of new 'coins'/units

Central Banks vs. cryptocurrency

▼ Cryptocurrency “Advantages”

- ▼ Money supply immune to political interference/pressure. Many proponents of cryptocurrencies are particularly concerned with increases in money supply / inflation
- ▼ Cannot deny access to individual participants (non-permissioned blockchains)
- ▼ Seigniorage (the benefits of the issuance of new units) accrues to miners as opposed to political entities in exchange for the costs they incur in providing transaction security
- ▼ To the degree that any particular money supply algorithm is desirable or non-desirable, open market competition between private currencies will come to the most efficient outcome



~“Austrian” economics philosophy

▼ Traditional CB “Advantages”

- ▼ Supply-side tools / intervention tools to manage price of the currency relative to other currencies (cryptocurrencies fully exposed to changes in demand with no ability to counteract them)
- ▼ Ability to manage money supply to balance inflation/deflation with unemployment/economic growth. Most cryptocurrencies would struggle to stimulate economic growth in a recession/depression for example.
- ▼ Tools / framework / authority to manage financial / depositary institutions (Potential depositary institutions operating with cryptocurrencies could not perform fractional reserve on the same coin, since the network would not accept them as valid. Solutions are offered both by sidechains and off blockchain networks, but these require trust to the issuer)
- ▼ Ability to be a lender of last resort



~“Keynesian” economics philosophy

Central Banks vs. cryptocurrency

▼ Cryptocurrency Point of View

- ▼ Most fiat currencies over the history of time have not ended well, due to over-issuance, devaluation or external events (wars, etc). A limited digital currency will have lasting value and preserve wealth
- ▼ Open, auditable records and better models (like multi-sig) will actually reduce fraud in the long run by forcing more transparency
- ▼ Ability to control the currency gives significant power to governments that is better devolved to individuals
- ▼ Liquidity support and “too big to fail banks” create distortions to incentives and markets
- ▼ Protocols are extensible for more advanced uses

▼ Traditional CB Point of View

- ▼ Without tools to manage currency supply and be a market maker in the currency, the currency will always be (more) volatile
- ▼ Financial institutions **will** emerge and regulation, as well as the ability to provide backstops will be needed. Most people, in practice, will give up some independence in exchange for less day-to-day personal responsibility for fraud, theft, etc.
- ▼ While theoretically decentralized, many early cryptocurrencies (such as bitcoin) currently show centralization both in distribution of coins and distribution of hashing power



***Both are right. One significant point that might integrate the two views to some degree:
To the degree that a cryptocurrency is not the unit of account for a whole economy, some of its
disadvantages in CB terms (aka it might be deflationary) become much less important***

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The ECB and the Fed on Bitcoin and DCs

Fed on Bitcoin and DCs

Bitcoin was discussed at length at the latest Federal Reserve Advisory Council and the Board of Governors, held in May 9th, 2014 in a thoughtful and largely positive report. The key conclusions to date were:

- ▼ **1. The **banking system** is not threatened at this time by either of three mechanisms notes, primarily because Bitcoin is not yet big enough to be a threat**
 - ▼ Disintermediation of traditional payment networks: Not enough adoption yet (*“a curiosity, not a threat”*), due to fluctuation in value, no deposit insurance and security threats
 - ▼ Illicit Use: While “rampant”, this is not different than sovereign-issued currencies or other precious goods
 - ▼ Financial Stability: Bitcoin not at sufficient scale to have systemic economic impact. *“In an economy hypothetically dominated by Bitcoin, its finite number (21 million) would prevent the application of traditional monetary policy tools to provide support in downturn or reduce growth during excessive expansion”*

Fed on Bitcoin and DCs

- ▼ **2.** Bitcoin could have a longer-term positive impact on payment processors
 - ▼ Allow for lower transaction fees
 - ▼ Expand cheap international remittances to developing world and “unbanked”
 - ▼ If adoption increases and reputational effects subside, banks will likely start offering more Bitcoin based services

- ▼ **3.** Bitcoin could be a “boon” to economic activity
 - ▼ Global transmissability could open new markets
 - ▼ Driving capital flows to developing world could increase consumption

- ▼ **4.** Regulation should be thoughtful to avoid Balkanization
 - ▼ Key areas of focus are: consumer protection, consumer knowledge and addressing illicit use
 - ▼ Aiming for standardization across geography and regulators to provide consistent regulatory environment

- ▼ **5.** Lael Brainard, a member of the U.S. Federal Reserve’s Board of Governors, stated during a [speech](#) in 2016, that the Federal Reserve will continue to evaluate distributed ledger technology and engage actively with the industry’s stakeholders and regulatory authorities to work through challenges and implement solutions whereas appropriate.

ECB on Bitcoin and DCs

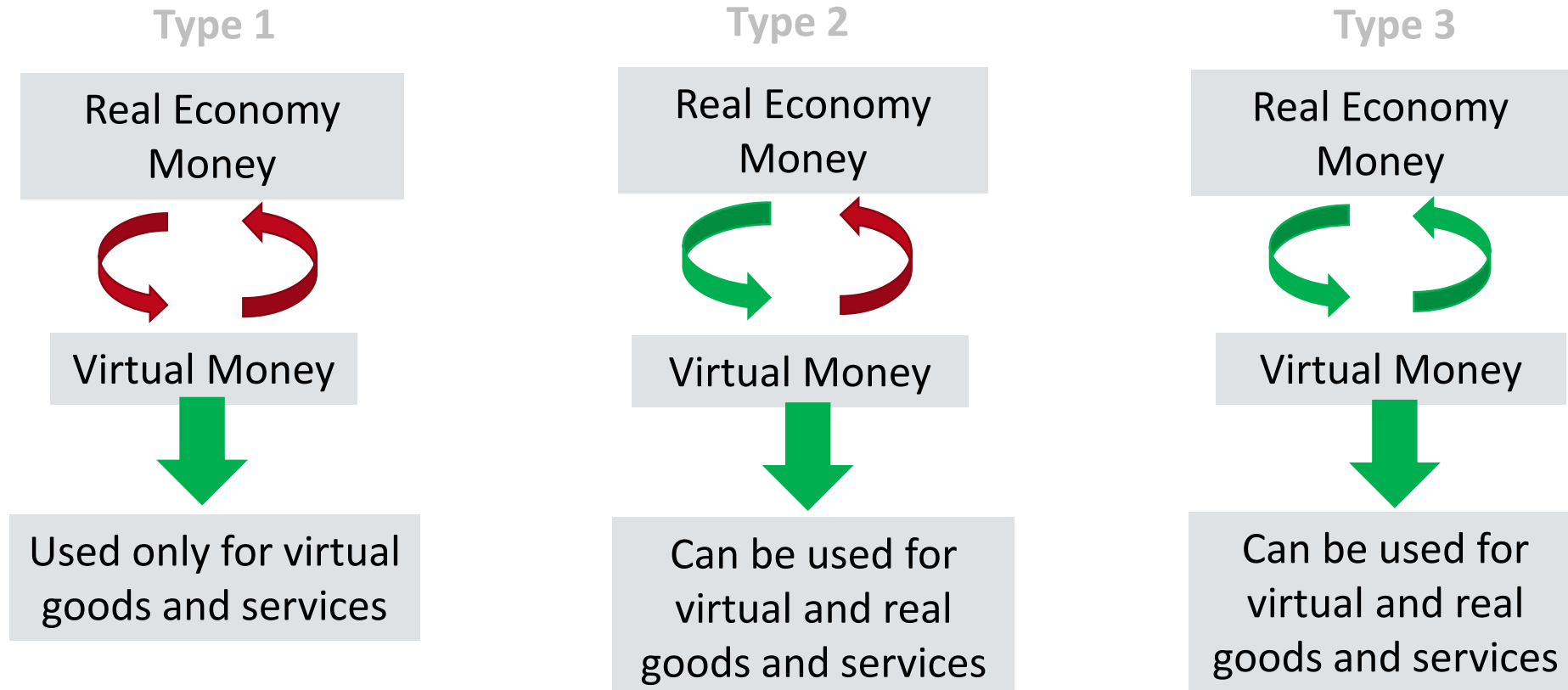
- ▼ The ECB has two pronouncements on digital currencies:
 - ▼ One older and less specifically oriented to Bitcoin (Oct 2012)
 - ▼ A more recent, further analysis (Feb 2015)

According to the European Central Bank (ECB, 2015) the definition has been updated to “a digital representation of value, not issued by a central bank, credit institution or e-money institution, which in some circumstances can be used as an alternative to money.”

- ▼ In these papers, the ECB defines and classifies virtual currency schemes based on observed characteristics (which according to the ECB might change in the future affecting therefore its definition). So, *“depending on their interaction with traditional, “real” money and the real economy, virtual currency schemes can be classified into three types:*
 - ▼ *Type 1, which is used to refer to closed virtual currency schemes, basically used in a game*
 - ▼ *Type 2, virtual currency schemes which have a unidirectional flow (usually inflow)*
 - ▼ *Type 3, virtual currency schemes which have bidirectional flows”*

Types of Virtual Currency Schemes

(Categorization by the ECB)



Note:

Red arrows denote non-allowable function

Green arrows denote allowable functions

Virtual Currencies – Further discussion

- ▼ According to the ECB, reasons for implementing virtual currencies vary from enabling a company to increase its revenue to supporting customers by making transactions easier to be conduct / eliminating the need to spread personal information each time they want to purchase goods or services, thus enhancing customer loyalty.
- ▼ The virtual currency market is also discussed in a sense that no reliable data could indicate the real size of it. According to the papers, innovation in this area is growing and spreading significantly fast, making it difficult, if not impossible, to collect accurate and reliable information to provide a complete and comprehensive picture of the virtual communities and the virtual currencies that exist.
- ▼ Bitcoin is then discussed as a related case study, providing information for its basic features, a technical description of how a transaction is conducted as well as its monetary aspects. Distinct reference is made to security issues and negative press and criticism that Bitcoin has found itself subject to from its infancy.

Virtual Currency Schemes and their Relevance to Central Banks

- ▼ ECB considers the extent to which virtual currency schemes might affect a central bank's tasks in the areas of payments systems, regulation, financial stability, monetary policy and price stability.

- ▼ Thus, in its paper, the ECB focused, as an attempt to set the basis for further discussion, on the potential impact that virtual currencies may have in relation to the following central bank tasks:
 - ▼ Price Stability
 - ▼ Financial Stability
 - ▼ Payment Stability

Price stability

- ▼ With regards to price stability , the greatest challenges identified were:
 - ▼ The preservation of the unit of account
 - ▼ The risks to the effectiveness of monetary policy and its implementation
 - ▼ The possible distortions to the formation of monetary aggregates

- ▼ The ways that virtual currencies could affect price stability are identified as the following:
 - ▼ by affecting the money supply
 - ▼ by modifying the velocity of money circulation
 - ▼ by enabling the interaction between virtual currencies and the real economy, through the substitution effect and the crowding-out effect of virtual on “real” money

- ▼ While subject to lack of reliable information, the ECB concludes that virtual currencies do not consist a threat for price stability of the “real economy”. Stability in new currency issuance is a sign towards velocity of money not being dramatically affected. Nevertheless, the interaction of virtual and real economy definitely deserves attention.

Financial Stability

- ▼ To protect financial stability of a currency, virtual or not, attention should be paid to the factors that can cause price swings and can be a source of potential financial volatility. According to the ECB, factors that have a major role in the financial stability of virtual currency schemes are:
 - ▼ **The supply of money and the other issuer actions:** For example, market intervention to maintain a fixed or semi-fixed exchange rate
 - ▼ **The dimensions of the network:** Virtual currency schemes exhibit network externalities, such as the value of the currency that depends on the number of users and the number of merchants accepting it
 - ▼ **Institutional conditions governing the virtual community**
 - ▼ **The virtual currency issuers' reputation for meeting its commitments:** Since virtual currency payments are not settled in central bank money or commercial bank money, nor is there any lender of last resort, a crucial element affecting the virtual currency rate is the trust gained by the virtual currency issuer
 - ▼ **Speculation:** Regarding the future value of the currency and history of cyber attacks suffered in the virtual community

Financial Stability

- ▼ The ECB notes the high volatility of the value of bitcoins to date and identified “speculation” as the main cause of that volatility
- ▼ It further notes that stability of the “real economy” can not yet be affected, since volume of transactions is low and no interface has practically connected the two economies to a great extent.
 - ▼ However, ECB identifies the risk of no central authority being able to act as the lender of the last resort and support the monetary system, should adoption of such currencies gain wide acceptance
- ▼ If and as adoption of virtual currencies increases, this remains an important area to monitor as, in time, they could be a source of financial instability if they reach scale.

Payments System Stability

- ▼ The ECB approaches virtual currency payment systems as the actual payment arrangements among members of certain virtual communities. The major risks faced are categorized as follows:
 - ▼ **Credit Risk:** *“Users exposed to this in relation to funds held on virtual accounts (cannot be guaranteed that the settlement institution is able to fully meet its financial obligations when due at any time in the future)”*
 - ▼ **Liquidity Risk:** Users may face such risks, if the settlement institution does not meet its commitments to provide them with financial liquidity upon request
 - ▼ **Operational Risk:** Both participants in a transaction run the risk of inefficiency and ineffectiveness of the settlement institution, being uncertain of its operational continuity
 - ▼ **Legal Risk:** Uncertainty and the lack of a legal framework exacerbate the aforementioned risk factors
- ▼ In conclusion, the ECB: (a) identifies virtual payment systems as valid payment systems within a virtual community, (b) believes users face the aforementioned risks, (c) does not believe that they pose a broader threat at this time.

ECB report - Feb 2015

The latest ECB report expand on the previous material by examining other aspects of the ecosystems that have developed since the first report, also examining the following:

▼ **Payments related aspects of Virtual Currency Schemes**

- ▼ A renewed view is made on the Key Actors and their Roles in most popular types of currencies existing, including Bitcoin, Ripple and Litecoin
- ▼ Their diversity and the large number of Altcoins is examined, as well as the differentiating elements between them, as we saw in session 7
- ▼ Emerging business models are examined based on what has been observed so far in the markets
- ▼ Comparisons are made in market capitalization, transaction numbers with established systems like VISA, Mastercard, Paypal and MPESA
- ▼ and the potential advantages and risks of using virtual currencies are also recouped as in the first report

ECB report - Feb 2015cont.

▼ Virtual Currency Schemes from the perspective of a Central Bank

- ▼ Virtual currencies do not fit the economic or legal definition of money or currency
- ▼ This means that virtual currencies can be used only as contractual money, when there is an agreement between buyer and seller in order to accept a given virtual currency as a means of payment.
- ▼ They should not be bundled into the generic words of money or currency, even though their technical appearance takes a form which has some similarities to scriptural money and/or electronic money.
- ▼ They do not currently pose a risk for price stability in practice, provided that the issuance volume of virtual currency continued to be stable and their usage low.
- ▼ An increase in the usage of VCS is conceivable and thus surveillance of the take-up of VCS is important from a financial stability perspective.
- ▼ As in 2012, VCS do not pose a threat to payment system stability
- ▼ Some elements of the technological set-up of VCS could perhaps serve as the inspiration or even basis for traditional PSPs (Payment Service Providers) to offer innovative payment solutions.

ECB report - Feb 2015 cont.

▼ Legislative and Regulatory Responses to Virtual Currency Schemes

- ▼ The international interest is examined with mentions of the reports of the following:
 - ▼ The World Bank conference on Virtual Currencies
 - ▼ EBA's report in July 2014
 - ▼ FATFs report in June 2014
 - ▼ European commission discussions
 - ▼ EUROPOL's call for police to be given greater powers to identify criminals using crypto-currencies to launder money on the internet
 - ▼ Mario Draghi, president of the ECB, was recently asked whether a regulatory framework would be issued. He stated that *"it would actually not be in our powers to prohibit and regulate"* bitcoin and other digital currencies. Draghi went further on to describe cryptocurrencies as "immature" and highlighted the importance of cybersecurity as ECB's primary concern.
- ▼ Further national responses from central banks and supervisory authorities will be examined in more detail in the session on Regulation.

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State Owned Cryptocurrencies

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State Owned Cryptocurrencies

- ▼ Several initiatives and discussions from Central Banks have surfaced on potential ways that the technology behind Bitcoin could be used to issue government controlled currencies. Some governments are actively exploring this as we'll see in the next slide.
- ▼ Government issued currencies wouldn't be permissionless and open, as a cryptocurrency would be, for a multitude of reasons (several of which the FED and ECB mentioned above).
- ▼ But they would potentially allow citizens to hold CB money directly into their digital currency wallets and transact with them directly under the permissioned auspices of the Central Bank.
- ▼ This could have some obvious advantages like cost savings, faster clearing and settlement, as well as increased transparency and real-time analytics of the status of payments, credit balances and more.
- ▼ If a Central Bank was the issuer and administrator of a digital currency, most e-money companies (PayPal, Alipay, etc) and perhaps even most banks, would perhaps find themselves with new competition.
- ▼ China may present one of the most interesting cases of how it develops. More reading on China's Blockchain based currency can be found [here](#), [here](#) and their recruiting announcement [here](#).

The Central Bank Blockchain

Other notable initiatives and discussions on the topic of Government controlled Crypto Currencies can be found here:

- ▼ A 2015 study by Deloitte on the potential :
 - ▼ <http://www2.deloitte.com/content/dam/Deloitte/us/Documents/strategy/us-cons-state-sponsored-cryptocurrency.pdf>
- ▼ A proposal called Rcoin was drafted by two Bank of England researchers:
 - ▼ <http://www0.cs.ucl.ac.uk/staff/G.Danezis/papers/ndss16currencies.pdf>
- ▼ Some thoughts from the VP of the Federal Reserve bank of St. Louis on a potential Fedcoin
 - ▼ <http://andolfatto.blogspot.gr/2015/11/bitcoin-and-central-banking.html>
 - ▼ <http://andolfatto.blogspot.gr/2015/02/fedcoin-on-desirability-of-government.html>
- ▼ Dutch Central Bank to Create Prototype Blockchain-Based Currency
 - ▼ <http://www.coindesk.com/dutch-central-bank-to-create-dnbcoin-prototype/>
 - ▼ <http://www.coindesk.com/dutch-central-bank-preparing-boldest-blockchain-experiment-yet/>
- ▼ Estonia's "estcoin"
 - ▼ <https://www.cnbc.com/2017/08/23/estonia-cryptocurrency-called-estcoin.html>

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Conclusions

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Conclusions

- ▼ Central Banks play a wide variety of roles in a modern economy, including monetary stability, financial stability / regulatory, policy operations, and financial infrastructure and provisioning
 - ▼ Most cryptocurrencies cover some of the monetary policy and financial infrastructure functions of a modern Central Bank but are, overall, much lighter and more laissez-faire models
 - ▼ The degree to which the functions “missing” in cryptocurrencies “matter” has a lot to do with how broadly adopted a cryptocurrency is in an economy and if a cryptocurrency is the main unit of account for an economy
- ▼ The Federal Reserve and the ECB are both monitoring the development of cryptocurrencies and share most of their conclusions:
 - ▼ They are too small at this time to have a systemic impact on the overall economy or banking system or to be a meaningful source of illicit transactions
 - ▼ They may offer transaction, efficiency and financial inclusion benefits
 - ▼ As they become larger, more regulation and monitoring will be required
- ▼ Several Central Banks are looking into the technology behind Bitcoin to create similar experiments



Further Reading



Further Reading

▼ Roles and objectives of modern central banks

- ▼ A report provided by the Bank of International Settlements.
http://www.bis.org/publ/othp04_2.pdf

▼ RECORD OF MEETING, Federal Advisory Council and Board of Governors

- ▼ Friday, May 9, 2014. <http://www.federalreserve.gov/aboutthefed/fac-20140513.pdf>

▼ Gresham's Law and private currencies:

- ▼ F.A. Hayek's perspective on the competition between public and private currencies
<https://mises.org/books/denationalisation.pdf> (p 41-43)

▼ Virtual currency schemes – a further analysis, February 2015 and October 2012

- ▼ <https://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemesen.pdf>
- ▼ <http://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemes201210en.pdf>

▼ Innovations in payment technologies and the emergence of digital currencies, The Bank of England

- ▼ <http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2014/qb14q3digitalcurrenciesbitcoin1.pdf>



Questions?

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