Would We Like Central Bank Digital Cash? Experiment with a Baumol Friedman Demand for Money

Speakers:
Alessandra Cillo and Donato Masciandaro
Bocconi University
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Motivation

- Is money changing its face?
- The macroeconomic interest of such a question becomes evident observing three recent and parallel trends in the advanced economies:
- On the one side the puzzling resilience of the public paper currency (cash), notwithstanding the wide diffusion of the cashless payment technologies.
Motivation

- On top of that the specific resilience of cash
- Can be correlated with a general popular demand of more safe assets issued by the State
- Special Example: The Swiss referendum (June 10th, 2018) on Sovereign Money ("Voll Geld") = a State entity has the exclusive right to issue means of payments
Motivation

- On the other side a particular innovation is characterizing such as diffusion, i.e. the issuing of the so called crypto currencies ...

Source: Bohme et al., JEP, 2015

Mr. Satoshi Nakamoto (2008)
Motivation

- ... Becoming both a fast growing phenomenon (As of March 31, 2018, a total of 1,595 cryptocurrencies are reported)
- And a regulatory puzzle ...
Motivation

- Indeed (Bank of Italy, The Governor’s Concluding Remarks, May, 29, 2018)

New technologies are increasing productivity and giving users greater choice, but due care must be taken as regards the potentially negative consequences. In a financial system by now steeped in digital technology, the damage caused by cyberattacks can go beyond individual operators and become systemically important. The central banks and supervisory authorities are committed, together with the other authorities and intermediaries, to safeguarding cyber security in the financial sector. The unregulated spread of crypto-assets could also put consumer protection at risk and encourage illegal activities; going forward, it could pose a threat to financial stability.
Motivation

- Finally, beyond the resilience of the traditional cash on the one side, and the emerging interest for new private electronic currencies on the other side, one more question is arising: Is there any role for a CBDC (digital cash)?
Motivation

- CBDC =
  - electronic
  - public
  - legal
  - tender
  (=central bank liability)

Table 1: Characteristics of CBDC and other money-like assets

<table>
<thead>
<tr>
<th></th>
<th>CBDC</th>
<th>Reserves</th>
<th>Central Bank Notes</th>
<th>Deposits</th>
<th>Bitcoin</th>
<th>Ether*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liability of the central bank</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Electronic</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Universally accessible</td>
<td>?</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Interest bearing</td>
<td>?</td>
<td>?</td>
<td>x</td>
<td>?</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Trades at par</td>
<td>?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cryptocurrency</td>
<td>?</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Token or account based</td>
<td>?</td>
<td>A</td>
<td>T</td>
<td>A</td>
<td>T</td>
<td>A</td>
</tr>
</tbody>
</table>

*We have taken Bitcoin and Ether as the best known examples of privately-issued cryptocurrency. The characteristics shown are also accurate for the majority of cryptocurrencies, although the economic and technological design of different cryptocurrencies can vary significantly.

b) Trades at par with other central bank liabilities

Source: Meaning et al. 2018
The Research Question

- Research Question: Would We Like Central Bank Digital Cash (CBDC)?

- The features of a demand for the CBDC would have implications for both:
  - Monetary Policy (examples: negative interest rates, quantitative easing, helicopter money)
  - Banking Policy (examples: commercial bank model sustainability, bank run risks)

- As well as for some crucial trade off between the two:

- For example: “Should a CBDC be a very close substitute for banking money then that may maximize the improvement in the monetary transmission but, all else equal, it also increases the risk of bank runs” (Meaning et al, 2018),

- But, even more importantly....
“... Spanning in all of these areas is the need for robust quantitative insights into CBDC.

But this is complicated by a lack of data and a lack of good proxies for CBDC.

A problem that would be resolved (in the future) with time one a CBDC had been introduced, but that is hard to deal with ex ante.

High on the list of empirical questions that will need to be answered are: What would be the size of CBDC demand? How volatile would this demand be? What would be the interest rate elasticity between CBDC and bank deposits? ...”(Meaning, 2018)

Our Answer: The future is now, i.e. a theoretically micro founded experiment with a “new” demand for money.

Background Paper: Borgonovo, Caselli, Cillo and Masciandaro (2018)
Setup

- Theory
- Experiment Design
- Conclusion
Principles: The Money Demand Redux

- Consider a population with a continuum of individuals, each of them free to choose his/her – thereafter her – financial portfolio composition.

- Alternative financial assets can be potentially use as a medium of exchange, i.e. any individual can use it to finalize an exchange being alternatively the payer or the payee. In other words, any of such financial asset can be used as medium of payment (MOP), other things being equal.

- The individual preferences are heterogeneous respect to the three crucial properties of a MOP: medium of exchange, store of value and store of information.

- The three properties capture the different risks that the holding of a financial asset can imply for any individual in any given moment.
Principles: Money as a Medium of Exchange

(Illiquidity Risk)

- First of all we assume that any individual cares about the expected illiquidity costs, which are associated with the probability that the asset cannot be traded, i.e. used as a medium of exchange and transformed in other goods and services.
- We assume that the issuer type can influence the shape of the liquidity costs.
- When the currency is a public legal tender, we assume that in a given country it is the safer asset, being the obligation for each trader to accept in any exchange between both public and private traders; in other words any trader cannot refuse to accept the legal tender as payment.
- The legal tender, which is also the unit of account, minimized the expected liquidity costs. The expected excess level of return captures the standard transaction motive for money holding.
Principles: Money as a Safe Asset

Figure 1. US currency-to-deposit ratio

Source: Ashworth and Goodhart, 2015
Principles: Money as a Safe Asset

Figure 2. Eurozone currency-to-deposit ratio

Source: Ashworth and Goodhart, 2015
Principles: Money as a Safe Asset

Figure 3. UK currency-to-deposit ratio

Source: Ashworth and Goodhart, 2015
Principles: Money as a Safe Asset

Figure 4. Switzerland currency-to-GDP

Source: Berentsen and Schar 2018
Principles: Money as a Safe Asset

Figure 5. Cyprus 2013

Source: Brown, Evangelou and Stix, 2018
Principles: Money as a Safe Asset

Figure 6. Turkey 2018

Source: FT, May 25., 2018
Principles: Money as a Store of Value (Opportunity Cost Risks)

- Regarding the second property of a financial asset – i.e. its expected value – we acknowledge its relevance for each individual, using as its proxy the real expected return of each portfolio asset, which summarizes the corresponding purchasing power expected gains/losses.

- Holding a MOP implies an expected opportunity cost which is equal to the overall excess level of return. The excess return can be calculated by comparing the total return in holding assets different from the MOP with its return.

- The expected excess level of return captures the standard speculative motive for money holding.
Principles: Money as a Store of Value

Figure 1: Prices of Gold and Bitcoin from July 2011 to December 2017, $n = 1695$.

Source: Klein et al., 2018
Principles: Money as a Store of Value

Figure 2: Plots of the daily return series of Gold and Bitcoin

Source: Klein et al., 2018
Principles: Money as a **Store of Information**

- VIDEO
Principles: Money as a **Store of Information**

- Finally, respect to the traditional demand for money, we assume that using money can spread information on the money holder.

- The relevance of the **privacy costs** can be found in a statement that Milton Friedman did during an interview:

  “I think the Internet is going to be one of the major forces for reducing the role of government. The one thing that’s missing but that will soon be developed is a reliable e-cash, a method whereby on the Internet you can transfer funds from A to B without A knowing B or B knowing A.” (1999)
Principles: Money as a Store of Information
(Privacy Risks)

- We assume that using money can spread information on the money holder.
- In other way we assume the existence of expected privacy costs in using money for exchanges.
- The relevance of the privacy costs is linked to the so called demand for trustlessness.
- A currency is a store of information: the individuals consider the privacy (transparency) risks that using a given currency for trading can imply, given that any exchange can disseminate information on the exchangers.
- In general anonymity characterizes an asset as a store of information.
Principles: Money as a Store of Information

- Among the individuals that like the currency anonymity a relevant group are the people that appreciate such as property being motivated by illegal reasons, given that an anonymous currency can be an effective device to implement money laundering operation.

- In fact, the conduct of any illegal activity may be subject to a special category of transaction costs, linked to the fact that the use of the relative revenues increases the probability of discovery of the crime and therefore the likelihood of incrimination.

- Those transaction costs can be minimized through an effective money laundering action.
To describe the Baumol-Friedman demand for money we can use a standard portfolio model to develop a framework where risk averse individuals choose the currency composition of their portfolios in an economy with alternative assets that can be used as medium of payments (MOP).

The portfolios can comprise n assets which are heterogeneous in terms of the three abovementioned properties: illiquidity risks, opportunity cost risks, and privacy risks.

The model adopted is a standard Baumol-Tobin framework (Santomero and Seater 1996) with on top the introduction of the Friedman privacy risks.

We analyse a situation where alternative MOP are present and each individual define the optimal portfolio taking into account her own preferences.
Optimal Portfolio Allocation: Goods, MOPs and a Financial Asset

- In every period each individual receives an income $Y$ that she can store in a portfolio.
- Where the assets are different consumption goods, alternative medium of payments (MOP) and a financial (saving) asset that cannot be used as a medium of exchange.
- Each asset is associated with its own utility, which is proxied by its net expected return.
- The individual seeks to optimize her portfolio allocation, defining, among other choices, the optimal quantity for each asset, including the alternative MOP.
Assets and Opportunity Costs (1/2)

- The individual uses her income by buying an amount $G$ of $j$ different consumption goods:
  \[ Y = \sum_{j=1}^{J} G_j \]

- During the period a series of consumption expenditures (exchanges) occur at discrete interval and the individuals have to use a MOP to finalize them.

- First of all she holds inventories of the various goods that consume. Each good inventory is associated with an expected rate of return $r_{Gj}$ which captures its utility; such a return can be either positive or negative, being the likelihood for example of a spoilage rate.
On top of that the individual holds the unspent income in two different kind of financial assets:

- A saving(investment) asset $S$, that cannot be used as medium of payment, with its expected rate of return $r_S$
- The alternative moneys, with their respective expected returns that are used to proxy the opportunity costs of money holding
- Each medium of payment $M_i$ is associated with its own rate of return $r_{Mi}$
- Without any loss of generality we assume that:

$$r_s > r_{Mi} > r_{Gj}$$
Assets and Illiquidity Costs

- The individual implements any exchange using one of the available \( n \) different medium of payment, where the quantity of good \( j \) purchased using the medium \( i \) is \( G_{ji} \), where

\[
G_j = \sum_{i=1}^{n} G_{ji}
\]

- For finalizing the overall consumption expenditure for every good the individual implements a number of monetary exchanges using the medium.

- The probability that any medium \( M_i \) is accepted can range between 0 and 1, i.e. each medium is associated with perceived illiquidity costs.

- We assume that in each exchange such costs are equal to \( \beta_{ji} \), i.e. a lump-sum cost independent from the value of the exchange.
Assets and Privacy Costs

- At the same time any medium $M_i$ is characterized by its properties in terms of store of information, i.e. its degree of anonymity.

- We assume that the privacy costs associated with each medium can be proxied using the switching cost $\alpha_i$ with captured the privacy losses from converting income in such as medium to implement exchanges.

- Again we modelled such as losses as a lump-sum cost independent from the amount of the conversion.

- Exchanges occur between conversions and both are evenly spaced.

- Being $N_{ji}$ the number of exchange to buy good $j$ with money $i$ per conversion of $M_i$, we have that

$$Z_{ji} = T_j N_{ji}$$
The Baumol-Friedman Money Demand

- Given that consumption, exchanges and conversions are all evenly spaced, the profit function of each individual can be expressed using the average values of the assets as follows:

$$\pi = r_s \bar{S} + \sum_i r_{Mi} \bar{M}_i + \sum_j r_{Gj} - \sum_i T_i \alpha_i - \sum_i \sum_j Z_{ji} \beta_{ji}$$

- For the first order conditions we can get the optimal average quantity of each alternative medium of exchange:

$$\bar{M}_i = \left[ \frac{\alpha_i}{2(r_s - r_{Mi})} \sum_j G_{ji} \right]^{1/2} - \sum_j \left[ \frac{\beta_{ji} G_{ji}}{2(r_{Mi} - r_{Gj})} \right]^{1/2}$$

- Given the income and the consumption choices, each money holding money is: i) directly associated with the anonymity risk per conversion; ii) inversely associated with the illiquidity risks; iii) inversely associated with the opportunity cost risks
Experiment Design

- In our framework the individuals face portfolio decision problems with value trade-offs, given that any MOP can be differently characterized respect to three abovementioned properties: safeness, profitability and anonymity.
- The model can be tested in a laboratory experiment.
- At the best of our knowledge the money demand features has been analyzed so far in a laboratory experiment only in two cases, and exclusively for pedagogic reasons (Ewing 2004, Chen 2018).
Subjects and Procedure

- Experiment will be run at Bocconi University in Milan with 82 subjects.

- Flat fee payment of 10 EUR. 10% of the subjects will play for real one choice question.

- Sessions computer run: maximum of 12 subjects with a minimum of 2 interviewers.

- Each session will last, on average, one hour.

- Choice task with a bisection procedure will be implemented, joint with Prince method.
**Prince Method**

- The choice question is randomly selected prior to the experiment; subjects' answers are framed as instructions to the experimenter; the real choice is provided in the concrete form (sealed envelope); the entire choice situation is described in the envelope.

- Advantages: the incentive compatibility is crystal clear to subjects and subjects cannot answer strategically.
Methodology

- The experiment has three parts: Part I, II, and III.

- Part I: we determine the value subjects assign to liquidity risk, expected return, and anonymity in the transaction, and possible interactions.

- Part II: we determine the direct value subjects assign to anonymity.

- Part III: we determine how subjects allocate their wealth between different types of currencies.
Part I

- There are 18 types of currencies/payment methods.

- Each type of currency is of 100 Euro and has a specified level of liquidity risk (0%, 1%, 10%), expected return (0%, 2%, 20%), and anonymity (Yes/No).

- We assess the value subjects assign to each currency.

- We have 18 values for each type of currency, determined via a bisection procedure.
INSTRUCTIONS FOR ENVELOPE OF TYPE THETA

In each of 4 envelopes of type theta, option A is a card (currency) of 100 Euro with three different features: Liquidity Risk, Expected Return, Anonymity; the option B is a money amount of x Euro. The money amount x varies in different envelopes.

The note in each envelope of type theta is as follows:

<table>
<thead>
<tr>
<th>Option A</th>
<th>Liquidity Risk</th>
<th>Expected Return</th>
<th>Anonymity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00%</td>
<td>20.00%</td>
<td>No</td>
</tr>
</tbody>
</table>

Option B: x Euro

Your envelope may contain two Options of the following forms.

For small values of x you prefer Option A. For large values of x you prefer Option B. There is a threshold value above which you prefer Option B, and below which you prefer Option A.

For each number x, instruct which Option you want to be taken from the envelope if its content is as above, by clicking on Option A or Option B, in the next type theta questions. You will get what you want.

Please select the option you prefer, by clicking on the option. Once you have selected the option, you will be asked if you want to confirm your choice.

<table>
<thead>
<tr>
<th>Option A</th>
<th>Liquidity Risk</th>
<th>Expected Return</th>
<th>Anonymity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00%</td>
<td>20.00%</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option B</th>
<th>Cash Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option B</td>
<td>100</td>
</tr>
<tr>
<td>Option B</td>
<td>80</td>
</tr>
<tr>
<td>Option B</td>
<td>50</td>
</tr>
</tbody>
</table>
PART II

- There exist two types of currencies, which have the same liquidity risk (0%) and expected return (0%), but differ in the anonymity dimension.

- The subjects have to decide how to allocate 100 Euro between these two currencies.

- We have 1 elicitation via a bisection procedure, to determine the optimal wealth allocation between the two different types of currency.
Screenshot from the Experiment: Part II

INSTRUCTIONS FOR ENVELOPE OF TYPE RHO

In each of 4 envelopes of type rho, there are two options, which differ in the way 100 Euro is allocated between Asset I and Asset II. Asset I is a card (currency) with three different features: Liquidity Risk, Expected Return, Anonymity. Asset II is a card (currency) with three different features: Liquidity Risk, Expected Return, Anonymity. The money amount x varies in different envelopes.

The note in each envelope of type rho is as follows.

<table>
<thead>
<tr>
<th></th>
<th>Asset I</th>
<th>Asset II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquidity Risk</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Expected Return</td>
<td>100</td>
<td>100-x</td>
</tr>
<tr>
<td>Anonymity</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Option A: y = x
Option B: y = 100-x

Your envelope may contain two Options of the following form. There is a threshold value for x below which you prefer Option B, and above which you prefer Option A.

For each number x, instruct which Option you want to be taken from the envelope if its content is as above, by clicking one Option A or Option B, in the next type rho questions. You will get what you want.

You have selected the option A. Do you confirm?

<table>
<thead>
<tr>
<th>Option A</th>
<th>Asset I</th>
<th>Asset II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option A</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option B</th>
<th>Asset I</th>
<th>Asset II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option B</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>

YES NO
There exist three types of currencies: two are the same as in Part II, while the third has different levels of liquidity risk, expected return, and anonymity.

The subjects have to decide how to allocate 100 Euro among these three currencies.

We have 9 elicitations via a bisection procedure, to determine the optimal money allocation in the 9 combinations of three different types of currencies.
Screenshot from the Experiment: Part III
ROBUSTNESS CHECKS

- To check for response errors, 9 iterations are repeated, at the end of Part I and Part III.

- In Part I, we repeat the third iteration of 7 randomly selected elicitations.

- In Part III, we repeat the second iteration (or the first when the second not present) of 4 randomly selected elicitations.
Results

- Only pilots have been run: good news but let's wait for the final experiment!
Conclusion