The Digitalization of Money

Markus K. Brunnermeier, Harold James and Jean-Pierre Landau
Princeton University - Sciences Po

On the Equivalence of Private and Public Money

Markus K. Brunnermeier and Dirk Niepelt
Princeton University - Study Center Gerzensee, University of Bern

BIS-CEPR Conference Sept 2019

Introduction

Ubiquitous private money

- Claims on central bank money, claims on claims, ...
- Private digital "currencies" (e.g., M-Pesa, Alipay, Libra)

Currency Competition: Will new private money drive out cash?

- Will central banks lose their grip on monetary policy
- Digital Dollarization
- Digital Currency Areas
- Will CBDC be the answer? Embrace it, rather than fight it.
- How to design CBDC in a "neutral way"? Can it be done?

Currency Competition

Hayek's (1976) idea: competing private currencies

Unbundeling of the *3 roles of money*

- Unit of account
  - fewer relative prices (bounded rationality) - stickiness
  - nominal debt contract - affects risk sharing
- Store of value Gresham's law
- Medium of exchange $\Rightarrow$ liquidity value

Re-bundeling with *platform/ecosystem*

Currency Competition

Unbundeling of the *3 roles of money*

...

Re-bundeling with *platform/ecosystem*

- Money product-differentiation
- "Privacy currency"
- Bundle with platform/eco system - discounts
- smart contracts
- closed ecosystems $\Rightarrow$ Digital Currency Areas

International Monetary System

Digital Currency Area (new concept)

- Complementarity with platform, data linkages (not geographic)
- Price discounts, discovery, transparency within

Digital Dollarization (new concept)

- Store of value vs. payment/invoicing
- Sudden take-over due to non-linearity
- Vulnerability: small socially open countries

Digital Synthetic World Currency

Public vs. Private Money Competition

Loss of “monetary power”

- Store of value focus: Tax backing

  Iraqi dinar, Somali shilling

- Medium of exchange focus: Payment settlement outside

- Unit of account feature is key

  – New Keynesian: stickiness in private/public money

  – FinFrictions: Denomination of nominal debt contracts

CBDC to maintain monetary sovereignty

Cash is poor substitute $\Rightarrow$ calls for CBDC

- Back "stable coins" with CBDC
- Retail CBDC

Key policy decisions

- Interoperability
- Convertibility

How to design CBDC in a "neutral" manner?

"On the Equivalence between Private and Public Money"
(with Dirk Niepelt)

- Money creation generates rents—they belong to the public
- Outside money crowds out capital—inside money funds it
- CBDC chokes off credit
- CBDC triggers bank runs

Contributions

- Generic model of money, liquidity, financial frictions
- Liquidity and value

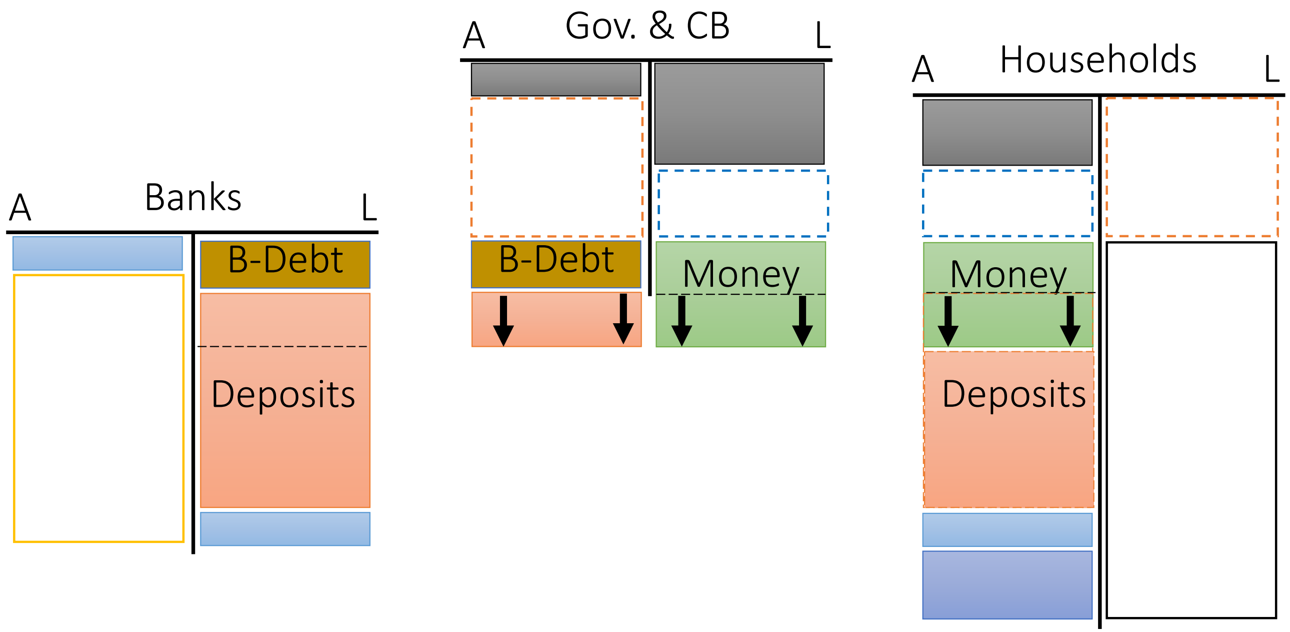
  Liquidity (relaxation of means-of-payment constraints) renders bubbles more likely, generates seignorage rents
- Sufficient conditions for equivalence of monetary systems

  Swap public, private money
- Applications: CBDC, Chicago Plan, ...

Does swap undermine credit, financial stability?

- Not, with pass-through funding by central bank

  Central bank intermediates between non-banks and banks



Does swap undermine credit, financial stability?

- Not, with pass-through funding by central bank

  Central bank intermediates between non-banks and banks

  Implicit LOLR guarantees become explicit

- Run from deposits into CBDC

  Bank funding *automatically* replenished

Equivalence—under broad conditions

- Wealth neutrality
- Liquidity neutrality (requires condition)
- Invariant asset span (condition)
- Same resource cost private/public liquidity (Friedman, 1969)

Implementation

- Pass-through funding subject to deposit rates, to insulate (even non-competitive) banks
- Contingent transfers to compensate for payoff differentials

  Unless little heterogeneity (cf. Barro, 1974)

Theorem serves as benchmark

- To identify possible sources of non-equivalence
- In spirit of Modigliani and Miller (1958), Barro (1974), ...

Related work

- Fisher (1935), Gurley and Shaw (1960), Tobin (1963; 1969; 1985)
- Wallace (1981), Bryant (1983), Chamley and Polemarchakis (1984), Sargent (1987, 5.4)
- Benes and Kumhof (2012), Andolfatto (2018), Faure and Gersbach (2018)
- Niepelt (2018; 2020)
- Merkel (2019) “On Narrow Banking”

Model

Stochastic, discrete time, finite or infinite horizon

Households, government, firms, banks (owned by households)

General technologies, securities

Complete or incomplete markets

Households

$$\mathcal{U}^h(x^{\cdot,h}) \text{ s.t. } \sum_j a_t^{j,h} p_t^j = \sum_j a_{t-1}^{j,h}(p_t^j + z_t^j) - \sum_n x_t^{n,h} q_t^n - \tau_t^h(x^{\cdot,h}, q) \;\forall t$$
$$\mathcal{L}_t^h(\{a_t^{j,h} p_t^j\}_j, \{a_{t-1}^{j,h}(p_t^j + z_t^j)\}_j, p, x^{\cdot,h}, q) \geq (=)\; 0 \;\forall t$$
NPG

Stochastic security price (e.g., bank run), distorting transfers/taxes

Vector of medium-of-exchange restrictions, $\mathcal{L}_t^h$

Examples (without/with $\mathcal{L}_t^h$)

- OLG: Samuelson (1958), Wallace (1980), Townsend (1980)
- Incomplete markets: Brunnermeier and Sannikov (2016)
- Medium-of-exchange friction: CIA (Clower, 1967; Grandmont and Younes, 1972; Lucas, 1980; Lucas, 1982; Svensson, 1985), transaction costs (Baumol, 1952; Tobin, 1956), shopping-time (Saving, 1971; McCallum and Goodfriend, 1987), MIU (Sidrauski, 1967), "New Monetarist" (Kiyotaki and Wright, 1993; Lagos and Wright, 2005)
- Incomplete markets and borrowing constraints: Bewley (1980), Woodford (1990), Kiyotaki and Moore (2012), Holmström and Tirole (1998)

Firms

Profit maximization s.t.

- Budget constraint
- Production possibilities
- Medium-of-exchange constraints ($\mathcal{L}_t^f$)

Possibly price, wage setting friction (Calvo, 1983; Clarida, Galí and Gertler, 1999; Woodford, 2003; Galí, 2008)

Banks

$$\sum_t \mathbb{E}_0 \left[\mu_{0,t} z_t^b \right] \text{ s.t. } \sum_{j \neq b} a_t^{j,b} p_t^j = \sum_{j \neq b} a_{t-1}^{j,b} (p_t^j + z_t^j) - z_t^b \; \forall t$$

$$\mathcal{C}_t^b(a_t^{\cdot,b}, p_t^{D^b}, z_{t+1}^{D^b}, \text{state}_t^b) \leq (=) \; 0 \; \forall t$$

$$\mathcal{L}_t^b(\{a_t^{j,b} p_t^j\}_j, p) \geq (=) \; 0 \; \forall t$$

NPG

Non-competitive bank chooses deposits, return subject to $\mathcal{C}_t^b$

$\mathcal{L}_t^b$-constraint due to regulation, money markets, incentive constraints (Calomiris and Kahn, 1991; Diamond and Rajan, 2001)

Zero marginal cost of deposit creation, possibly fixed cost

Central Bank/Government

$$\sum_{j \neq c} a_t^{j,c} p_t^j = \sum_{j \neq c} a_{t-1}^{j,c} (p_t^j + z_t^j) + \int_h \tau_t^h (x^{\cdot,h}, q) dh \; \forall t$$

NPG

Liquidity and Value

Security price, from Euler equation

$$\tilde{\mu}_t^h p_t^j = \mathbb{E}_t\left[\tilde{\mu}_{t+1}^h(p_{t+1}^j + z_{t+1}^j)\right] + p_t^j \tilde{\lambda}_t^h \mathcal{L}_t^{h'}$$

$$p_t^j = \mathbb{E}_t\left[\mu_{t,t+1}^h(p_{t+1}^j + z_{t+1}^j)\right] + p_t^j \lambda_t^h \mathcal{L}_t^{h'}$$

$$p_t^j = \mathbb{E}_t\left[\frac{\mu_{t,t+1}^h}{\underbrace{1 - \lambda_t^h \mathcal{L}_t^{h'}}_{=\mu_{t,t+1}^h \Lambda_{t,t+1}^h}}(p_{t+1}^j + z_{t+1}^j)\right], \quad \Lambda_{t,t+1}^h \geq 1$$

Liquidity modifies fundamental, bubble values

$$p_t^j = \lim_{T\to\infty} \mathbb{E}_t \left[\sum_{s=1}^{\infty} \mu_{t,t+s}^h \Lambda_{t,t+s}^h z_{t+s}^j \right] + \lim_{T\to\infty} \mathbb{E}_t \left[\mu_{t,t+T}^h \Lambda_{t,t+T}^h p_{t+T}^j \right]$$

Liquidity payoff

- Effectively lowers discount rate

  Renders bubble more likely

- Creates rents for issuer

  Franchise value, reflected in equity value

Equivalence

Swap CB money for bank deposits, for one period (generalizes)

Open market operation at t

- CB money, deposits, possibly third security
- Latter could be implicit (cf. Barro, 1974)

Contingent transfers at $t+1$, compensate for payoff differentials

Wealth Neutrality

Lemma Given SDF, security prices, fundamental payoffs OMO with compensating transfers does not change date-t financial wealth iff unchanged liquidity payoffs of portfolios

Proof. Asset pricing condition, OMO □

Market value of contingent transfers then equals zero

Liquidity Neutrality

Definition Given prices, fundamental payoffs

Swap *liquidity neutral* if for any plan in agents' choice sets, swap does not change $\mathcal{L}_t^i$- or $\mathcal{L}_{t+1}^i$-function values, nor derivatives

Baseline Case $\mathcal{L}_t^i$(weighted sum (CB money, deposits), other) & swap leaves weighted sum unchanged

Examples of liquidity neutral swap

- CIA (with two monies), different "liquidity," payoffs
- Almost all standard models (with two monies), to first order

Counterexample: Svensson (1985) CIA in some cases

Equivalence

Theorem Given equilibrium, consider span neutral, liquidity neutral OMO with compensating transfers

Central bank can always assure same equilibrium allocation, prices

Equivalence

Theorem Given equilibrium, consider span neutral, liquidity neutral OMO with compensating transfers

Central bank can always assure same equilibrium allocation, prices

Proof. Conjecture unchanged prices

PE: Liquidity neutrality $\Rightarrow$ wealth neutrality $\Rightarrow$ unchanged choice sets of households, firms $\Rightarrow$ unchanged choices

Pass through deposit supply *schedule* $\Rightarrow$ unchanged bank choices

GE: Unchanged commodity demands, supplies $\Rightarrow$ market clearing; securities markets continue to clear

Unchanged allocation, liquidity neutrality $\Rightarrow$ unchanged liquidity payoffs, prices $\square$

Applications

Central Bank Digital Currency

Equivalence

- No security s needed if same liquidity
- But possibly transfers at $t + 1$, depending on risk characteristics of CBDC vs. deposits

  Not needed if deposits are insured to start with (or households have same exposures to deposits, taxes)

What about **bank runs** …?

- Theorem: Initial equilibrium (or equilibria) still supported
- Beyond theorem: Should expect *fewer* bank runs

  One large depositor, *optimally* behaves differently

  Remaining small depositors have less incentive to run

Chicago Plan and “Vollgeld” - for “stable coins”

Equivalence

- Extreme form of CBDC
- Requires pass-through at deposit rates

  But “Vollgeld” proposal aims at redistribution

Cryptocurrency

Proof of work

- No equivalence

No proof of work

- Stable coin: Equivalence
- Partial backing (fractional reserve): Sufficient conditions for equivalence require transfers

Conclusions

Contributions

General model Liquidity and value, bubble, seignorage
Equivalence conditions Applications, CBDC, run risk

When should we expect *non*-equivalence?

- Limited transfers, limited substitutability of monies
- Restrictions on pass through: Information, differential collateral requirements (central bank independence)

  Not an issue with competitive banks
- Political economy (Gonzalez-Eiras and Niepelt, 2015)

*

References

Andolfatto, D. (2018), Reconciling orthodox and heterodox views on money and banking, Working Paper 2018-27A, Federal Reserve Bank of St. Louis, St. Louis.

Barro, R. J. (1974), 'Are government bonds net wealth?', *Journal of Political Economy* **82**(6), 1095–1117.

Baumol, W. J. (1952), 'The transactions demand for cash', *Quarterly Journal of Economics* **67**(4), 545–556.

Benes, J. and Kumhof, M. (2012), The Chicago plan revisited, Working Paper 12/202, International Monetary Fund, Washington.

Bewley, T. F. (1980), The optimum quantity of money, *in* J. H. Kareken and N. Wallace, eds, 'Models of Monetary Economies', Federal Reserve Bank of Minneapolis, Minneapolis, pp. 169–210.

Brunnermeier, M. K. and Sannikov, Y. (2016), The I theory of money, Working Paper 22533, NBER, Cambridge, Massachusetts.

Bryant, J. (1983), 'Government irrelevance results: A simple exposition', *American Economic Review* **73**(4), 758–761.

Calomiris, C. W. and Kahn, C. M. (1991), 'The role of demandable debt in structuring optimal banking arrangements', *American Economic Review* **81**(3), 497–513.

Calvo, G. A. (1983), ‘Staggered prices in a utility-maximizing framework’, *Journal of Monetary Economics* **12**(3), 383–398.

Chamley, C. and Polemarchakis, H. (1984), ‘Assets, general equilibrium and the neutrality of money’, *Review of Economic Studies* **51**(1), 129–138.

Clarida, R., Galí, J. and Gertler, M. (1999), ‘The science of monetary policy: A New Keynesian perspective’, *Journal of Economic Literature* **37**(4), 1661–1707.

Clower, R. W. (1967), ‘A reconsideration of the microfoundations of monetary theory’, *Western Economic Journal* **6**(1), 1–8.

Diamond, D. W. and Rajan, R. G. (2001), ‘Liquidity risk, liquidity creation, and financial fragility: A theory of banking’, *Journal of Political Economy* **109**(2), 287–327.

Faure, S. and Gersbach, H. (2018), Money creation in different architectures, Discussion Paper 13156, CEPR.

Fisher, I. (1935), *100% Money*, Adelphi, New York.

Friedman, M. (1969), The optimum quantity of money, *in* M. Friedman, ed., 'The Optimum Quantity of Money and Other Essays', Aldine, Chicago, chapter 1, pp. 1–50.

Galí, J. (2008), *Monetary Policy, Inflation, and the Business Cycle*, Princeton University Press, Princeton.

Gonzalez-Eiras, M. and Niepelt, D. (2015), 'Politico-economic equivalence', *Review of Economic Dynamics* **18**(4), 843–862.

Grandmont, J.-M. and Younes, Y. (1972), 'On the role of money and the existence of a monetary equilibrium', *Review of Economic Studies* **39**(3), 355–372.

Gurley, J. G. and Shaw, E. S. (1960), *Money in a Theory of Finance*, Brookings Institution, Washington.

Holmström, B. and Tirole, J. (1998), 'Private and public supply of liquidity', *Journal of Political Economy* **106**(1), 1–40.

Kiyotaki, N. and Moore, J. (2012), Liquidity, business cycles, and monetary policy, Working Paper 17934, NBER, Cambridge, Massachusetts.

Kiyotaki, N. and Wright, R. (1993), 'A search-theoretic approach to monetary economics', *American Economic Review* **83**(1), 63–77.

Lagos, R. and Wright, R. (2005), 'A unified framework for monetary theory and policy analysis', *Journal of Political Economy* **113**(3), 463–484.

Lucas, R. E. (1980), Equilibrium in a pure currency economy, *in* J. H. Kareken and N. Wallace, eds, 'Models of Monetary Economies', Federal Reserve Bank of Minneapolis, Minneapolis, pp. 131–145.

Lucas, R. E. (1982), 'Interest rates and currency prices in a two-country world', *Journal of Monetary Economics* **10**(3), 335–359.

McCallum, B. T. and Goodfriend, M. S. (1987), Demand for money: Theoretical studies, *in* J. Eatwell, P. Newman and

M. Milgate, eds, 'The New Palgrave: A Dictionary of Economics', Macmillan Press, London, pp. 775–781.

Modigliani, F. and Miller, M. H. (1958), 'The cost of capital, corporation finance and the theory of investment', *American Economic Review* **48**(3), 261–297.

Niepelt, D. (2018), Reserves for all? Central Bank Digital Currency, deposits, and their (non)-equivalence, Discussion Paper 13065, CEPR.

Niepelt, D. (2020), 'Reserves for all? Central Bank Digital Currency, deposits, and their (non)-equivalence', *International Journal of Central Banking* **forthcoming**.

Samuelson, P. A. (1958), 'An exact consumption-loan model of interest with or without the social contrivance of money', *Journal of Political Economy* **66**(6), 467–482.

Sargent, T. J. (1987), *Dynamic Macroeconomic Theory*, Harvard University Press, Cambridge, Massachusetts.

Saving, T. R. (1971), 'Transactions costs and the demand for money', *American Economic Review* **61**(3), 407–420.

Sidrauski, M. (1967), 'Rational choice and patterns of growth in a monetary economy', *American Economic Review* **57**(2), 534–544.

Svensson, L. E. O. (1985), 'Money and asset prices in a cash-in-advance economy', *Journal of Political Economy* **93**(5), 919–944.

Tobin, J. (1956), 'The interest elasticity of the transactions demand for cash', *Review of Economics and Statistics* **38**(3), 241–247.

Tobin, J. (1963), Commercial banks as creators of "money", Discussion Paper 159, Cowles Foundation, New Haven.

Tobin, J. (1969), 'A general equilibrium approach to monetary theory', *Journal of Money, Credit, and Banking* **1**(1), 15–29.

Tobin, J. (1985), 'Financial innovation and deregulation in perspective', *Bank of Japan Monetary and Economic Studies* **3**(2), 19–29.

Townsend, R. M. (1980), Models of money with spatially separated agents, *in* J. H. Kareken and N. Wallace, eds, 'Models of Monetary Economies', Federal Reserve Bank of Minneapolis, Minneapolis, pp. 265–304.

Wallace, N. (1980), The overlapping generations model of fiat money, *in* J. H. Kareken and N. Wallace, eds, 'Models of Monetary Economies', Federal Reserve Bank of Minneapolis, Minneapolis, pp. 49–82.

Wallace, N. (1981), 'A Modigliani-Miller theorem for open-market operations', *American Economic Review* **71**(3), 267–274.

Woodford, M. (1990), 'Public debt as private liquidity', *American Economic Review* **80**(2), 382–388.

Woodford, M. (2003), *Interest and Prices*, Princeton University Press, Princeton.