

Peer-to-Peer Public Money System

– Focusing on Payments –

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*Throughout our history no economic problem has been more passionately discussed than the money problem. Probably none has had the distinction of suffering so much from general misunderstanding... As a result, not only is our monetary system now wholly inadequate and, in fact, unable to fulfill its function; but the few reforms which have been adopted during the past three decades have been **patch-work**, leaving the basic structure still unsound.*

— Irving Fisher, et al. [3, 1939, emphasis added]

Abstract

Lehman Shock in 2008 was the final proof that our current debt money system does not work. In that year, two historical publications took place coincidentally, which might transform our current money system of more than 250 years old: ASD macroeconomic model and Bitcoin.

Since then, with the ASD modeling method, the alternative system design of debt-free money, first proposed by Irving Fisher [2, 1933], has been developed as the public money system [19, 2013]. It provides a significant part of economic solutions, but it lacks a system design of

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bitcoin, a peer-to-peer blockchain-based payment, proposed by Nakamoto [6, 2008].

This paper proposes a unified design that integrates public money system and peer-to-peer blockchain technology as *p2p public money system*. It identifies 6 different payments, with simple SD models, under the current debt money system, and argues that these complicated payments remain under the public money system to a certain degree, but gets simplified into only one peer-to-peer payment under the p2p public money system, eliminating income inequality between financiers and non-financiers. Finally, it suggests the need for world-wide blockchain protocols that enable these transactions of p2p public money system.

1 Introduction: The Year 2008

Currently we are living under the debt money system which has evolved since the middle of 18th century. This is a system in which money can be issued against someone's debt at interest. The year 2008 became the epoch-making year. First, the so-called Lehman Shock of financial crisis hit our economy, providing the final proof, following the Great Depression in 1929, that our current debt money system does not work. Second, two papers were published in that year, which might eventually transform our current debt money system into a new economic system of public money; that is, the accounting system dynamics (hereafter called ASD) macroeconomic model by Kaoru Yamaguchi [14, 2008] and Bitcoin by Satoshi Nakamoto [6, 2008].

ASD Macroeconomic Model

Yamaguchi [10, 2003] proposed the Principle of Accounting System Dynamics, a new modeling method that combines Accounting System - a robust double-entry bookkeeping foundation of social science - and System Dynamics - a dynamical foundation of differential equation in natural science. By applying this ASD method, the author has developed a series of macroeconomic modeling step-by-step; [11, 2005], [12, 2006], [13, 2007]. Then at the 26th international conference of the system dynamics society held in Athens, Greece, July 20-24, 2008, he presented a complete ASD open macroeconomic model as cited above.

Lehman Shock took place on the 15th of September, less than two month after his presentation of the paper. Being deeply distressed by this economic disaster, he began to search for a new economic system which will be free from the failure of the current debt money system; [15, 2009], [16, 2010], [17, 2011], [18, 2012], [20, 2014], [22, 2015], [23, 2016]. His research has been led by the so-called Chicago Plan of monetary reform [3, 1939].

In his book [19, 2013], the public money system is proposed as the alternative system to the current debt money system. He further introduced this alternative system in Japanese [21, 2015]. The upper part of Figure 1 briefly illustrates how the proposal of the public money system has evolved since the year 2008.



Figure 1: Public Money System and Blockchain Revolution

Bitcoin

In the year 2008, Satoshi Nakamoto, a pseudonymous author, submitted a 9 page paper: Bitcoin: A Peer-to-Peer Electronic Cash System [6, 2008], and its implication of peer-to-peer Bitcoin transaction began on Jan. 3, 2009 on the internet. The essence of peer-to-peer electronic cash system or bitcoin is summarized elegantly in the first sentence of the original paper

A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution [6, 2008].

Bitcoin is the first decentralized electronic cash payment system on the internet that has solved "double-spend" problem, by combining the innovative technologies of cryptography and blockchain. According to [1, 2015], Bitcoin "includes four key innovations brought together (p.3):

- A decentralized peer-to-peer network (the bitcoin protocol)
- A public transaction ledger (the blockchain)
- A decentralized mathematical and deterministic currency issuance (distributed mining)

- A decentralized transaction verification system (transaction script)

Since then blockchain technology has been revolutionizing the way we communicate and organize our society, including payment system. The lower part of Figure 1 briefly illustrates how the blockchain technology has been evolving since the year 2008. According to the journal, *Economist*, it is the most innovative technology since the invention of double-entry bookkeeping accounting and joint stock ownership more than 200 years ago, and "could transform how the economy works":

The notion of shared public ledgers may not sound revolutionary or sexy. Neither did double-entry book-keeping or joint-stock companies. Yet, like them, the blockchain is an apparently mundane process that has the potential to transform how people and businesses co-operate. Bitcoin fanatics are enthralled by the libertarian ideal of a pure, digital currency beyond the reach of any central bank
 – *The Economist*, Oct. 31st 2015.

Indeed, Blockchain technology is now affecting not only electronic payment but also "everything of value and importance to humankind" as specifically pointed out:

Some scholars have argued that the invention of double-entry bookkeeping enabled the rise of capitalism and the nation-state. This new digital ledger of economic transactions can be programmed to record virtually everything of value and importance to humankind: birth and death certificates, marriage licenses, deeds and titles of ownership, educational degrees, financial accounts, medical procedures, insurance claims, votes, provenance of food, and anything else that can be expressed in code (p.7). [9, 2016].

Unfortunately, however, many financial and banking applications of blockchain technology are now being developed and applied under the effete current system of debt money, as illustrated in the lower part of Figure 1. The current debt money system is shown to have system design failures of monetary instability [23, 2016]. Therefore, applications of blockchain technology under the current system are nothing but banking patchworks, and can be said to be destined to doom.

The purpose of this paper is to re-direct the blockchain technology toward the public money system so that it can draw a unified design of "peer-to-peer public money (electronic public money, EPM) system".

2 What are Money and Bitcoin?

2.1 Money as Legal Tender

Bitcoin was originally referred to as "peer-to-peer electronic cash" by Satoshi Nakamoto in his paper [6, 2008], then began to be called cryptocurrency, digital

currency, virtual currency, digital money, etc. Is it really cash, or currency, or money? As researchers in monetary economics, we feel very uncomfortable with such inexplicit naming. Accordingly, it is better to start precisely defining what money and Bitcoin are.

Money is fundamentally nothing but information of value. Information in general needs media that carries it. As such, it does not concern how it is represented on what kind of physical media except that its unit of measure is defined by law (legal tender) as posed by the Greek philosopher Aristotle (384-322 BC) in ancient Greece. He claimed money as follows:

and this is why it has the name *nomisma* - because **it exists not by nature, but by law (*nomos*)** and it is in our power to change it and make it useless [24, p.34].

Contrary to his recognition, money has historically been thought in terms of its physical characteristics, even though it has changed its form of media from physical to abstract one through the development of technology. For example, money in Japan is defined in terms of government coins, Bank of Japan notes and electronic digits in the deposits ledgers of bank database, all of which have no intrinsic values. Table 1 from Yamaguchi [19, p.131] classifies various media of money into two categories; that is, public money and debt money. Public money is the one issued by the consent of the public, while debt money is the one issued privately at interest.

Classification of Money			
	Public Money		Debt Money (at interest)
Media	Money as Legal Tender		Functional-Money
Non-metal Commodities	Shell, Cloth (Silk) Woods, Stones, etc		
Metal Coinage	Non-precious Metal Coins Gold, Silver & Copper Coins		(Metal Ingots: such as Gold)
Paper Notes	Public Money Admin. and Government Notes	Goldsmith Certificates Central Bank Notes	
Electronic Card & Substitutes	Electronic Cash (Intangible Digits)		Deposits (Credits by Loans)
Blockchain	P2P Electronic Money	(not in use)	(Bitcoin as Ingots)

Table 1: Public Money vs Debt Money

Today, as one can see from Table 1, almost all of medium of exchange used in daily transactions are in the form of intangible digits, starting roughly around 1970's. Unfortunately, however, Adam Smith (1723-1790), known as the father of economics, reversed the definition of money by Aristotle as follows:

By the money price of goods it is to be observed, I understand always, *the quantity of pure gold and silver* for which they are sold, without any regard to denomination of the coin. [24, p.313].

In this way, Adam Smith reversed definition of *money as legal tender* and defined it as commodity. This erroneous logical step by the father of economics planted dogma into the heads of many people until this day. Advancing his idea more axiomatically, many macroeconomics textbooks define money as the entity that meets the following three functions; (1) unit of account, (2) medium of exchange and (3) store of value. According to this axiom of money, gold and silver can be best qualified as ideal money, because *by nature* their physical property perfectly meets these three functions of money. This reversed definition of money has become a root cause of confusion even among professional economists, not to mention the public who are heavily influenced by them. Unfortunately, the same logical deduction is widespread among virtual currency enthusiasts.

2.2 Bank Deposits as Functional-Money

Money we use in our daily transactions is called *money stock* as monetary aggregate according to standard textbooks. It is defined as

$$\text{Money Stock} = \text{Currency in Circulation} + \text{Deposits} \quad (1)$$

Money stock thus defined is the total amount of money available in the economy as medium of exchange, regulating transactions and economic activities. The word, currency, appeared in this definition of money stock for the first time. It is strictly defined as

$$\text{Currency} = \text{Coins} + \text{Central Bank Notes} \quad (2)$$

Therefore, currency is the same as "cash", and by definition it is *legal tender* in the sense that no one can reject to receive it for transactions.

How about deposits? Are they also money as *legal tender*? According to Masaaki Shirakawa, former governor of the Bank of Japan, the answer is negative.

Contrary to the central bank notes, creditors can refuse to accept bank deposits as the payments of debt obligations because of credit risks associated with bankruptcies of debtors' banks. However, in normal times, bank deposits **function as money** because of creditors' confidence that bank deposits can be converted to central bank notes [8, p.13] (translated by the authors).

In this sense, bank deposits are neither money as *legal tender* nor currency. That is why they are called *functional-money* in Table 1. Yet, they are widely accepted as the most important means of economic transaction, because their convertibility with legal tender is presumed at least by the recipients of such transactions. Accordingly, many people, including economists and bankers, regard deposits mistakenly as currency. Let us emphasize in this paper that bank deposits are nothing but *functional-money*, absolutely not *currency* at all.

2.3 Bitcoin as Functional-Money

Since the introduction of bitcoin, many confusions have emerged as to the usage of money. Before bitcoin, electronic money (digits) saved in electronic card, etc., in exchange for currency (cash) is the only digital currency or e-cash.¹

Bitcoin is referred to as digital currency, crypto currency, electronic currency, virtual currency, etc. as if it is currency or cash.

Indeed, if it's not cash, peer-to-peer transaction cannot take place. Therefore, bitcoin is interpreted as "a peer-to-peer electronic cash" in the paper by its originator, Satoshi Nakamoto, as if it is exchanged as currency.

Yet, from our strict definition of currency discussed above, bitcoin is not legal tender, and cannot be currency, because we can refuse to accept it for transactions. In this sense, it would be more appropriate to regard it as "bitcoin ingot" or "crypto ingot" similar to gold ingot, which can be only accepted as long as both sides of transaction agree. Consequently, it is functional-money, similar to deposits, according to our classification of money in Table 1.

3 Debt Money System

3.1 System Structure of Debt Money

Our current economic activities are being run under the debt money system. System structure of the debt money is summarized in Table 2, which is taken from [19, Chapter 15]. It is a fully centralized system in which bank notes are issued by the privately-owned central banks, and bank deposits as functional-money are created and destructed by commercial banks out of nothing due to a fractional reserve banking system.

	Public Money System	Debt Money System
Money Issuer Its Owner	Public Money Administration Government (Public)	Central Bank Private Banks and Financiers
Bank Reserves	100% Reserve	Fractional Reserve
Money Supply	Public Money directly put into Circulation as Economy grows Private Banking unaffected	Base Money: by Central Bank Deposits: by Bank Loans Money in Circulation: by Public
Interest	Interest-free	Interest-bearing Debt
Economic Policies	Public Money Policy (Public Money Financing)	Monetary Policy: Central Bank Fiscal Policy: Government

Table 2: Public Money vs Debt Money System Structures

¹Debit cards and credit cards such as Visa are not E-cash. They are used for payments in exchange for deposits at banks through card companies as nonbank intermediaries of deposits.

3.2 System Behaviors of Debt Money

Behaviors of the debt money system are also compactly summarized in Table 3 taken from [19, Chapter 15]. Debt money system triggers monetary and financial instabilities which in turn cause boom and bust, followed by the accumulated debt of government due to the fiscal policy to recover from economic recessions. As a result, it also causes income inequality and environmental destructions. Accordingly, debt money system is concluded to have built-in system design failures in [23, 2016].

	Public Money System	Debt Money System
Monetary Stability	Stable Money Supply Stable Price Level	Bubbles and Credit Crunches Inflation & Deflation
Financial Stability	No Bank-runs	Business Cycles (Booms and Depressions)
Employment	Full Employment	Involuntary Unemployment
Government Debt	No Government Debt	Built-in Debt Accumulation → Recession & Unemployment
Inequality	Income Inequality between Workers and Capitalists	Income Inequality between Financiers and Non-financiers
Sustainability	Sustainability is Possible	Accumulated Debt → Forced Growth → Environmental Destruction

Table 3: Public Money vs Debt Money System Behaviors

a. Instability of Functional-Money

Since monetary stability is the most important feature of system design failure, let us further consider it according to [23, 2016]. Under the debt money system, deposits are created by commercial banking sector tied with bank loans. As such, when banks make new loans, new deposits are created. When loans are repaid, deposits are destroyed. That is to say, money stock, mainly consisting of deposits, for transactions is *endogenously* created or destroyed. This leads to the instability of money stock in the economy especially in the period of booms and busts. Inevitable results are bank run, credit defaults, bankruptcies followed by unemployment and long term economic recessions.

In this way, current debt money system of fractional reserve banking has built-in system design failure that inherently causes monetary instability. To be more specific, what will happen if capricious attitudes of the public toward liquidity preferences and impatient lending behaviors of bankers are combined in the economy? Figure 2 taken from [23, 2016] illustrates these combined effects on the money stock. The fluctuation of money stock (line 2) gets amplified irrespective of the stable base money (line 1).

Base money (= currency in circulation + reserves) is still stable, yet compound changes in currency and lending ratios trigger wilder instability of money

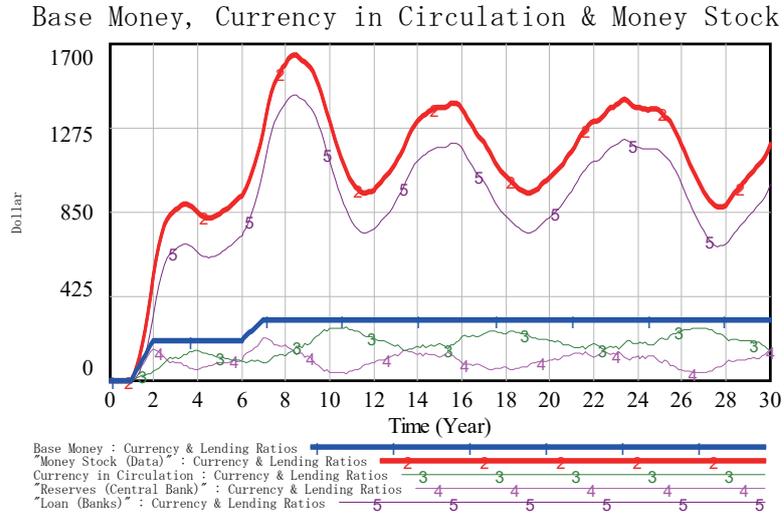


Figure 2: Amplified Instability of Money Stock under Stable Base Money

stock. This amplified behaviors of the system reminds us of "Bullwhip Effect" in supply chain; that is, roaring production in upper stream caused by relatively stable downstream demand. System dynamics researchers would unanimously agree that this is an example of *system design failure!*

b. Government Debt Accumulation

Under the debt money system, government borrows money from private commercial banks (and indirectly from central bank and the public through its securities holding). Therefore, government is destined to accumulate its debt and pay ever increasing interests to its security holders such as private banks and central bank.

In 2008, our global economy was hit by another financial crisis followed by long-term recession. Private sectors stopped borrowing money from banks, and government is, instead, forced to borrow to overcome economic recessions, further accumulating its debts. These accumulated debts will surely trigger another type of crisis; debt crisis. In system dynamics, when an event is observed repeatedly and becomes a pattern, there is a specific structure of system that produces such pattern of behavior. Following this scientific approach, Yamaguchi [19, 2013] explored system structure of the current debt money system by applying accounting system dynamics method and identified it as a debt-end system. In short, current debt money system is sooner or later globally destined to crash.

c. Income Inequality between Financiers and Non-financiers

The current debt money system inevitably brings about inequalities between interest-earning financiers and non-financiers. This system behavior will be more precisely explored after we examine the payments of the current debt money system in the following section.

4 Payments under Debt Money System

We are now in a position to explore payment methods of the current debt money system in detail. Payments have to be done with money stock that consists of currency (cash) and demand deposits. Accordingly, payments are divided into two categories; payments with cash and payments with deposits. Payments with deposits are further broken down into the one through banks and the other through nonbanks. Figure 3 illustrates these payment methods; payments with cash (① and ②), payments through banks (③ and ④), and payments through nonbanks (⑤ and ⑥).

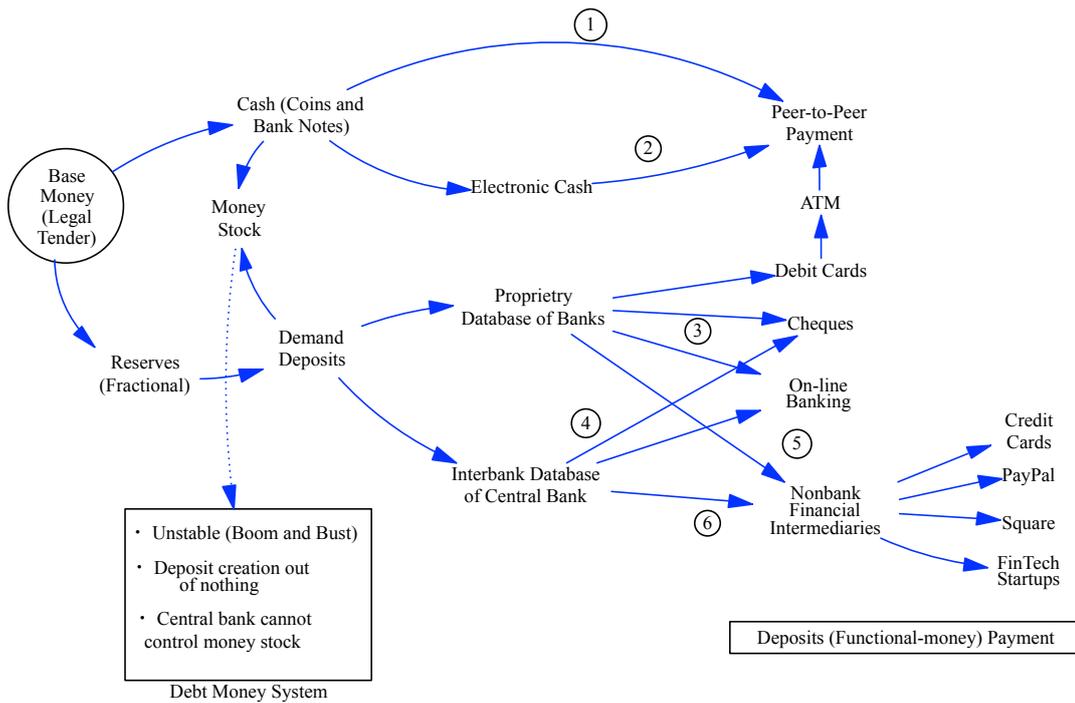


Figure 3: Overview of Debt Money Payment Systems

4.1 With Cash and Electronic Cash

① Payments with Cash

Money Stock consists of cash and deposits. In Japan, Currency in Circulation as cash constitutes only as much as 15% and the remaining 85% are deposits. Let us explore, first, how cash is used for transactions. Figure 4 is a simple SD model of transaction with cash. Cash moves from buyers to sellers, while goods and services co-flow in an opposite direction.

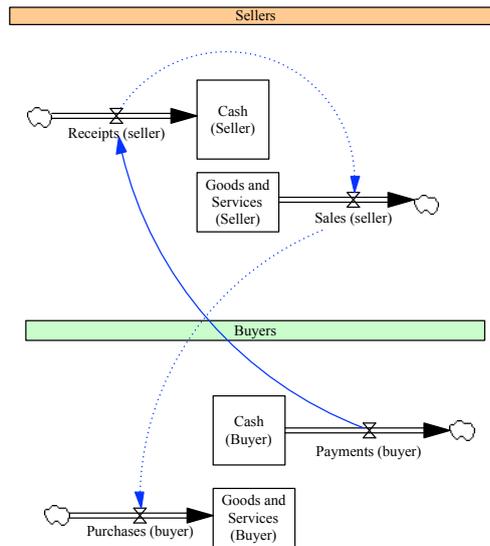


Figure 4: Payment System with Cash: Peer-to-Peer

② Payments with Electronic Cash

Cash can be easily substituted by electronic cash. Electronic digits are stored in electronic cards as prepaid cash in exchange for currency (coins and bank notes), and used for transactions. Since payments with electronic cash is convenient, this type of payment is getting widely used. This payment model is presented in Figure 17 in the Appendix

4.2 With Deposits through Banks as Intermediaries

③ Payments through Banks

Deposits as functional-money are created out of nothing as electronic digits (data base) in the computers of banks as already explained above.. They are used for transactions by transferring them in the databases of buyers or sellers

or their inter-bank databases at the central bank by means of debit cards, credit cards and cheques.

Traditionally most payments are done through cheques, and recently by on-line banking. If buyers and sellers reserve their checking accounts in the same bank, their transactions can be easily done through the proprietary database of their bank. This payment is modeled in Figure 18 in the Appendix

④ Payments Settled through Central Bank

If buyers and sellers have their checking accounts at the different banks, their transactions have to be cleared thorough the inter-bank database at the central bank. This payment is modeled in Figure 19 in the Appendix.

4.3 With Deposits: Non-banks as Intermediaries

⑤ Payments through Nonbanks and Banks

Recent FinTech revolution is advancing in the area of deposit payments; that is, payments by smart phones such as iPhone. Some examples are PayPal, ApplePay, Square Reader(NFC) and Square Stand. Traditional service charge for credit card is between 5% and 8%. Square now offers only 3.25% for similar services. This reduction of service charge is due to FinTech revolution. All other credit cards are forced to reduce their service charges of 4% - 5% to around 3%. In this way FinTech revolution is advancing the efficiency of credit card payments.

When buyers and sellers as well as nonbank intermediaries such as credit cards have their checking and deposits accounts within the same bank, their transactions are done through the proprietary database of the same bank. This payment is illustrated in Figure 20 in the Appendix

⑥ Payments through Nonbanks and Central Bank

When buyers, sellers and nonbank intermediaries such as credit cards keep their checking and deposits accounts at different banks, their transactions are cleared through the inter-bank database at the central bank. This payment is modeled in Figure 21 in the Appendix.

4.4 Income Inequality caused by Payments

(c) Income Inequality (continued)

We are now ready to continue our assertion of the previous section on the income inequality as a system design failure of debt money. Under the debt money system, most transactions are done through the accounts of deposits, which are created out of nothing as functional-money. When we make loans at interest, interest payments go out of the equity of borrows into the equity of banks. When buyers use credit cards, that is, they make loans from nonbank intermediaries

and pay by installment, they have to pay higher interest to nonbanks. At the same time, sellers also have to pay card fees to nonbank intermediaries for the services they receive from them. In this way, equities of buyers and sellers move to equities of nonbank intermediaries and banks.

To sum, under the debt money system income re-distribution is forcefully done from non-financiers such as buyers and sellers to financiers such as banks and nonbank intermediaries. This is the main cause of income inequality under the current debt money system. If all payments are done with cash, no such income inequality never takes place. Figure 5 is produced by running "the payment system model through nonbank intermediaries and multiple banks" exhibited in Figure 21 in the Appendix. It shows how equities are shifted from non-financiers (lines 1 and 2) to financiers (lines 3 and 4) when buyers purchase goods and services of 10 (thousand) yen every 3 months for two years (line 6).

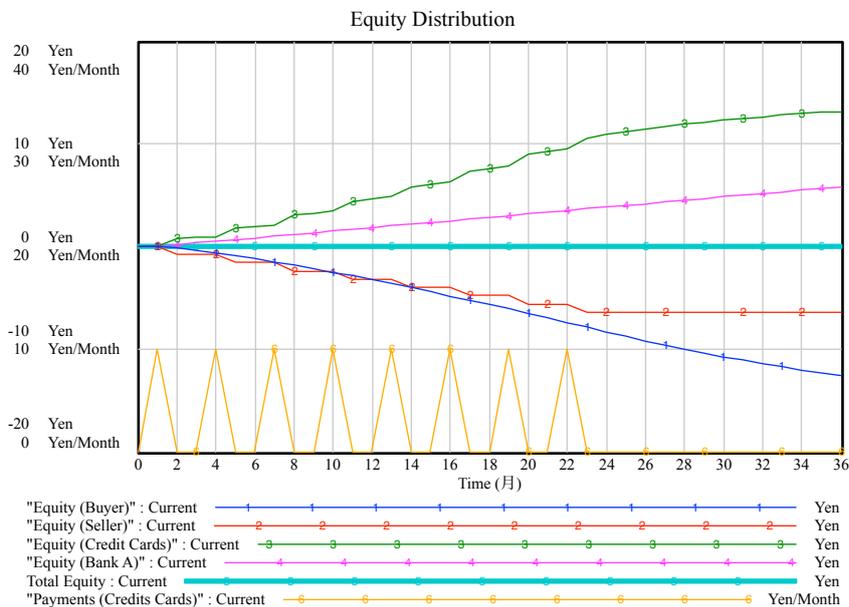


Figure 5: Income Inequality between Financiers and Non-financiers

In this way, the current debt money system has built-in system design failures such as (a) monetary instability, (b) government debt accumulation, and (c) income inequality.

5 Public Money System

5.1 The Origin: Chicago Plan and 100% Money

As the alternative system design to the effete debt money system, public money system is proposed in [19, 2013] and [23, 2016]. Before we examine its system structures and behaviors, it may be worth briefly visiting the origin of the public money system.

The Great Depression in 1929 was the first major economic disaster caused by the system design failures of the debt money system. Faced with this design failure, eight economists at the University of Chicago² proposed an alternative system design called "The Chicago Plan for Banking Reform" in 1933 [7]. The plan was, then, vehemently carried on by Irving Fisher, Yale University [2, 1935] and his group of five economists³ as "A PROGRAM FOR MONETARY REFORM" in [3, 1939] and later by Milton Friedman [4, 1960].

The authors of the monetary reform program in 1939 assert that the history of fractional reserve banking practices can at least be traced all the way back to private bankers in Venice in the middle of the Fourteenth century. They analyzed that those bankers who happened to find out that they could earn "handsome profits" by lending out other people's money were found out by the public to be *breach of trust*. *Banking alchemy* has started at least from the middle of the fourteenth century. Since then the age of free banking took place in which commercial banks issued their own bank notes against deposits of precious metals.

For various historical contexts and political reasons, fragmented private banking system began to be centralized through central banking system around 17th century. Then, industrialized nations in the west, having suffered from the deflation caused by gold standard, abolished it and made transitions into fiat currency system one after another. This transition into fiat currency system, from another perspectives, was a completion of *Debt Money System* in which money stock is no longer limited by physical amount of gold and silver.

The monetary reform proposal posed by these authors was to introduce 100% required reserve ratio for demand deposits such that

$$\text{Money Stock} = \text{Base Money} \tag{3}$$

Under the full reserve (100% money) system, functional-money disappears completely from the circulation and money stock becomes equal to legal tender

²They are; G.V. Cox, Aaron Director, Paul Douglas, A.G. Hart, F.H. Knight, L.W. Mints, Henry Schulz, and H.C. Simons. Their proposal was handed over, through Henry A. Wallace, Secretary of Agriculture, to the President Franklin D. Roosevelt on March 16, 1933. Unfortunately it failed to be implemented. Instead, less restrictive Banking Act of 1933 to bankers, known as Glass-Steagal Act was legalized on June 16, 1933, by FDR. See [7, 1995]. The Act was repealed in 1999 by the President Bill Clinton, which was claimed to have triggered the financial crisis in 2008.

³They are; Paul H. Douglas, University of Chicago; Frank D. Graham, Princeton University; Earl J. Hamilton, Duke University; Willford I. King, New York University; and Charles R. Whittlesey, Princeton University.

(that is, base money). Accordingly, monetary stability is completely restored and money stock never gets affected by the changes in currency ratio and lending ratio as well as repayment of loans as demonstrated in the above Figure 2.

5.2 System Structures of Public Money

The system structures of the public money as the alternative system design are compactly summarized in the above Table 2. To be specific,

- Public money is issued by the public money administration.
- Full (100%) reserve ratio is required.
- Public money is put into circulation to sustain economic growth and welfare at interest-free.

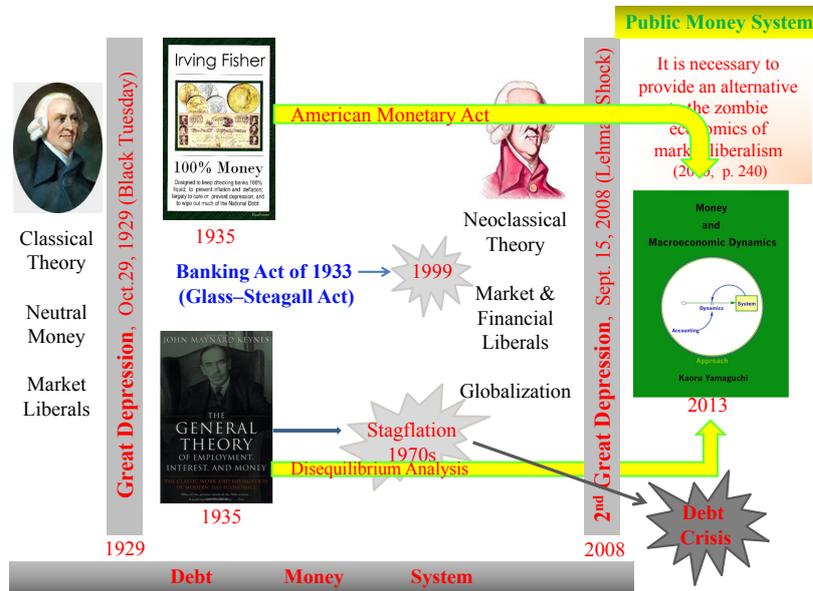


Figure 6: From Debt Money to Public Money Systems

Figure 6 illustrates a transition from the debt money system to the public money system. It shows that macroeconomic theory of public money is the integration of two alternative theories proposed in 1935 after the Great Depression in 1929; that is; The General Theory by John M. Keynes [5, 1935] and 100% Money by Irving Fisher [2, 1935].

Issuance of Public Money

Who should create public money, then, in place of the privately-owned central banks? Its issuer has to be a public organization politically independent from the influences of government and vested interest groups, and at the same time be the sole entity under the publicly elected legislative management such as Congress, Parliament and Diet. Such an organization is called the *Public Money Administration* (PMA) in Yamaguchi [19, 2013]⁴

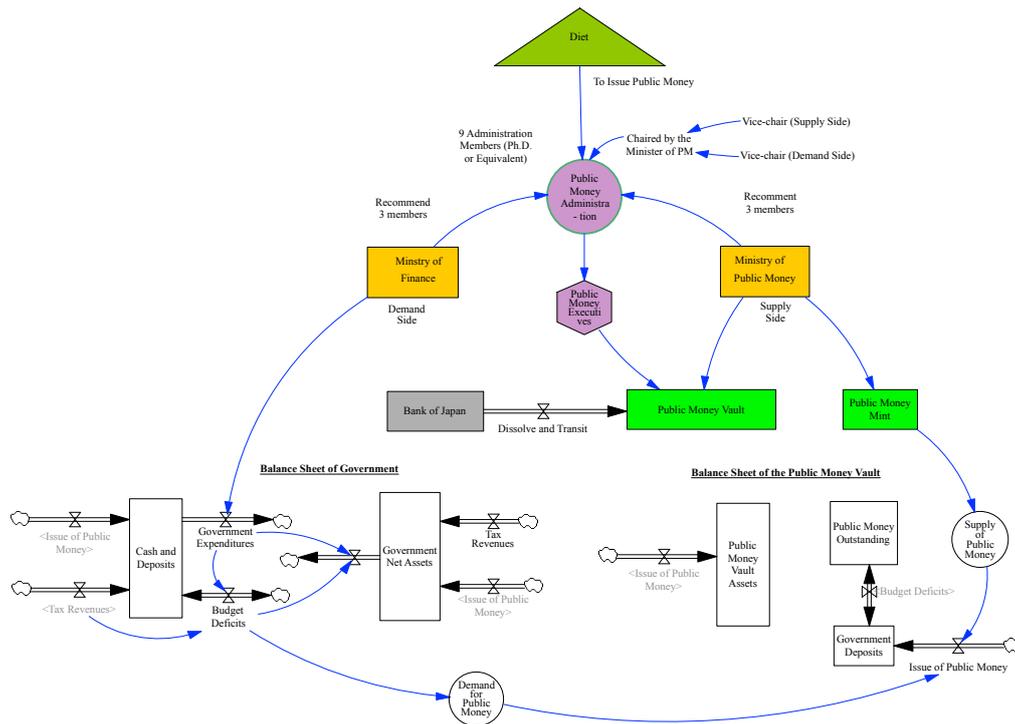


Figure 7: Organization of Public Money Administration in Japan

To make this alternative system design workable by avoiding political pressures of printing more money and causing inflation, the following two conditions have to be strictly met.

- C1. The public money administration plays a role of *supply side* of public money, while the government (Dept. of Treasury, Ministry of Finance, etc.) plays a role of *demand side*. The amount of public money is determined by the interplay of demand and supply sides.

⁴Chapter 15 of his book compares system structures and behaviors of debt money and public money systems, and the next chapter 16 presents a generic transition process from the debt money system to the *public money* system. The specific transition process in the case of Japan is proposed in [21, 2015].

C2. Transparency on the decision process of public money issuance has to be fully guaranteed to the public.

To implement them, the organizational structure of demand and supply of public money is proposed in [21, 2015], as illustrated in Figure 7. Public money administration is established under the direct supervision of the Diet as an politically independent organization from the influences of the government and politicians as well as special interest groups and lobbyists.

Some examples of public money spending policies are as follows.

- Public investment in education and research (tuition-free higher education etc.) as human and future investment.
- Investment for constructing 21st century infrastructures such as IT network, green energies, and green transportation.
- Universal medical and healthcare program and other social welfare programs.

5.3 System Behaviors of Public Money

aa. Monetary and Financial Stability

Table 3 compactly summarizes the behaviors of the public money system. As expected, three main system design failures are shown to be removed; that is, (a) monetary and financial instability, (b) accumulated government debts, and (c) income inequality between financiers and non-financiers. Let us examine (a) first. Under the public money system, monetary and financial stabilities are attained, followed by the fulfillment of full employment. Figure 8, taken from

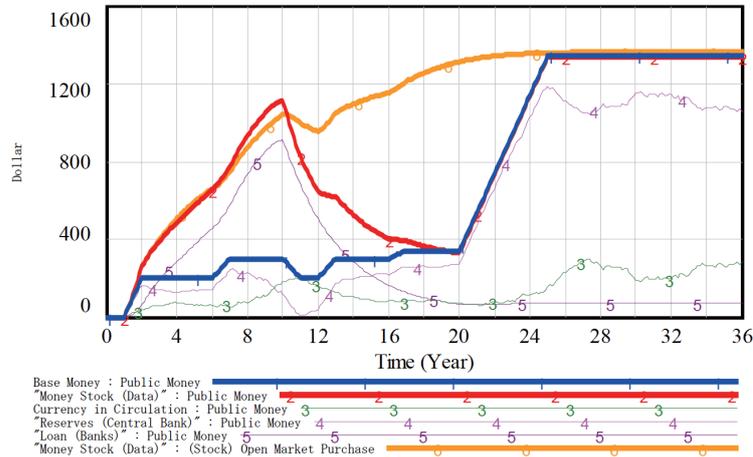


Figure 8: Public Money Put into Circulation at t=18 for 5 years

[23, 2016], shows how unstable money stock (line 2) illustrated in Figure 2 is stabilized under the public money system, because money stock becomes equal to base money. Moreover, in the Figure public money of \$200 is assumed to be newly issued (line 1) at $t=18$ for 5 years, totaling the input of \$1,000. This process can be done as fast as over night, for example. In this way, the original level of money stock (line 6) under debt money system is stably restored by the newly created public money under the public money administration. If further money stock is needed for the expanded economic activities and social welfare, more amount of public money is surely put into circulation by the public money administration.

bb. No Government Debts

Concerning (b) government debts, government now becomes debts free as its securities are getting paid off with public money whenever they become due. As a result, government becomes free-hand to pursue its public policies without being constrained by the burden of national debts.

cc. Income Inequality

Concerning (c) income inequality, it's better to explore its payments methods first as we did in the previous section, to find out how income inequality gets reduced under the public money system.

5.4 Payments under Public Money

Banks as Genuine Intermediaries

Under the public money system banks can no longer create functional-money (deposits) and become genuine intermediaries. As a result, their business models are forced to change and their new sources of income become the following two.

Service Charges. Under the public money system, commercial banks are obliged to fully hold customers' deposits. In consequence, depositors can safely use their money anytime for their transactions and economic activities. In exchange, they are asked to pay service charges to the banks for these transaction services, like the present-day ATM service charges. These service charges in turn become stable source of earned income to the commercial banking sector. In this way a robust and stable financial foundation will be established.

By definition, banks no longer need to look for reserves in the inter-bank money market. Thus, inter-bank rate become less applicable for borrowing or lending excess reserves one another. In this sense, the public money administration (former central bank) will be free from complex market operations conducted daily under the current debt money system.

Earned Interest Income. If deposits are fully obliged to be kept at banks, how can those banks find extra money for making loans? Loanable funds come from three sources: their own capital (retained earnings), newly repaid loans and time deposits (savings). Among these, time deposits will constitute a main source of

loanable funds. Time deposits are nothing but extra amount of deposits that are not needed for daily and short-term transactions so that they are saved to the time deposits account.⁵

Income Inequality still remains

Under the public money system, monetary stability is restored and government debts are liquidated. Yet, payment methods do not change drastically; that is, payment methods ① through ⑥ discussed in Section 4 remain the same except that banks can no longer charge interest on their loans out of nothing. In other words, income inequality between bankers and non-bankers are reduced by the amount of loan interests. Yet, nonbank financiers continue to charge transaction fees so that income inequality between financiers and non-financiers still remains as before, though its level gets more moderate.

6 Bitcoin and Blockchain Revolution

6.1 Payments with Bitcoin

⑦ Payments with Bitcoin

It is already pointed out above that bitcoin is neither legal tender nor currency by all means; that is, it must be functional-money. Accordingly, if we want to use bitcoin for transaction, it must be exchanged for currency, or deposits. This relation is briefly illustrated in Figure 9 as overview of payments with bitcoin. Therefore, it's better to be called digital (or crypto) ingot, similar to gold ingot. Gold ingots have been historically used to clear trade balances, and are nowadays traded as investment commodities. In this sense, it is appropriate if we interpret bitcoin as digital ingot, which plays a role of functional-money, similar to bank deposits that can be legally refused to accept as a means of transaction payments. Indeed, Figure 9 demonstrates how it is constrained as a means of exchange.

Figure 22 in the Appendix presents its detailed payment system. Even though bitcoin payments are peer-to-peer and in this sense the same as cash payments in Figure 4, it requires additional exchanger sector of bitcoin, similar to gold traders.

6.2 How Bitcoin Transactions Work?

Distributed Ledger

Until the introduction of bitcoin, the only payment method with digital currency is through electronic cash stored in prepaid cards, etc. as illustrated in Figure

⁵A detailed accounting representation of this transaction is laid out in the paper [23, 2016]. Since this paper only focuses on the transaction payments, investment activities and earned interest income from investment returns are not further discussed here.

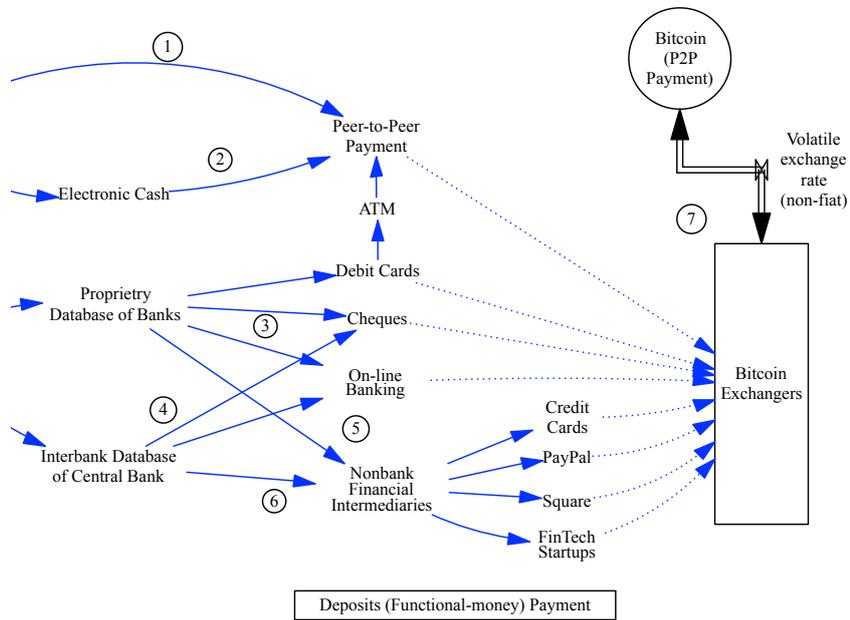


Figure 9: Overview of Debt Money and Bitcoin Payments

17 in the Appendix, because of the difficulty to avoid the so-called *double-spend* problem.

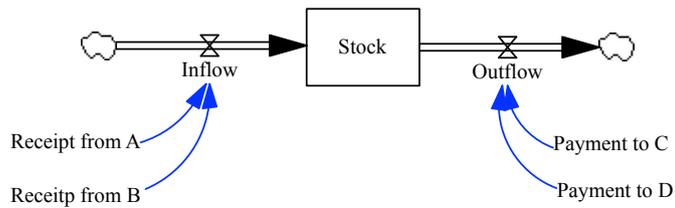


Figure 10: Stock-Flow Presentation of Transaction Ledger

In system dynamics modeling, cash flow of peer-to-peer transaction can be easily captured by stock-flow diagram as in Figure 10, whose dynamic equations are written as follows:

$$\begin{aligned}
\text{Inflow}_t &= \text{Receipt from A}_t + \text{Receipt from B}_t \\
\text{Outflow}_t &= \text{Payment to C}_t + \text{Payment to D}_t \\
\text{Stock}_{t+1} &= \text{Stock}_t + \text{Inflow}_t - \text{Outflow}_t, \quad t = 0, 1, 2, \dots
\end{aligned} \tag{4}$$

Without losing generality, these equations of stock-flow relation are easily broken down and re-arranged into an accounting ledger of inputs and outputs relation at a discrete time $t = 0, 1, 2, \dots$ such that

$$\text{Inputs}_t \left\{ \begin{array}{l} \text{Stock(unspent)}_t \\ \text{Receipt from A}_t \\ \text{Receipt from B}_t \end{array} \right. \implies \text{Outputs}_t \left\{ \begin{array}{l} \text{Payment to C}_t \\ \text{Payment to D}_t \\ \text{Stock(unspent)}_{t+1} \end{array} \right. \tag{5}$$

This is how system dynamics structure of stock-flow relation is transformed into distributed ledger of transaction and propagated to the Bitcoin network and shared with decentralized Nodes world-wide. Almost every 10 minutes these transactions are collected and put into a *block*. The so-called miner who has solved the mathematical problem for the first time is given the right to validate the block and add it to the previous chain of block called *blockchain*.

Once new blockchain is created in this way, the transaction in the latest block becomes authenticated, and transactions will be confirmed by having the subsequent blocks built upon the block, reinforcing its validity. No centralized authority through trusted third parties such as banks is needed to authenticate this blockchain. This vividly contrasts with payments described above under the debt money system, in which every transaction in our economy has to be executed through the centralized and trusted third parties.

This decentralized peer-to-peer trust networks is starting to fundamentally changing the payment methods in finance. A fundamental difference between the debt money system and Bitcoin is that ledgers are controlled by centralized institutions in the debt money system, whereas in Bitcoin, they become decentralized open-source public ledgers.

6.3 Impediments of Bitcoin Payments

Volatility of Bitcoin Value

Though peer-to-peer bitcoin transaction seems to be getting popular, we want to point out two fundamental impediments that bitcoin payments face under the current debt money system; that is, volatility of bitcoin value and its supply limitation. Let us take a look at volatility issue first.

Figure 11 is the time series data of bitcoin price for the last two years. Bitcoin price has been fluctuating as if it is gold price. Because of this volatility of price, it has not been so seriously used as a means of transaction, instead, it has been regarded as an investment target similar to gold.



Figure 11: Bitcoin Price Volatility in the last 2 years. Source: blockchain.info

Root cause of this volatility is that it is nothing but functional-money, and not *legal tender*. As long as bitcoin is used under the current debt money system, bitcoin cannot replace currency as legal tender, forever.

Limitation of Bitcoin Supply

Bitcoin protocol is programmed such that its maximum amount is attained at 21,000,000 BTC. Figure 12 shows how bitcoin has been supplied since its start on January 3, 2009. At this moment, the authors of this paper are not aware of the reason why its maximum amount is pre-set, and cannot be changed.

Convertibility of bitcoin with debt money is dependent on how bitcoin is being supplied constantly according to its demand. Fixed maximum amount of bitcoin sooner or later imposes deflationary trend of its quantity, pushing up bitcoin prices as gold price used to be. This reminds us of the historical collapse of gold standard in 1930s, and collapse of gold-dollar convertibility in 1971.

In other words, bitcoin cannot be sound means of exchange, or money, under a growing economy as long as its supply is limited. Yet, this is a technical problem which can be easily solved if we wish to use bitcoin as legal tender.

6.4 Bitcoin as Blockchain Patchworks

Because of the impediments discussed above, the use of bitcoin has been constrained in our current economy. The recent focus has been blockchain technology itself that enabled to create bitcoin. As already pointed out in section 1, applications of blockchain technology have been mushrooming not only as alt coins but also as "virtually everything of value that can be expressed in code".

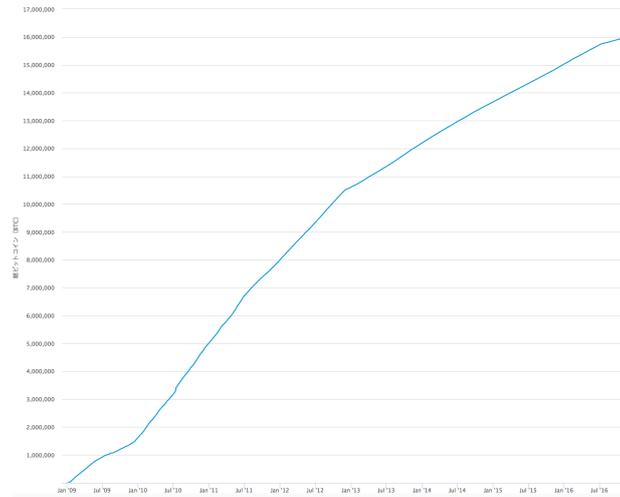


Figure 12: Bitcoin Supply: Jan. 2009 - July 2016. Source: blockchain.info

Confining our discussions to alt coins, they are destined to have the same impediments as bitcoin. As long as they are created and sitting on the surface of debt money system, they are nothing but *blockchain patchworks*, and destined to fluctuate along with debt money, as already illustrated in Figure 2. It cannot solve the economic problems such as monetary instability and government debts that have been caused by our current debt money system.

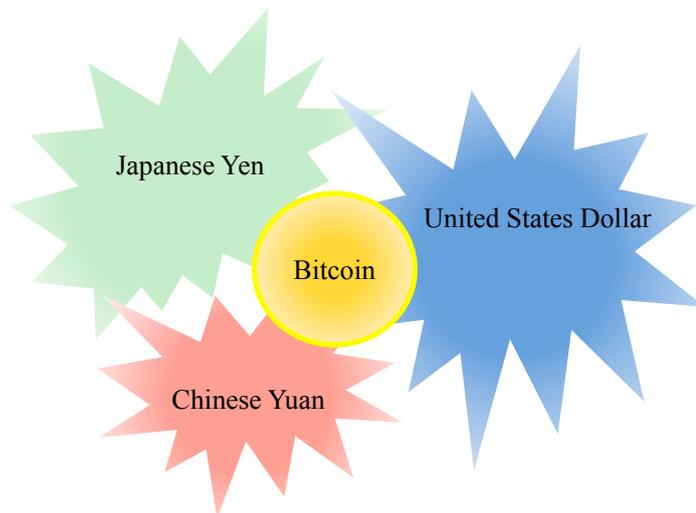


Figure 13: Debt Money System and Bitcoin

Bitcoin was not designed to provide solutions to these imminent problems as

its system design. It may find its niche along cross-national borders of collapsing current financial systems in a foreseeable future, as illustrated in Figure 13. But it cannot be peer-to-peer money that saves our current effete monetary system.

7 Peer-to-Peer Public Money Systems

7.1 The Ultimate System Design of Monetary Reform

The ultimate system design of monetary reform that saves our current economic disasters is to integrate public money system in Section 5 and blockchain technology in Section 6 and create *Peer-to-Peer Public Money System*. "P2P Public Money System" is what we like to propose in this paper as the ultimate system design of monetary reform. Figure 14 illustrates its unified system design.

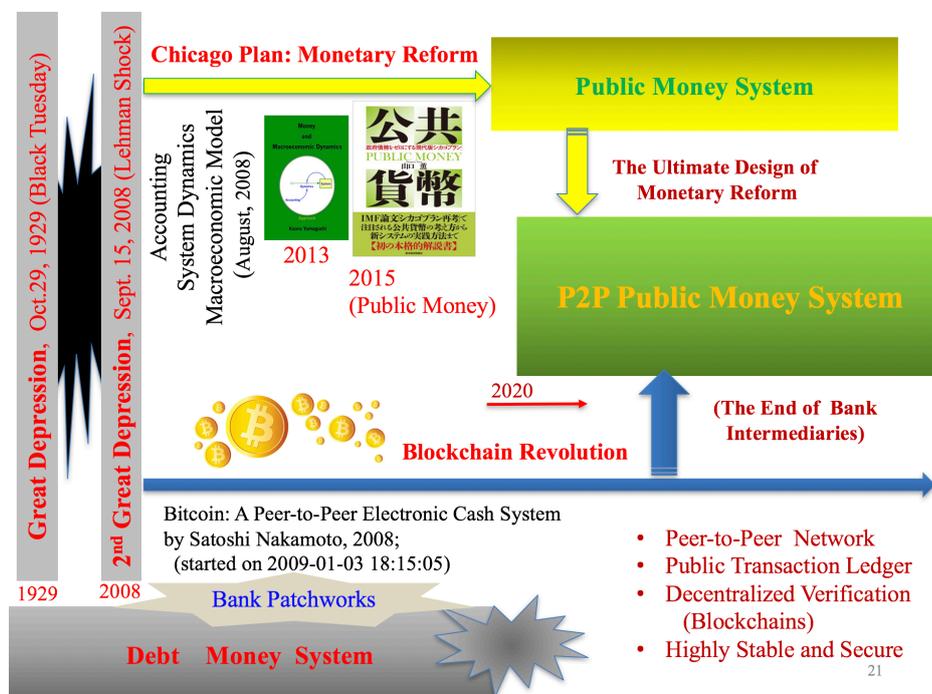


Figure 14: Unified System Design of Peer-to-Peer Public Money

The framework of peer-to-peer public money or simply p2p public money system is designed to overcome the shortcomings of existing debt money and functional-money such as bitcoin as complimentary system of debt money. Peer-to-peer public money system is a network that exhibits neutrality and allows equal access to financial system. Its network allows every nodes to make payments directly without going through financial intermediaries.

Payments under P2P Public Money System

All kinds of money used for payments are no longer functional-money based on debt, but public money as legal tender issued by the public money administration. Every nodes can send and receive public money across physical borders with very little or no transaction fees. In this sense, traditional centralized financial institutions become meaningless. To be more specific, banks are gradually destined to be waning intermediaries under the P2P public money system.

As a result, payment methods under the debt money and public money systems such as ② through ⑥ will be eventually forced out of transaction markets. This is what we predict as future trend of payments. Payments with bitcoin ⑦ may survive as international payment means.

7.2 World-wide Protocols for P2P Public Money

P2P public money is interchangeably called hereafter "Electronic Public Money (EPM)". To implement EPM world-wide, we need to develop world-wide EPM protocol that is accepted by all countries. Surely, this new protocol has to overcome the impediments of bitcoin discussed above. In this paper, we briefly discuss main framework of new protocols to be implemented by blockchain technologies.

- 1. EPM Supply** The amount of EPM that is to be put into circulation annually to sustain economic growth and welfare is determined by the Public Money Administration. This contrasts with bitcoin whose total amount is limited. How should it be put into EPM blockchain ledger? This is the most essential protocol to be agreed.
- 2. EMP in Circulation** To avoid inflation and deflation and attain monetary stability, the amount of EPM in circulation has be constantly adjusted through *uniform tax rate* (remark 1 below) which is built into ledger as transaction fees against all transactions. For instance, in case of inflation, this fee is increased to siphon EMP from circulation, and vice versa. How should it be siphoned, then? This is another essential protocol to be agreed.
- 3. EPM Verification** Public money administration plays a similar role as given to *miners* in bitcoin, and is allowed to authenticate all EPM ledgers into its blockchain. To guarantee the status of distributed trust and avoid the concentration of centralized power, the public money administration has to be managed independently but in a perfectly democratic way, including the comprehensive disclosure of all information on public money. How should it be fairly and safely managed, then? This is a managerial protocol to be agreed.
- 4. EPM Region** The effective region of EPM needs not be constrained within the nation-state. Instead, it is allowed to be traded everywhere on earth as long as its users accept each nation-state EPM. Gradually the EPM

regions of all nationality begin to emerge world-wide and overlap one another as if colorful flower petals (remark 2 below). Exchange services of different national EPM will be provided by private exchangers, including bitcoin exchangers. Embassies located world-wide could become additional such exchangers. How should such foreign exchange services be smoothly handled? This is an important foreign exchange protocol to be agreed.

Remark 1: Unified Tax System

The introduction of uniform tax rate proposed above in item 2 simplifies the current complicated tax system. In other words, transaction fees are fairly levied as taxes against all transactions without exception, just like highway tolls or mobile phone bills. This will be the most important structural change in government organization. Tax collecting offices such as Internal Revenue Service in the US will be shut down, saving lots of tax-levying costs.

Moreover, it becomes an effective system for solving tax-haven evasion, because whoever send money to wherever, tax is levied according to the amount of transactions without identifying its senders and receivers.

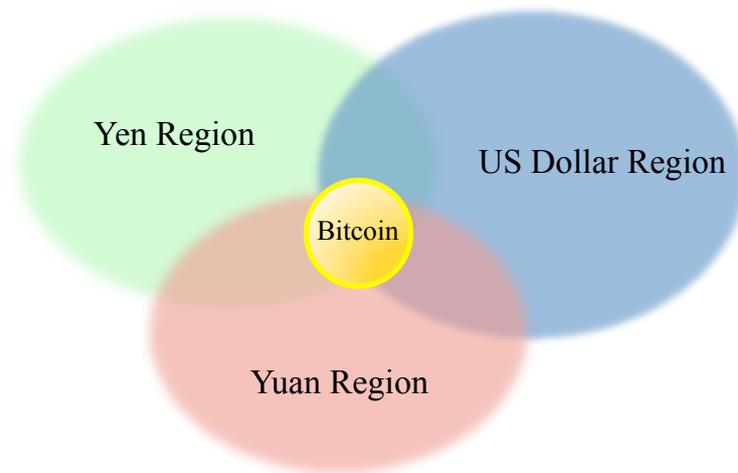


Figure 15: Emerging EPM Regions World-wide

Remark 2: Foreign Exchange Market

Under the peer-to-peer public money system, every node in the network across country-boarders can exchange EPM on a peer-to-peer basis. As such, the current foreign exchange markets expand even to individuals who had previously no choice but to pay unnecessary transaction fees to financial institutions. Once pure peer-to-peer network reaches a certain threshold in its size, as many nation-state EPM regions as all countries will start to emerge and begin to overlap one

another as if colorful international flower petals. Figure 15 only illustrates three such major regions. People living in ethnic community outside of their original country may start using their original EPM since financial borders becomes less and less significant.

7.3 Behaviors of P2P Public Money System

P2P public money system of world-wide network may behave as follows.

- Stabilization of monetary system (elimination of bank runs)
- Stable economic growth within EPM regional economies (no physical border but network border in cyber space)
- Liquidation of government debt within EPM regions (no need for forced austerity measures)
- No income inequality between financiers and non-financiers (democratization of finance)
- Equal access of world-wide citizens to financial services (desktop banking, investing, portfolio management etc.)
- Remittance by foreign workers to their native countries (seamless real time settlement, 24 hour service)
- Emerging financial infrastructure that wipes out poverty in developing countries (world-wide co-prosperity)

Conclusion

In the year 2008, two influential papers are published: ASD macroeconomic model and Bitcoin. ASD model has developed into the public money system as alternative to the current debt money system. Meanwhile, bitcoin has developed and gradually gotten accepted as functional-money (crypto-currency), and blockchain technology itself behind the bitcoin is transforming our society as a whole. Yet, it is argued that bitcoin is not currency as legal tender, and accordingly destined to encounter impediments such as volatility of its value and supply limitation along with economic calamities of the current system.

To fully utilize the better features of public money system and blockchain technology, we have proposed a unified system of public money and peer-to-peer blockchain technology, and called it *peer-to-peer public money system* as the ultimate system design of monetary reform.

This integration is approached with a focus on payment methods in this paper. Six different payments are identified under the current debt money system, and their SD models are constructed. It is then argued that these payments may, to a certain degree, remain even under the public money system. Yet, they get drastically simplified into only one peer-to-peer payment under the

p2p public money system, which eventually eliminate income inequality between financiers and non-financiers.

Finally the need for world-wide agreed blockchain protocol is proposed to implement this ultimate system. In consequence, this paper would like to conclude with our immediate call for the following forum, Japan or wherever possible:

**World-wide System Forum on EPM
– Electronic (p2p) Public Money –**

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Appendix 1: Payment System of Debt Money

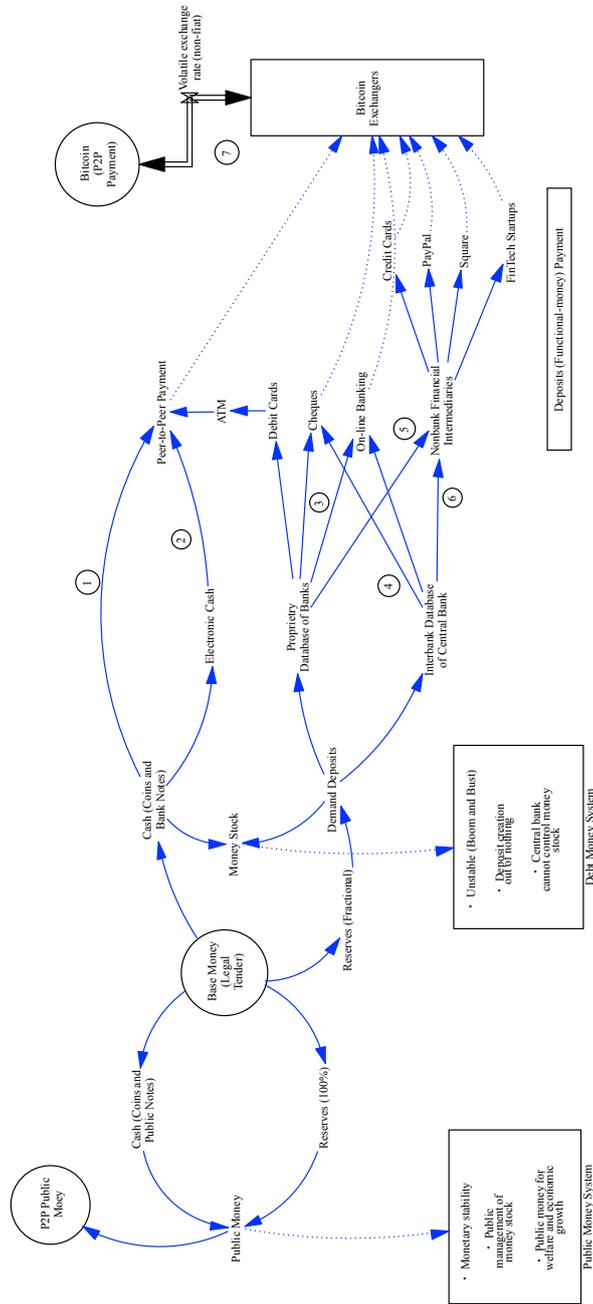


Figure 16: Payment System (0) Overview

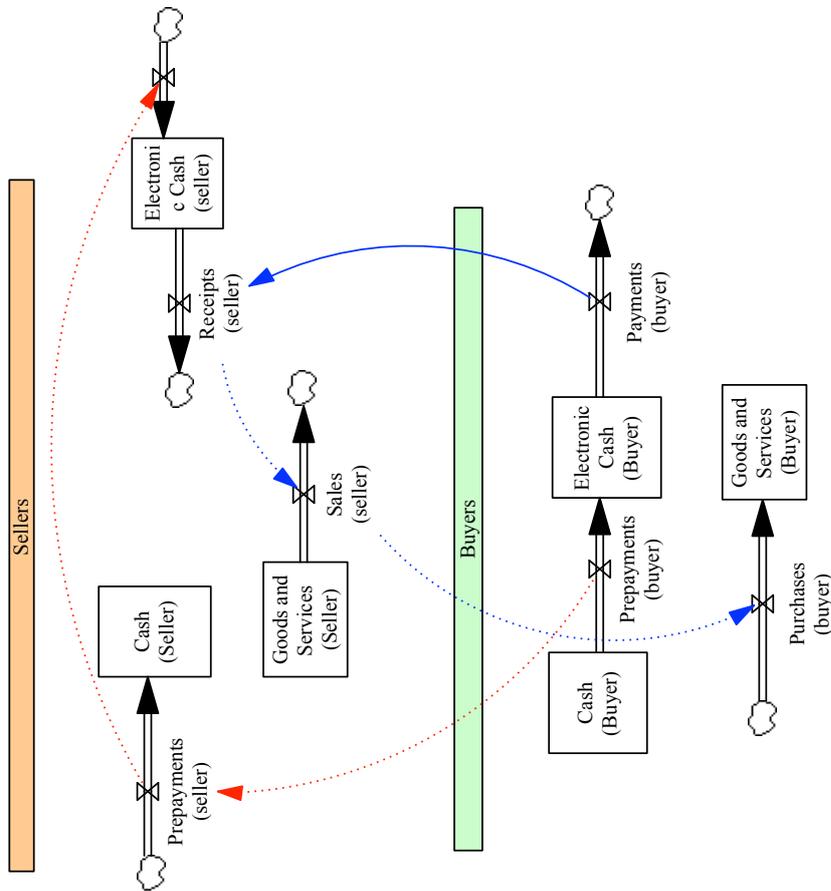


Figure 17: Payment System (2) with Electronic Cash

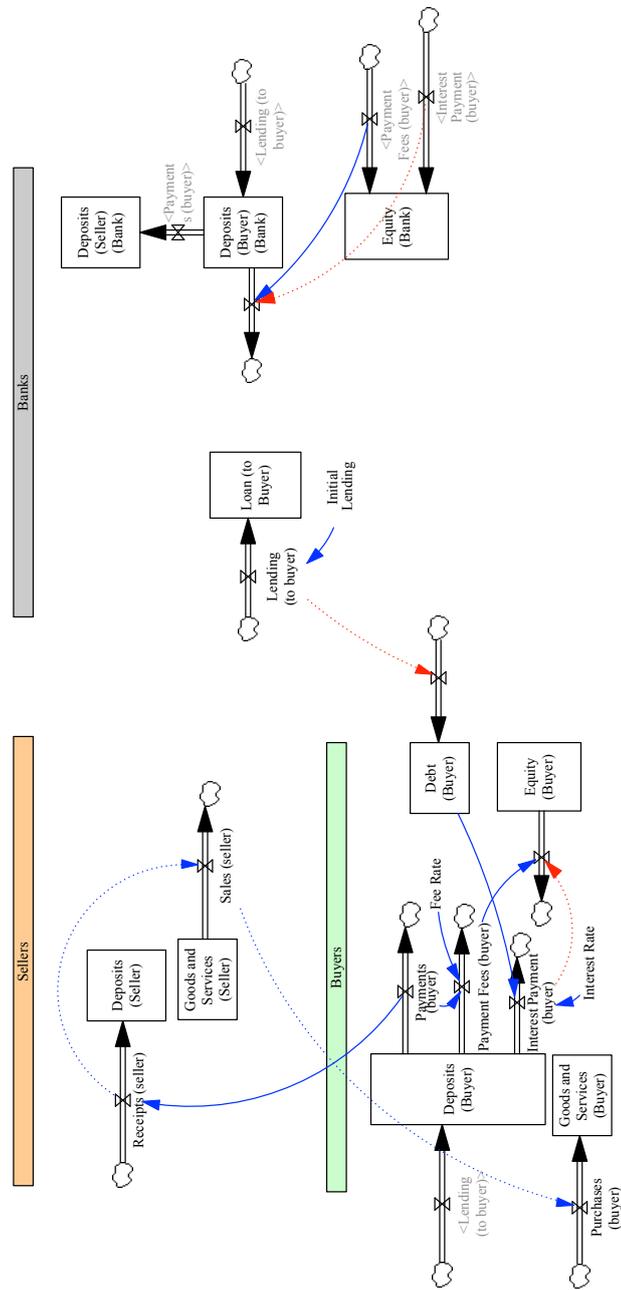


Figure 18: Payment System (3) with Bank Deposits

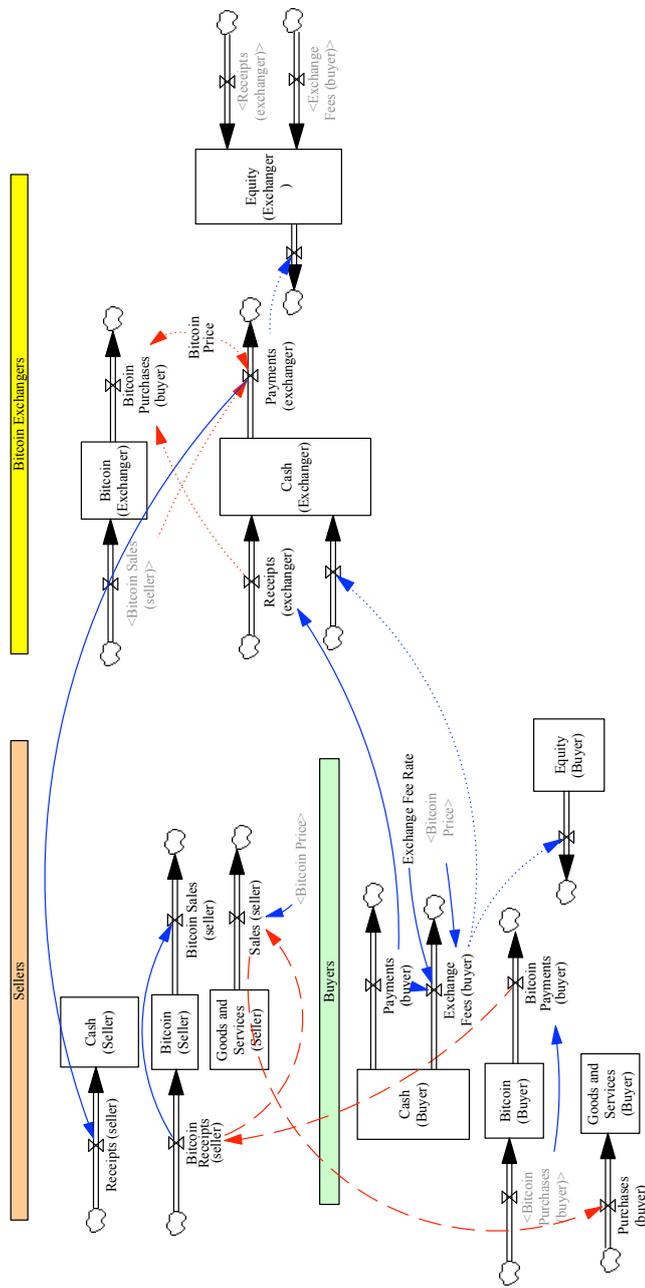


Figure 22: Payment System with Bitcoin: Peer-to-Peer