Public Money, Debt Money and Blockchain-based Money Classified
– EPM as Money of the Futures –

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Abstract

Under the current debt money system, large amount of money stock is created by commercial bank loans at interest due to fractional reserve banking. The prolonged global recession since 2008 prompted a discussion again, following the Great Depression in 1930's, that this debt money system does not fulfill its function due to its structural defects, systematizing banking crisis, government debt accumulation, income inequality and environmental destruction. An alternative system of public money is proposed to solve the inherent problems of the debt money system. In the mean time, the proposal and implementation of Bitcoin inspired various blockchain-based money, including the proposal of electronic public money (EPM) system. An expanded classification of money presented in this paper categorizes blockchain-based money into four types: Crypto-coin, Central Bank Cryptocurrency, Crypto-token and EPM. Then it is

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analyzed that all blockchain-based money except the EPM still suffer from the structural defects of the debt money system due to their dependence on it. A need for development of new EPM protocol is thus re-emphasized along with core design configuration. Finally, a regional experiment of EPM token in Japan is briefly described as a case study that bridges a transitional gap between the current system and EPM system.

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1 Introduction: The Year 2008

The current monetary system is based on a fractional reserve banking system. This is a system where bank deposits, which constitute large amount of money stock, are created when commercial banks grant loans at interest, or purchase existing financial assets from non-banking sectors. In short, the amount of nation's money is tied with investment activity of private commercial banks. Since every aspect of our lives has come to rely on bank deposits created as interest-bearing debts, the present economic system is alternatively called the *debt money system*.

The year 2008 became an epoch-making year for this debt money system. Firstly, the financial crisis and global recession reconfirmed, following the Great Depression in 1929, that the debt money system embodies structural design failures, systematizing monetary and financial instabilities. Secondly, two papers were published in that year which provided foundations for rethinking the debt money system: a paper on the accounting system dynamics macroeconomic model by Yamaguchi [21, 2008], which later became a theoretical foundation of the proposal of public money system [24, 2011], and a paper on Bitcoin by Nakamoto [11, 2008], which provided technological breakthrough in designing peer-to-peer transaction system through blockchain technology.

ASD Macroeconomic Model

Yamaguchi [17, 2003] proposed the Principle of Accounting System Dynamics (ASD), a new computer simulation modeling method that combines Accounting System and System Dynamics; a robust double-entry bookkeeping foundation of social science and dynamical foundation of differential equation in natural science. By applying this analytical method, the author has developed a series of macroeconomic modeling step-by-step; [18, 2005], [19, 2006], [20, 2007]. Then at the 26th international conference of the system dynamics society held in Athens, Greece, July 20-24, 2008, the author presented a complete accounting system dynamics (ASD) open macroeconomic model as cited above.

Less than two months after the presentation of the paper, the financial crisis took place. Being deeply distressed by this economic disaster, the author began to search for a new economic system which will be free from the detrimental effects of the debt money system; [22, 2009], [23, 2010], [24, 2011], [25, 2012], [27, 2014], [29, 2015], [30, 2016]. His research has been led by the so-called Chicago Plan of monetary reform [5, 1939], which is briefly covered in Section 4 below. In the same author's book [26, 2013], the public money system is proposed as the alternative monetary system that addresses four systemic problems of the present debt money system: 1. Monetary and financial instability, 2. Government debt crisis, 3. Income inequality, and 4. Environmental destruction. Particularly, it has been emphasized that these problems are symptoms (system behaviors), not the causes (system structure), of the debt money system, and that, accordingly, re-designing the underlying structure is essential to genuinely overcome these issues. The alternative system design of public money is further

introduced in the context of Japan [28, 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: Separate Proposals for Public Money System and Bitcoin

Bitcoin

On October 31st of 2008, less than two months after the collapse of Lehman Brothers, Satoshi Nakamoto, a pseudonymous author, submitted a 9 page-long paper in a mailing list of cryptography: "Bitcoin: A Peer-to-Peer Electronic Cash System [11, 2008]". Then, in January of 2009, the source code, later known as the Bitcoin reference code, was made open-source. On Jan. 3rd, 2009, the genesis block, the very first block of ever-extending blockchain for Bitcoin transactions, was successfully mined on the internet, breaking the dawn of unprecedented experiment of global peer-to-peer transaction system. The essence of Bitcoin is summarized 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 [11, 2008].

Bitcoin achieved the first decentralized transaction system on the internet that has practically avoided "double-spending problem" by combining the exist-

ing technologies of cryptography, the innovative idea of blockchain, and proof-of-work (PoW) consensus algorithm in distributed computing system. Since then applications of blockchain technology opened up a possibility for designing a new type of decentralized infrastructures and organizations. The lower part of Figure 1 briefly illustrates how the blockchain technology has been evolving since the year 2008.

Blockchain for Genuine Monetary Reform

We are currently observing hundreds of new blockchain applications being proposed and developed across industries. As illustrated in the lower part of Figure 1, however, all blockchain applications are built upon the vulnerable structure of the debt money system, which was identified to cause monetary and financial instability [4, 1935] [5, 1939], and government debt crises [26, 2013] [30, 2016]. Main benefits of the technological applications will be lost when the underlying monetary system remains unfixed and fails to fulfill its functions. What is now needed is to reform the basic structure of the current debt money system through blockchain technology.

Structure of the Paper

Towards this end, we must understand which part of the debt money system represents structural flaws that are causing problematic system behaviors. To achieve this, we first need to know which type of money exists and are being used at present. Accordingly, we begin by strictly defining what money is in Section 2, where a classification table of money before the year 2008 is reviewed briefly. In Section 3, structure of the debt money system is summarized in contrast to the proposed system of public money, which is reviewed in Section 4. In Section 5, structural challenges of Bitcoin are briefly analyzed with a focus on its functional aspect as a medium of exchange. Section 6 revisits the alternative blockchain-based system proposal called the electronic public money (EPM) system that is designed to address imminent problems facing the debt money system. A need for development of new EPM protocol is emphasized along with its basic design requirements. Then, in Section 7, an expanded classification table of money after the year 2008 is presented, categorizing four different types of blockchain-based money and proposals. It is analyzed that almost all blockchain-based money, except the EPM, are directly or indirectly dependent on the current debt money system, leaving the structural defects of the current system still unfixed. Finally in Section 8, an experiment of EPM token in Japan is described as a case study that bridges transitional gap between the current system and EPM system.

2 What is Money?

2.1 Public Money and Debt Money

Our first step in rethinking the current debt money system begins by looking at different nature of money by analyzing how money is issued. Table 1 adopted from Yamaguchi [26, p.131] first classifies different types of money into two categories; public money and debt money. Public money is issued by the consent of the public as interest-free money, while debt money is issued by private parties as interest-bearing debt.

2.2 Money as Legal Tender

Table 1 then introduces the definition of money as legal tender. Money is nothing but information of value which can be exchanged for goods and services, and the stability of its purchasing power must be maintained over a period of time. As such, it does not concern how it is represented on what kind of media, be it tangible or intangible, except that its unit of measure is defined by law (legal tender) as observed by Aristotle (384-322 BC) in ancient Greece 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 [32, p.34].

Contrary to his recognition, money has historically been explained in terms of its physical properties, even though it has changed its form of media from physical to an abstract one along with rapid development in information technology. As an example, money in Japan consists of government coins, Bank of Japan notes and reserves (which are essentially electronic digits in the ledgers of Bank of Japan's database), all of which have no intrinsic values. Today, as

Classification of Money

	Public Money	Debt Money	
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 Notes by PM Admin.	Goldsmith Certificates Central Bank Notes	
Digital Cards & Accounts	Digital Public Money (PM)	Digital Cash Central Bank Digital Currency (CBDC)	Bank Deposits (Credits by Loans)

Table 1: Public Money vs Debt Money

one can see from Table 1, almost all of medium of exchange used in daily trans-

actions are deposits expressed in the form of electronic digits at commercial banks' database.

Unfortunately, however, Adam Smith (1723-1790), known as the father of economics, reversed the definition of *money as legal tender* 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 [32, p.313].

In this way, Adam Smith defined *money as commodity*. This erroneous logical step by the father of economics seemed to be widely used until this day. Advancing this idea axiomatically, many macroeconomics textbooks define money as an entity that meets the following three functions; (1) unit of account, (2) medium of exchange and (3) store of value. According to this axiom, gold and silver could be best qualified as ideal money because, *by nature*, their physical properties perfectly meet the three functions of money. This reversed definition has been a root cause of the confusion on the definition of money even among professional economists, and the public who are heavily influenced by them.

2.3 Bank Deposits as Functional-Money

Let us now look at three different measurements of money used in modern economy. Money used in our daily transactions is called money stock or money supply. It is defined as

$$\text{Money Stock} = \text{Currency} + \text{(Commercial Bank) Deposits} \tag{1}$$

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* appears for the first time in this measurement of monetary aggregates. It is strictly defined (such as in Japan and other nations) as

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

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 payments.

Under the current fractional reserve banking system, there is another type of money called (central bank) reserves, which are mainly used for final settlements between commercial banks. Reserves are legal tender held by commercial banks and other non-banking financial institutions at central bank. With currency and reserves, base money or monetary base is defined as follows:

$$\text{Base Money} = \text{Currency} + \text{(Central Bank) Reserves} \tag{3}$$

How about commercial bank deposits? Are they also *money as legal tender*? According to Masaaki Shirakawa, a 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 [14, p.13] (translated by the authors).

Deposits are neither money as *legal tender* nor *currency* in this sense. That is why they are classified as *functional-money* in Table 1 even though they are widely accepted as the chief means of payment due to its convertibility with currency (legal tender). Let us emphasize again that deposits are nothing but *functional-money* created or destroyed by commercial banks under the fractional reserve banking system. This distinction of money from functional-money is the first step in rethinking the basic structure of the present debt money system.

3 Debt Money System

3.1 The Origin: Fractional Reserve Banking

The history of fractional reserve banking practices can at least be traced all the way back to the Venetian bankers in the middle of the 14th century [5, 1939]. Since then the age of free banking followed, in which commercial banks issued their own bank notes against deposits of precious metals such as gold and silver. For various historical contexts and political reasons, fragmented private banking systems began to be centralized through central banking system around the 17th century. No later by 19th century, gold standard system was begun to be established. In order to maintain the gold standard as international monetary system by assuring the fixed gold unit against national currencies under the growing economy, central banks needed to take deflationary policy action (raise interest rates) as a result of a shortage in world's gold reserves.[1] Industrialized nations in the west suffered from the deflation, and transfer of large amount of gold for settling international trades became impractical particularly during the war time. Eventually, 'gold currency' nations were forced to abolish it. Finally, after the unilateral cancellation of the direct convertibility of the United States dollar to gold in 1971, the international monetary system abolished gold as a basis of money. This transition into fiat currency system under the fractional reserve banking, from another perspective, was a completion of the present *Debt Money System* in which money stock would no longer be limited by physical amount of gold and silver.

3.2 Structure of Debt Money System

Since the financial crisis in 2008, enormous amount of regulations and supervisory mechanisms have been implemented. However, they made the existing reg-

[1] The central banks were accustomed to maintain a reserve of upwards of forty per cent in gold or gold exchange behind their note issuances [5, 1939].

ulatory system more complex at best, if not any. In essence, the basic structure of debt money system remained the same before and after the crisis. Structure of the debt money system is summarized in the last column of Table 2, which is adopted and modified from the original version in [26, Chapter 15]. It is a system in which base money is issued by central banks which are privately-owned in many nations, and deposits are supplied into the economy as interest-bearing debts through commercial banks' loans.

	Public Money System (Proposed)	**Debt Money System** (Current)
Money Issuer Its Owner	Public Money Administration The government (Public)	Central Bank & Commercial Banks
Required Reserves	100% (for Demand Deposits)	Fractional
Role of Banks	Intermediaries of Money	Creators of Deposits
Money Supply	Base Money = Money Stock (Financial system unaffected)	Base Money: by Central Bank Deposits: by Bank Loans
Issuance of Money	Interest-free	Interest-bearing Debt
Economic Policies	Public Money Policy (Direct Public Money Injection)	Monetary Policy: Central Bank Fiscal Policy: Government

Table 2: System Structures of Public Money and Debt Money

3.3 System Behaviors: Four Built-in Failures

Behaviors of the debt money system are summarized in the last column of Table 3 which is taken from [26, Chapter 15]. Debt money system has been observed to cause boom and bust, which in turn trigger monetary and financial instabilities, followed by accumulation of government debt caused by capital injection necessary to save the banking system and to implement fiscal stimulus policy. Over time, this system structure inevitably brings income inequality between a handful of financiers and the remaining non-financiers, leading to an extreme concentration of wealth. Furthermore, the debt-based monetary system forces economic growth that puts eco-systems under enormous stress, leading to environmental destruction. Accordingly, the debt money system is concluded to entail built-in system design failures of monetary and financial instability, accumulation of government debt, income inequality and environmental destruction [26, 2013], [30, 2016].

It is emphasized that these problems are system behaviors (symptoms) largely driven by the underlying structure of the debt money system. Thus they can be only fixed by re-designing the structure which directs how the system would behave. Let us re-examine these four system design failures in more detail below.

	Public Money System (Proposed)	**Debt Money System** (Current)
Monetary Stability	Stable Supply of Money Stable Price Level	Excessive Credit Creation & Crunches Inflation & Deflation
Financial Stability	No Bank-runs	Business Cycles, Banking Crisis (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	Debt Accumulation (Private and Public) → Forced Growth → Environmental Destruction

Table 3: System Behaviors of Public Money and Debt Money

1. Monetary and Financial Instability

Instability of Money Stock

Let us first consider monetary and financial instability since it is one of the most important criteria and the main purpose of system re-design. Under the debt money system, new deposits are created when commercial banks make loans, while, conversely, existing deposits are destroyed when loans are repaid. This way, money stock or money supply, which we all rely on as chief mediums of exchange, is *endogenously* created and destroyed. This leads to inherent instability of money stock (supply) especially during the period of booms and busts as money creation is tied to lending business of commercial banks.[2] Instability of money stock under the fractional reserve banking system was observed in the U.S during the Great Depression and is documented by Fisher [4, 1935]. In a recent cases of Japanese asset price bubble and burst during late 1980's and early 1990's, money stock continued to increase unlike the case of the Great Depression, because the government continued to borrow money this time, instead of debt-repaying private sectors, by issuing government bonds, which in turn has led to an acceleration of the government debt accumulation [29, 2015].

Financial System Crisis

Inevitable results of booms and busts are credit defaults, bankruptcies, foreclosures and bank runs, followed by higher rate of unemployment and long term recession. Financial crises are systematized by the underlying system structure of fractional reserve banking such that rational economic behaviors of repaying

[2]The simulation experiment using simple ASD model in [30, 2016] shows that compound changes in currency ratio and capricious behavior of banks' lending ratio amplify instability of money stock, although base money remains entirely constant and stable.

loans by private sectors during the economic downturn precipitate recession by further destroying money stock. The occurrence of this paradoxical phenommenon is identified as *fallacy of composition*.

2. Government Debt Accumulation

Under the debt money system, government is obliged to finance through taxation. For the amount of fiscal deficits, it has to rely on borrowings from private sector, mainly from banks and non-bank financial institutions (and indirectly from the central bank through open market purchases). Under such system, the government debt could grow at an exponential rate caused by a reinforcing loop of compounding interests. When private sectors stop borrowing from banks during economic recessions, the government instead has no choice but to borrow for implementing fiscal stimulus in order to maintain the level of aggregate demand, leading to further increase in its outstanding debts. These accumulated debts will surely trigger another type of economic crisis; debt crisis. In system dynamics, whenever an event is observed repeatedly and becomes a pattern, there must be a underlying system structure producing such a pattern of the event. Following this analytic approach, Yamaguchi [26, 2013] explored system structure of the present system and identified it as a *debt-end* system. In short, the current debt-based system is far from a sustainable path and, sooner or later, destined to crash if no structural change is to be taken.

3. Income Inequality between Financiers and Non-Financiers

As we have seen above, commercial banks and central bank collectively administer both payment system and money creation under the present system. Since almost all money exists in the form of debt, interest has to be paid as long as money exists. To be more specific, banking institutions earn vast amount of interest by creating and lending money to other non-banking private sectors and the government. This way, the current system works like a gigantic vacuum machine of national income, transferring large amount of income from non-financiers to financiers. In short, the current system of debt money is structured in such a way that it concentrates wealth into a handful of interest-earning financiers. Income inequalities is, indeed, an inevitable result of the system structure.

4. Environmental Destruction

Under the debt money system, borrowers are under enormous stress to repay loans at interest. Perpetual pressure to keep paying interests and pay back the principal incentivize borrowers (debtors) to minimize costs, discarding social investments for environmental protection. In other words, the system structure of the debt money system reverse systematic efforts for environmental protection and impose behavioral structure of forced economic growth at the price of ecosystem.

4 Public Money System

4.1 The Origin: Chicago Plan and 100% Money

The Great Depression in 1929 was the first major economic disaster caused by the system design failures of the debt money (fractional reserve banking). Having recognized this, eight economists at the University of Chicago[3] proposed an alternative system design called "The Chicago Plan for Banking Reform" in 1933 based on the original idea put forward by Frederick Soddy in 1926, who won the Nobel prize in chemistry in 1921. Their proposal was handed over to the President Franklin D. Roosevelt on March 16, 1933 through Henry A. Wallace, then Secretary of Agriculture. Unfortunately, however, it failed to be implemented as political oppositions, especially from bankers who retain the profitable system, were substantial [13, 1995]. Instead, the Banking Act of 1933 known as Glass-Steagal Act, which was less restrictive to bankers, was enacted on June 16, 1933 by FDR.[4] Then, the Chicago Plan was vehemently carried on by Irving Fisher from Yale University [4, 1935] and his group of five economists[5] as "A PROGRAM FOR MONETARY REFORM" [5, 1939], and later by Milton Friedman [6, 1948], [7, 1960]. Gradually, the Chicago Plan and similar sort of proposals began to be neglected and made *a taboo subejct* [16, 2013] as an alternative economic policy discussion.[6]

The monetary reform thus proposed as the Chicago Plan simply aimed to introduce 100% required reserve ratio for demand deposits such that

$$\text{Money Stock} = \text{Base Money} \tag{4}$$

Under this full reserve (100% money) system, all demand deposits (functional-money) will be all backed by base money, legal tender. This way, money stock, being defined by currency and demand deposits, becomes equal to base money. Based on the Chicago Plan, *Public Money System* is proposed [26, 2013], [30, 2016] as an alternative system design to overcome structural flaws of the debt money system.

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[3] They are: G.V. Cox, Aaron Director, Paul Douglas, A.G. Hart, F.H. Knight, L.W. Mints, Henry Schulz, and H.C. Simons.

[4] The Act was repealed in 1999 by the President Bill Clinton, and replaced with the Glamm-Leach-Billey Act also known as the Financial Service Modernization Act of 1999, which was criticized of having ultimately led to the financial crisis in 2008,

[5] They 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.

[6] As a recent case, Congressman Dennis John Kucinich, a member of the U.S. Representative from Ohio between 1997-2013, put forward the American Monetary Act in 2011, which is an equivalent of the Chicago Plan.

> On 26 July 2011, Kucinich invited Professor Kaoru Yamaguchi from the University of California at Berkeley and Doshisha University in Japan, to give a congressional monetary briefing on this idea. ... Any version of the Chicago Plan will be fought to the death by the banking system because it threatens both its power base and its business model. [2, 2012, pp.129-130]

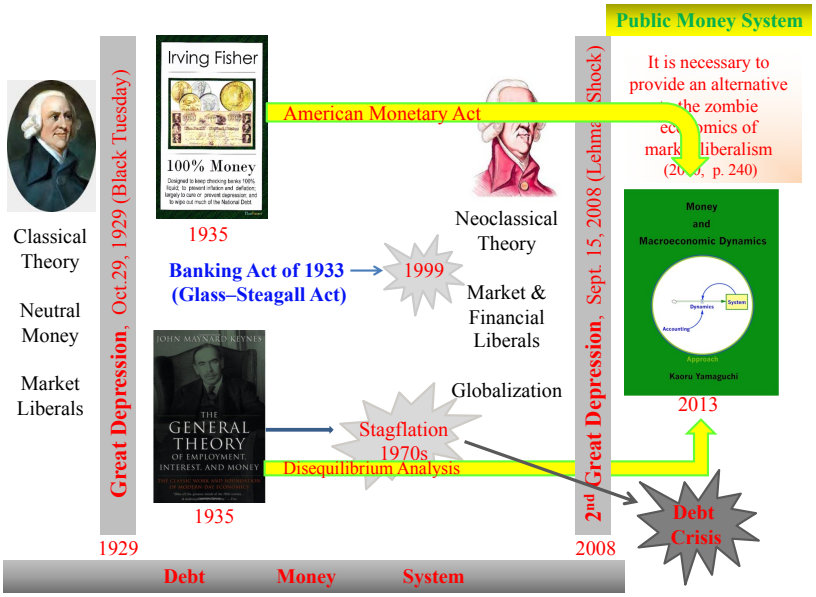

Figure 2: From Debt Money to Public Money System

Figure 2 illustrates how economics learned two important lessons after the Great Depression in 1930's; that is, 100% Money by Irving Fisher [4, 1935] and The General Theory of Employment, Interest and Money by John M. Keynes [8, 1935]. It also shows that a new macroeconomic theory of public money system developed with Accounting System Dynamics (ASD) modeling approach [26, 2013] is an integration of two alternative theories proposed in 1935 in the wake of the Great Depression in 1930's.

4.2 Structure of Public Money System

Money exists by law as discussed in Section 2. Accordingly, money must be issued as decreed by law (legal tender). And a reliable monetary system must provide stability of its purchasing power. System structure of public money is summarized in the second column of Table 2 shown above. Its gists are as follows:

- Public money is issued at interest-free by the Public Money Administration (PMA) as equity of the nation, not by commercial banks as interest-bearing debt.
- 100% required reserve ratio is held for demand deposits.
- Public money is put into circulation to sustain economic growth and welfare.

Banks as Intermediaries of Public Money

By requiring banks to keep 100% reserve ratio for demand deposits and to follow appropriate accounting journal entries for bank-lending transaction, banks become genuine intermediaries of existing money under the public money system. Separation of money creation and private lending business is thus achieved.[7]

Loanable funds of banks come from three sources: (1) their own money (retained earnings), (2) time (savings) deposits and (3) loans repaid. Especially time deposits are savings of the economy and become a main source of loanable funds for commercial banking sector, connecting savers and borrowers in the economy. As a result, main source of income for commercial banking institutions consists of (a) earned interest income from lending business and (b) service fees for providing payment and custody service. In this way a robust and stable foundation of banking system will be established.

This business model of banks, which is what normal textbooks regard them to be, provides them with economic incentives to put weights on real investments that would result in stable returns rather than on zero-sum financial gambling. Consequently, banks under the public money system seek for real investment opportunities in more productive markets, making the whole financial sector more competitive and efficient. Thus, interest rates are determined in the financial market competitively. In this respect, the Public Money Administration will be free from monetary policy of manipulating interest rates through market operations as presently done by the central banks of the debt money system.

Issuance of Public Money

Who should issue money, then, in place of the privately-owned central banks and commercial banks? Issuance of money or legal tender is the prerogative of the *public*. Thus, we submit that the issuer has to be a *public* organization, politically independent from the influences of the government and vested interest groups. Secondly, it must be a sole entity under the publicly-elected legislative branch of the government regulated by the constitution, such as the Congress in the United States, the Parliament in the United Kingdom and the Diet in Japan. Such an organization is commonly referred to as the *Public Money Administration* (PMA) in Yamaguchi [26, 2013].

To make this alternative system design workable while avoiding political pressures and fiscal dominance, the following two conditions must be strictly met:

C1. The Public Money Administration plays a role of *supply side* of pub-

[7] Concerning the role of government in the process of money creation, Frank. H. Knight, one of the original proponents of the Chicago Plan in 1933 and of the founding members of the Chicago School of Economics, stated:

> No violation of the basic principles of extreme *laissez faire* theory would be involved in separating the monetary system from the vicissitudes of speculative private business. [9, 1933]

lic money, while the executive branch of the government (Department of Treasury in the U.S, Ministry of Finance in Japan, etc.) plays a role of its *demand side*. The amount of public money is determined by the interplay of demand and supply sides.

C2. Transparency of both information and decision processes of public money issuance has to be fully guaranteed to the public.

To implement the conditions of C1 and C2, an organizational structure of demand and supply side of public money administration is proposed in [28, 2015] as illustrated in Figure 3 as a case example in Japan. According to the proposal, the PMA is established under the direct supervision of the Diet as an politically independent organization from the influences of other branches of the government, politicians, lobbyists as well as special interest groups.

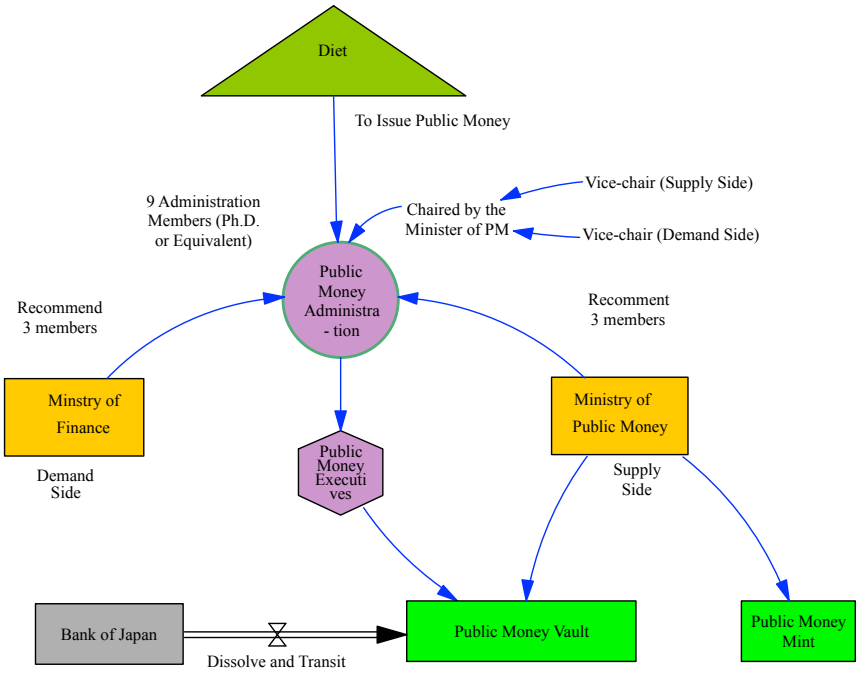

Figure 3: Organizational Structure of the Public Money Administration (Japan)

Public Money Policy and Fiscal Policy

Government needs to collect taxes for providing public services to the people. However, tax increase necessary for fiscal spendings during economic recession could dampen the aggregate demand and prolong or worsen the recession. Under the situation, the demand side of the PMA, say, Ministry of Finance, demands

for additional amount of money to finance the fiscal deficits. Under the public money system, the demand side of the PMA needs to publicly disclose all fiscal information to justify their demand for additional money issuance. In this way both the supply and demand sides of the PMA interplay one another and perform a "check and balance" mechanism to keep fiscal (and governmental) dominance away from money issuance.

One may still wonder what happens if both sides of the PMA are corrupted, and large amount of money is issued in a short period of time? To guarantee the price stability even under such possibility, a third condition must be clearly stated as in the article 8 of the Public Money Act proposed in [28, 2015]:

C3. Minister of Public Money Administration shall resign, without exception, whenever price level fluctuates beyond ± 2 % in 3 consecutive months, compared with a corresponding period of previous year.

Choice of price index such as Consumer Price Index (CPI), the range of price fluctuation and its period shall be determined nation by nation on the basis of domestic economic conditions in accordance with monetary and financial environment of her neighboring nations.

Spending policies of public money may be outlined in the following categories:

- 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 networks, green energies, and green transportation system.
- Universal medical and healthcare program and other social welfare programs.

It should be noted that the Public Money Administration is an entity exclusively responsible for the management of money stock, and nothing else. Thus, under the public money system, the nation's financial system remains the same except the detachment of money creation from commercial lending businesses.

4.3 System Behaviors: Four Failures Getting Fixed

Second column of Table 3 above summarizes the behaviors of the public money system. Under the public money system, four major system design failures in the debt money system are shown to be removed; that is, (1) monetary and financial instability, (2) accumulated government debts, (3) income inequality between financiers and non-financiers, and (4) environmental destruction.

1. Monetary and Financial Stability

Stability of Money Stock

Let us first examine the failure of monetary and financial instability. Whenever 100% required reserve ratio is introduced, money stock becomes equal to base

money, meaning that all money in the economy is issued by the PMA (government) as its equity, and every commercial bank deposit becomes money (legal tender), as opposed to functional-money under the current system. Accordingly, instability in money stock is stabilized, and it would no longer be affected by the changes in liquidity preferences of depositors, capricious lending behaviors of banks, and debt repayments by borrowers [30, 2016].

Financial Stability

Under the public money system, bank runs no longer occur as each unit of demand deposits at each banking institution is fully reserved all the time. This leads to a robust banking system, and abolishment of too-big-too-fail policy.

2. Liquidation of Government Debt

Concerning the system behavior of government debt accumulation, the government now becomes debt-free as its securities are getting paid off with public money whenever they become due [23, 2010], [24, 2011], [25, 2012]. Government securities may be used as substitution by commercial banks for attaining 100% reserve ratio during the transition process. Consequently, the executive branch of the government (MoF in Japan, and the Dep. of Treasury in the U.S.) becomes free-hand to pursue its public policies without being constrained by the burden of national debts and interest payments.

3. Income Inequality

Income inequality between financiers and non-financiers is reduced by the amount of interests previously concentrated to banking sector through public and private debts. Hence, income inequalities between financiers and non-financiers will be substantially removed over time. However, it should be remarked that no system structure is introduced to reduce income inequality between workers and stockholders (or capitalists) under the public money system.

4. Improvement of Environmental Protection

Under the present system, banks ultimately decide where to invest and to which industry necessary funds are supplied. The system structure of public money introduces a number of economic incentive loops towards green businesses. One of them, which we believe is significant, is for commercial banks to take depositors' opinion (social aspect of lending business) into account since they will become intermediaries of money between savers and borrowers under the proposed system. In other words, socially responsible investments become more accessible. In this way, the structural cause of forced economic growth is removed in the public money system.

4.4 Transition Steps to the Public Money System

The current debt money system is transitioned to the public money system in the following two steps;

Step 1 Enact, say, the Public Money Act [28, 2015], thereby replacing the existing laws that authorize a fractional reserve banking system with 100% reserve requirement system.

Step 2 The Public Money Act dissolves the current central bank such as Bank of Japan, and incorporates it into the newly established Public Money Vault administered by the PMA.

Public money system discussed in this section did not consider any application of blockchain technology when it was first proposed in [24, 2011]. With the new proposal of electronic public money (EPM) system [30,2017] revisited in Section 6, the public money system discussed in this section is now referred to as the original public money system in comparison to EPM. Before we revisits the EPM, however, let us first overview Bitcoin in the next section, which is the very first application of blockchain.

5 Bitcoin and Blockchain

5.1 System Structure of Bitcoin

Bitcoin has provided a new method to make peer-to-peer payments electronically across national borders. As described by Andreas [1, 2017, p.2], Bitcoin consists of:

- A decentralized peer-to-peer network (the Bitcoin protocol)
- A public transaction ledger (the blockchain)
- A set of rules for independent transaction validation and currency issuance (consensus rules)
- A mechanism for reaching global decentralized consensus on the valid blockchain (Proof-of-Work algorithm)

To avoid a trusted party in coin generation, the Bitcoin protocol is designed such that miners gain new amount of Bitcoin as a reward for successfully creating a new candidate block containing Bitcoin transactions, and being confirmed by other network peers. Each block is generated every 10 minutes on average. The maximum amount of Bitcoin supply is predetermined at 21,000,000 BTC that will be attained approximately by the year 2140. A rate of new Bitcoin generation per block is decreased by half in every 210,000 blocks (or 4 years approximately) and each block contained 50 new BTCs for the first four years. Anyone who wish to use Bitcoin can either try to mine new Bitcoin or purchase it at exchangers who facilitate potential buyers and sellers. However, the difficulty of Bitcoin's mining have increased so high that ordinary users with normal

computing machine cannot expect to win against other professional miners in the network.

5.2 Challenges facing Bitcoin

Currently, Bitcoin faces fundamental challenges if it were to serve as a robust monetary system; that is, the fixed supply and volatility of its value.[8]

a. Fixed Amount of Bitcoin Supply

The fixed amount of supply pushes up the Bitcoin prices as gold price used to be in the face of increasing demands, imposing deflationary pressure. The system design of fixed supply worked well during the infant phase of Bitcoin, because that attracted more Bitcoin users as its value went up as intended by Satoshi Nakamoto (unidentified) explained in the following internet post:

> As the number of users grows, the value per coin increases. It has the potential for a positive feedback loop; as users increase, the value goes up, which could attract more users to take advantage of the increasing value [12, 2009].

The increasing value keeps incentivizing miners to invest more in hashing race, making the network more resistant to double-spending attacks. However, this fixed supply reminds us of the structural limitation under the international monetary system based on gold standard, which eventually forced the collapse of dollar-to-gold convertibility in 1971. In other words, as long as its supply is limited, Bitcoin continues to face similar challenges before serving as a sound means of exchange under a growing economy.

b. Volatility of Bitcoin Price

The increasing value has made Bitcoin an investment target, like gold, rather than a means of payment. The volatility of its purchasing power, thus, makes it unsuitable as a means of real transaction of goods and services.

5.3 Current Blockchain Applications as Patchworks

In retrospect Bitcoin was the first application of blockchain technology. More precisely, Bitcoin and blockchain was inseparable. However, recent focus has

[8] In addition to these economic problems, Bitcoin faces technical issues arising from the specific approach it has adopted. To incentivize minings in proof-of-work approach, coin generation and block construction (transaction validation) are intertwined, concentrating the important functions of the monetary system into miners. Specifically, system design of Bitcoin results in: 1) high energy costs due to massive computations, 2) risk of validator concentration of power into five large-scale mining pools, and 3) ambiguity in forming a unique blockchain (forking) and limited scalability. To overcome these issues, entirely new approach have been proposed such as *Algorand* (algorithmic randomness) by Micali [10, 2016].

been more on blockchain technology rather than Bitcoin itself. It is now recognized that the idea of blockchain can be applied, independent of Bitcoin, through different consensus algorithm other than proof-of-work, which has led to the Blockchain Revolution [15, 2016]. Blockchain is technically evolving into Distributed Ledger Technology (DLT). Many applications of blockchain technology have been mushrooming not only as Alt(ernative) coins but also as "virtually everything of value and importance to humankind ··· that can be expressed in code [15, page 7]". However, as pointed out in Section 1, these blockchain

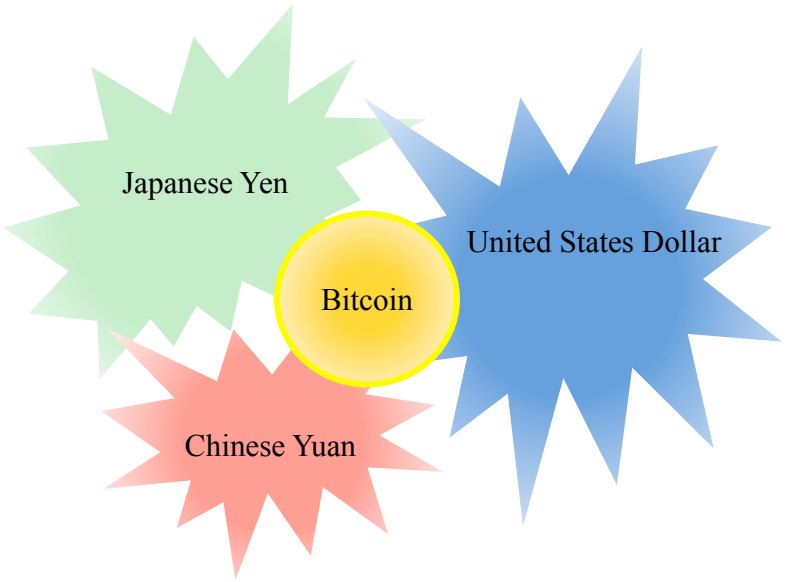

Figure 4: Collapsing Debt Money Systems

technology are currently applied to improve financial services of the debt money system by minimizing operating costs of the existing financial institutions.

As long as current blockchain applications continue to be developed on top of the debt money system, they could become nothing more than *blockchain patchworks* since they were not designed to address problems of the underlying system of debt money as depicted in Figure 4.

6 Electronic Public Money (EPM) System

6.1 Unified Design of Public Money and Blockchain

The public money system revisited in Section 4 is shown to fix system design failures of the debt money system revisited in Section 3. Yet its implementation has been difficult since its birth [24, 2011] as its predecessor, the Chicago Plan in 1933, has been made "taboo" in monetary reform discussions as discussed in Section 4. In Section 5, we revisited Nakamoto's approach in designing a new

electronic payment system that relies on cryptographic proofs in transaction validation and (computational) mining for new Bitcoin generation. Yet, the absence of any trusted party to manage the supply of Bitcoin, thus its purchasing power, has led to challenges for Bitcoin to serve as an alternative monetary system to the debt money system.

Under these circumstances, blockchain technology appeared all of sudden as if it were a *savior* for the public money system, because it could bring back, from a completely different angle of information technology, the old but greatly relevant issue of monetary reform out of the "taboo subject". The practical use and implementation possibility of blockchain technology for nation's settlement system are becoming increasingly hot subject. More specifically, blockchain could be built into the system design of public money to save the current debt money system from its complete meltdown. Such an integrated system design proposal is called *Electronic Public Money (EPM) System* by Yamaguchi and Yamaguchi [31, 2017]. Figure 5 illustrates how the two separate developments

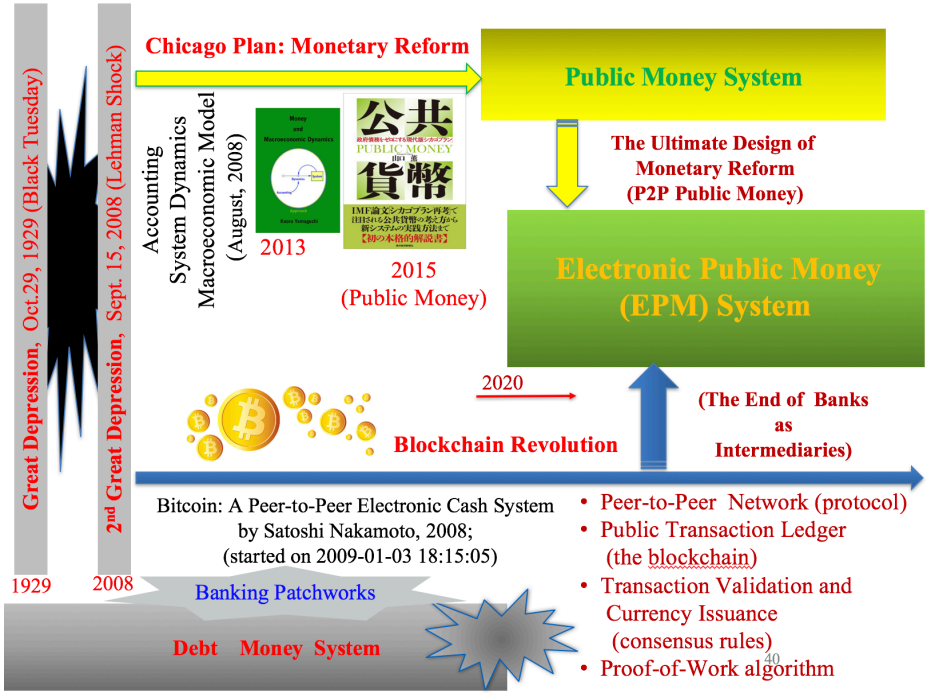

Figure 5: Unified System Design of Electronic Public Money

of system concepts are integrated into an unified design of Electronic Public Money (EPM) system.

6.2 Structure of EPM System

The essence of the public money system is the separation of money creation process from commercial lending and investment activities, both of which are done by private banking sector under the current debt money system. This separation of two important functions of monetary system holds true in EPM system design. Thus, as in the original public money system, structure of EPM system is featured as follows.

- Electronic public money (EPM) as legal tender is issued at interest-free by the Public Money Administration (PMA) as equity of the nation.
- EPM is put into circulation to sustain economic growth and welfare at interest-free.

It is worth remarking here that the second structural feature of the public money system explained in Section 4.2 is missing; that is, "100% required reserve ratio is held for demand deposits". Under the EPM system, payments can be done directly between two parties (peer-to-peer electronic cash). Under such system, payments by deposit transfer become less and less needed. Consequently, bank deposits are expected to gradually lose its dominance as chief means of payment, making the second feature of the public money system less irrelevant over time. Even so, nation's financial system will remain the same in a foreseeable future under the EPM system as in the original public money system until a full transition to the EPM system is completed. Accordingly, it is fair to say that, as long as demand deposits exist,

- Commercial banks are required to hold money against every demand deposits (100% required reserve ratio).

As a result, money in the EPM system consists of coins, notes (replacing former central bank notes) and electronic public money (EPM) all issued by the PMA.

Issuance of Electronic Public Money

In order to facilitate economic growth and welfare, EPM is issued by the (supply side of) Public Money Administration, which plays the ultimate role of *a trusted party* as in the original PM system. The PMA is a public institution established under the direct supervision of the legislative branch of the government, and is responsible for managing the amount of EPM stock (supply) as discussed in Section 4.2. This vividly contrasts with Bitcoin whose total amount of supply is predetermined to avoid any trusted (third) party in generation of new coins, or the debt money system where deposits are endogenously created and destroyed by commercial bank loans so that money stock cannot be directly controlled even by the central bank.

Public Money Policy and Fiscal Policy

Money stock is managed by the PMA in EPM system as public money policy. In case of fiscal deficits, *a uniform tax* (a new tax scheme proposed as *public service fees* in Remark 1 below) is increased to meet budgetary balance. This public service policy is conducted by the Ministry of Finance (MoF) in Japan, for instance, in consultation with the PMA. Increasing the tax during economic recession, however, could worsen the recession. In such a case, the PMA could issue additional money (EPM), which will be put into circulation through expansionary fiscal policy. Recall, however, that the fiscal dominance over issuance of money is avoided since any final decisions on the new issuance of money are determined independently of the fiscal needs as explicated in Section 4.2.

6.3 System Behaviors of Worldwide EPM Systems

EPM system fixes the four design failures of debt money system as the original public money system is expected to address. As listed below, behaviors of the public money system discussed in Section 4.3 are similarly observed under the electronic public money system such as monetary and financial stability, liquidation of government debt, income equality, and environmental protection. Income inequality will be more drastically eliminated because various payment methods will be simplified into one peer-to-peer payment method under the EPM system.

a. Stabilization of monetary system and its increased resiliency to the internal and external financial shocks

b. Liquidation of government debt within each EPM region.[9]

c. Elimination of income inequality between financiers and non-financiers.

d. Environmental protection within each EPM region.

Additionally, we consider that a world-wide network of EPM systems would attain, for example, the following cross-national behaviors.

e. Acceleration of cross-boarder capital flows into socially responsible investments, and environmental projects.

f. Expansion of peer-to-peer micro-lending investments, thereby stimulating community projects and small or medium-sized business opportunities.

g. Reduction of over-indebtedness and social unrests in favor of a sustainable growth path within each EPM region.

[9] As shown in Figure 7 below, EPM regions based on different currency are expected to emerge.

6.4 Core Design Configuration of EPM Protocol

To implement the EPM system world-wide, a new EPM protocol needs to be developed. Since the introduction of Bitcoin [11, 2008], several approaches for attaining network-wide consensus on a single transaction history have been proposed such as Proof of Work (PoW), Proof of Stakes (PoS), Proof of Importance (PoI) and Practical Byzantine Fault Tolerance (PBFT). In the proposed EPM protocol design below, issuance of EPM (coin generation transactions in Bitcoin) and transaction validation process must be separated to overcome the technical problems facing, say, the "Proof of Work" approaches. However, this involves in-depth technical discussions that are beyond the reach of the topic of this paper. Therefore, we only outline a high-level system configuration that must be incorporated into the design of EPM protocol.

1. **Manageability of EPM Supply** Total supply of EPM is managed by the PMA. The new EPM protocol must be able to accommodate the controllability of EPM stock by the PMA (public money policy). How should such transactions be recorded into the distributed ledger?

2. **Controllability of Uniform Tax Rate** To meet the balance of fiscal budgets, government must collect taxes. One possible way to implement this fiscal policy in the EPM system is through a *uniform tax rate*, which could be built into distributed ledgers as *public service fees* (Remark 1 below), or as conventional transaction fees against all transactions.

3. **EPM Transaction Verification** How should transactions be verified? Who should be responsible for verifying a new block, and which decision rule should be followed for reaching a consensus? Is the data structure of 'block' and 'blockchain' an optimal approach for attaining higher throughputs, traceability and provability of certain transactions made in the past? These questions must be answered together with the level of security the new EPM protocol is required to provide.

As in the original public money system, the PMA has to be managed independently but in a perfectly democratic and transparent way to avoid concentration of power in the PMA node(s). This includes the comprehensive disclosure of all information related to monetary policy decision processes (conditions C1 and C2 discussed in Section 4.2). Thus, the EPM protocol must be carefully designed both as a technical protocol for transaction system and as an organizational management one, which in turn must be reflected upon the overall governance of the EPM systems both within and across EPM regions. Given these discussions, Figure 6 illustrates a single EPM region in which the issuance of money is centrally administered by the PMA node(s) where payments are done directly between any two parties.

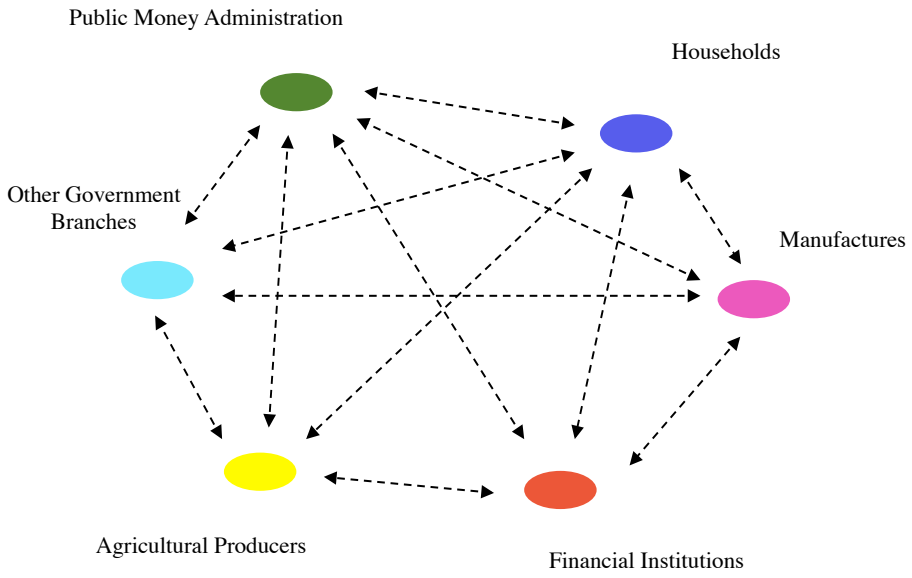

Figure 6: A Network within a Single EPM Region

Remark 1: Public Service Fees as Uniform Tax

Government needs to levy taxes for providing public services to the people in the EPM region. For this purpose the government is recommended to charge *Public Service Fees* (PSF) as proportionate transaction fees against all P2P transaction. In this way, all conventional taxes, such as excise tax, income tax and corporate tax, may be replaced with this new uniform tax. The introduction of the PSF will tremendously simplify the current complicated tax system since it could remove intermediary processes necessary in tax collection today, saving significant amount of bureaucratic costs, while increasing efficiency and reducing frauds.

Moreover, the scheme of PSF as Uniform Tax provides a new mechanism for addressing tax-haven evasions because tax-fees are levied fairly and proportionately to the amount of transactions without the need for identifying individuals and their sources of income.

Remark 2: EPM Regions

The effective region of EPM spans across physical borders of nation-states. Transactions of EPM can be made available everywhere on the planet as long as its users accept each nation-state's EPM just as central bank notes today

are used everywhere in transactions with cash. Gradually, EPM regions of all nationality begin to emerge world-wide. Figure 7 illustrates how each EPM region starts to emerge and begin to overlap as if diverse colors of floral petals open up internationally.

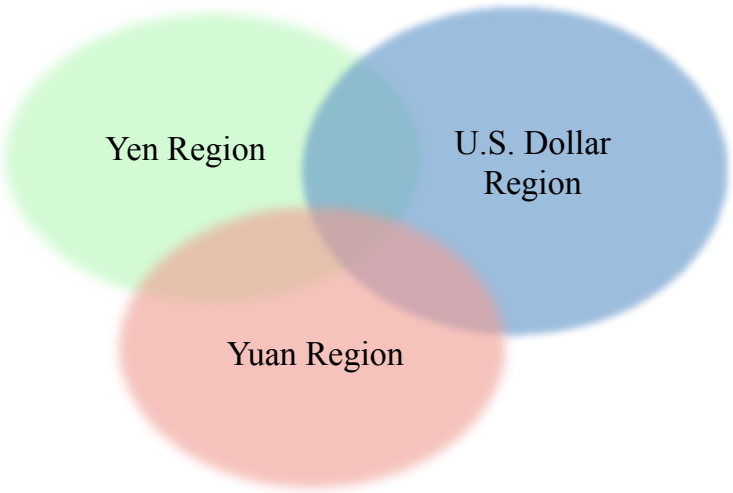

Figure 7: A Network of Worldwide EPM systems

Remark 3: Foreign Exchange Markets

Under the EPM system, anyone who wishes to sell or buy foreign currency may well be able to exchange on a peer-to-peer basis. In this sense, the current foreign exchange markets will expand even to individuals who previously had no choice but to pay unnecessarily high transaction fees to the foreign exchange service providers. How should such foreign exchange services be smoothly handled across different EPMs? This is an important foreign exchange protocol to be agreed. Yet, foreign exchange services between different EPMs and protocol required in such business should be developed separately from the regional EPM protocol, and be left entirely to private sectors to promote their business opportunities.

7 Blockchain-based Money Classified

7.1 Classification of Money (after the Year 2008)

We are now in a position to classify money, the main purpose of this paper, specifically blockchain-based money. To begin with, we broadly define blockchain-based money as (crypto-)money created by blockchain technology

that are transacted on blockchain-based payment system. That includes Bitcoin and all other types of 'cryptocurrencies'. Since the emergence of Bitcoin in 2008, more than 800 different blockchain-based money have been said to be created as Altcoins (alternative coins). Bitcoin was originally referred to as "peer-to-peer electronic cash" by Nakamoto [11, 2008]. Then all these blockchain-based money began to be called digital currency, virtual currency, digital money, digital cash and cryptocurrency without much care in their usage. Unfortunately, many confusions seem to have emerged as to the usage of the words such as *money* and *currency* in cryptocurrency space. As we classified different types of money between public money and debt money, and between legal tender and functional-money in Table 1, the same classification should be applied to blockchain-based money.

According to our analysis, all Altcoins are similar to Bitcoin as far as their functional aspect as medium of exchange is concerned. Therefore, they should be classified as functional-money because they are not legal tender. On the other hand, the concept of electronic public money (EPM) has been introduced as an another type of blockchain-based money. These two types are positioned in the functional-money and public money columns respectively in our extended classification Table 4. Yet, debt money (as legal tender) column between the two still remains blank.

Only recently, as if these blank spaces in the classification table are being filled in, other types of blockchain-based money have been proposed and experimented. They are central bank cryptocurrency (CBCC) and crypto-tokens. As a result, four different types of blockchain-based money are newly added into the classification table of money: Crypto-coin, CBCC, Crypto-token, and EPM as shown in the extended Table 4. Let us now explore these blockchain-based money in more detail.

7.2 Crypto-coin

Bitcoin as Functional-Money

Crypto-coins, consisting of Bitcoin and Altcoins,[10] are what is often referred to as cryptocurrrencies. Before Bitcoin, electronic money (digits) stored in digital cards and other substitutes issued in exchange for *currency* (cash) were the only digital cash or e-cash.[11] From our strict definition of currency and money discussed in Section 2, Bitcoin must be distinguished from legal tender or currency because we can refuse to accept it in payments. In this sense, it is more appropriate to regard it as "digital ingot" or "crypto ingot" generated by

[10] Crypto-coins could further be classified into permission or permission-less (Public) types, depending on whether a validating node is required a permission to join the network. Permission-type crypto-coins allow more functionality such as higher transaction throughputs. For the purpose of this paper, however, the distinction between these two may not be needed.

[11] Debit cards and credit cards such as Visa are not digital cash. They are payment instruments used in exchange for deposits at banks through card-issuing companies (non-bank payment service providers) by transfer of bank deposits.

Classification of Money (after the Year 2008)

	Public Money	Debt Money	
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 Notes by PM Admin.	Goldsmith Certificates Central Bank Notes	
Digital Cards & Accounts	Digital Public Money (PM)	Digital Cash Central Bank Digital Currency (CBDC)	Bank Deposits (Credits by Loans)
(After 2008)	< **EPM** >	< CBCC >	< Crypto-coin >
Blockchain & Distributed Ledgers	Electronic Public Money issued by PM Admin. (Peer-to-Peer PM)	Central Bank Cryptocurrency (issued as Base Money)	Bitcoin and approx. 800 Altcoins
		< Crypto-token (as Notes)	(as Deposits) >
		· M_1-backed Bank token: MUFG coin (Japan)	
		· M_1-backed Non-Bank token: Zen token (Japan)	
		· M_0-backed EPM token (cash)	

Table 4: Classification of Blockchain-based Public and Debt Money

miners similar to gold ingot, which can only be accepted as long as both parties in transaction agree. Accordingly, Bitcoin is categorized as functional-money in the classification of money in Table 4, since it functions as money similar to bank deposits under the debt money system. Other crypto-coins (Altcoins), though each crypto-coin may consider different security models and consensus algorithms, are also not legal tender, and only play a role as functional-money under the debt money system.

Readers may now wonder why these crypto-coins are classified under the umbrella of debt money? For an example, a new amount of Bitcoin is generated as new candidate block is successfully constructed and validated by other network peers. There is no debt or any form of lending activity involved in the process. The same principle also applies to Altcoins in general. However, as discussed in Section 5, the use of Bitcoin and Altcoins is very limited, and they function not as alternative monetary systems, but as supplementary payment methods under the debt money system. Hence, they are classified so in the sense that they serve as "functional money under the debt money system".

The World's Top 10 Crypto-coins

Their fixed amount of supply caused by the absence of value adjustment mechanism brings about volatility of values. Many crypto-coins are observed to share the same structural challenges as Bitcoin discussed in Section 5, and have been regarded as high-risk and high-return investment products. Accordingly, almost all Altcoins that we know of today are classified as functional-money. Table 5

lists the top 10 crypto-coins according to their scales of market capitalization.[12] It has been said that more than 800 Altcoins have been created so far and many have already disappeared from the market. Accordingly, the list of top 10 rankings continues to change quarterly. Until recently, Bitcoin has dominated more than 50% of the market capitalization.

Top 10 Crypto-coins (as of Sep 2nd, 2017)

Rank	Name	Market Capitalization	Price
1	Bitcoin	$76,561,792,510	$4629.09
2	Ethereum	$33,622,114,919	$356.22
3	Bitcoin Cash	$9,769,799,507	$590.08
4	Ripple	$8,872,381,573	$0.231390
5	Litecoin	$4,196,792,392	$79.56
6	NEM	$2,770,884,000	$0.307876
7	Dash	$2,689,302,539	$357.20
8	Ethereum Classic	$1,927,363,497	$20.26
9	Monero	$1,925,085,092	$128.13
10	IOTA	$1,839,117,905	$0.661665

Table 5: Ranking By Market Capitalization

7.3 Central Bank Cryptocurrency (CBCC)

The current debt money system has been examined to have built-in system design failures that cause monetary and financial instability, government debt accumulation, income inequality and environmental destruction, and the electronic public money (EPM) system has been proposed as its alternative system that eliminates these system failures. Recently a new possibility of utilizing blockchain technology for nation's settlement system is increasingly discussed and experimented by central banks around the world. Yet we have not discussed whether the design failures of debt money system could also be removed if central banks issue digital currencies (CBDC) and cryptocurrencies (CBCC). In other words, the issuance of CBDC and CBCC under the debt money system is left unanalyzed so far in our research.

To answer this question, it's essential to define CBDC and CBCC precisely. CBDC is digital currency issued by central banks; that is, electronic digits stored in the reserve accounts at their traditional data centers. Meanwhile, CBCC is the cryptocurrency (blockchain-based money) issued by central banks through distributed ledger technology and stored in the wallets of its users along with or in replace of central bank notes. Thus, CBCC and M_0-based EPM token (discussed below) become similar type of blockchain-based money in the sense that all EPM tokens are backed by base money under the current debt money system. Some technical proposals have already appeared to implement CBCC such as RSCoin (a permission-type blockchain)[3, 2015].

[12]Source: https://coinmarketcap.com/currencies/

<Public Money vs CBDC>

From the extended classification of money after the year 2008 (Table 4), it becomes clear that CBDC has to be discussed vis-a-vis Public Money (PM) in the original PM system, because they are based on the same media of digital numbers. PM is defined above as the money issued by the Public Money Administration (whose issuance is authorized by Congress, Parliament or Diet) under the condition of the 100% reserve ratio for demand deposits in order to remove the four system design failures of the current system. On the other hand, CBDC is issued when central banks newly allocate deposits accounts even to non-banking financial institutions, non-financial corporations and households in addition to the traditional reserve accounts currently held by commercial banks and other financial institutions. In short, anyone can open demand deposit account with the central banks under CBDC.

Then, the question we have to pose more specifically becomes the following: Can CBDC thus issued fix the system design failures of debt money system? There are three major issues, it is analyzed, that would make the actual implementation of CBDC very difficult as follows.

1. Shortage of base money (M_0) due to the fractional reserve banking system
2. Disruptive payment services of private sectors
3. Continuing design failures of the debt money system.

The first issue occurs during the transition phase. Surely the transition from the current system to CBDC will be hindered as soon as reserves of commercial banks are dried up as the demand for conversion from demand deposits (functional-money) to CBDC (legal tender) increases. However, this hindrance could be avoided either by requiring 100% reserve ratio in advance or an additional supply of CBDC through central banks' purchases of government securities held by commercial banks, which has similar effects on the financial market as QE (Quantitative Easing) policies have had. However, QE policy and further injection of reserves into the banking system distorts the financial markets and incur various risks such as inflation under the current system.

The second issue is related to inconvenience caused by CBDC and disruption of financial innovation. Upon transition to CBDC, ordinary depositors will have to open at least two deposits accounts: CBDC demand deposit account at the central bank and savings account at the commercial banks. Would this inconvenience be accepted by them? Another issue is that CBDC would disrupt payment services industry since central banks will process all payments done by CBDC. Indeed, this is the issue that one of the Fed Governor has already pointed out:

> A central bank-issued digital currency would compete with these and other innovative private-sector products and may stifle innovation over the long run.[13]

[13] http://www.coindesk.com/fed-caution-central-bank-digital-currencies/

Let us now consider the third issue by assuming that the transition is completed irrespective of such inconveniences experienced by users of CBDC. Even so, a more fundamental question remains unsolved. Under the current debt money system, the amount of CBDC (a part of M_0) in circulation is determined by the central banks that are privately owned in many nations. Under the circumstances, CBDC would still be issued at interest and the basic structure of debt money system remains the same. To avoid this monopolistic management of currency by private parties as well as political influences on them, we contend that central banks must be placed under the control of legislative branch of the constitutional government such as Congress, Parliament and Diet, as discussed in Section 4.2. Ironically, this reform turns out to be the same mechanism incorporated into the public money system for maintaining price stability.

As we have examined this way, it becomes clear that CBDC cannot remove system design failures, and, consequently, its benefits are minimal in comparison to the public money system. In other words, monetary and financial stability is impossible unless the structural elements of the public money system are incorporated into CBDC.

In addition to these three issues, it should be further pointed out that CBDC could expose the vulnerability of cyber security, because it concentrates the current centralized settlement system furthermore into a single point of failure at the data center of central bank. This makes the nation's financial infrastructure a vulnerable target by an increased number of cyber attacks and potential terrorist attacks. In other words, CBDC will have less tolerance to external attacks and internal malfunctions than the current system.

<EPM vs CBCC>

CBCC is issued by central banks as cryptocurrency. Accordingly, it has to be compared with the blockchain-based money of EPM (Electronic Public Money) for the comparative analysis. Contrary to CBDC, CBCC uses blockchain and may avoid centralization of settlement system as in implementing CBDC. Except this point, implementation issues discussed above under CBDC apply similarly to CBCC since every demand deposits (functional-money) is not backed by base money under the factional reserve banking system, CBCC is continued to be issued by the same central bank of the debt money system.

Differences in institutional design between CBDC and CBCC become clear at this point. Commercial banks no longer need to collect time deposits for investment under CBCC, simply because all transactions will be done on peer-to-peer basis and private investors will find direct investment opportunities by themselves through online peer-to-peer investment platforms. Such peer-to-peer lending businesses are emerging by now.[14] Hence, under such landscape in the coming age of blockchain, it seems desirable that the nation's payment system such as CBCC and EPM will be run by blockchain or, more generally, by distributed ledger technology. An ultimate question then arises; Can CBCC thus issued fix the system design failures of debt money system? In other words, can

[14]http://www.coindesk.com/foxconn-wants-take-global-supply-chain-blockchain.

monetary and financial stability, liquidation of government debt, and reduction of income inequality be attained under CBCC?

The answer will be Yes, if CBCC is to be integrated to EPM for the same reason as CBDC will be merged to PM in order to attain monetary and financial stability.

7.4 Crypto-token

To avoid price volatility of crypto-coins, crypto-token is proposed such that one unit of crypto-token is exchanged for one unit of money stock at any time. In Table 4, this type of crypto-token with stability of real money is further broken down into the following three groups according to different types of money with which crypto-token is backed.

- M_1-backed Bank token
- M_1-backed Non-Bank token
- M_0-backed EPM token

M_1-backed Bank token

This is the crypto-token issued by banking institutions, and backed by money stock M_1; that is, currency in circulation and demand deposits. As an example, MUGF coin is issued by the Bank of Tokyo-Mitsubishi UFJ (MUFG), Japan's largest bank, at an exchange rate of one MUFG coin for one Yen. According to several media reports, it is under experiment, starting May, 2017, among about 27,000 employees of the bank, and planed to be made available to the public from next year.

Another example is the token issued by Santander, a part of the Spanish Santander Group, which is using the Ethereum Blockchain technology. Santander will be the first bank, its officials confirmed, that utilizes the existing public Blockchain for issuing digital currency (or bank token in our classification). [15]

These banks experimenting M_1-backed bank tokens also belong to "R3 CEV's Consortium" that uses Ripple coin (XRP). The Consortium is said to consist of 42 Banks with combined $600 billion market capitalizations, 8 times as big as crypto-coin market capitalizations. Moreover, 60 % of these banks are said to be global SIFIs (Systemically Important Financial Institutions); namely, "too-big-to-fail" banks.

It is interesting to observe that these SIFIs in the Consortium were the banks which received massive bailouts from the US government after the Financial Crisis in 2008, according to the "United States Government Accountability Office (GAO) Report to Congressional Addressees, July 2011"; that is,

> Citigroup Inc., Morgan Stanley, Bank of America Corporation, Barclays, Goldman Sachs, Deutsche Bank, UBS, JP Morgan, Credit

[15] According to: https://cointelegraph.com/news/santander-confirms-fiat-backed-token-project-on-ethereum-blockchain

Suisse Group, Wells Fargo & Co., Societe Generale, BNP Paribas, Dresdner Bank.[16]

In addition, big Japanese banks and financial institution such as Mizuho, SMBC, and Nomura as well as non-Japanese HSBC are the consortium SIFI members. We predict that global token wars for issuing their own crypto-token will break up among these SIFIs sooner or later in order to enclose clients towards their own crypto-token networks. However, as long as crypto-tokens are backed by M_1, their stability as blockchain-based money is subject to the system design failure of boom-bust banking crisis under the debt money system.

M_1-backed Non-Bank token

To avoid the volatility of crypto-coin values, another type of crypto-token backed by money stock M_1 is issued by non-bank consortium, consisting of fin-tech startups and other non-banking companies. For instance, Zen token issued by the Japanese non-bank consortium called Blockchain Collaborative Consortium is now under experiment.[17]

M_0-backed EPM token

M_0-backed EPM token is the third type of crypto-token, which is backed by M_0; that is, base money. In other words, this type of crypto-token is issued only in exchange for base money. Practically, among two components of base money in equation (3), only currencies are in circulation outside of the banking system. Therefore, EPM token, which is explained in the next section as a case, is issued in exchange for currencies (mainly central bank notes) at the designated exchangers who are, in turn, obliged to keep these exchanged notes at their vaults or their reserve accounts at central bank for future conversion into currency. By confining the issuance of crypto-token this way, EPM token has a functional feature of EPM itself as discussed in Section 6; 100% reserve ratio for demand deposits or "100% money" as described by Fisher [4, 1935]. Hence, crypto-tokens issued and backed only by base money are classified collectively as M_0-backed EPM token even if whichever type of blockchain technology is applied to the underlying transaction system.

EPM token is in this way introduced as a half way step towards the full implementation of the EPM system for pre-testing its safety and performances in a regional economic environment. Due to this feature of 100% money, EPM token is expected to attract steady demands as the most stable and safe crypto-token for P2P payments, compared with crypto-coins and M_1-backed crypto-tokens under the current debt money system.

[16] On Nov. 2016, Goldman Sachs, Santander and Morgan Stanley withdrew from the R3 CEV Consortium. J.P Morgan also exited the consortium by April, 2017

[17] According to: http://bccc.global/ja/articles/20170705.html (last access on Sep 2, 2017).

8 Experimenting EPM-token in Japan

We have now completed the extended classification of Public Money, Debt Money and Blockchain-based Money, and explored money of the futures. We now wish to invite the reader to an on-going experiment of initiating EPM-token in Japan.

The EPM system revisited in Section 6 is shown to address system design failures of debt money system. In the previous section, the EPM system is discussed to function far better than the current debt money system, CBDC or CBCC. Accordingly, a complete transition to the EPM system from the current debt money system becomes our next objective. Yet before its implementation at a national level, various transitional steps are required such as the development of EPM protocol proposed in Subsection 6.4 and its test performances as the blockchain-based settlement system.

Accordingly, as its first step toward this goal, an experiment of EPM token project is planned as a business-oriented project[18] to provide such opportunities, while helping to revive regional economy of Japan simultaneously. To the best of our knowledge, the EPM-token project is the first "cash remittance" business model ever proposed on the basis of blockchain-based money system under the current debt money system.

The EPM-token project in general has to go through the following steps:

Step 1. Establish EPM Users Association (EPM-UA) as an incorporated company that manages the EPM-token project. EPM-UA issues EPM token in exchange for central bank notes, free of charge, at the one-to-one fixed rate.

Step 2. Find the associated token exchangers, who are wiling to provide the exchange service between bank notes and EPM token, preferably among local cooperative banks and financial institutions. Associated token exchangers exchange bank notes into EPM-token, and keep the exchanged notes at their vaults or their reserve accounts at the central bank to guarantee 100% Token $\Longleftrightarrow$ Notes convertibility at all times. In this way EPM-token becomes truly M_0-backed token. In return, associated token exchangers receive exchange service fees from EPM-UA.

Step 3. Confirm "Know Your Customers (KYC)" at the associated exchangers for the first time users. EPM-token users are charged "Community Service Fees (CSF)", a kind of transaction fees[19] , which are used to cover operational-costs of EPM-UA, including exchange service fees to the associated exchangers and EPM-token blockchain developers.

[18] Following the guidance by the Japanese Financial Services Agency, it turned out that this project needs to be carried out as "Cash Remittance" business by a corporate organization, not by a non-profit organization, according to the Japanese commercial laws.

[19] A system dynamics simulation model of EPM-token project will be developed and utilized to figure out optimal fees that cover all of its running costs. As the users and transactions of EPM-token increase, optimal CSF are surely reduced such that benefits are paid back to communities.

Step 4. Carry out a pilot experiment of EPM-token for several months among local communities by inviting local shops, producers, farmers and consumers to help stimulate and revive their economy.

Step 5. Expand the EPM token region to nation-wide simultaneously, as long as the management capacity of EPM-UA is secured. Maximum amount of EPM-token to be exchanged would be as large as the amount of bank notes in circulation, about 100 trillion yen in Japan as of August 2017, and as large as the amount of base money, about 460 trillion yen in Japan.

The objective of this EPM token project is to serve as a bridge from the current debt money system to EPM system by converting central bank notes $\Longleftrightarrow$ EPM tokens $\Longleftrightarrow$ EPM. Therefore, EPM-UA will fulfill its objective once the current system is fully transitioned to EPM system. The project will then be transferred to the PMA (Public Money Administration) of each nation state.

Conclusion

Four different types of blockchain-based money are newly added to the classification of money since the year 2008; Crypto-coin, CBCC, Crypto-token and EPM. Then, it is analyzed that all blockchain-based money except EPM are directly or indirectly dependent on the fractional reserve banking system that entails structural defects such as monetary and financial instabilities, government debt accumulation, income inequality and environmental destruction. The distinction between public money and debt money is particularly emphasized to clarify the need for and benefits of structural reform towards the public money system, which is designed to fix imminent problems facing the current system. Then, a unified design of electronic public money (EPM) system was revisited, which is designed to fully utilize the benefits of public money system by applying blockchain technology. Finally, the on-going experiment of EPM token in Japan is described, which is aimed to provide a bridge for the transition from the current system to the EPM system.

Finally, we would like to conclude this paper with a call for the advancement of design configuration of world-wide EPM systems openly and interdisciplinarily among blockchain developers, cryptography researchers, system engineers, economists as well as policy makers.

World-wide EPM System Forum
– Electronic (P2P) Public Money –

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