The Long-Run Endogenous Money-Interest ASD Model of the Debt Money System (Part IV)

– Built-in Unfair Income Distribution and Inflation –

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Yokei Yamaguchi †
System Dynamics Group
Japan Futures Research Center
Hyogo, Japan

Kaoru Yamaguchi
Director
Japan Futures Research Center
Hyogo, Japan

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Abstract

Income distribution has long been a central subject in economics in terms of social equity, welfare and macro stabilization policy. Yet we have so far omitted it from our analyses. In part IV we have further refined the long-run endogenous money ASD model developed in Part III to incorporate five additional types of interest rate and show that the present debt money system has a built-in income distribution mechanism in favor of bankers, while systematizing inflation of total income distributed to households beyond income distributed by producers (GDP less depreciation) and causing wage share to diminish. Our findings indicate the revised definition of wage share based on inflated income gauges interclass and intergenerational inequality more precisely and reflects the economic reality of the debt money system more accurately. These built-in unfair features of the debt money system have been largely neglected even in Post-Keynesian literature that stress endogenous money. As with Part III, Part IV model is able to reproduce behaviors consistent with the Great Depression and the case of Japan's lost 30 years qualitatively. The model expansion now allows us to analyze functional income distribution more explicitly in relation to neoclassical long-run growth dynamics and Keynesian income determination. Accordingly, the long-run endogenous money-interest ASD model developed in Part IV could serve as a standard model that fully embodies the paradigm shift in economics as a science.

Keywords: Accounting System Dynamics (ASD) framework, built-in inflation, built-in unfair income distribution, debt money, endogenous money, fractional reserve banking system, interest, inflated income, loanable funds, public money, macro agent-based modeling, wage share, the Great Depression, Japan's lost 30 years, paradigm shift

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†The first author (yokei.yamaguchi@gmail.com) is currently a researcher at Japan Futures Research Center (M.Phil. and M.Sc., European Master in System Dynamics). The second author (director-jfrc@muratopia.net) is a former professor at Social Sciences University of Ankara, Turkey (Ph.D. from University of California at Berkeley), currently the director of Japan Futures Research Center (www.muratopia.net). This research is partially supported by the research fund of Japan Futures Research Center.

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1 A Summary of Macroeconomic Modelings (Part I ∼ III)

Soon after Keynes (1936) published the *General Theory*, Hicks (1937) devised a simple analytical apparatus based on his interpretation of the Keynes's theory, which was subsequently refined and popularized by Hansen (1949) as the IS-LM diagram, *a.k.a.* Hicks-Hansen Synthesis. Although Hicks himself became gradually dissatisfied with it (Hicks, 1980), and the model has been the target of criticisms (both theoretically and methodologically) and attempted revisions have been made over the years, especially in the Post-Keynesian literatures (see Kriesler and Nevile 2016; Palley 2017; Rochon and Rossi 2017, for instance), few have presented an alternative simulation model that clarifies their critiques and support their claims.

While much has been discussed about the origin and conformity of the IS-LM model to the Keynes's original conceptualization and its lasting influence on the course of the subsequent evolution of macroeconomic thinking and teaching (see Young and Zilberfarb 2001; Backhouse and Laidler 2004; Brady 2017, for example), the pedagogical device, which will turn 100 years old in about a decade from now, still features in popular textbooks used worldwide including Mankiw (2016). In this sense, the IS-LM framework still underlies the dominant thinking and continues to influence generation of future economists as if there is a rationale of monetary and fiscal polices adopted by governments and central banks under the present debt money systems.

As discussed in Part I, however, virtually all economic policies suggested by the mainstream theories failed to recover the Japanese economy from decades-long stagnation since the burst of the bubble in the early 1990s, *a.k.a Japan's Lost 30 Years*. As we discussed in detail in Part I, the IS-LM analysis is founded on the premise that money stock is controlled by the monetary authority. We then identified that these policy failures were due to the failures of economic analyses rooted in the IS-LM model and proposed the paradigm shift from the comparative statics to dynamic endogenous money IS-LM model (Yamaguchi and Yamaguchi, 2022a).

From Part II onward, the model has been further extended to relax assumptions inherent in the traditional IS-LM to overcome its limitations grounded on the general equilibrium framework. In doing so, we have presented mathematical analyses of the *paradigm shift* and developed corresponding SD (System Dynamics) and ASD (Accounting System Dynamics) models in Part I, II and III step-by-step (Yamaguchi and Yamaguchi, 2022b, 2023). Since our analyses have become complex, let us begin this Part IV by first overviewing what has been attained so far. Table 1 summarizes the corresponding SD and ASD models presented in Part I, II and III.

	(Main Features)	Exogenous Debt Money (flawed)	Endogenous Debt Money (valid)
Part I	Fixed Price	Case 1 Keynesian IS-LM (SD)	Case 3 Endogenous Money IS-LM (SD)
	Flexible Price	Case 2 Flexible Price IS-LM (SD)	Case 4 Endogenous Money IS-LM (SD)
Part II	Sectoral Budget Equations	Case 5 Loanable Funds (ASD)	Case 6 Endogenous Money (ASD)
Part III	Capital Accumulation	Case 7 Long-run Loanable Funds (ASD)	Case 8 Long-run Endogenous Money (ASD)
Part IV	Interest and Unfair Income Distribution	Case 9 Long-run Loanable Funds at Interest (ASD)	Case 10 Long-run Endogenous Money at Interest (ASD)

Table 1: Classification of SD and ASD Macroeconomic Models

1. We began our research in Part I with the Keynesian Short-Run IS-LM model, which is built on the assumptions of fixed price and exogenous debt money. Based on this standard IS-LM model, Mankiw (2016) rejected the Money Hypothesis and only accepted the Spending Hypothesis as a plausible cause of the Great Depression. Since it is a com-

parative statics model, we have first converted it to a dynamic model with SD modeling approach. The Keynesian IS-LM model thus constructed failed to explain the behaviors of the Great Depression under both Spending and Money Hypotheses (Case 1 simulation).

2. Next, following the Mankiw's extended version of the Keynesian IS-LM model, we have built the corresponding SD model of Flexible Price IS-LM in which price is made flexible under the exogenous debt money assumption. Yet, both Spending and Money Hypotheses still failed to explain the behaviors of the Great Depression (Case 2 simulation).

3. Failures of these Keynesian models are caused by the assumption of exogenous money. By hypothesizing this way, we have reviewed the Fisher's *Debt-Deflation* and *100% Money* theories (Fisher, 1933, 1935) as originally presented, which has led us to formulate Endogenous Money Spending Hypothesis in place of the Spending and Money Hypotheses.

4. Based on this hypothesis we have developed the SD model of Endogenous Money IS-LM. Yet, this model also failed to explain the behaviors of the Great Depression under the fixed price assumption (Case 3 simulation). However, the model was able to explain the behaviors in a manner consistent with data under the flexible price (Case 4 simulation).

5. Accordingly, the Endogenous Money IS-LM model could be our paradigm shift model, we thought initially, because, as discussed in Part I, under the present debt money system, both *IS* and *LM* curves must move simultaneously in the phase diagram of income and interest rate, and this model can demonstrate such dynamic joint behaviors of *IS* and *LM* curves. Hence, the conventional Keynesian IS-LM model, in which *IS* and *LM* curves are shifted separately for macro stabilization policy analysis, is no longer valid as a reliable model of the economy operating under the fractional reserve banking system.

6. The Endogenous Money IS-LM model, however, failed to explain the on-going case of Japan's lost 30 years, which was represented as a "point J" in the IS-LM phase diagram (Figure 18) in the Part I paper. Specifically, we have identified that its explanatory limitation is due to the mechanistic application of the Endogenous Money Spending Hypothesis where money stock is assumed to fluctuate according to the growth rate of income.

7. To overcome this limitation in Part II, we have further expanded the above IS-LM model by incorporating the budget equations of domestic sectors such as producers, households, government and banks. Specifically we have first presented mathematical model of the Loanable Funds Model with Budgets and discussed its validity by introducing the concepts of *ex ante* and *ex post*. Next, we have presented a mathematical model of the Endogenous Money Model with Budgets (reproduced in Appendix I) and shown that it can capture the macroeconomic relationships empirically observed in Japan and the US such as "Money Stock $\simeq$ Total Debts" (Yamaguchi and Yamaguchi, 2021a; Yamaguchi, 2021).

8. To examine behaviors of these two models, we have incorporated sectoral budgets and transactions among all domestic sectors including the central bank based on Accounting System Dynamics (ASD) method. The two models developed in Part II are called Loanable Funds and Endogenous Money models, respectively. They are tested against three validation checks; unit check (as SD models), balance sheets and flow of funds consistency checks (as ASD models), and debt money checks (as macroeconomic models).

9. The Loanable Funds Model failed to explain the Great Depression (Case 5 simulation). At this stage of research we were convinced that the Keynesian view of exogenous money does not hold as a valid macroeconomic theory under the current debt money system,

as demonstrated in Cases 1, 2, and 5 simulations. On the other hand, the Endogenous Money ASD Model (Case 6) is shown to be able to reproduce behaviors that are consistent with data as the Endogenous Money IS-LM model developed in Part I (Case 4) did.

10. To examine the versatility of Endogenous Money Model developed in Part II, we have arranged parameter values such that it captures the "point J" in the phase diagram as a case of Japan's prolonged stagnation, at least qualitatively. Specifically, our model is able to (i) simulate point J, (ii) revealed the myth of crowing out effect, and successfully reproduced (iii) the debt money relationships, all of which are discussed in Part II paper.

11. In this way, the Endogenous Money Model is shown to explain the two major events that have taken place in modern economic history. Therefore, it must be the benchmark model that can be used to study complex macroeconomic dynamics under the present debt money system. All textbooks that still apply traditional (static) and flawed (exogenous money) IS-LM analysis must be rewritten based on this integrated framework. These are what we have attained in our series of macroeconomic modeling up to Part II.

12. In Part III we have further expanded the endogenous money ASD model developed in Part II to *long-run*[1] models by incorporating production function and capital accumulation, and reconfirmed that our long-run endogenous money model (Case 8) can explain the two historical cases, while the long-run loanable funds model (Case 7) failed to do so (Appendix II and III reproduce their mathematical models). This implies the Long-Run Endogenous Money ASD model provides the *general theory* of economic recessions under the debt money systems. Being convinced this way, we have further expanded our analysis in Part III to show that public money is the solution out of "Point J" against the debt money solution (such as MMT) that aggravates public debt and income inequality.

13. Yet we have so far omitted the analysis of income distribution from our Part I∼III papers. Table 1 shows the current Part IV, which incorporates additional types of interest rate and analyzes resulting income distribution under Cases 9 and 10. Our series of SD and ASD macroeconomic modeling research becomes more comprehensive in this sense.

This finishes the bird's-eye view of Table 1 as the paradigm shift in economics. In the next Section 2, different types of interest rate newly incorporated in Part IV are described, and mathematical model of this part IV is presented. In Section 3, long-run endogenous money-interest ASD model is formally presented. After performing its validation tests in Section 4, our main findings will be discussed in Section 5. In Section 6, we will further examine the model behaviors and see if the long-run stability discussed in Part III can be similarly observed. Finally, in Section 7, we will revisit the Japanese case once again with the newly developed model.

2 Long-run Endogenous Money-Interest Mathematical Model

The Long-run Endogenous Money ASD model presented in Part III lacks the analysis of various interest rates, which are essential in understanding economic dynamics under the debt money system. Specifically, the model has only one representative Interest Rate expressed in nominal

[1]Recall from Part III that the term "long-run" is is used here to indicate that the model incorporates production adjustment and capital accumulation. Note also that after Parts II & III, when aggregate production function is incorporated into the model (in addition to flexible price in Part I) our model is no longer the IS-LM framework in the traditional sense, but rather an advanced and dynamic version of AD-AS model. Therefore, the term "IS-LM" is dropped from the names after Part II in Table 1.

(i) and real (r) terms. Furthermore, distribution of income has long been a central issue in economic theory and policy. Yet we have so far omitted it from our simulation analyses. In this sense, the Part III model is not complete yet to assert the paradigm shift in macroeconomics. Therefore, our primary focus in Part IV is to incorporate various types of interest rates and analyze functional income distribution from system structure-behavior relationships.

2.1 Five Interest Rates Incorporated into the Part IV Model

As illustrated in Figure 1, we have introduced four additional interest rates into Part IV model (both in nominal and real terms). Specifically, nominal interest rate (i), which was determined

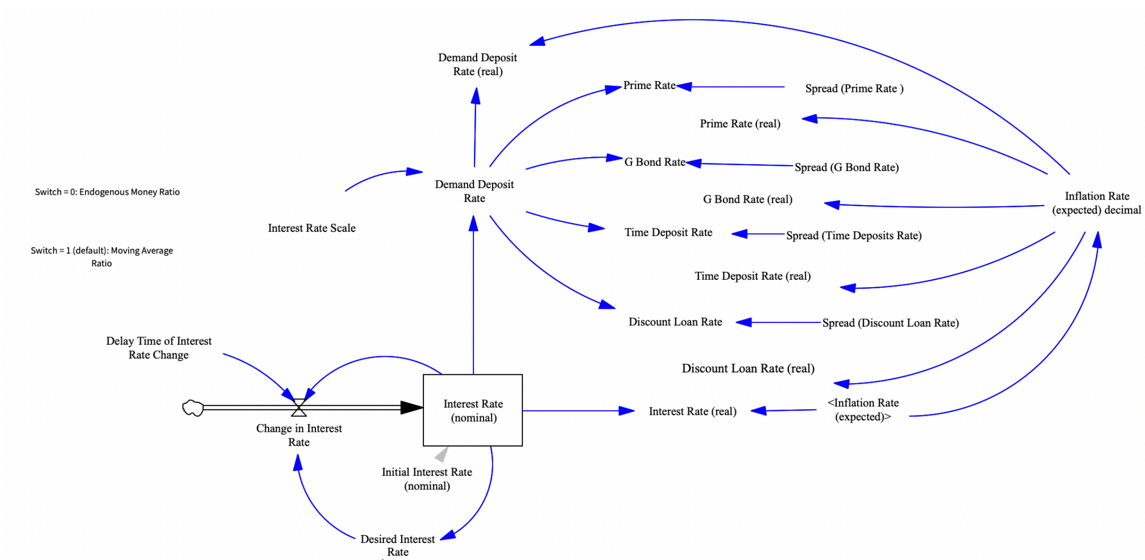

Figure 1: Five Interest Rates Incorporated into ASD Macroeconomic Model (Part IV)

by demand and supply of money stock in the previous Part III model, is now converted to *Demand Deposit Rate* (i_d). Taking this interest rate as a reference ("base") rate, we have introduced four types of interest rates such as *Prime Rate* (i_p), *Government Bond Rate* (i_{gb}), *Time Deposit Rate* (i_{td}) and *Discount Loan Rate* ($i_{d\ell}$), as similarly done by Yamaguchi (2017).[2] To make our analysis straightforward at this stage of modeling phase, they are simply assumed to be determined by the factors of interest rate spread (each defined by a scale factor of above 0) from the Demand Deposit Rate, which is set at 1 by default.

Under the present system, 99% of money stock (M_2 in the US; and M_3 in Japan) are created by central and commercial banks as "lenders" of those money at interests (Yamaguchi

[2]In Part IV model presented here, base interest rate is determined by the ratio of demand and supply of money stock, which inherits the same interest rate adjustment process adopted in Part I. On the other hand, Yamaguchi (2017) modeled the interest rate determination whereby the central bank affects base rate in the money market, which is determined by the supply and demand for reserves (akin to Federal Funds Rate in the US or Call Rate in Japan). The latter approach is more realistic as it incorporates monetary policy transmission mechanism as structured in the real world, and thus becomes useful when we make monetary policy endogenous as a reaction function of different policy targets such as rate of growth of GDP, income, inflation, unemployment, money stock (Friedman's k% rule), etc., or their reasonable combination such as Taylor rules (Taylor, 1993). In both ways, however, the underlying adjustment mechanism is similar whereby the interaction of the central bank, banks, producers (firms), households and the government all affects the base interest rates.

and Yamaguchi, 2021a; Yamaguchi, 2021). Specifically, there exist four instances in which deposits are created as a result of bank loans at different rates as listed in Column 3 of Table 2. Table 2 also shows their spread values used in our base run simulation. "(1a), (2a), ..." in Column 3 correspond to each flow illustrated in Figure 2 that indicates interest payments.

Lender	Borrower	Type of Interest Rate
(1) Central Bank	Banks	(1a) Discount Loan Rate (spread=0.6)
(2) Banks	Non-Bank Private	(2a) Prime Rate (spread=3.5)
Non-Bank Private (Demand Deposits)	Banks	(2b) Demand Deposits Rate (spread=1)
Non-Bank Private (Time Deposits)	Banks	(2b) Time Deposits Rate (spread=1.5)
(3) Banks	Government	(3a) Govt. Bond Rate (spread=2.5)
(4) Central Bank	Government	(4a) Govt. Bond Rate (spread=2.5)
(5) Public Money issued by Government		Interest Free (Money as Public Equity)

Table 2: Lender-Borrower Relations of Debt Money: Structure of Built-In Zero-Sum Game

(1) *Discount Loan Rate* ($i_{d\ell}$). Banks are required to keep a fraction of deposits as reserves.[3] Whenever they fail to meet the legal requirement, they are obliged to borrow reserves from the central bank at the discount loan rate. In our model, spread scale of discount loan rate is set at 0.6 by default; that is, it is determined as 60% of demand deposit rate.

(2) *Prime Rate* (i_p). Banks extend loans to producers and households at prime rates, with the spread scale of 3.5 by default; that is, a factor of 3.5 higher than demand deposit rate.

Demand Deposit Rate (i_d). Demand Deposits (DD) thus created by banks are their liabilities, though legally deposits are owned by banks. Banks pay interest according to demand deposit rate (interest spread scale = 1 by definition).

Time Deposit Rate (i_{td}). Non-banking private sectors (households, producers in our model) keep surplus funds as time deposits (savings), expecting to receive higher interest at time deposit rate, which is set to be spread =1.5 by default.

(3) *Government Bond Rate* (i_{gb}). Government finance its budget deficit by issuing treasury bonds. Banks invest in these bonds at interest rate spread = 2.5. by default.

(4) *Government Bond Rate* (i_{gb}). Central bank purchases government bonds from banks, which increases reserve deposits (which is part of base money M_0) through asset purchase operation. From macroeconomic standpoint, this is essentially the same as government indirectly borrowing from the central bank at interest (spread = 2.5) by issuing treasury bonds and selling them to the central bank. Therefore, the bond rate in our model functionally substitutes the rate applied on central bank's lending facility rate.

(5) Public Money issued at Interest Free. When the current debt money system is transitioned to the public money system, 100% of money is issued at interest free and put into circulation. See Yamaguchi (2013) further for the details on Public Money System.

2.2 Long-run Endogenous Money-Interest Mathematical Model

Let us now present our long-run endogenous money-interest ASD model used in Part IV by adding five interest rates to our previous endogenous money ASD model presented in Part III (Appendix 2). Equations (1) through (13) are the same as the equations (79) through (91) in Appendix 2.

[3]Some central banks have already lowered the required reserve ratio to zero including the Federal Reserve.

Keynesian Short-run IS-LM

$$\begin{aligned}
Y &= AD && \text{(Aggregate Demand Equilibrium)} && (1)\\
AD &= C + I + G && \text{(Aggregate Demand)} && (2)\\
C &= C_0 + cY_d && \text{(Consumption Decisions)} && (3)\\
Y_d &= Y - T - \delta K && \text{(Disposable Income)} && (4)\\
T &= T_0 + tY - T_r && \text{(Tax Revenues)} && (5)\\
I &= \frac{I_0}{r} - \alpha r && \text{(Investment Decisions)} && (6)\\
G &= \bar{G} && \text{(Government Expenditures)} && (7)\\
\frac{M^s}{P} V &= L^d && \text{(Equilibrium of Money)} && (8)\\
L^d &= aY - bi && \text{(Demand for Money)} && (9)\\
r &= i - \pi^e && \text{(Fisher Equation)} && (10)
\end{aligned}$$

Long-run Dynamic IS-LM

$$\begin{aligned}
\frac{dK}{dt} &= I - \delta K && \text{(Net Capital Accumulation)} && (11)\\
Y_{full} &= F(K, L) && \text{(Production Function)} && (12)\\
\frac{dP}{dt} &= \Psi(Y - Y_{full}) && \text{(Flexible Price)} && (13)
\end{aligned}$$

ASD Budget Equations at Interest

With the introduction of interest rates, households, producers and government receive interest against their deposits, and simultaneously pay interest rates agains the debts from banks. Let us denote their net interest incomes as NII_H, NII_P, NII_G, respectively (to be defined below). Then, their budget equations in Part III must be revised by adding these net interest incomes as follows:

$$\begin{aligned}
PC + PT + PI_H + S &= W + \Pi + \Delta D_H + NII_H && \text{(Households Budgets)} && (14)\\
W + \Pi &= PY && \text{(Distributed Income)} && (15)\\
PI_H &= \Delta D_H && \text{(Housing Budgets)} && (16)\\
I_H &= \bar{I}_H && \text{(Housing Investment)} && (17)\\
W + \Pi + PI_P &= PY + \Delta D_P + NII_P && \text{(Producers Budgets)} && (18)\\
I_H + I_P &= I && \text{(Private Investment)} && (19)\\
PG &= PT + \Delta D_G + NII_G && \text{(Government Budget)} && (20)\\
\Delta D_H + \Delta D_P + \Delta D_G &= \Delta LF && \text{(Loanable Funds as Debts)} && (21)
\end{aligned}$$

Money Stock and Deposits Creation: Endogenous Money

$$M^s = M_1 + TD_H \quad \text{(Money Stock Definition)} \tag{22}$$

$$M_1 = DD_P + DD_H + DD_G \quad \text{(Money Stock } M_1 \text{ Definition)} \tag{23}$$

$$\Delta LF = \Delta M^s \quad \text{(Endogenous Deposits Creation)} \tag{24}$$

$$M^s = \int \Delta M^s dt \quad \text{(Endogenous Money Stock)} \tag{25}$$

Net Borrowing, Debts and Demand Deposits

So far the structure of endogenous money-interest ASD model in Part IV remains the same as the long-run endogenous money ASD model in Part III, reproduced in Appendix 2, except some additional unknown variables such as net interest incomes (to be defined below). From now on, let us explain newly added variables. First of all, to calculate interest income, we need to specify the stock amount of debts (D) and demand deposit (DD) by producers, households and government. In system dynamics modeling, stock amount can only be changed by the net inflow. In this Part IV moddel let us specify net borrowing (= borrowing - repayment) by ΔD, which is, under the endogenous money system, credited as net increment of deposits ΔDD. Thus, we have the following net borrowing relations for producers, households and government, respectively.

$$\Delta DD_P = \Delta D_P \quad \text{(NetBorrowing of Producers)} \tag{26}$$

$$\Delta DD_H = \Delta D_H \quad \text{(NetBorrowing of Households)} \tag{27}$$

$$\Delta DD_G = \Delta D_G \quad \text{(NetBorrowing of Government)} \tag{28}$$

The stock amounts of debt and demand deposit are further obtained as the accumulated amounts of net inflows as follows.

$$D_P = \int \Delta D_P dt \quad \text{(Debt of Producers)} \tag{29}$$

$$D_H = \int \Delta D_H dt \quad \text{(Debt of Households)} \tag{30}$$

$$D_G = \int \Delta D_G dt \quad \text{(Debt of Government)} \tag{31}$$

$$DD_P = \int \Delta DD_P dt \quad \text{(Demand Deposits of Producers)} \tag{32}$$

$$DD_H = \int \Delta DD_H dt \quad \text{(Demand Deposits of Households)} \tag{33}$$

$$DD_G = \int \Delta DD_G dt \quad \text{(Demand Deposits of Government)} \tag{34}$$

Time deposits of households are additionally calculated as the accumulated amount of savings:

$$TD_H = \int S dt \quad \text{(Time Deposits Definition)} \tag{35}$$

ASD Net Interest Income

With these newly added variables, we are now ready to calculate net interest income (NII). Producers receive interest for their deposits ($i_d DD_P$) and pay interest against their debts ($i_p D_P$) to banks. Households receive interest for their deposits ($i_d DD_P$) and time deposits ($i_{td} TD_H$), and pay interest against their debts ($i_p D_H$) to banks. Government receive interest for their deposits ($i_d DD_G$) from central bank, and pay interest against the debts of government bonds ($i_{gb} D_G$) to bonds holders such as banks ($i_{gb} GB_B$) and central bank ($i_{gb} GB_{CB}$). Banks receive interest from producers ($i_p D_P$) and households ($i_p D_H$) for their loans and from government ($i_{gb} GB_B$) for their holdings of government bonds. On the other hand, banks pay interest to producers ($i_d DD_P$) and households ($i_d DD_H$) against their demand deposits and time deposits ($i_{td} TD_H$). Banks also pay interest to central bank agains their debts ($i_{d\ell} D_B$). Finally, central bank receive interest from banks for its discount loans to banks ($i_{d\ell} D_B$) and interest for its holding of government bonds ($i_{gb} GB_{CB}$), and pay interest against government deposits ($i_d DD_G$).[4]

$$\begin{aligned}
NII_P &= i_d DD_P - i_p D_P && \text{(Producers)} && (36)\\
NII_H &= i_d DD_H + i_{td} TD_H - i_p D_H && \text{(Households)} && (37)\\
NII_G &= i_d DD_G - i_{gb} D_G && \text{(Government)} && (38)\\
NII_B &= i_p D_P + i_p D_H + i_{gb} GB_B && && \\
&\quad - i_d DD_P - i_d DD_H - i_{td} TD_H - i_{d\ell} D_B && \text{(Banks)} && (39)\\
NII_{CB} &= i_{d\ell} D_B + i_{gb} GB_{CB} - i_d DD_G && \text{(Central Bank)} && (40)\\
D_G &= GB_B + GB_{CB} && \text{(Government Bonds)} && (41)
\end{aligned}$$

where five interest rates are assumed to be determined by the factors of the nominal interest rate spreads as follows.

$$\begin{aligned}
i_p &= i \cdot sp_p / unit_{\%} && \text{(Prime Interest Rate by Bank Loans)} && (42)\\
i_{gb} &= i \cdot sp_{gb} / unit_{\%} && \text{(Interest Rate on Government Bonds)} && (43)\\
i_{td} &= i \cdot sp_{td} / unit_{\%} && \text{(Interest Rate on Time Deposits)} && (44)\\
i_d &= i \cdot sp_d / unit_{\%} && \text{(Interest Rate on Demand Deposits)} && (45)\\
i_{d\ell} &= i \cdot sp_{d\ell} / unit_{\%} && \text{(Interest Rate on Discount Loans)} && (46)
\end{aligned}$$

Spread values are assumed to keep the following relations under the debt money system:

$$sp_p \geqslant sp_{gb} \geqslant sp_{td} > sp_d (= 1) > sp_{d\ell} \quad (47)$$

Model Equations, Unknowns and Parameters

Our long-run endogenous money-interest model is now complete with 46 equations: (1) ∼ (46). Total unknowns of this model consist of the 23 unknowns from Part III and and 24 unknowns newly added to the Part IV; that is, in total 46 total Unknowns (= 23 + 23).

23 unknowns from Part III

$$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W + \Pi, I_P,$$

$$\Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s, K, Y_{full}, P$$

[4] In reality, under the persistent deficits government deposits are negligible, and it is neglected in our ASD model.

23 unknowns (added) from Part IV

$$NII_P, NII_H, NII_G, NII_B, NII_{CB}, i_d, i_{d\ell}, i_{gb}, i_{td}, i_p,$$

$$D_H, D_P, D_G, GB_B, GB_{CB}, \Delta DD_P, \Delta DD_H, \Delta DD_G, DD_P, DD_H, DD_G, TD_H, M_1$$

On the other hand, in addition to the 15 parameter values from Part III, 5 parameters are newly added to Part IV as follows:

15 parameters from Part III

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H,\ \delta,\ L$$

6 parameters (of interest rate spreads added) from Part IV

$$sp_p,\ sp_{gb},\ sp_{td},\ sp_d(=1),\ sp_{d\ell}, D_B$$

Five interest rates newly added to the model are treated as constant variables at this stage of the modeling to simplify our analysis here. Surely, they have to be made endogenous variables structurally for a comprehensive model.

Out of the model thus presented above, we can matehmatically derive two features of the endogenous money-interest model.

Model Feature 1: Money Stock = Total Debts

(proof)

$$\begin{aligned} M^s &= \int \Delta LF dt && \text{(Endogenous Money Stock)} \\ &= \int (\Delta D_H + \Delta D_P + \Delta D_G) dt \\ &= D_H + D_P + D_G && \text{(Total Debts)} \end{aligned} \tag{48}$$

Model Feature 2: Zero-Sum Game of Net Interest Income

(proof)

$$(NII_P + NII_H + NII_G) + (NII_B + NII_{CB}) = 0 \qquad \text{(Zero-Sum Game)} \tag{49}$$

This implies that total amount of net interest income is equal to zero. Furthermore, net interest income of producers, households and government $(NII_P + NII_H + NII_G)$ become negative as shown in our ASD model below, while net interest income of banks and central bank $(NII_B + NII_{CB})$ becomes positive. Hence, interest incomes flow from producers, households and government to banks and central bank, that is, constant one-way flow.

We have discussed in Part II that under the endogenous debt money system Walras law holds as follows:

$$P(C + I + G - Y) + \Delta LF - (\Delta D_H + \Delta D_F + \Delta D_G) + S - \Delta M^s \equiv 0 \text{ (WalrasLaw)} \tag{50}$$

With the introduction of five interest rates, the expanded Walras law with interest under the ASD model of Part IV becomes as follows:

$$\begin{aligned}\text{Walras Law with Interest} &= \text{Walras Law} + \text{Zero-Sum Game} \\ &= \text{Walras Law} \equiv 0 \end{aligned} \tag{51}$$

Hence, thanks to the zero-sum game of net interest income, our analysis on Walras law in Part II holds in this Part IV ASD model as well.

3 Long-run Endogenous Money-Interest ASD Model

3.1 ASD Modeling of Net Interest Income

To confirm one-way flow of interest payments, we have constructed a simple ASD model of net interest income. Figure 2 illustrates five instances of money creation and resulting interest payments incorporated in Part IV model. Flow numbers in parentheses such as (1a), (2a), (2b) correspond to those indicated in Table 2.

Here, double-entry booking is applied to all transactions based on the ASD modeling framework; whenever loans are made, lender's asset (loans) and borrower's liability (debts) increase simultaneously, while borrower's asset (deposits) and lender's liability (deposits) also increase simultaneously. On the other hand, whenever borrowers pay interests, their equity is transferred into the lender's equity. In this way, we can visualize how money (income) flows from equities of borrowers (producers) to lenders (bankers). Figure 3 illustrates such income transfers via interests on money created as a result of bank loans. By also applying the ASD method on interest payments transactions, we have completed the addition of interest rates successfully.

Essence of Debt Money System

By looking at Figures 2 and 3, we can deduce the essence of debt money system as follows:

1. Most economic transactions require money. Under the present system, 99% of money is created as "demand deposits" and put into circulation as someone's debt at interest.

2. Money is thus issued as debts at various interest rates, and the resulting interest payments flow from borrowers' equities (such as producers, households and the government) into lenders' equities (such as banks and the central bank). Interest payments on those loans become a zero-sum game, and this lender-borrower relationships systematize constant one-way flows of equities to bankers who ultimately receive interests through dividends.

3. In this monopoly-like game, borrowers who would be unable to service their debts are destined to be losers. This debt-based zero-sum economic system is therefore designed from the beginning to benefit bankers and unfair against the rest of non-banking sectors who must borrow money to invest and produce income by going into debts with banks.

3.2 ASD Model of Transactions and Balance Sheets

Figures 21, 22, 23, 24 and 25 in Appendix 4 present transactions and balance sheets of five sectors incorporated in Part IV model. Compared with full-scale ASD macroeconomic models with population cohorts, labor market and open economy structure developed by Yamaguchi (2013, 2017), Part IV model presented here priorities simplicity and has a relatively simple structure.

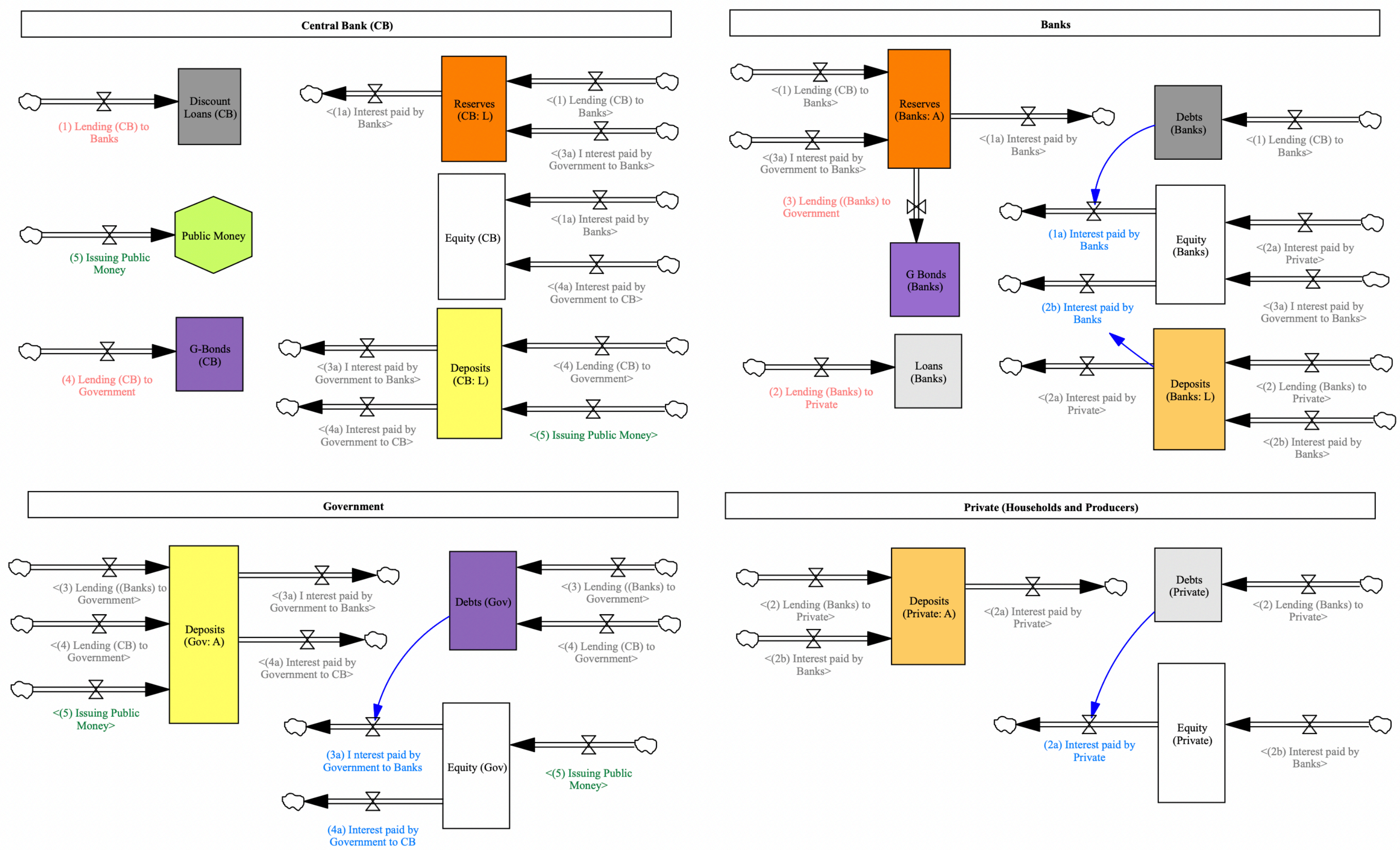

Figure 2: Five Instances of Deposit Creation at Interest and Double-entries of Interest Payments (Illustration)

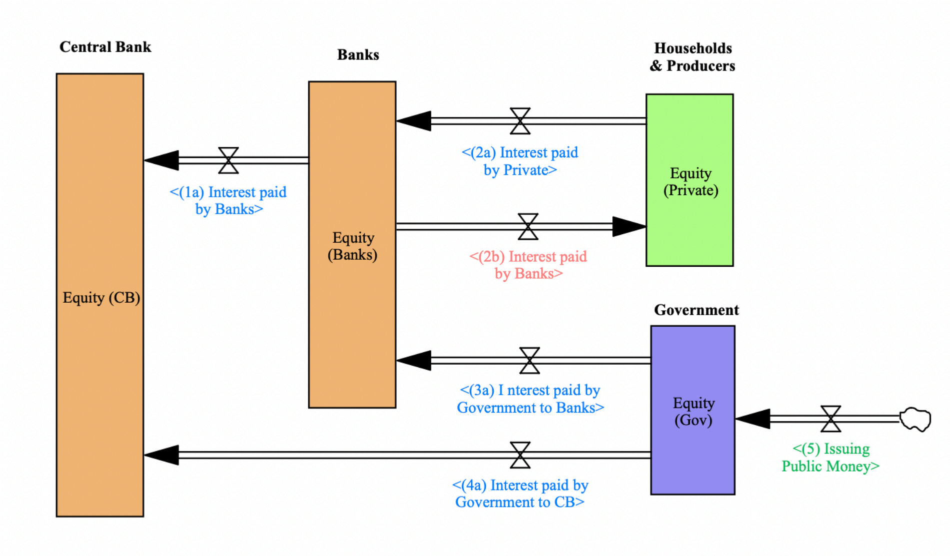

Figure 3: Income Transfer from Debtors to Bankers via Interests (Illustration)

4 Validations of the ASD Model

Our long-run endogenous money-interest ASD model is now complete. We then performed three validation tests that were discussed in Part II and the additional fourth test proposed in Part III, which checks whether the model can handle off-equilibrium condition of four macroeconomic aggregates defined from production, distribution, and expenditure sides. In Part III paper we have claimed that all macroeconomic models must meet these tests in order to be qualified as genuine models. In this sense, these validation tests comprises another aspect of the *methodological* paradigm shift that we discussed in Part I paper.

(1) Validation As SD Model: Model and Units Check

First, built-in model tests performed by the SD simulation software (Vensim) such as "Check Model" and "Units Check" must be all cleared. Our model has passed both tests. In Part I we have pointed out that the extended IS-LM model with expected inflation presented by Mankiw (2016, Chapter 12) failed to pass this basic unit consistency check.

(2) Validation As ASD Model: Balance Sheets and Flow of Funds Checks

Accounting system requires that balance sheets of all sectors must be in balance at any point in time and their transactions are coherent. This first test to ensure such consistency of the model is called balance sheets (B/S) check. In addition, the flow-of-funds account framework requires that all assets and liabilities (equity) of all financial transaction items in the model must be in balance across all sectors involved at every time step. This second test is called the flow-of-funds (F/F) check. Left diagram of Figure 4 illustrates that each sector's balance sheet are close to zero and remain in balance (Assets = Liabilities + Equities), indicating that our Long-run Endogenous Money model passes B/S check for all five sectors. The right diagram shows that each financial transaction item are all in balance (close to zero) across sectors that are holding them as assets, liabilities (or equities), such as demand and time deposits, bank

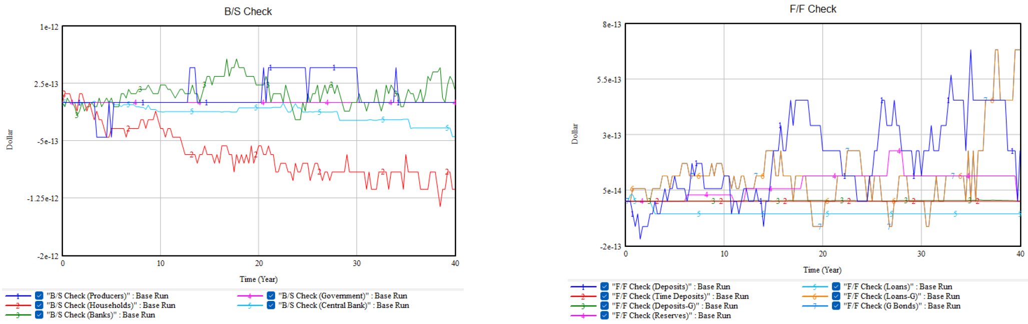

Figure 4: Validation Test (2) - Balance Sheets (B/S) and Flow-of-Funds (F/F) Checks

loans, reserves, government bonds and government deposits. We have also performed B/S and F/F checks on the Long-run Loanable Funds model confirm the model passed these tests.

(3) Validation As Macroeconomic Model: Debt Money Check

Yamaguchi and Yamaguchi (2021b) reported that the following three relationships hold in Japan between 1980 and 2019 (line numbers in parentheses correspond to those in Figure 5).

1. Total Money Stock (M_3) $\simeq$ Total Debts (line 1 $\simeq$ line 2)
2. Time Deposits (M_T) $\simeq$ Private Debts (by Producers and Households) (line 3 $\simeq$ line 4)
3. M_1 (= Currency + Demand Deposits) $\simeq$ Government Debts (line 5 $\simeq$ line 6)

We have already proven mathematically in equation (48) that the first equation holds true all the time under the debt money systems. Similar relationships to the Japanese case are observed in the US since 1945 where total money stock is M_2 (Yamaguchi, 2021). Empirical results thus indicate that the first relation must hold in other economies operating under the fractional reserve banking (debt money) system. In Part II we have mathematically presented why total debts (D) approximate money stock (M^s). Hence, this additional validation test was introduced in Part II as "Debt Money check".

Figure 5 confirms that all of the above three relations of Debt Money Check hold for the cases of Long-run flexible price when primary balance ratio is reduced by -0.12 from 1.0 at t = 15. That is to say, Endogenous Money case shown in the right diagram shows that total money stock defined as M_2 in the model is equal to total debts, while the remaining two relations also hold in our generic model. Loanable Fund case (left) also shows that all three relations hold.

(4) Production, Distribution and Expenditure: Non-Equivalence Checks

Our final and fourth validation test is the relations of newly introduced four macroeconomic aggregates; Production (GDP), Production (Unit Cost Basis), Distributed Income and Aggregate Demand. They are in general not equivalent in values. As illustrated in Figure 6, only at

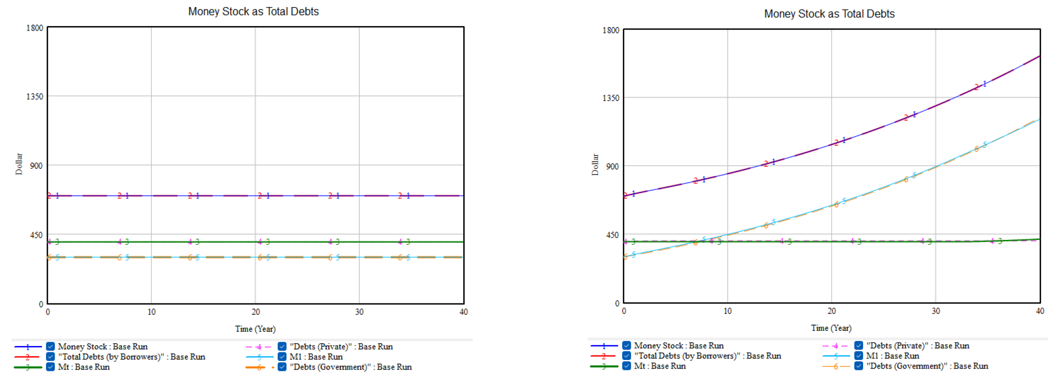

Figure 5: Validation Test (3) - Debt Money Check: Money Stock $\simeq$ Total Debts

the equilibrium where Unsold Products = 0, we have the following equivalence relations:

$$\begin{aligned} \text{Production (GDP) (1)} &= \text{Production (Unit Cost Basis) (2)} \\ &= \text{Aggregate Demand (3)} \\ &= \text{Distributed Income (4)} + \text{Depreciation (Cost) (6)} \\ &\geq \text{Distributed Income (4)} \\ &\quad\ \text{(for Depreciation (Cost)} \geq 0) \end{aligned} \tag{52}$$

Numbers in parentheses indicate simulation line numbers. In Figure 6 investment is increased by 20 dollars at t=15. Around the time t=21 and t=26 when Unsold Products (at Price) (line 5) is positive (line 5), the following relations are observed:

$$\begin{aligned} \text{Production (GDP) (1)} &> \text{Production (Unit Cost Basis) (2)} \\ &> \text{Aggregate Demand (3)} \\ &> \text{Distributed Income (4)} \end{aligned} \tag{53}$$

Around t=24 when Unsold Products (line 5) is negative, these relations are reversed such that

$$\begin{aligned} \text{Aggregate Demand (3)} &> \text{Production (Unit Cost Basis) (2)} \\ &> \text{Production (GDP) (1)} \\ &> \text{Distributed Income (4)} \end{aligned} \tag{54}$$

These disequilibrium relationships are central to economic dynamics. Macroeconomic models that only presume the equivalence relation (equation (52)) cannot differentiate basic concepts such as GDP, income, profits and are incomplete from the ASD modeling approach.

The above four tests completes validation of the ASD model developed in Part IV. We believe it is a one of the most comprehensive models in the sense that theoretical controversies between neoclassical and Keynesian schools[5] of economics can be uniformly analyzed under

[5] Although we do not prefer the terms "∼ school" or "ism" alike (see our discussion in Part III further), contemporary scholars of Post-Keynesian school list five key characteristics that help distinguish it from other heterodox schools; (1) principle of effective demand, (2) monetary theory of production (monetized economy), (3) fundamental uncertainty, (4) historical and irreversible time, and (5) income distribution (see Hein (2017); Lavoie (2015) for instance). With the introduction of production function in Part III and interests in Part IV, the long-run endogenous money-interest ASD model developed in Part IV embodies these features.

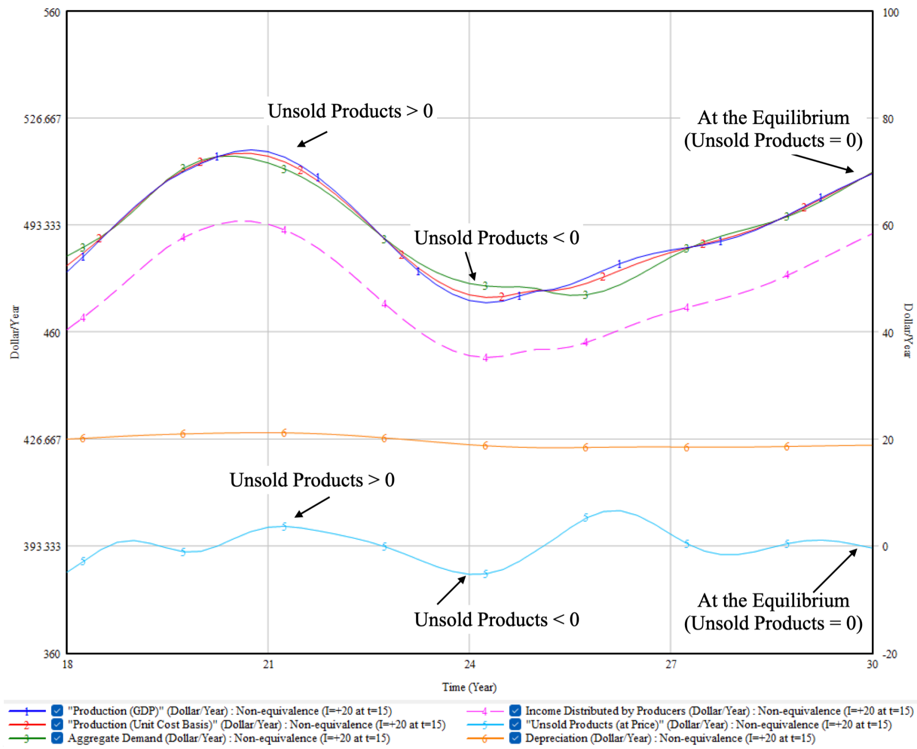

Figure 6: Validation Test (4) – Non-equivalence of Four Macroeconomic Aggregates

the same model by changing the parameters to account for different behavioral hypotheses, or, if necessary, by further expanding the model structure such as monetary policy reaction function. Many heated controversies in the mainstream economics have given us an impression that their models are mutually exclusive and cannot be integrated like oil and water. The ASD macroeconomic model provides an effective platform to test different hypotheses and can potentially provide common understandings on the long-standing controversies.

5 Built-in Unfair Effects of Debt Money System

Integration of five different interest rates into the model reveals unfair income distribution mechanism that have been built into our capitalist economy and their undesirable macroeconomic effects arising from the present debt money system; that is, persistent inflation of income in favor of bankers and diminishing wage share. Let's examine them one by one.

5.1 Built-in Unfair Distribution of Income

Figure 7 illustrates how interest income is distributed among lenders (bankers) and borrowers (non-banking sectors) under the base run in stacked graphs. First, the left diagram shows how interest income is distributed as dividends of bankers (blue area) and dividends of central banker (red area). The right diagram shows how producers, households, and the government (as borrowers) pay interest out of their equities. Specifically, blue mesh area shows interest paid out by producers (thus negative value) and red area shows those by households. Producer's interest income is always negative as they pay interest for the funds borrowed from banks.

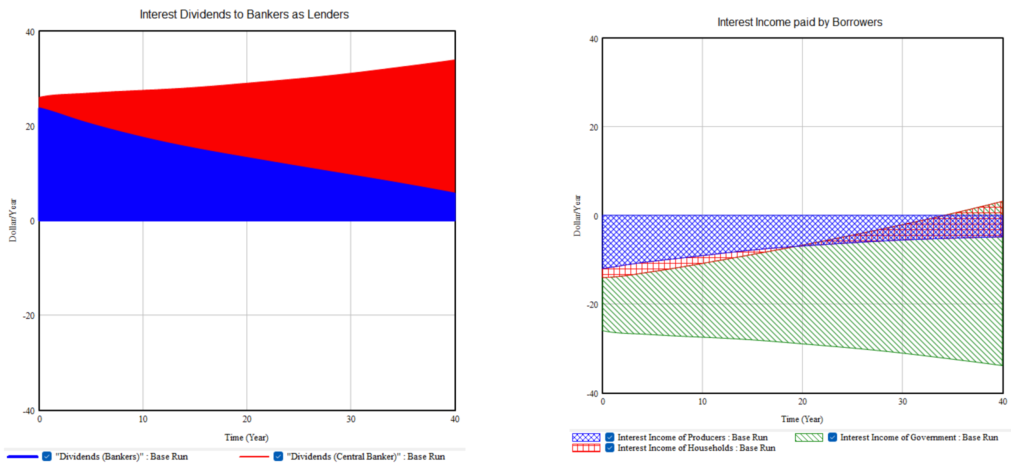

Figure 7: Interest and Dividends received by Lenders (left) vs. paid by Borrowers (right)

On the other hand, interest income received by households may become negative or positive as they receive higher interest from their time deposits than interests accrued from housing loans (debt). Indeed, under the base run scenario, interest income received by households turns positive at around t=20, thus canceling out the blue area in the stacked graph. Lastly, interest paid by the government shows that it is always negative and the green area widens, indicating that interests accruing on treasury bonds are increasing year after another. This also explains why the combined area (blue and red) shown in the left diagram, which is the total interest income received by bankers and central bankers, is constantly increasing.

Figure 8 shows built-in unfair distribution of income from borrowers to lenders. In the left diagram, line 1 (bold blue) shows the total amount of interest income received by lenders as dividends. that is, bankers and central banker, while line 2 (bold red) indicates the total amount of interest paid to banks by the borrowers, that is, households, producers, and government. Lines 3 through 5 show breakdowns of interest incomes paid by producers, households and government, while lines 6 (orange) and 7 (semi-light blue) are those of interest incomes received by banks and central bank as dividends. Here we can easily observe that lines 1 and 2 are symmetrical on the center line (= 0), which means that the sum of lines 1 and 2 is equal to zero. That is, at a macroeconomic level, distribution of interest income becomes zero-sum game under the debt money system.

Right diagram indicates cumulative amount of interest incomes presented in the left diagram. Line 1 (bold blue) indicates how interest income received by bankers (as dividends) continue to accumulate, while line 2 (bold red) shows how borrowers are obliged to pay the corresponding amount of interest income to bankers. Compared to the right diagram, lines 1 and 2 on the left diagram reveal the nature of zero-some game more vividly. If the government issue "public money" at interest-free Yamaguchi (2013), no such interest payments and unfair income transfers do not take place. In this sense, the present debt money system has built-in income distribution mechanism in favor of bankers from the beginning.

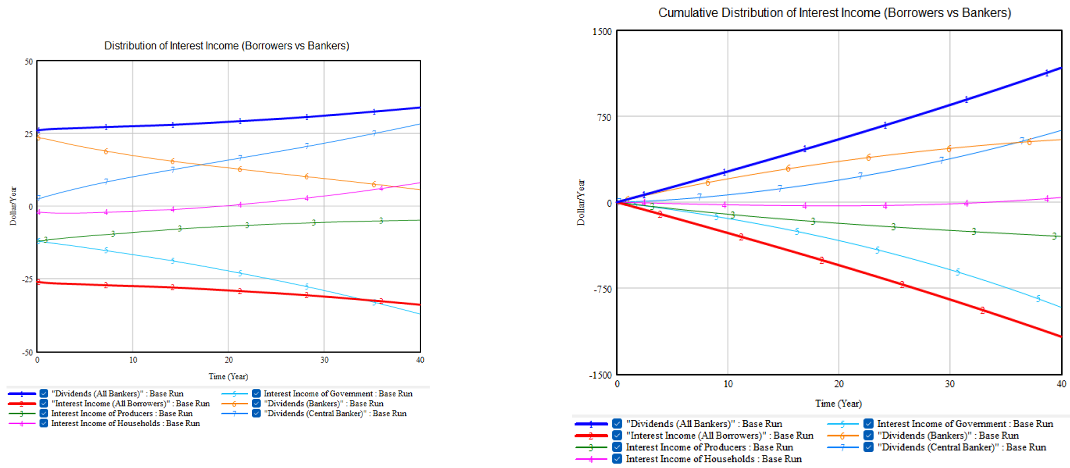

Figure 8: Built-in Unfair Distribution of Income as Zero-Sum Game

5.2 Built-in Inflation and Diminishing Wages Share

For simplicity, our model assumes that all profits realized by producers are distributed as dividends to households without being retained. Thus, shareholders (who are households) receive dividends fully from producers and shareholders of banks (also households) receive dividends fully from banks and the central bank out of their interest incomes. Hence, in our model, income of households consists of wages of workers, dividends of corporate shareholders and dividends of bankers. Left diagram in Figure 9 illustrates how workers, shareholders, bankers and households sector as a whole receive factor incomes as a stacked graph.

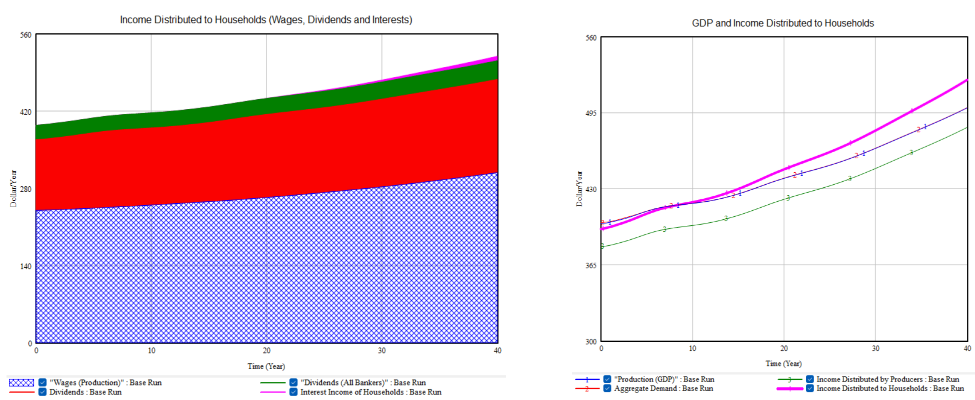

Figure 9: GDP and Inflated Income Distributed to Households

In the right diagram, total amount of these distributed income to households is indicated by line 4 (bold pink). From the principle of double-entry bookkeeping, it should be equal to the income distributed by producers shown by line 3 (green), which is the economy's total value-added (GDP) less depreciation. Let's call this aggregate concept as "total income distributable" alternatively (note the difference from disposable income Y_d). Yet, the distributed income to households is larger than total income distributable and seems to be inflated. How come?

By running many simulations, we have confirmed that line 1 (blue) becomes equal to line 3 only when government transfers (T_r) as well as government bond rate (i_{gb}) is zero. Government transfers and interest on bonds must be paid out of the government's tax revenues. If tax revenues are smaller than expenditures, the government is forced to borrow by (further) issuing bonds. Hence, interest and transfer payment tend to drain from the government's equity into the equity of households. This is why the income distributed to households tends to inflate above the total income distributable by producers as illustrated in the right diagram.

Note that this phenomenon can occur only at the expense of negative equity incurred by the government. If the government follows normal accounting rule, it is already broke and has to be shut down just as private institutions are obliged to file a bankruptcy. Yet, as a sovereign entity, it has the ability to continue and incur more debts, which, under the debt money system, increases total money stock. And this becomes the source of the inflated income.

Impacts of Inflated Income on the Economy

What is the macroeconomic impact of such inflated income, then? To examine this, we have run four simulations by assuming zero transfers and different spread scales for government bond; that is, 0, 1, 2 and 3, respectively. Figure 10 illustrates behaviors of Production (GDP), Price, Money Stock, and Income distributed from the top left in clockwise under these scenarios; line 1 (blue; spread=0), line 2 (red; spread=1), line 3 (green; spread=2) and line 4 (pink; spread=3).

Firstly, we can observe that Production (GDP) gets inflated as government bond rate increases. Prices increases similarly as well as money stock. In other words, the whole economy gets "inflated" as government bond rate increases and persistent inflation begins to dominate.

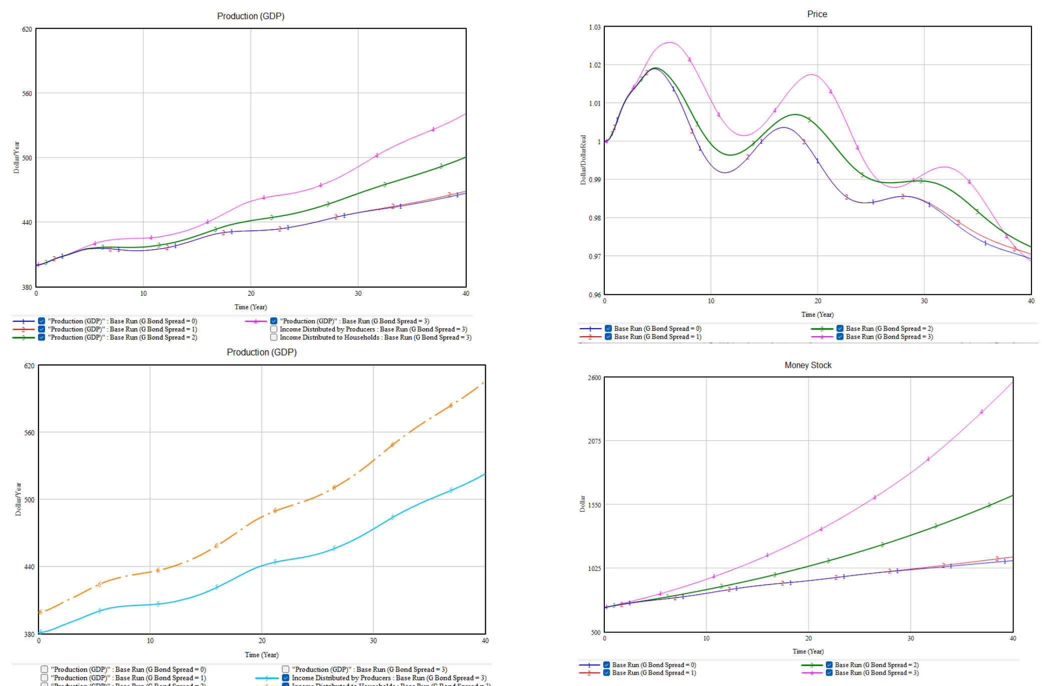

Figure 10: Impact of the Inflated Income to Households

To trace the source of such inflationary trend, we have focused on the behaviors under the case of spread=3, and compared income distributed by producers (line 5; light blue) and income distributed to households (dashed line 6; orange) shown at the bottom left diagram of Figure 10. The difference between two lines shows how the total income is inflated due to the interest payment generated by government bonds. Indeed, line 4 at the bottom right diagram shows how money stock keeps increasing from 700 at t=0 to 2,560 at t=40, more than threefold.

This was one of surprising findings obtained from our analyses. That is, under the present system where money is endogenous, the economy is put under a persistent inflationary pressure as the government continues to increase its debt (especially from banks), and monetary value gets deteriorated as a result such policy. Our simulations show that this devaluation of money, *i.e.*, currency depreciation, is indeed one of the features (design failure) of the debt money system as "built-in inflation". We have been brainwashed by mainstream textbooks that central bank and government can control inflation if their policies are implemented at right timing, size, and combination. This built-in inflation also causes money and wealth devaluation, especially on pensioners. On the contrary, under the public money system, structural cause of this type of persistent inflation will be eliminated.

Impact of Inflated Income on Wage Share

This time we have further found out that workers are inevitable to suffer under this inflation as well. Textbooks in general define labor distribution as formalized in equation (55).

$$\text{Wage Share} = \frac{\text{Wages}}{\text{Income Distributed by Producers}} \tag{55}$$

Left diagram of Figure 11 shows that wage share does not get affected by the government's interest payments. It stays around 0.63, and increases slightly as the economy continues to grow as shown in the top left diagram of Figure 10.

Yet this time we have realized that this concept of wage share does not reflect the real economics situation because bankers who are part of households also receive interests and reflate the total income of households. To reflect this reality, the concept of wage share must be revised so that wages are valued against inflated income of households as follows:

$$\text{Wages Share (Inflated Income)} = \frac{\text{Wages}}{\text{Income Distributed to Households}} \tag{56}$$

Right diagram of Figure 11 depicts how the newly revised wages share behaves under different spread scales. As the spread for government bond rate increases, wage share decreases, and workers get relatively poorer in comparison with non-wage incomes earners. This is the second type of built-in unfair effects observed under the debt money system.

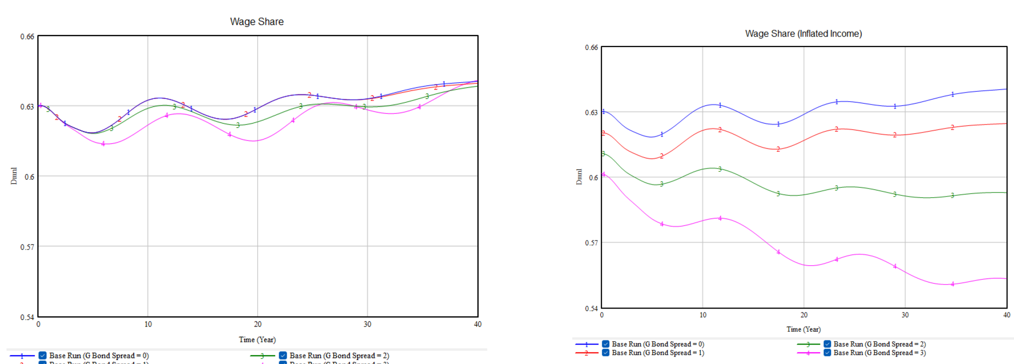

Figure 11: Impact of Inflated Income on Wages Share

After the Lehman Shock, central banks have implemented QE and lowered nominal interest rates including those on government bonds. The Part IV model allows us to analyze potential impacts of such interest rate policies on income distribution and other macroeconomic variables.

Built-in Effects of Debt Money System vis-a-vis Public Money System

By incorporating five types of interest rate into the ASD model developed in Part III, we have now identified four built-in features of the debt money system in Part IV as follows.

1. Money is created only when non-banking sectors (producers, households and the government) borrow from banks at interest; that is, Total Money Stock $\simeq$ Total Debts.

2. This built-in income distribution via interest payments among lenders and borrowers becomes an unfair zero-sum game in favor of bankers who ultimately receive dividends (as shareholders of banks). By institutional design, bankers always receive net interest income from the rest of non-banking sectors in this zero-sum game (debt money system).

3. This built-in unfair income distribution causes constant transfers of equity from the government to lenders (bankers) and inflates total income of households beyond income realized by producers (GDP less depreciation). Consequently, the economy gets inflationary as long as the government is obliged to keep borrowing and pay interest to bankers.

4. Inflated income of households in turn diminishes wage share, causing workers relatively poorer against bankers as unearned income earners (interclass inequality).

5. This built-in unfair income distribution and inflation cannot be controlled by central bank nor the government, devalues value of money and life savings of pensioner's in particular in nominal terms (intergenerational inequality).

To overcome these built-in unfair effects of the debt money system, Yamaguchi and Yamaguchi (2021b) proposed a transition to the public money system, which has the following features.

1. Money Stock = Net Equity of the Public. All money is issued by the government as public equity at interest-free and put into circulation (exogenously) to support sustainable growth under price stability objective.

2. Built-in equitable distribution of interest income. Under the public money system, interest income is generated only when the economy grows (part of GDP), so that the increased amount of GDP is fairly distributed among wage earners and bankers who reinvest Savings (S), causing fair and positive-sum game among investment stakeholders.

3. Built-in stability of the quantity of money (M^s) and its value. Public money is additionally put into circulation only when the growing economy needs it through government expenditures. The government is provided with such additional money as equity, not as interest-bearing debts. Price (P) and purchasing power of money is stabilized accordingly.

6 Behaviors of the ASD Macroeconomic Model

In order to show that the long-run endogenous money-interest ASD model developed in this Part IV become indeed the standard macroeconomic model of our paradigm shift, let us now examine the model and confirm if long-run behaviors discussed in the paper of Part III are similarly obtained.

6.1 Long-run Flexible Price Equilibria

In the long run price P must be flexible. This price flexibility is assumed by default in the model such that Initial Ratio Elasticity (Price) = 6. Left diagram of Figure 12 demonstrates long-run equilibria thus attained under the endogenous money (Case 10); that is, full capacity production (line 1 in blue), desired production (line 2 in red) and production (line 3 in green) are all matched. This long-run equilibrium is attained under the additional assumption that Inventory gap does not affect price fluctuation; that is, Weight of Inventory Ratio = 0.

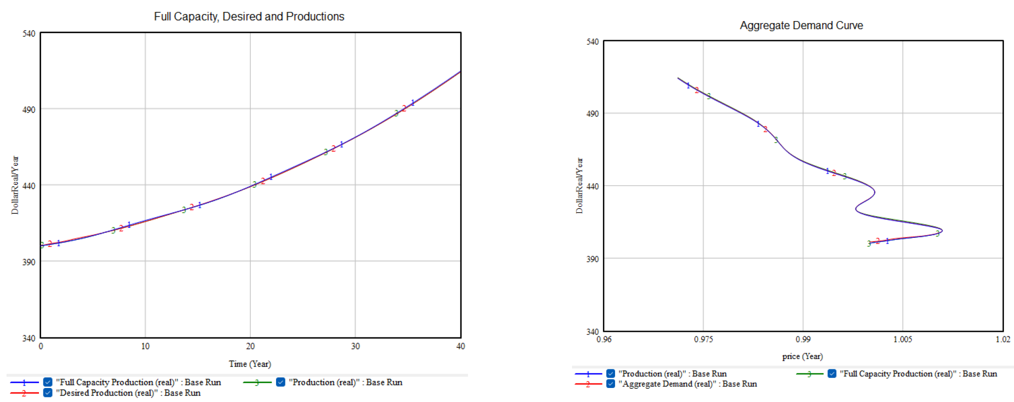

Figure 12: Long-run: Flexible Price Equilibria and Aggregate Demand Curves

Aggregate Demand Curve

Let us next examine if the long-run equilibrium exhibits a long-run aggregate demand curve. Its existence is derived as already discussed in Part III as follows. First, let us rewrite the simple IS-LM equilibrium of production obtained in Part I as a function of price:

$$Y(P) = A + B\frac{M^s}{P}V \tag{57}$$

where A and B are combined constant amounts. Then it becomes clear that this equation only provides a relation between Y and P. Hence, $Y(P)$ is called an aggregate demand function of price. Only when price is flexible in the long run, full capacity production becomes equal to the production as presented in the above left diagram such that

$$Y_{full} = Y(P) \tag{58}$$

This is how the long-run aggregate demand function is theoretically derived. It can be also interpreted as the long-run aggregate supply function. Right phase diagram of Figure 12 indeed demonstrates production (line 1 in blue) and full capacity production (line 3 in green) as functions of price in the long run successfully.

6.2 Stability of Long-run Flexible Price Equilibria

Long-run equilibria attained under price flexibility can be shown to be stable in the sense that any outside shocks are in the long-run as the neoclassical (general equilibrium) theory claims. Let us consider the case in which outside shocks of investment increase and decline take place at t=10 such that $\Delta I = +20$ and -10 from the initial level of $I = 60$. Left diagram of Figure

13 shows how off-equilibria caused by outside shocks of investment increase (lines 1,2,3) and investment decrease (lines 4,5,6) are restored to the equilibria. In a similar way, let us consider another case of off-equilibria caused by outside shocks of changes in Marginal Propensity to Consume (MPC) by $\Delta MPC = \pm 0.03$ at t=10 from the initial level of $MPC = 0.6$. Right diagram shows how equilibria are restored in the long run when MPC is increased or decreased.

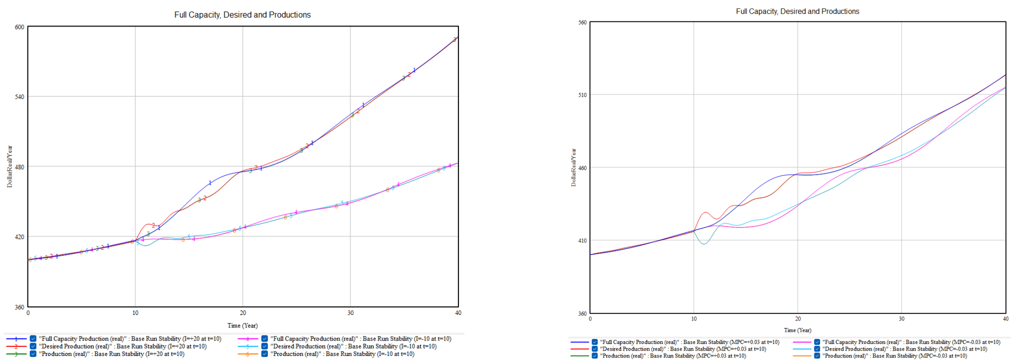

Figure 13: Stability of Long-Run Equilibria under Flexible Price

In this way, our long-run endogenous money-interest ASD model is demonstrated to attain long-run stability and can also capture the features of neoclassical growth model succesfully.

7 Case of Japan's Lost 30 Years Revisited

For Part IV model to be claimed as the standard macroeconomic model of debt money system, it has to be able to capture two historical cases as analyzed in Part III; that is, the Great Depression and the recent case of Japan's lost 30 years since the early 1990s. The Great Depression case will be examined here as an prolonged case of Japan's lost 30 years. Accordingly, let us focus solely on the Japanese case. Specifically, the ASD model has to be able to reproduce the following features of Japan's lost 30 years as analyzed in Part II and III:

- Decomposition of Debt-Money Relationship (Section 7.1)
- Japan's Lost 30 Years as the Prolonged Case of Great Depression (Section 7.2)
- "Point J" as the Representative Case of Japan's Lost 30 Years (Section 7.3)

Our simulations are performed over 40 years from 1980 through 2020[6] for three cases as listed in Table 3. The first two are hypothetical cases or "what if" scenarios. The first scenario is called (1) "Japan as No.1" where we assume the growth path even after the burst of the bubble, that is no decline in private demand occurs. The second case is called (2) "Japan's Great Depression" in which government does not implement fiscal spendings, and leave the economy as it is with the hope that the economy would self-recover. We call this second case "Japan's Great Depression" because, as already discussed in Part I, the US government at the time of the Depression of the 1930s did not increase its expenditure, which was contrary to what the Japanese government did during the post-bubble recession phase in the mid-90s.

[6] We specified Initial simulation time t=0 as t=1980 in the model using time axis labeling functionality. Accordingly, simulation time t=11 implies 1991 and t=13 implies 1992.

Comparing the two scenarios thus provides us a good case for "what if" simulation experiments. The third scenario is called (3) Japan's Lost 30 Years, in which we attempt to simulate the actual historical case, with continuous government deficit spendings.

Japan as No. 1 ("As Usual" Growth Path)	(1) Technological Change = 0.013 (← 0.01) (2) Initial MPC = 0.68 (← 0.6) Change in MPC = 0.1 at t = 6 (3) Initial Interest Sensitivity of I = 16 (← 12.4) Change in Interest Sensitivity = -1 at t = 12 (4) Initial Ratio Elasticity (Price) = 2.5 (← 2) (5) Repaying Withdrawal Ratio = 0 (← 1.6) (6) Initial Deposits (Households) = 70 (← 100) (7) Initial Time Deposits (Households) = 380 (← 400) (8) Initial Deposits (Producers) = 70 (← 200)
Japan's Great Depression (without govt. spending)	(9) ΔC_0 caused by Unit Cost (wages) change (Figure 14) $\Delta I_{01} = -15$ at t=1990, $\Delta I_{02} = -44$ at t=2001 $\Delta \bar{I}_H = -12$ at t=1992 (10) Change in Repayment Ratio (Producers) = 1 (← 0) at t=12
Japan's Lost 30 Years	(11) $\Delta PB = 0.2$ at t=1999 (Fiscal Policy)

Table 3: Parameter Values for the Simulation of Japan's Lost 30 Years

In our previous analyses in Part II and III, we have identified eleven parameters, which are listed in Table 3, in order to run simulations in a manner consistent with data. However, it should reminded here that the purpose of our analysis here is to test if the Part IV model can capture the behaviors observed during the Japan's lost 30 years, at least qualitatively. Therefore, they are still exploratory in nature as we utilize one-time parameter changes as economic shocks given from the outside.

Our simulation proceeds as follows. To start with the "Japan as No. 1" case, we have set parameter values (1) through (8) as listed above. To trigger a recession in the next "Japan's Great Depression" case, we have introduced outside shocks on the parameter values (9) such as basic consumption ΔC_0, investment (producers) ΔI_0 and housing investment $\Delta \bar{I}_H$, as well as (10) repayment of producers as shown in the table (see Appendix 4 for notations used in Part I∼IV papers). As the outside shock of ΔC_0, we have newly introduced the assumption that the structural reform (deregulation and privatization) implemented by the government since the 80s and 90s broke down the Japanese management practices and encouraged cheap labor policy among firms (producers), which significantly increased non-regular workers, followed by the decrease in unit wage cost (UC_w).

Left diagram of Figure 14 reflects such drop in unit wage cost, say, from 0.65 in 1990 to 0.55 in 2000, which then stays at this low level until 2010 and recovers slightly to 0.58 in 2020. The right diagram shows how such drops in unit cost of wages decreased the amount of basic consumption.

Finally, to produce "Japan's Lost 30 Years", we have further introduced outstanding fiscal policy by increasing primary balance ratio of ΔPB by 20% in 1999. Until that year balanced budget has been assumed in the model; that is, primary balance ratio = 1. These three steps complete our simulation analysis on the Japan's lost 30 years in this section.

7.1 Decomposition of Debt-Money Relationship

Using parameter values in Table 3, let us first examine if the model can capture the decomposition of debt-money relationships. Specifically, there are three macroeconomic relationships

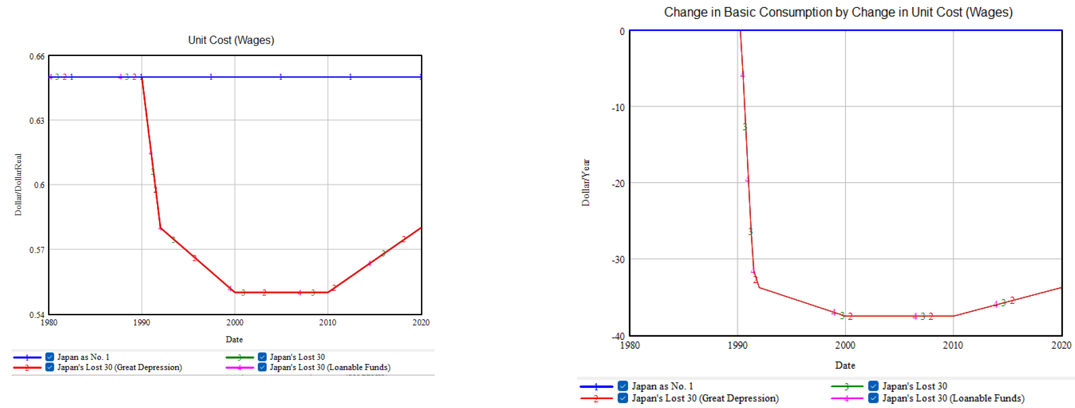

Figure 14: Change in Basic Consumption ΔC_0 caused by Unit Cost (wages) Changes

empirically observed in Japan (Yamaguchi and Yamaguchi, 2021b) as follows:

- Money Stock (M_3) $\simeq$ Total Debts (correlation coefficient = 0.987)
  (line 1 $\simeq$ line 2)
- Time Deposits (M_T) $\simeq$ Non-Banking Private Debts (correlation coefficient = 0.928)
  (line 3 $\simeq$ line 4)
- M_1 $\simeq$ Government Debts (correlation coefficient = 0.992)
  (line 5 $\simeq$ line 6)

The first relation is already examined in Section 4 as the model validation test (3). Lines 1 (blue) and 2 (red) in the left diagram of Figure 15 confirms the relationship in our simulation of "Japan's Lost 30 Years" case. On the other hand, lines 3 (green) and 4 (pink) approximately confirm the second relationship, while line 5 (light blue) and line 6 (orange) confirms the third relationship. Line 7 in the left diagram displays the behavior of Production (GDP) in the model. On the right diagram, line 1 plots the Japan's nominal GDP data since 1980.

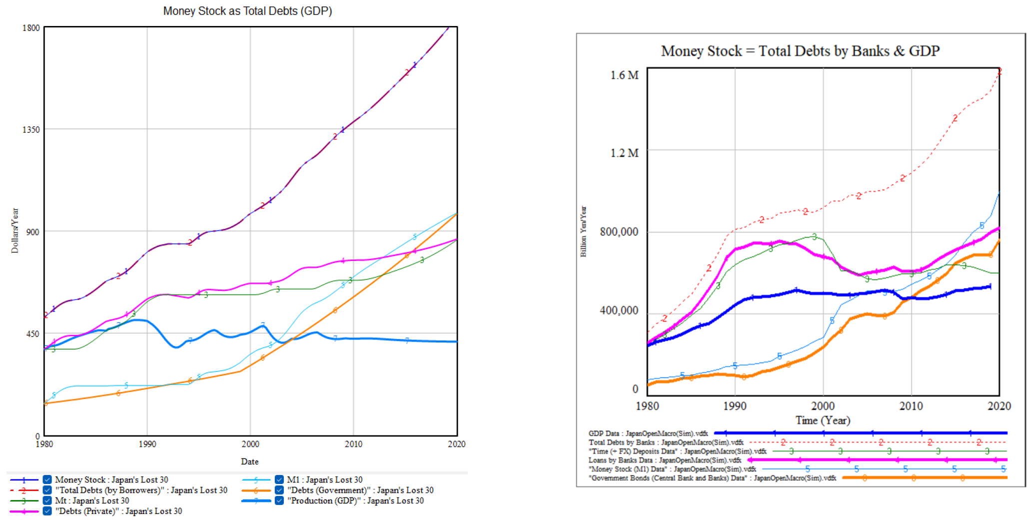

Figure 15: Japan's Lost 30 Years: Simulation (left) and Data (right)

Comparing these two diagrams, we may affirm that the model can reproduce debt-money relationships observed during the past three decades, at least qualitatively. Hence, the model should be able to analyze the Japan's lost 30 years and identify the system structure underlying the phenomenon by introducing behavioral hypothesis customized for the Japanese case (through changing the parameter sets).

7.2 Japan's Lost 30 Years as the Prolonged Great Depression

Now let us use this model to perform the structural analysis of Japan's lost 30 years. We have run four simulations as listed in Table 7.2. Figures 16 and 17 compare the model behaviors under these simulations. "Japan as No.1" (lines 1) shows baseline case as if the high economic growth

Endogenous Money ASD (Case 10)	Loanable Funds ASD (Case 9)
Line 1 (blue): Japan as No.1 Line 2 (red): Japan's Lost 30 (Great Depression) Line 3 (green): Japan's Lost 30 Years	(With Fiscal Policy) Line 4 (dotted pink): Japan's Lost 30 Years

Table 4: Legend Names for Simulations of Japan's Lost 30 Years

that Japan achieved until the early 1990s continued. "Japan's Lost 30 (Great Depression)" (lines 2) simulates "what if" case without fiscal spendings of the government; that is, $\Delta PB = 0$ at t=1991 (no fiscal policy). In other words, behaviors presented by lines 2 illustrate a hypothetical scenario where Japan could have undergone sever economic downturns similar to that of the Great Depression.

"Japan's Lost 30 Years" depicted by lines 3 (green) presents simulation under active fiscal policy; that is, $\Delta PB = 0.2$ at t=1999 (fiscal policy). Accordingly, by comparing lines 2 and 3 plotted in Figures Figures 16 and 17 we can analyze behaviors under the two contrasting scenarios under the Japan's recession without or with fiscal policy.

Production (GDP) shown in the left diagram of Figure 16 indicates that Japan's GDP would have been reduced significantly (line 2 in red), compared with line 3 in green, if the government did not apply active fiscal stimulus. "Japan's Lost 30 Years (Loanable Funds)" indicated by

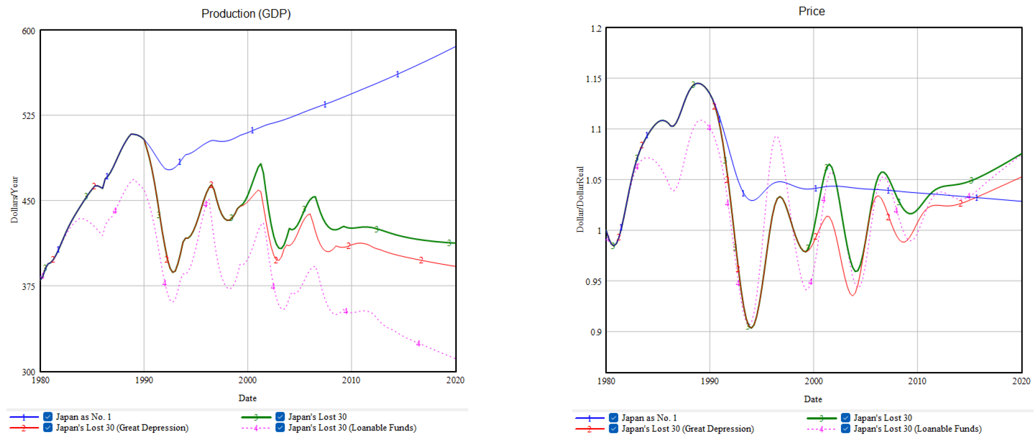

Figure 16: Japan's Lost 30 Years – Production (left) and Price (right)

dotted lines 4 is added to see if Japan's lost 30 years could have been described under the mainstream exogenous money assumption, i.e., under the Loanable Funds ASD model.

We have now run four different simulations over the Japan's lost 30 years, By running four different simulations, we have now obtained the following observations:

(1) In our model, behaviors of key macroeconomic variables are similar under recessions, with or without fiscal policies (lines 2 and 3). However, their degrees of change vary.

(2) Money stock first decreases under recessions, then continues to increase.

(3) Under the loanable funds, money stock is constant. Thus, the Loanable Funds model is disqualified as a model of the debt money system as in Part I, II and III.

Our first observation may be indicating that whenever fiscal policy is applied, degrees of variation in the key macroeconomic variables could be reduced and economy seem to be stabilized. Yet the effects of recession cannot be entirely mitigated. As for the second and third observations, we have created Figure 18, which summarizes the direction of changes in each variable (just as we did in Part I, II and III analyses). Figure 18 evaluates direction of change in money stock M^s, price P, real money balance $\frac{M^s}{P}$, nominal interest rate i, and real interest rate r, respectively. First row shows the US data observed during the Great Depression. Second row indicate our behaviors observed in Part II model, which proved that our endogenous money model can reproduce behaviors the Great Depression qualitatively.

	M^s	P	$\frac{M^s}{P}$	i	r
The Great Depression (1929-1933)	↓	↓	↑	↓	↑
Endogenous Money ASD Model (Part II)	↓	↓	↑	↓	↑
Loanable Funds ASD Model (Part II)	→	↓	↑	↓	↑
Endogenous Money ASD Model (Part IV) (Japan's Lost 30 Years)	↓	↓	↑	↓	↑
Loanable Funds ASD Model (Part IV) (Japan's Lost 30 Years)	→	↓	↑	↓	↑

Figure 18: Qualitative Evaluation of Japan's Lost 30 Years as Prolonged Depression

The third row show that Loanable Funds model failed to explain the decline in money stock, which is indicated by the black arrow. The right-pointing arrow indicates no change, i.e.

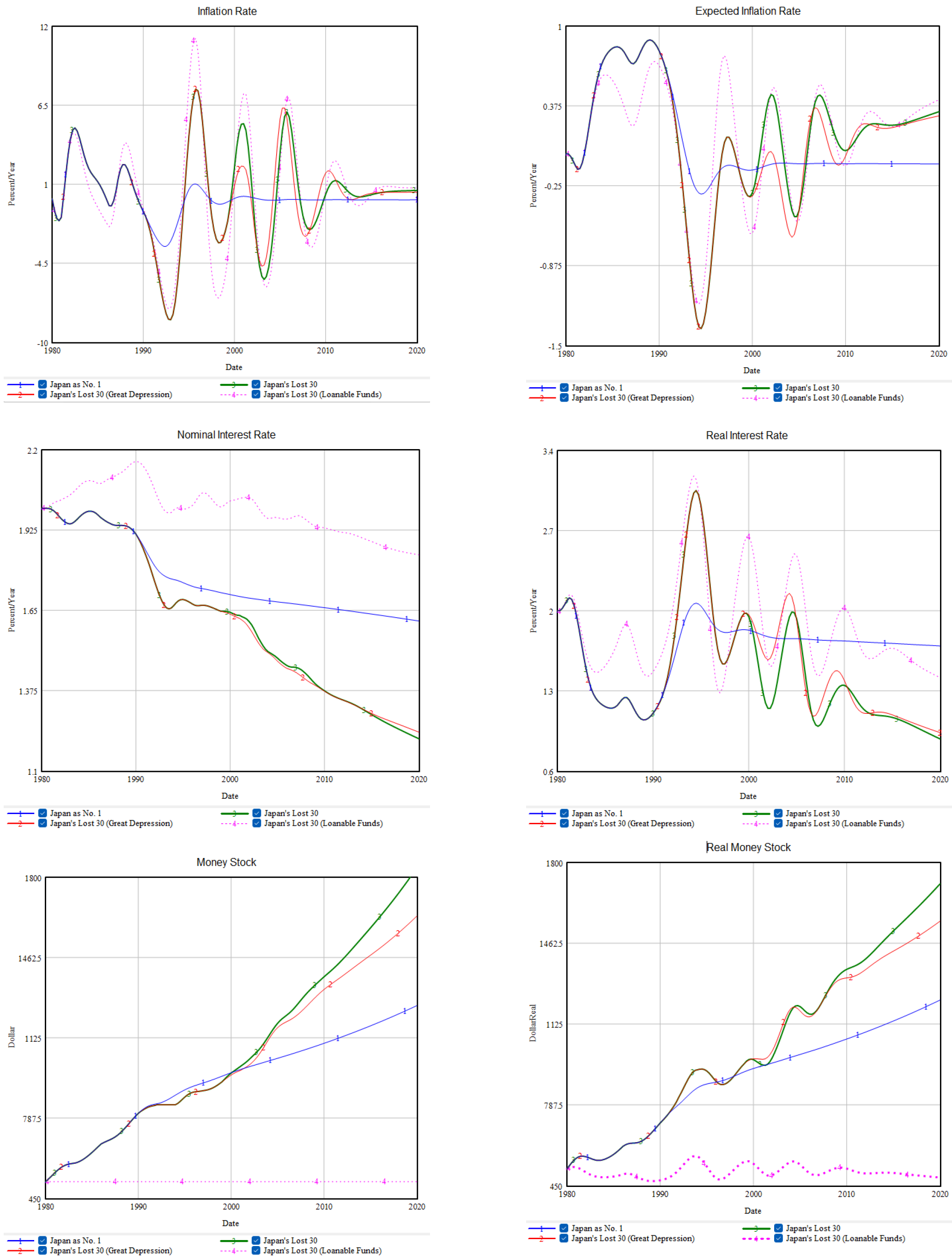

Figure 17: Japan's Lost 30 Years – Inflation, Interest Rates and Money Stocks

money is constant (exogenously given). Hence, loanable funds model was rejected in Part II as legitimate macroeconomic model of debt money.

Fourth and fifth rows are newly added this time. As indicated by a blue arrow in the fourth row, the endogenous money model in Part IV captures a decrease in money stock as depicted in Figure 17. On the other hand, Real Money Stock increased. Therefore, behaviors of Japan's lost 30 years turned out to be the same as those in the Great Depression.

Although money stock could be heavily affected by the debt repayment attitude of households and producers (firms), our simulations suggest that economic recessions under the debt money system exhibit similar macroeconomic behaviors if similar policy reactions were taken.

7.3 Japan's Lost 30 Years as Joint Shifts of IS-LM Curves

For our ASD model to be a standard macroeconomic model, it has to be able to produce "point J" discussed in Part I ∼ III papers. Figure 19 plots our simulations under the four cases discussed above on the phase diagram of production (GDP) taken on the horizontal axis and nominal interest rate taken on the vertical axis. Line 1 (blue) indicates a base run case of "Japan as No.1". Line 2 (red) indicates how production (GDP) and nominal interest rate would have declined further if no fiscal stimulus were implemented in Japan. Bold line 3 (green) indicates the third case where production continued to decline in the beginning and failed to recover in spite of the aggressive fiscal policy by the government. Note that interest rate continued to decline even though the government increases borrowing, which is contrary to the mainstream claim of the crowding out effect.

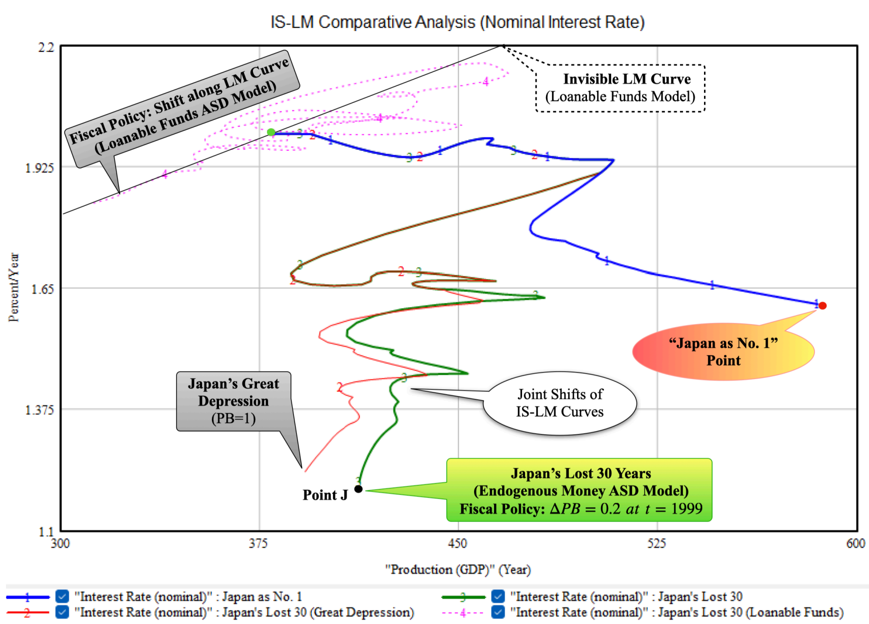

Figure 19: Point J as the representative case of Japan's Lost 30 Years

On the contrary, if we were to apply mainstream exogenous money view such as the reflected in our loanable funds ASD model, its economic behaviors are always constrained as if they are moving only along the LM curve as depicted by dotted line 4 (pink). In other words, as long as we keep using the loanable funds model to analyze recessions, we cannot understand why the Japanese economy exhibited such a movement toward point J. As long as economists stick to the old paradigm of exogenous money, no viable solution cannot be proposed. This is why the need for paradigm shift is ever greater.

Diminishing Wage Share under Japan's Lost 30 Years

Figure 20 shows how wages share worsenes under "Japan's lost 30 years" (left diagram) compared with "Japan as No. 1" case (right diagram). Specifically, under the "Japan as No. 1" case, wage income (blue mesh area) and dividends received by households (red area) increased along with economic growth. In the "Lost 30 Years" case, the government tried to prop up the economy through fiscal spending, but the wage income tends to be transferred to bankers as dividends (green area) through interest generated from government debts. Of course, in a more advanced empirical analysis, it would be necessary to estimate dividend payout ratios and calibrate the model to data. Our simulation demonstrates that such kind of income distribution analysis can now be performed. In this sense, we have indeed obtained the macroeconomic model of paradigm shift in this Part IV that can be applicable to diverse economic environment.

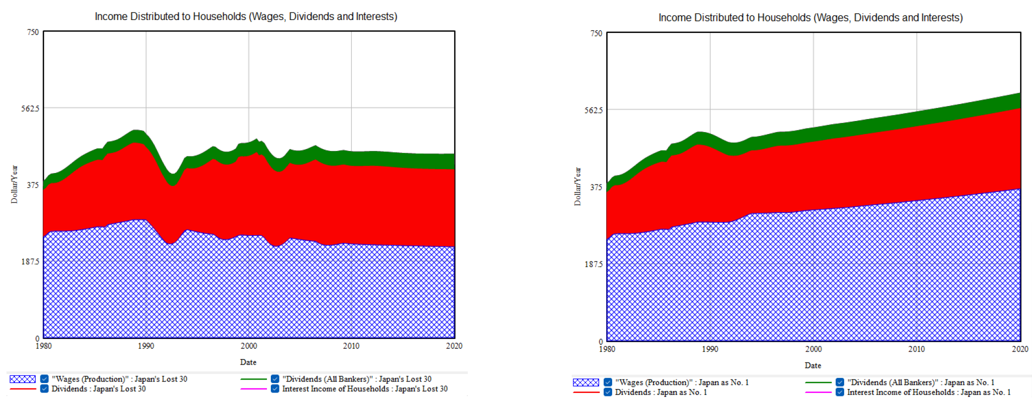

Figure 20: Income Distribution under Japan's Lost 30 Years (left) and Japan as No.1 (right)

8 Conclusion

In Part IV we have additionally incorporated five types of interest rate and identified the unfair income distribution mechanism built into our economy in favor of bankers as the creators and lenders of money stock based on the fractional reserve banking. Under this debt-based system, (1) 99% of money stock is issued as someone's debts at interest, and interest on those debt become zero-sum game that transfer income from borrowers to bankers as lenders. (2) When the government borrows from banks at interest, total income distributed to households gets inflated beyond income distributed by producers (GDP less depreciation), creating persistent inflation, which in turn creates unfair income distribution against pensioners. (3) Inflated income of households has diminishing effect on the wage share even if GDP remains stable. These unfair distribution mechanism built into our economic system have been largely ignored in the literature. Then, we have shown that the ASD model can accommodate the nature of neoclassical-Keynesian behaviors of stability discussed in Part III as well as behaviors of the Great Depression and Japan's lost 30 years. In this sense, the ASD model developed in Part IV can indeed serve as the *Standard ASD Macroeconomic Model* of the paradigm shift discussed in our paper series. Though the model does not directly incorporate labor market yet (instead we assumed reduction in unit wage cost by manually changing the parameter), depending on research questions, our future research may expand the model to incorporate population cohort structure, which will close the feedback loops relating to the production part of the model.

References

Backhouse, R. E. and Laidler, D. E. W. (2004). What was lost with is-lm. *History of Political Economy*, 36(Supplement):25–56.

Brady, M. E. (2017). The is–lm debacle: An analysis of nearly nine decades of errors committed by economists attempting to deal with j m keynes's (not hicks's) is-lm analysis in the general theory. Available at SSRN: http://dx.doi.org/10.2139/ssrn.2960817.

Fisher, I. (1933). The debt-deflation theory of great depressions. *Econometrica*, 1(4):pp. 337–357.

Fisher, I. (1945 [1935]). *100% Money: Designed to Keep Checking Banks 100% Liquid; to Prevent Inflation and Deflation; Largely to Cure or Prevent Depressions; and to Wipe Out Much of the National Debt*. The City Printing Company, New Haven, third edition. First edition published in 1935 by Adelphi Company, New York.

Hansen, A. H. (1949). *Monetary Theory and Fiscal Policy*. McGraw-Hill Kougakusha, Ltd., Tokyo, international student edition.

Hein, E. (2017). Post-keynesian macroeconomics since the mid 1990s: main developments. *European Journal of Economics and Economic Policies: Intervention*, 14(2):131–172.

Hicks, J. (1937). Mr. Keynes and the "classics": A suggested interpretation. *Econometrica*, 5(2):pp. 147–159.

Hicks, J. R. (1980). "Is-lm": An explanation. *Journal of Post Keynesian Economics*, 3(2):139–154.

Keynes, J. M. (1936). *The General Theory of Employment, Interest, and Money*. Macmillan, London.

Kriesler, P. and Nevile, J. W. (2016). Is-lm and macroeconomics after keynes. In Halevi, J., Harcourt, G. C., Kriesler, P., and Nevile, J. W., editors, *Post-Keynesian Essays from Down Under*, volume 1: Essays on Keynes, Harrod and Kalecki of *Theory and Policy in an Historical Context*. Palgrave Macmillan, London, UK.

Lavoie, M. (2022 [2015]). *Post-Keynesian Economics: New Foundations*. Edward Elgar Publishing, Cheltenham, UK, second edition.

Mankiw, N. G. (2016). *Macroeconomics*. Worth Publishers, A Macmillan Education Imprint, New York, ninth edition.

Palley, T. I. (2017). The theory of endogenous money and the lm schedule: prelude to a reconstruction of islm. *Brazilian Joournal of Political Economy*, 37(1):3–22.

Rochon, L.-P. and Rossi, S., editors (2017). *Advances in Endogenous Money Analysis*. Edward Elgar Publishing, Cheltenham, UK.

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39:195–214.

Yamaguchi, K. (2022 [2013]). *Money and Macroeconomic Dynamics – Accounting System Dynamics Approach*. Japan Futures Research Center, Awaji Island, Japan. Edition 1.0 published in 2013. Edition 6.0 published in 2022. Aavailable at: http://www.muratopia.org/Yamaguchi/MacroBook.html.

Yamaguchi, K. and Yamaguchi, Y. (2021a). Accounting System Dynamics Modeling of Money Stock as Debts – Theory and Case Analysis of Japan. In Cavana, R. Y., Dangerfield, B. C., Pavlov, O. V., Radzicki, M. J., and Wheat, I. D., editors, *Feedback Economics*, Comtemporary Systems Thinking. Springer Cham, Cham, Switzerland.

Yamaguchi, K. and Yamaguchi, Y. (2021b). *Introduction to Public Money (in Japanese)*. Shueisha International, Tokyo.

Yamaguchi, Y. (2017). Developing An ASD Macroeconomic Model of the Stock Approach– With Emphasis on Bank Lending and Interest Rates. Master's thesis, University of Bergen, Bergen, Norway.

Yamaguchi, Y. (2021). Money Stock As Total Debts - A Case Study on the Financial Accounts of the United States. Working paper no. 01-2021, Japan Futures Research Center.

Yamaguchi, Y. and Yamaguchi, K. (2022a). The Endogenous Money IS-LM Model of the Debt Money System (Part I) – A Paradigm Shift in Macroeconomics. JFRC Working Paper No. 01-2022 http://muratopia.net/research/papers/EndogenousIS-LM.pdf.

Yamaguchi, Y. and Yamaguchi, K. (2022b). The Endogenous Money IS-LM Model of the Debt Money System (Part II) – Loanable Funds vs. Engogenous Money. JFRC Working Paper No. 01-2022 http://muratopia.net/research/papers/EndogenousIS-LM(Part2).pdf.

Yamaguchi, Y. and Yamaguchi, K. (2023). The Long-Run Endogenous Money ASD Model of the Debt Money System (Part III) – Paradigm Shift in Economics As A Science. JFRC Working Paper No. 02-2023 http://muratopia.net/research/papers/EndogenousASD(Part3).pdf.

Young, W. and Zilberfarb, B. Z., editors (2001). *IS-LM and Modern Macroeconomics*. Recent Economic Thought. Springer, Dordrecht, Netherlands.

Appendix 1: Endogenous Money ASD Model (Part II)

$$Y = AD \quad \text{(Aggregate Demand Equilibrium)} \tag{59}$$
$$AD = C + I + G \quad \text{(Aggregate Demand)} \tag{60}$$
$$C = C_0 + cY_d \quad \text{(Consumption Decisions)} \tag{61}$$
$$Y_d = Y - T \quad \text{(Disposable Income)} \tag{62}$$
$$T = T_0 + tY - T_r \quad \text{(Tax Revenues)} \tag{63}$$
$$I = \frac{I_0}{r} - \alpha r \quad \text{(Investment Decisions)} \tag{64}$$
$$G = \bar{G} \quad \text{(Government Expenditures)} \tag{65}$$
$$\frac{M^s}{P}V = L^d \quad \text{(Equilibrium of Money)} \tag{66}$$
$$L^d = aY - bi \quad \text{(Demand for Money)} \tag{67}$$
$$r = i - \pi^e \quad \text{(Fisher Equation)} \tag{68}$$

$$PC + PT + PI_H + S = W + \Pi + \Delta D_H \quad \text{(Households Budgets)} \tag{69}$$
$$W + \Pi = PY \quad \text{(Distributed Income)} \tag{70}$$
$$PI_H = \Delta D_H \quad \text{(Housing Budgets)} \tag{71}$$
$$I_H = \bar{I}_H \quad \text{(Housing Investment)} \tag{72}$$
$$W + \Pi + PI_P = PY + \Delta D_P \quad \text{(Producers Budgets)} \tag{73}$$
$$I_H + I_P = I \quad \text{(Private Investment)} \tag{74}$$
$$PG = PT + \Delta D_G \quad \text{(Government Budget)} \tag{75}$$
$$\Delta D_H + \Delta D_P + \Delta D_G = \Delta LF \quad \text{(Loanable Funds of Debts)} \tag{76}$$

$$(\Delta LF = S\ ) \quad \text{(Savings as Loanable Funds by Banks)}$$
$$\Delta LF = \Delta M^s \quad \text{(Endogenous Deposits Creation)} \tag{77}$$
$$M^s = \int \Delta M^s dt \quad \text{(Endogenous Money Stock)} \tag{78}$$

The endogenous money short-run IS-LM model consists of the above 20 equations with 20 unknowns:

$$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W + \Pi, I_P, \Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s$$

and 14 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ P,\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H.$$

Appendix 2: Long-run Endogenous Money ASD Model (Part III)

$$Y = AD \quad \text{(Aggregate Demand Equilibrium)} \tag{79}$$
$$AD = C + I + G \quad \text{(Aggregate Demand)} \tag{80}$$
$$C = C_0 + cY_d \quad \text{(Consumption Decisions)} \tag{81}$$
$$Y_d = Y - T - \delta K \quad \text{(Disposable Income)} \tag{82}$$
$$T = T_0 + tY - T_r \quad \text{(Tax Revenues)} \tag{83}$$
$$I = \frac{I_0}{r} - \alpha r \quad \text{(Investment Decisions)} \tag{84}$$
$$G = \bar{G} \quad \text{(Government Expenditures)} \tag{85}$$
$$\frac{M^s}{P}V = L^d \quad \text{(Equilibrium of Money)} \tag{86}$$
$$L^d = aY - bi \quad \text{(Demand for Money)} \tag{87}$$
$$r = i - \pi^e \quad \text{(Fisher Equation)} \tag{88}$$

$$\frac{dK}{dt} = I - \delta K \quad \text{(Net Capital Accumulation)} \tag{89}$$
$$Y_{full} = F(K, L) \quad \text{(Production Function)} \tag{90}$$
$$\frac{dP}{dt} = \Psi(Y - Y_{full}) \quad \text{(Flexible Price)} \tag{91}$$

$$PC + PT + PI_H + S = W + \Pi + \Delta D_H \quad \text{(Households Budgets)} \tag{92}$$
$$W + \Pi = PY \quad \text{(Distributed Income)} \tag{93}$$
$$PI_H = \Delta D_H \quad \text{(Housing Budgets)} \tag{94}$$
$$I_H = \bar{I}_H \quad \text{(Housing Investment)} \tag{95}$$
$$W + \Pi + PI_P = PY + \Delta D_P \quad \text{(Producers Budgets)} \tag{96}$$
$$I_H + I_P = I \quad \text{(Private Investment)} \tag{97}$$
$$PG = PT + \Delta D_G \quad \text{(Government Budget)} \tag{98}$$
$$\Delta D_H + \Delta D_P + \Delta D_G = \Delta LF \quad \text{(Loanable Funds of Debts)} \tag{99}$$

$$\Delta LF = \Delta M^s \quad \text{(Endogenous Deposits Creation)} \tag{100}$$
$$M^s = \int \Delta M^s dt \quad \text{(Endogenous Money Stock)} \tag{101}$$

The long-run endogenous money model consists of the above 23 equations with 23 unknowns such that

$$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W+\Pi, i_p,$$
$$\Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s, K, Y_{full}, P$$

and 15 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H,\ \delta,\ L$$

Appendix 3: Long-run Loanable Funds ASD Model (Part III)

The long-run loanable funds model presented in Part III consists of the above 21 equations; (80) through (99) and (102) shown below.

$$(\Delta LF \quad = \quad S\ ) \qquad \text{(Savings as Loanable Funds by Banks)} \tag{102}$$

The model has corresponding 21 unknowns such as

$$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W+\Pi, i_p,$$
$$\Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, K, Y_{full}, P$$

and 15 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H,\ \delta,\ L.$$

Appendix 4: ASD Model of Five Macroeconomic Sectors

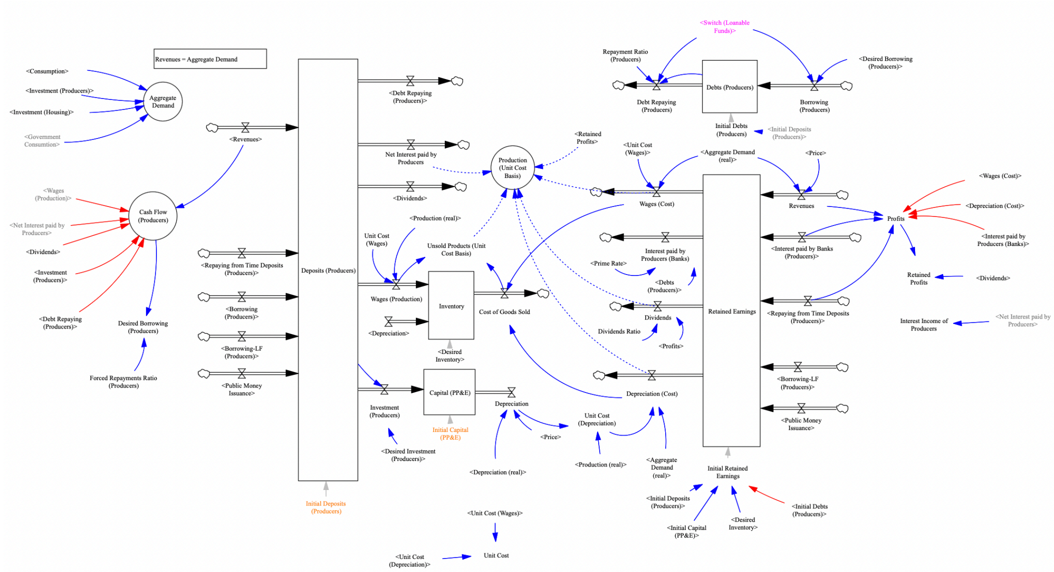

Figure 21: Transactions and Balance Sheet of Producers

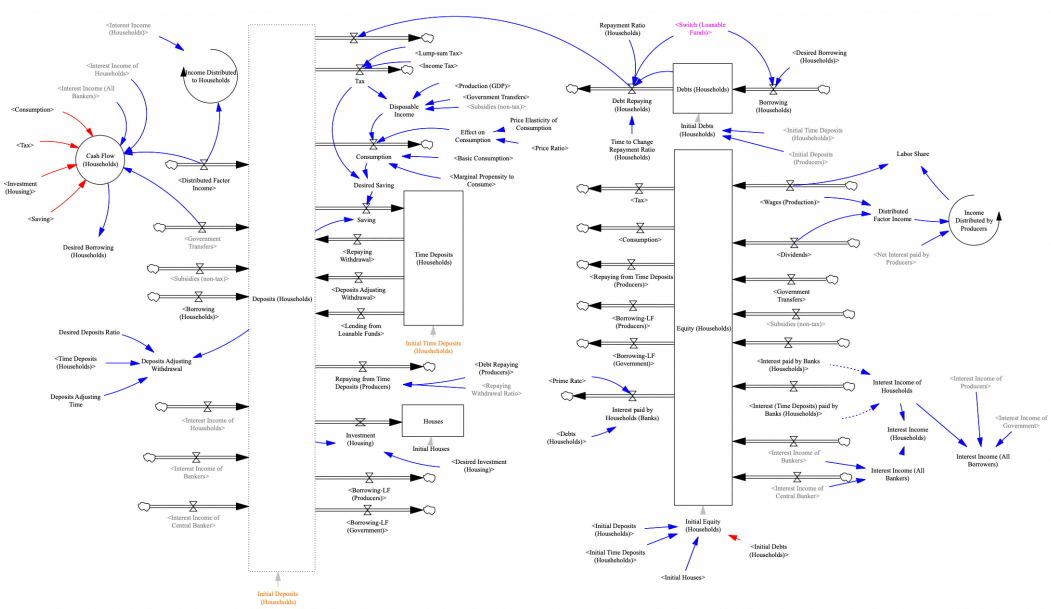

Figure 22: Transactions and Balance Sheet of Households

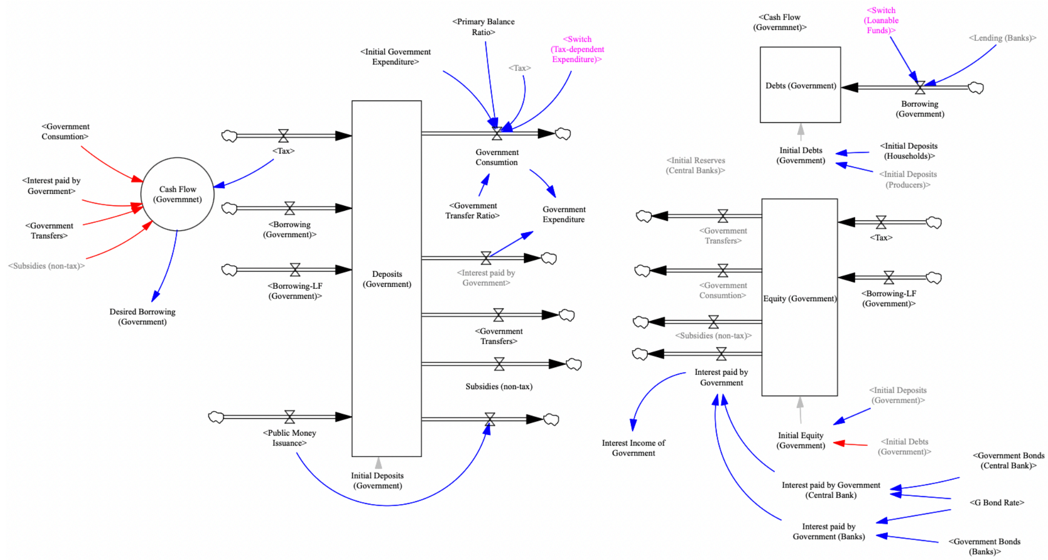

Figure 23: Transactions and Balance Sheet of Government

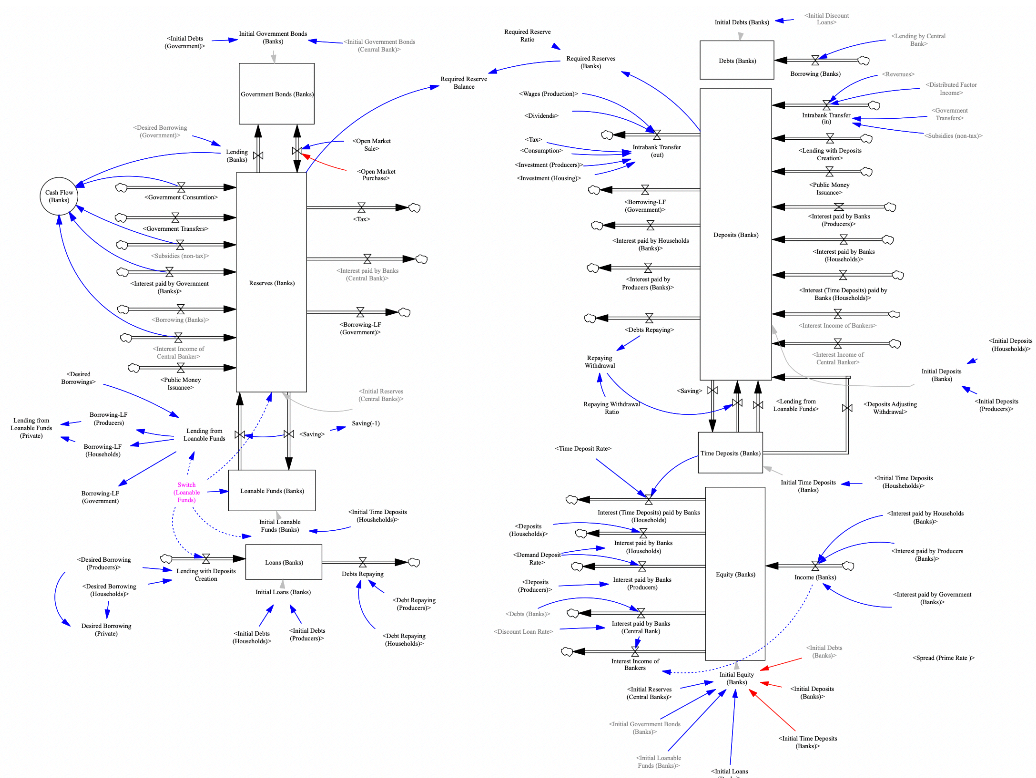

Figure 24: Transactions and Balance Sheet of Banks

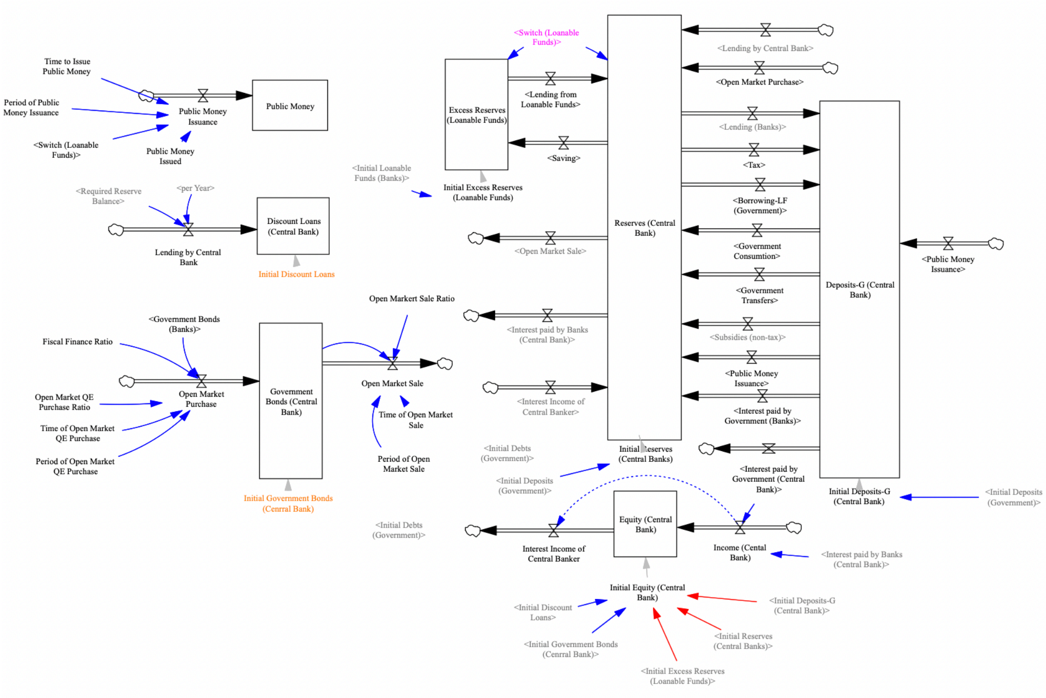

Figure 25: Transactions and Balance Sheet of Central Bank

Appendix 5: Notations used throughout Part I∼IV

Notation	Description	Unit	Introduced (Part I∼IV)
Stock (Level)			
D_P	Debt: Producers (⇒ DD_P)	Dollar	II
D_H	Debt: Households (⇒ DD_H)	Dollar	II
D_G	Debt: Government (⇒ DD_G) (= $GB_B + GB_{CB}$)	Dollar	II
D_B	Debt: Banks (⇒ RD_B)	Dollar	II
DD_P	Demand Deposits: Producers	Dollar	II
DD_H	Demand Deposits: Households	Dollar	II
TD_H	Time Deposits: Households	Dollar	II
DD_G	Demand Deposits: Government	Dollar	II
RD_B	Reserve Deposits: Banks	Dollar	II
GB_B	Government Bonds: Banks	Dollar	II
GB_{CB}	Government Bonds: Central Banks	Dollar	II
INV	Inventory Asset	Dollar	II
I_{nv}	Inventory Stock	DollarReal	I
K	Capital Stock (Productive Capacity)	Dollar	III
LF	Loanable Funds; Banks	Dollar	II
M^s	Money Stock: (= $M_1 + TD_H$)	Dollar	I
M_1	Money Stock: (= $DD_P + DD_H + DD_G$)	Dollar	I
M_0	Base Money: (= RD_{CB}) Reserves at Central Bank	Dollar	II
P	Price Level (Market Price)	Dollar/DollarReal	I
i	Nominal Interest Rate	%/Year	I
r	Real Interest Rate	%/Year	I
Flow (Rate)			
AD	Aggregate Demand	DollarReal/Year	I
AD_f	Aggregate Demand Forecast	DollarReal/Year	I
C_0	Autonomous or Basic Consumption	DollarReal/Year	I
C	Consumption	DollarReal/Year	I
G	Government Consumption	DollarReal/Year	I
I_0	Autonomous or Basic Investment	DollarReal/Year	I
I	Producer's Capital Investment	DollarReal/Year	I
I_H	Housing Investment	Dollar/Year	II
L^d	Demand for Money	DollarReal/Year	I
$P \cdot Y$	Production Value at Market Price (= Nominal GDP)	Dollar/Year	II
S	Households Saving as Loanable Funds	Dollar/Year	II
S_T	Saving as Net Change in Time Deposits	Dollar/Year	II
T	Tax Revenue	DollarReal/Year	I
T_0	Lump-sum Tax	DollarReal/Year	I
T_r	Government Transfer	DollarReal/Year	I
W	Wages (Employees Compensation)	Dollar/Year	II
Y	Real GDP (Production)	DollarReal/Year	I
Y^D	Desired Production	DollarReal/Year	I
Y_d	Disposable Income	DollarReal/Year	I
Y_{full}	Full Capacity Production	DollarReal/Year	III
Y_{unsold}	Change in Inventory Stock (= ΔInv)	DollarReal/Year	III
Π	Dividends; all sectors	Dollar/Year	II
Auxiliary			
i_d	Interest Rate on Demand Deposits	1/Year	IV
$i_{d\ell}$	Interest Rate on Discount Loans	1/Year	IV
i_{gb}	Interest Rate on Government Bonds	1/Year	IV
i_{td}	Interest Rate on Time Deposits	1/Year	IV
i_p	Interest Rate on Bank Loans; Prime Rate	1/Year	IV
P_{uc}	Unit Cost	Dollar/DollarReal	II
UC_δ	Unit Depreciation Cost	Dollar/DollarReal	II
π	Inflation Rate	%/Year	I
π^e	Expected Inflation Rate	%/Year	I

Constant			
a	Coefficient of Transactional Money Demand	Dimensionless	I
b	Coefficient of Speculative Money Demand	Dimensionless	I
c	Marginal Propensity to Consume (MPC)	Dimensionless	I
e	Ratio Elasticity of Price (Effect on Price)	Dimensionless	I
t	Income Tax Rate	Dimensionless	I
UC_w	Unit Wage Cost	Dollar/DollarReal	III
V	Velocity of Money	1/Year	I
α	Interest Sensitivity of Investment	Dimensionless	I
δ	Depreciation Rate	1/Year	III
θ	Capital to Output Ratio	Year	III
κ	Annual Rate of Technological Progress	1/Year	III
sp_d	Interest Rate Spread on Demand Deposits	Dimensionless	IV
$sp_{d\ell}$	Interest Rate Spread on Discount Loans	Dimensionless	IV
sp_{gb}	Interest Rate Spread on Government Bonds	Dimensionless	IV
sp_{td}	Interest Rate Spread on Time Deposits	Dimensionless	IV
sp_p	Interest Rate Spread on Bank Loans; Prime Rate	Dimensionless	IV
$unit_{\%}$	Unit Conversion of %	%	IV

Table 5: List of Notations used in Part I∼IV papers (showing main variables only)