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The Endogenous Money IS-LM Model of the Debt Money System (Part I)

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The Endogenous Money IS-LM Model of the Debt Money System (Part I)

– A Paradigm Shift in Macroeconomics –

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Abstract

The IS-LM analysis, first devised by Hicks (1937) based on his interpretation of the General Theory by Keynes (1936), has played a central role in the history of economic thoughts. Even today it is arguably the most popular model taught in undergraduate macroeconomics worldwide as a comparative statics method. For example, in order to analyze the causes of the Great Depression, Mankiw (2016) presented (1) *spending* hypothesis (shocks to *IS* curve) as proposed by Keynes and (2) *money* hypothesis (shocks to *LM* curve) as proposed by Friedman and Schwartz (1963), and then rejects the latter by applying them in the IS-LM model. This paper presents a system dynamics model of the Keynesian short-run IS-LM analysis and examine if one of the two seemingly contrasting hypotheses should really be dismissed in favor of the other in the dynamic model. Our simulation analyses indicate the standard short-run IS-LM model itself, which is built upon the 'exogenous money' and 'fixed price' assumptions, among others, needs to be rejected as a reliable model of the economy operating under the current fractional reserve banking system where money stock is determined endogenously by total debts from banks (Yamaguchi, 2021). We then develop an alternative endogenous money IS-LM model by relaxing the structural assumptions and integrating the two hypotheses as a dynamic feedback process. The model, though simple in structure, captures the unexplained behaviors of the Great Depression under the (3) *endogenous money spending* hypothesis, which turns out to be consistent with the original analysis presented by Fisher (1933, 1945) who emphasized the central role of deposit contraction in the overall dynamics of Booms and Depressions. The revised model, however, fails to explain the case of Japan's lost 30 years. Our next paper (Part II) explains the case by incorporating budget equations of domestic macroeconomic sectors. A paradigm shift to the endogenous money analysis is emphasized throughout the research.

Keywords: money, debt, fractional reserve banking, IS-LM analysis, system dynamics

*This paper is accepted to present at the 40th International Conference of the System Dynamics Society, to be held in Frankfurt am Main, Germany on July 18-22, 2022. The usual disclaimer for academic paper applies. The first author (e-mail: yokei.yamaguchi@gmail.com) is a researcher at Japan Futures Research Center (M.Phil. and M.Sc., European Master in System Dynamics). The second author (e-mail: kaoru.yamaguchi@asbu.edu.tr) is a professor at Social Sciences University of Ankara, Turkey (Ph.D. from the University of California at Berkeley). This research is partially supported by the research fund of Japan Futures Research Center.

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Introduction

The Great Depression in the 1930s plunged the U.S. and the world economy into an unprecedented turmoil, causing mass unemployment and creating gaps between the rich and poor. To overcome and prevent it from happening again, the two economists each proposed a remedy in 1935: John M. Keynes's *General Theory* (Keynes, 1936) and Irving Fisher's *100% Money* (Fisher, 1945).[1] Immediately following the publication of the *General Theory*, Hicks (1937) expanded the Keynesian model to include money market. The model is now well known as IS-LM analysis and taught in undergraduate macroeconomics textbooks worldwide. The Keynes's theory has since evolved into macroeconomics and served as the rationale of fiscal and monetary policies. However, its theoretical flaws have been brought to light due to the recent failures of fiscal spendings and a series of quantitative easing (QE) implemented in Japan after the burst of bubble in the 1990s. The massive deficit spendings by the Japanese government have increased its debts to an unprecedented level while the unconventional monetary policy remained largely ineffective to stimulate the real economy for almost 30 years. On the other hand, Fisher's analysis on the causes of the Great Depression and its prescription has completely disappeared from standard macroeconomic textbooks as if it were a *taboo* as this paper will highlight.

Yamaguchi and Yamaguchi (2021b, Chapter 1) estimated that the Japanese government debt will reach 1,674 trillion yen in 2036 and its debt-to-GDP ratio will reach a level exceeding 300% (to be exact, three years' worth of nominal GDP, calculated with GDP as of 2019). Thirty years later, in 2050, the government debts will be at 2,193 trillion yen and its debt-to-GDP ratio will reach 400%. They analyzed that the Japanese economy, if this situation continues, will have to face one of three following scenarios: (1) systemic crisis ('financial meltdown'), (2) hyperinflation, and (3) the *de facto* default of the Japanese government on its debts. It is inevitable that any of the above scenario will have devastating impacts on the domestic economy and international financial markets. Looking at other OECD countries, though the public debt problem is not yet as severe as in Japan, economic growth has slowed down, the low interest rate policy since the Lehman shock and the subsequent Euro crisis has been prolonging, the aging society with low birth rates, and income disparities are widening. Even before the corona pandemic, there was a growing concern that other OECD countries would fall and get trapped into similar situation as in Japan in the near future – a phenomenon dubbed 'Japanification'.

The corona virus (SARS-CoV-2) confirmed in the second half of 2019 quickly spread the world and caused demand and supply shocks. Supply chain bottlenecks and surge in energy

[1] The Keynes's General Theory was published in 1936. Its preface, however, was drafted on December 13, 1935 while Fisher's 100% Money (first edition) was published in 1935. Therefore the two leading economists at the time wrote their books in the same year coincidentally.

prices are causing inflation without full recoveries in the real sector. Fiscal spendings and massive injection of central bank reserves continue to fail while increasing the government debt further. The world economy as of 2022 is starting to look like an eve of stagflation and another depression. What went wrong with the Keynesian theory? In this paper we examine the validity and applicability of IS-LM analysis to real world cases by building the system dynamics model.

1 The Keynesian Short-Run IS-LM Analysis

The IS-LM model is introduced in many undergraduate textbooks to familiarize students with key concepts of macroeconomics in a simple closed-economy framework. It is a comparative static method for finding an equilibrium of interest rate and income simultaneously in the markets of goods and services and money.[2]

1.1 Model Equations

Let us start with a formal presentation of the short-run IS-LM model. IS-LM stands for Investment, Saving, demand for Liquidity and supply of Money. According to the Keynesian theory real income Y or Gross Domestic Product (GDP) is determined by the aggregate demand in the short-run. That is, a simple Keynesian short-run model is described as follows:

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

This short-run IS-LM model consists of 9 equations with 9 unknowns;

$$Y, AD, C, I, G, Y_d, T, i, L^d \ (L^d \text{ stands for liquidity demand})$$

with 13 exogenously determined parameters

$$C_0, c, T_0, t, T_r, I_0, \bar{G}, M^s, P, V, \alpha, a, b.$$

Equations (1), (2), (3) and (7) are standard formulation. In this IS-LM model, all variables are expressed in real units (e.g. DollarReal) except for money stock M^s, which has a nominal unit (Dollar). Note that capital accumulation ($\frac{dK}{dt}$) is excluded from this short-run IS-LM model. Accordingly, the capital depreciation (δK) is also removed from the equation (4).

Government taxes are assumed to be consisting of three parts in equation (5): lump-sum taxes such as property taxes (T_0), income taxes that are proportionately determined by the

[2] This section 1 is excerpted from Yamaguchi (2013, Chapter 9).

income level where t is an income tax rate, and government transfers such as subsidies (T_r). Hence we have a tax revenues equation (5). Investment is here assumed to be determined by interest rate i in equation (6) in which α is an interest sensitivity of investment. Thus, interest rate i becomes an unknown variable in the model. These equations (1) $\sim$ (7) complete the *IS* side of the short-run IS-LM model.

We have added a new unknown variable of the interest rate to the model. Hence an additional equation is needed to make it complete, which leads us to the construction of LM side of the short-run IS-LM model. According to the standard textbooks, it should be an equilibrium condition in the money market such that real money stock used in, say, a year, is equal to the demand for money L^d as shown in equation (8) where V is velocity of money having a unit 1/year, and P is a price level. It should be noted here that P is treated as a fixed exogenous parameter. Finally, the demand for money defined in equation (9) consists of two parts: transactional demand for money aY where a is a fraction of income, and speculative demand for money bi where b is an interest sensitivity of demand for money. This completes the *LM* side.

1.2 Simple IS-LM Equilibrium As Comparative Statics

For the purpose of manual analysis of the short-run IS-LM model described above, the investment decisions of the equation (6) is simplified in many textbooks as follows:

$$I = I_0 - \alpha i \qquad \text{(Simple Investment Decisions)} \tag{10}$$

Then, from the equilibrium condition in the goods market, a relation between GDP and interest rate, which is called *IS* curve, is derived as follows:

$$Y = \frac{C_0 + I_0 + G + c(T_r - T_0)}{1 - c(1-t)} - \frac{\alpha}{1 - c(1-t)} i \tag{11}$$

On the other hand, from the equilibrium condition in the money market, a relation between GDP and interest rate, called *LM* curve, is derived as follows:

$$Y = \frac{1}{a}\frac{M^s}{P}V + \frac{b}{a}i \tag{12}$$

Equilibrium GDP and interest rate (Y^*, i^*) are now completely determined by the *IS* and *LM* curves. For instance, the aggregate demand equilibrium of GDP is obtained as

$$Y^* = \frac{C_0 + I_0 + G + c(T_r - T_0)}{1 - c(1-t) + \alpha(a/b)} + \frac{\alpha/b}{1 - c(1-t) + \alpha(a/b)}\frac{M^s}{P}V \tag{13}$$

This is a standard Keynesian process of determining an aggregate demand equilibrium of GDP in the short run where price is assumed to be fixed. Figure 1 below (next page) illustrates how *IS* and *LM* curves determine the equilibrium GDP and interest rate (Y^*, i^*). The interest rate and income are taken on the vertical and horizontal axes respectively, and the intersection of the *IS* and *LM* curves is obtained as the equilibrium point. Then the effect of fiscal and monetary policies are analyzed based on this theoretical framework. When C_0, I_0, G increase or decrease, the *IS* curve shifts to the right or left, while *LM* curve shifts towards the right or left when money stock M^s or real money stock $\frac{M^s}{P}$ increases or decreases. As a result, we can easily predict a movement of new equilibrium GDP and interest rate (Y^*, i^*). This analytical method has been dominant in introductory and intermediate macroeconomic textbooks as the comparative statics.

As discussed in most textbooks well, GDP thus determined needs not to be equal to the full capacity output, Y_{full}. The Keynesian model only specifies GDP as determined by the level of

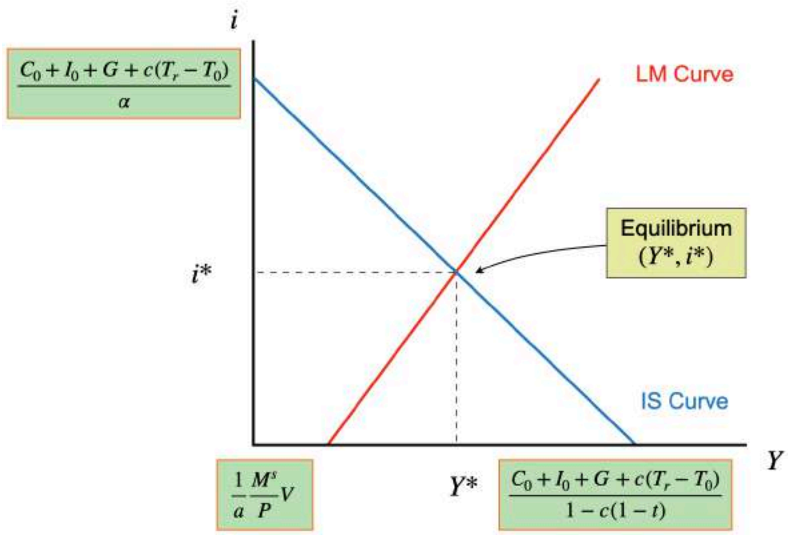

Figure 1: IS-LM Determination of GDP and Interest Rate

aggregate demand. This is why it is called *aggregate demand* equilibrium of GDP. To realize a *full capacity* equilibrium, that is $Y^* = Y_{full}$, price needs to be flexibly changed in the long run. The Keynesian model we presented above, however, lacks this type of price flexibility.[3]

2 A System Dynamics Model of the Short-Run IS-LM

Whenever the investment decisions in equation (6) is restored again, we can no longer apply the above simple determination process of GDP by comparative static analysis. To fully analyze the short-run IS-LM model, therefore, we need to construct a dynamic model of aggregate demand equilibria based on IS-LM curves.

2.1 Dynamic IS Sub-Model

The above Keynesian adjustment process is very mechanistic and does not reflect how actual production decisions are made. More realistic decision-making process of production is to introduce an inventory adjustment management. In reality a discrepancy between production and shipment (or aggregate demand) is adjusted first of all as a change in inventory stock. Thus

[3]Note that we employ the term 'short-run' to indicate that the model lacks a dynamics around capital formation. When capital accumulation is considered, the Keynesian models need to be revised as follows (where δ denotes a depreciation rate):

$$\begin{aligned} Y_d &= Y - T - \delta K \\ \frac{dK}{dt} &= I - \delta K \end{aligned}$$

Most textbooks explain that economists use different models for 'short-run' and 'long-run' analysis where price P is assumed to be fixed in the former. See Mankiw (2016), for instance. Such dichotomic reasoning is redundant and inappropriate in system dynamics (SD) modeling as we integrate price rigidity and flexibility as varying degrees of assumption on the price elasticity within a single model. This is one of examples of the flexibility in SD-based approaches. In section 3.4 we will extend the model to allow price to be flexible in response to changes in inventory. Yet, the flexible price model is called the *short-run* IS-LM model under our terminology.

the introduction of inventory as a stock is essential. Accordingly our System Dynamics (SD) modeling of Keynesian macroeconomic system begins with introducing an inventory stock. *IS* sub-model of the SD IS-LM model is already constructed as "Keynesian Adjustment SD Model with Inventory [Companion model: 2 Keynesian(SD).vpmx] in Yamaguchi (2013, Chapter 9). For reference, Figure 2 below illustrates the *IS* sub-model of SD version of the IS-LM model, with new investment and production decisions described above.

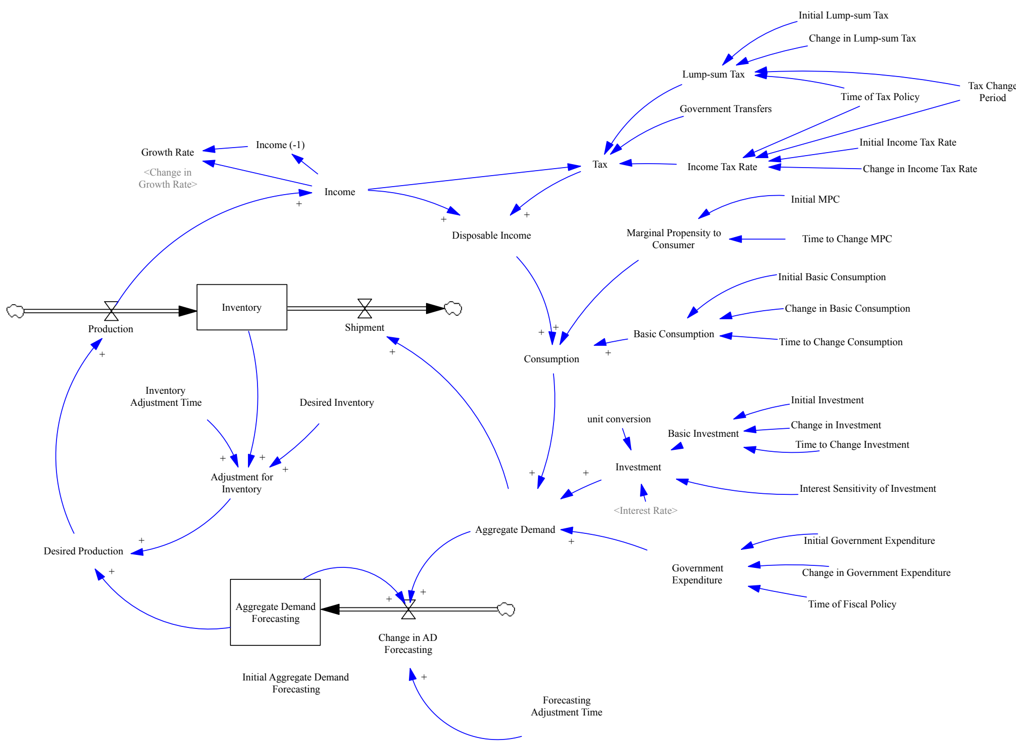

Figure 2: Aggregate Demand Adjustment with Inventory – IS Sub-model

Our dynamic *IS* sub-model incorporates such Keynesian process, in which an aggregate demand forecasting mechanism is additionally introduced without changing the essential mechanism of Keynesian adjustment process. A box in the figure indicates a stock variable in SD whereas double-line arrows pointing into and out from the stock indicate in- and out-flows. A single line arrow indicates instantaneous relationship between variables and parameters.

2.2 Dynamic LM Sub-Model

Interest Adjustment Process

Next, we need to build the *LM* sub-model of the SD version of the short-run IS-LM model. For this purpose, the equilibrium condition in the money market (equation 8) needs to be replaced with a dynamic adjustment process of interest rate as a function of excess demand for money such that:

$$\frac{d\ i}{dt} = \Phi\left((aY - bi) - \frac{M^s}{P}V\right) \tag{14}$$

Applying the general formulation of adjustment processes described in Yamaguchi (2013, Chapter 2, Section 4), the adjustment process of interest rate is further specified as

$$\frac{d\ i}{dt} = \frac{i^* - i}{\text{Delay Time}} \tag{15}$$

where i^* denotes desired interest rate. Desired interest rate i^* is obtained as

$$i^* = \frac{i}{\left(\frac{M^s}{P} V/(aY - bi)\right)^e} \tag{16}$$

where e denotes a money ratio elasticity of desired interest rate. Figure 3 below illustrates the LM sub-model of the adjustment process of interest rate. Since price is assumed to be fixed, there should be no price adjustment process incorporated into our model at this point. Yet Figure 3 additionally illustrates a price adjustment process for the uses in later sections.

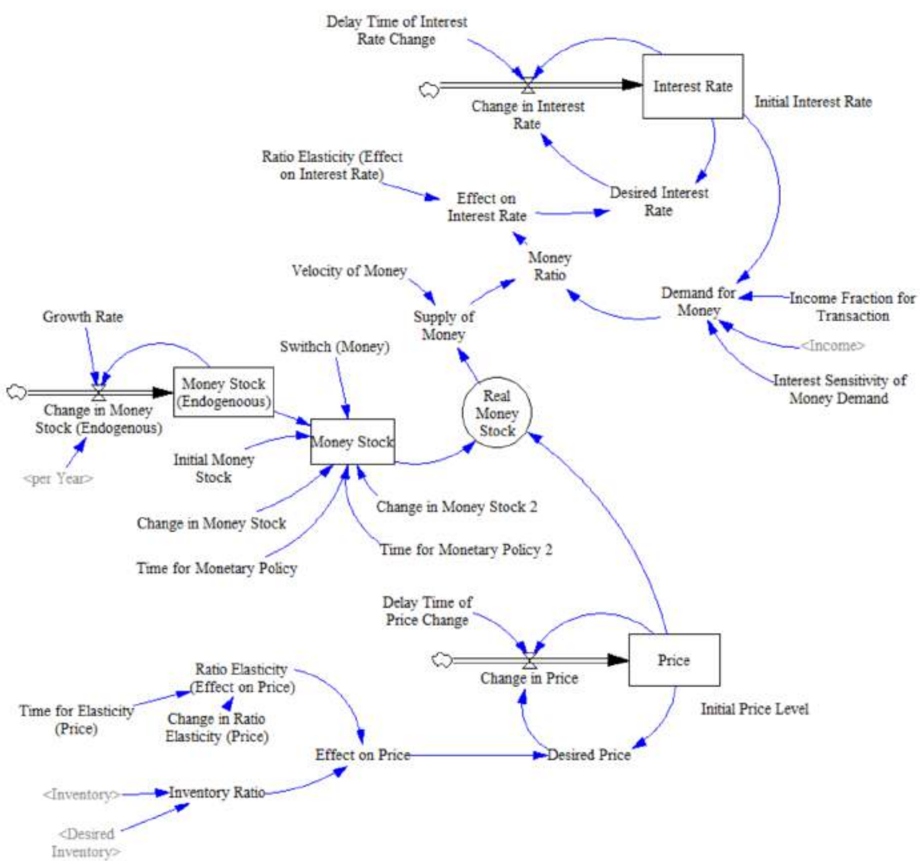

Figure 3: Interest Rate and Price Adjustment Processes – LM Sub-model

2.3 The Standard IS-LM Analysis of Recessions

Using the dynamic model thus developed, let us next see how the short-run IS-LM model can demonstrate the macroeconomic effects of monetary and fiscal policies as described in textbooks.

Economic recessions can be described as the decrease in income or GDP. One of the benefits of using the IS-LM framework in macroeconomic analysis is that we can visualize recessions as shifts in *IS* or *LM* curve. In other words, causes of recessions can be explained by the shifts in the *IS* curve and *LM* curves. If we can identify the causes of recessions in this way, we can then apply policies at our hands in a reverse way to recover from recessions.

Recessions caused by Shifts in *IS* Curve

Both diagrams in Figure 4 are phase diagrams consisting of interest rate taken on the vertical axis and income on the horizontal axis. First of all, the model is in the equilibrium as shown by the point A in the left diagram. Then recessions caused by decreases in aggregate demand such as investment and consumption can be illustrated by the leftward shift in the *IS* curve. In the left diagram, *IS* curve illustrated by a dotted black line is shown to shift leftwards as the original equilibrium point A moves to a new point at B, which is caused by the decrease in investment by $\Delta I = -20$ at t = 8. In our dynamic IS-LM model, this is implemented by decreasing the basic investment (I_0) using a STEP function. That is, the level of investment decline by 20 from t = 8 until the end of the simulation. As Figure 4 compares different simulations on the phase diagram, this shift in the *IS* curve is captured as a trajectory shown by a red line (point A $\rightarrow$ B).

Now let us further assume that consumption has declined by $\Delta C = -20$ at t = 24 by similarly decreasing the basic consumption (C_0). Then the *IS* curve is moved further towards the left. As a result, the second equilibrium point B moves to a new point C as captured by the green trajectory line (point B $\rightarrow$ C) . We can observe that the equilibrium level of income as well as interest rate decline. If the economy experiences these types of recessions caused by compound decreases in the aggregate demand of the real sectors, IS-LM model tells us that we can not only restore the equilibrium easily, but also grow the economy further to the point F by increasing the government expenditure by $\Delta G = 40$ at t = 35. The effects of such government spendings are shown by the gray trajectory line from the previous point C to point F (point C $\rightarrow$ F). Notice how these shifts occur along the linear *LM* curve (a thick black line drawn manually) since changes in aggregate demand do not affect the *LM* curve. This policy is known as the fiscal policy through government expenditure in standard macroeconomic textbooks.

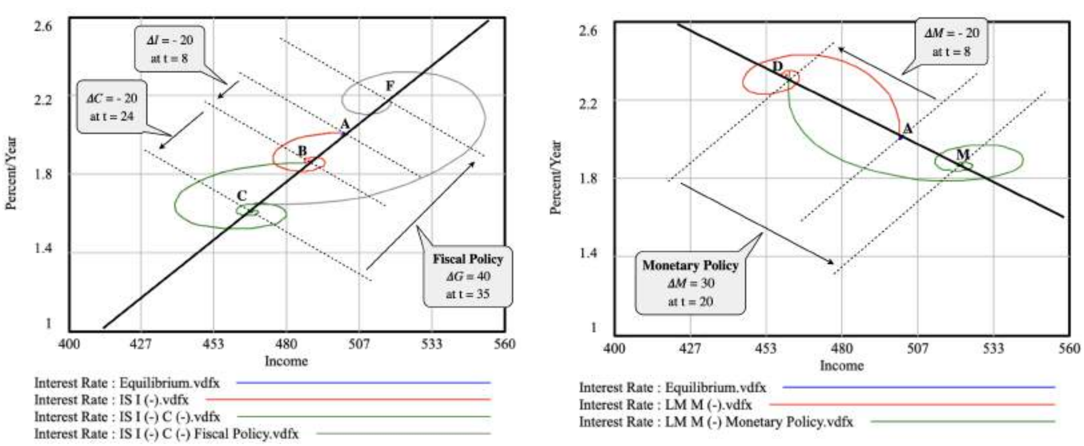

Figure 4: The Standard IS-LM Analyses of Fiscal (left) & Monetary Policy Effects (right)

Recessions caused by Shifts in *LM* Curve

Recessions caused by the decrease in money stock can be illustrated by leftward shifts of *LM* curve. For our purposes, we do not question how such reductions in money stock are brought about at this stage. In the right diagram of Figure 4, *LM* curve illustrated by a dotted black line is shown to shift towards the left as the original equilibrium point A move to a new point at D. In our dynamic IS-LM model, this shift in the *LM* curve caused by the decrease in money stock by $\Delta M^s = -20$ at t = 8 is captured by the red trajectory line. It can be observed that equilibrium level of income declines and interest rate rises as a result. If recessions are caused by reductions of money stock, the IS-LM model teaches us we can not only restore the equilibrium easily, but also grow the economy further to the new point M by increasing money stock by $\Delta M^s = 30$ at t = 20 as shown by the green trajectory line (point D $\rightarrow$ M). Notice how these shifts occur along the gentle hyperbolic *IS* curve (a thick black curve), which is produced by investment decisions in equation (6). This is the monetary policy under the IS-LM framework.

With the introduction of the IS-LM model, recessions are analyzed as the shifts of *IS* and *LM* curves toward left while recoveries are analyzed as the rightward shifts of *IS* and *LM* curves. Figure 4 illustrates these standard textbook explanations of IS-LM analysis as a phase diagram of income and interest rate in a system dynamics model. By combining the shocks to aggregate demand and money stock, we can describe many possible combinations of recessions. Furthermore the model indicates that we can attain recoveries from wherever recessions end by mixing fiscal and monetary policies (policy mix). Macroeconomics textbooks are full of these exercises and we have been taught in classes, for over 80 years since Hicks (1937) first introduced the framework, that economies are now under the control of policy makers. Indeed our short-run IS-LM model seems to support the effectiveness of such macroeconomic 'fine-tunings'.

3 The IS-LM Case Analysis of the Great Depression

Convinced by the analytical capabilities of IS-LM model, Professor Nicholas Gregory Mankiw at Harvard University (the title will be omitted hereafter) attempted to explain the causes of the Great Depression in his popular macroeconomics textbook used worldwide. Specifically Mankiw (2016, p.351) expresses that "[t]he Great Depression provides an extended case study to show how economists use the IS-LM model to analyze economic fluctuations". Let us next examine how the standard IS-LM analysis is applied to study the case of the Great Depression.

3.1 Spending Hypothesis vs Money Hypothesis

As discussed above, there are only two causes that trigger recessions in the IS-LM model; decreases in the aggregate demand causing leftwards shift of *IS* curve, and decreases in the money stock causing leftwards shift of *LM* curve. Mankiw (2016, Chapter 12) called the former *spending hypothesis* and the latter *money hypothesis*. The original proponent of the spending hypothesis was John M. Keynes. In essence Keynes (1936) analyzed that under-capacity (investment) and under-consumption in real sectors are the main causes of the Great Depression, and suggested the adjustment of aggregate demand through fiscal and monetary policies as a way out of the recession. In the context of the IS-LM framework, the policies should be aimed at economic stimulus through government expenditures and restoring investments by lowering the costs of borrowing, i.e. interest rates.

On the other hand, Mankiw (2016) argues that *money hypothesis* "places primary blame for the Depression on the Fed for allowing the money supply to fall by such a large amount (p.353)". He then continues to explain as follows:

The best-known advocates of this interpretation are Milton Friedman and Anna Schwartz, who defended it in their treatise on U.S. monetary history. Friedman and Schwartz argue that contractions in the money supply have caused most economic downturns and that the Great Depression is a dramatic example (p.353).

In order to examine which of the two seemingly contrasting hypotheses is the plausible causes of the Depression using the IS-LM model, Mankiw arranged time-series starting from 1929 until 1940. Figure 5 below reproduces all data presented in the original Table 12-1 in Mankiw (2016, pp.352-353). Here we can easily observe that the IS-related variables such as

Table 12-1: What Happened During The Great Depression?

Year	Unemployment Rate	Real GNP	Consumption	Investment	Government Purchases	Nominal Interest Rate	Money Supply	Price Level	Inflation	Real Money Balances
1929	3.2	203.6	139.6	40.4	22.0	5.9	26.6	50.6	—	52.6
1930	8.9	183.5	130.4	27.4	24.3	3.6	25.8	49.3	-2.6	52.3
1931	16.3	169.5	126.1	16.8	25.4	2.6	24.1	44.8	-10.1	54.5
1932	24.1	144.2	114.8	4.7	24.2	2.7	21.1	40.2	-9.3	52.5
1933	25.2	141.5	112.8	5.3	23.3	1.7	19.9	39.3	-2.2	50.7
1934	22.0	154.3	118.1	9.4	26.6	1.0	21.9	42.2	7.4	51.8
1935	20.3	169.5	125.5	18.0	27.0	0.8	25.9	42.6	0.9	60.8
1936	17.0	193.2	138.4	24.0	31.8	0.8	29.6	42.7	0.2	62.9
1937	14.3	203.2	143.1	29.9	30.8	0.9	30.9	44.5	4.2	69.5
1938	19.1	192.9	140.2	17.0	33.9	0.8	30.5	43.9	-1.3	69.5
1939	17.2	209.4	148.2	24.7	35.2	0.6	34.2	43.2	-1.6	79.1
1940	14.6	227.2	155.7	33.0	36.4	0.6	39.7	43.9	1.6	90.3

Figure 5: Key Macroeconomic Variables during the Great Depression (1929–1940) in Table

real GNP, consumption and investment all fell during the initial period between 1929-1933, while the LM-related variables such as nominal interest rate, money supply and price level also fell during the same period except real money balances, which rose slightly and then fluctuated. Figure 19 in Appendix 1 plots the same time-series in graphs.

Mankiw then examined both spending and money hypotheses by shifting IS and LM curves to the left, and then rejects the money hypothesis as the cause of the Depression as follows:

Using the IS-LM model, we might interpret the money hypothesis as explaining the Depression by a contractionary shift in the LM curve. Seen in this way, however, the money hypothesis runs into two problems.

The first problem is the behavior of *real* money balances. Monetary policy leads to a contractionary shift in the LM curve only if real money balances fall. Yet from 1929 to 1931 **real money balances rose slightly** because the fall in the money supply was accompanied by an even greater fall in the price level. Although the monetary contraction may have been responsible for the rise in unemployment from 1931 to 1933, when real money balances did fall, it cannot easily explain the initial downturn from 1929 to 1931.

The second problem for the money hypothesis is the behavior of interest rates. If a contractionary shift in the LM curve triggered the Depression, we should have observed higher interest rates. Yet **nominal interest rates fell continuously** from 1929 to 1933.

These two reasons appear sufficient to reject the view that the Depression was instigated by a contractionary shift in the *LM* curve. (Mankiw, 2016, p.354; Italics in original. Bold emphases added by the authors of this paper.)

3.2 Which Hypotheses explain the Great Depression?

Let us now turn to our short-run IS-LM model and examine if the Mankiw's assertions are justified. In the phase diagrams of Figure 4 above, shocks to the *IS* curve (spending hypothesis) is represented as a movement from point A to points B and C on the left diagram, and shocks to *LM* curve (money hypothesis) is illustrated as point D on the right digram. In order to study the spending and money hypotheses more in line with that of the Great Depression, let us run simulations by decreasing investment and consumption at the same time. For spending hypothesis, let us suppose that consumption decreases by $\Delta C = -20$ at t = 1930 once, and then investment decreases by $\Delta I = -20$ at t = 1930 and 1931 (for two consecutive periods) and then at t = 1935, respectively. For money hypothesis, let us assume that money stock M^s is now decreased by $\Delta M^s = -10$ at t = 1930. In our dynamic model, these scenarios are implemented through PULSE function. These scenarios are more realistic than simply decreasing the level of C and I separately in time using STEP function as was done in the case of Figure 4.

Figure 6 below shows the behaviors of income and interest rate under the two hypotheses as time-series. Note the time (1928-1940) displayed on the horizontal axis is a supplemental label. [4] Note also that the right graph shows the behavior for nominal interest rate instead of real

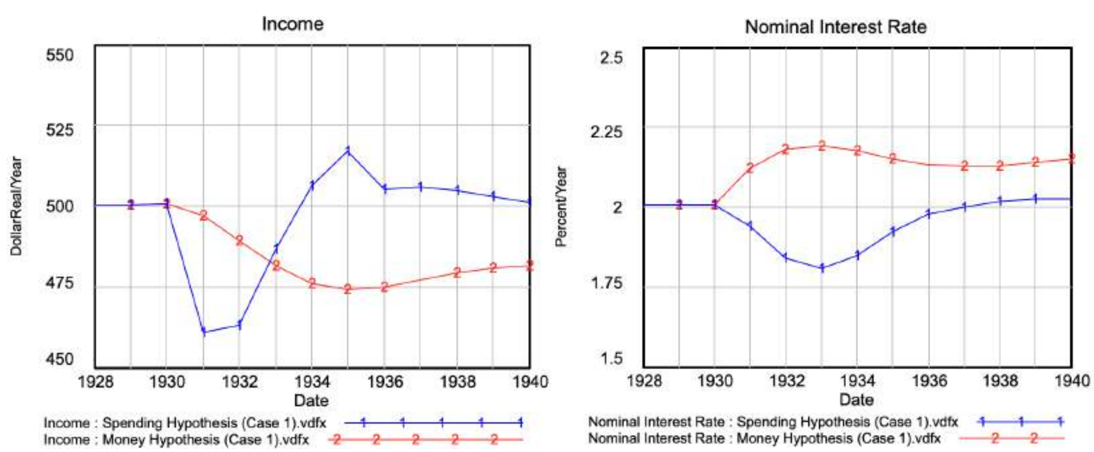

Figure 6: Income and Interest Rate under Spending and Money Hypotheses (Case 1)

interest rate. Under the fixed price assumption, however, there is no difference between nominal and real interest rates, and behaviors of the two exactly match in our simulation. Specifically line 1 (blue) in both diagrams show behaviors under the spending hypothesis whereas line 2 (red) shows that of the money hypothesis. On both diagrams the spending hypothesis indicates falls in both income and interest rate, while income falls but interest rate rises under the money

[4]The simulation software (Vensim) has a functionality that allows users to control the appearance of time label of graphs arbitrarily. Overlaying the time range allows us to focus on specific periods of simulation. Simulation is ran for 50 years (1920-1970) but we are only showing the period between 1928-1940 when pulse function is implemented using this graph displaying functionality. It does not mean, however, that model parameters and initial values have been calibrated and optimized using the actual reference data. Unit of time is set to year.

hypothesis. Indeed the rise in interest rate under the money hypothesis fails to explain the fall in nominal interest rate observed from the data in Figure 5. Mankiw pointed out this contradictory behavior in the nominal interest rate as "the second problem for the money hypothesis". Our simulation also shows that each hypothesis has different effects on income.

Note that "Case 1" in the caption of Figure 6 means the simulations are run under the fixed price and exogenous money assumptions. To give an overview in advance, these assumptions will be relaxed step-by-step as we proceed in the following sections in this paper. The case 2 model, which will be studied in section 3.4, relaxes the fixed price assumption but exogenous money is left untouched as summarized in Table 1. From the combination of two assumptions, we will examine four cases in total. As we explain in later sections, the model is developed so that all cases can be examined in a single model through parameters called "ratio elasticity of price" and "endogenous money switch".

	$M^s_{exogenous}$	$M^s_{endogenous}$
P_{fixed}	Case 1	Case 3
$P_{flexible}$	Case 2	Case 4

Table 1: Assumptions and Model Cases

How about the the behavior of *real* money balances, then? Figure 7 below shows both money stock and real money balance fell under the money hypothesis. Recall that price is fixed under both hypothesis in case 1, which reflects the assumption of the standard IS-LM model in macroeconomics textbooks. Therefore, as Figure 7 indicates, both spending and money hypotheses fail to explain that prices fell while real money balances rose during the Depression. In fact, this problem, which Mankiw called "the first problem" of money hypothesis, occurs under both hypotheses. Accordingly both hypotheses should have been rejected as the causes of the Great Depression. In other words the IS-LM model itself should have been rejected at this point of analysis as it cannot explain the behaviors of key macroeconomic variables. However, Mankiw fallaciously rejected the money hypothesis only without examining the applicability of the short-run IS-LM model itself grounded on exogenous money and fixed price assumptions.

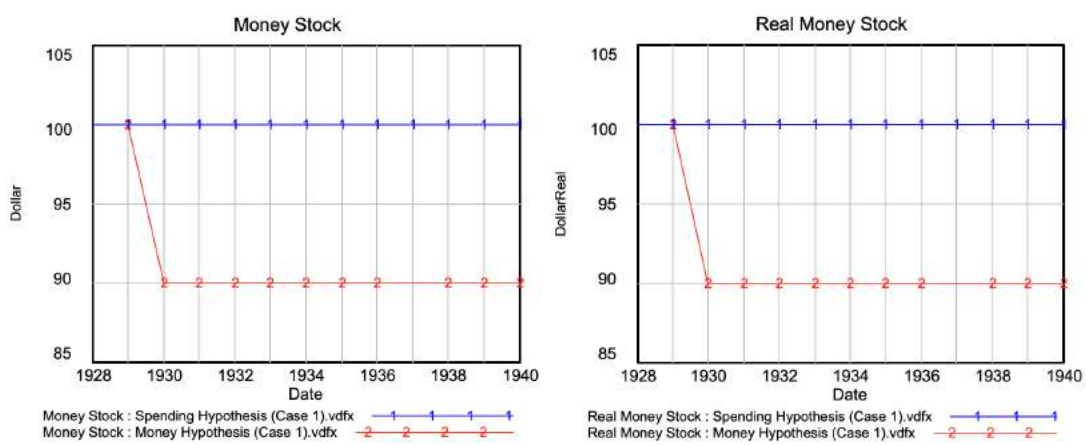

Figure 7: Money Stock and Real Money Stock under the Two Hypotheses (Case 1)

Money Hypothesis explains Money Contraction and Rise in Real Interest Rate

Rejecting the money hypothesis, however, runs into three problems. The first problem is the behavior of real interest rate. Figure 19 in Appendix shows the behavior of real interest rate (red line), which is obtained from the nominal interest rate and inflation data in Figure 5 using the Fisher equation.[5] To be precise the real interest rate shown in Figure 19 corresponds to *ex post* real interest rate since the actual inflation data was used instead of the expected inflation. As we can observe from the graph shown in Figure 19, the *ex post* real interest rate initially jumped during the Great Depression. Accordingly one may counter-argue that money hypothesis performs better than spending hypothesis when it comes to explaining the contraction of money supply and initial rise in the (ex post) real interest rate.[6]

The second problem is the contraction of money stock M^s. Money hypothesis accounts for the contraction in M^s, which caused the banking crisis of the 1930s in the U.S. On the other hand, spending hypothesis does not take into account this critical aspect of the Great Depression nor the rise in real money balance $\frac{M^s}{P}$. Furthermore M^s is treated as an exogenous variable as shown in the model equations. This reflects a key assumption of the standard IS-LM model that money stock can be controlled presumably by the central bank. Therefore it becomes logically incoherent to assume that "M^s has contracted endogenously" in the first place. In other words, economists should have verified whether the assumption that "M^s is given exogenously" is wrong or the hypothesis that "M^s has contracted" is wrong at this point. Looking at the data, we can clearly see that money stock has shrunk significantly. We then come to understand the assumption that "M^s is an exogenous variable" is strange, and that, if M^s is an endogenous variable, it would then be unreasonable to pursue the Federal Reserve with full responsibility for the Depression, given that it cannot control money stock directly but only influences it. This point will be discussed in detail in the next Section 4.

The third problem is the behavior of price changes, i.e. the deflation, which was one of the two main causes that precipitated the Depression according to Irving Fisher, who was one of the original proponents of money hypothesis as we also discuss in the next section.[7] Therefore rejecting the money hypothesis in favor of the spending hypothesis runs into its own problems. Rational economists should have questioned the validity of the IS-LM model itself, rather than applying each hypothesis separately and rejecting only one of them in favor of the other.

3.3 The Mankiw's Extended Model of the IS-LM Analysis

In an attempt to explain the effects of deflation on income under the spending hypothesis, Mankiw (2016, p.355) then presents an extended version of the IS-LM analysis in a section titled "The Money Hypothesis Again: The Effects of Falling Prices". Referring to the debt-deflation theory proposed by Irving Fisher in 1933, Mankiw introduces a new variable: expected future inflation ($E\pi$). His extended IS-LM analysis is then presented as follows:

$$Y = C(Y-T) + I(i - E\pi) + G \qquad IS \tag{17}$$

$$\frac{M}{P} = L(i, Y) \qquad LM \tag{18}$$

[5] From the Fisher equation, the *ex ante* real interest rate (r_{ante}) can be approximated by subtracting expected inflation (π^e) from nominal interest rate (i) such that $r_{ante} = i - \pi^e$.

[6] The fundamental issue here is that price level P is assumed to be fixed in the standard short-run IS-LM model; that is, expected inflation is zero ($\pi^e = 0$) as well as the actual inflation ($\pi = 0$). Thus there is no theoretical distinction between real (r) and nominal interest rate (i) in the IS-LM model. It can be both nominal and real interest rates under the fixed price assumption. Accordingly one cannot take the interest rate in the model as showing either nominal or real interest rate and then evaluate it as contrasting with the data. In this case Mankiw interpreted the interest rate in the IS-LM model as showing the nominal interest rate and then compared it with that of the real world as shown in Figure 5.

[7] Mankiw himself acknowledges this, though he does not specify the name, as in the following sentence: "From 1929 to 1933 the price level fell 22 percent. Many economists blame this deflation for the severity of the Great Depression. They argue that the deflation may have turned what in 1931 was a typical economic downturn into an unprecedented period of high unemployment and depressed income."(Mankiw, 2016, p.354)

where *ex ante* real interest rate (r) is the difference between nominal interest rate (i) and expected future inflation ($E\pi$) from the Fisher equation. With the introduction of expected future inflation, nominal and real interest rates are now distinguished. Mankiw (2016) then goes on to explain that the spending hypothesis in his extended version of the IS-LM analysis shown above can explain how the destabilizing effects of deflation affect income without a need to rely on the money hypothesis as follows:

> Now suppose that everyone suddenly expects that the price level will fall in the future, so that $E\pi$ becomes negative. The real interest rate is now higher at any given nominal interest rate. This increase in the real interest rate depresses planned investment spending, shifting the IS curve from IS_1 to IS_2. (The vertical distance of the downward shift exactly equals the expected deflation.) Thus, an expected deflation leas to a reduction in national income from Y_1 to Y_2. The nominal interest rate falls from i_1 to i_2, while the real interest rate rises from r_1 to r_2.
>
> Here is the story behind this figure. When firms come to expect deflation, they become reluctant to borrow to buy investment goods because they believe they will have to repay these loans later in more valuable dollars. The fall in investment depresses planned expenditure, which in turn depresses income. The fall in income reduces the demand for money, and this reduces the nominal interest rate that equilibrates the money market. The nominal interest rate falls by less than the expected deflation, so the real interest rate rises.
>
> Note that there is a common thread in these two stories of destabilizing deflation. In both, falling prices depress national income by causing a contractionary shift in the IS curve. Because a deflation of the size observed from 1929 to 1933 is unlikely except in the presence of a major contraction in the money supply, these two explanations assign some of the responsibility for the Depression—especially its severity—to the Fed. In other words, if falling prices are destabilizing, then a contraction in the money supply can lead to a fall in income, even without a decrease in real money balances or a rise in nominal interest rates. (*ibid.*, pp.355-356)

The first one of the "two stories of destabilizing deflation" refers to the debt-deflation theory proposed by Irving Fisher, which, according to Mankiw, analyzed that the wealth redistribution effects of deflation between debtors and creditors reduce the spending of debtors more than the creditors raise their spendings, thus giving rise to a net reduction in spending and causing contractionary shift in the IS curve. The second story is the role that expected inflation plays in the rise of real interest rate as explained in the quotation above.

There are two problems in this formulation when applying his extended analysis to the case of the Great Depression. The first issue is unit inconsistency in the LM equation (18). From system dynamics modeler's perspective, the supply of money $\frac{M}{P}$ on the left side of equation (18) has a stock unit expressed in real term (e.g. DollarReal) whereas the right side (demand for money) has a flow unit (e.g. DollarReal/Year). In system dynamics modeling convention, the Mankiw's extended version of the IS-LM model does not pass the unit consistency test.[8]

The second issue is the treatment of price P. The extended model introduced the expected inflation, which is a human psychological variable. However, P remains to be fixed in the short-run IS-LM model. Therefore it remains unclear how the Mankiw's extended model describe an expected deflation without flexible price in the first place. This leads us to a methodological issue, which is that he presents no dynamic model with which readers can run simulations and

[8]Refer to the equation (8) in our model where Real Money Balance (DollarReal) is multiplied by Velocity (1/Year). Our model clears both the unit as well as model checks built into the SD simulation software.

verify his claims. Model-less arguments can mislead policy makers and the general public at large, which we will discuss in Section 7 in the context of Japanese case since the 1990s.

The Flexible Price IS-LM Model

Let us incorporate the Mankiw's idea of extending the short-run model towards flexible price. The introduction of expected inflation allows us to distinguish nominal and real interest rates within our IS-LM model presented in Section 1.1. Based on the Fisher equation, an *ex ante* real interest rate r can be approximated as the difference between nominal interest rate i and expected inflation rate π^e such that $r = i - \pi^e$.[9] With the introduction of expected inflation and real interest rate, our extended version of the IS-LM model is now described as follows:

$$
\begin{aligned}
Y &= AD && \text{(Aggregate Demand Equilibrium)} && (19)\\
AD &= C + I + G && \text{(Aggregate Demand)} && (20)\\
C &= C_0 + cY_d && \text{(Consumption Decisions)} && (21)\\
Y_d &= Y - T && \text{(Disposable Income)} && (22)\\
T &= T_0 + tY - T_r && \text{(Tax Revenues)} && (23)\\
I &= \frac{I_0}{r} - \alpha r && \text{(Investment Decisions)} && (24)\\
G &= \bar{G} && \text{(Government Expenditures)} && (25)\\
\frac{M^s}{P}V &= L^d && \text{(Equilibrium of Money)} && (26)\\
L^d &= aY - bi && \text{(Demand for Money)} && (27)\\
r &= i - \pi^e && \text{(Fisher Equation)} && (28)
\end{aligned}
$$

With the addition of a new equation (28) into the previous model in Section 1.1, our extended IS-LM model now consists of 10 equations with 10 unknowns;

$$Y, AD, C, I, G, Y_d, T, i, r, L^d$$

with 14 exogenously determined parameters

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

Equations (19) through (23) are the same formulation as in equation (1) through (5) of the previous model under fixed price. The extended model above distinguishes nominal (i) and (*ex ante*) real interest rate (r) as in equation (28). Furthermore we can similarly define the *ex post* real interest rate (r_{post}) based on the Fisher equation. Note also that the investment decisions in equation (24) is now a function of *ex ante* real interest rate r whereas the liquidity demand is a function of *nominal* interest rate i.

3.4 The SD Model of Flexible Price IS-LM

To examine whether the Mankiw's assertions on the validity of spending hypothesis under the flexible price assumption are justified, let us introduce the expected inflation into our system dynamics model. To do so, we first need to incorporate price dynamics into our model.

[9]Notice the different symbols used for expected inflation in Mankiw's textbook ($E\pi$) and our model (π^e).

Price Adjustment Process

Price level in the short-run IS-LM model is assumed to be exogenously determined, by reflecting the Keynesian view that price tends to be rigid in the short run.[10] Hence price has been assumed to be fixed in our model so far. Introducing the inventory stock, which we discussed already in Section 2.1, allows us to model price dynamics even in the short run, because fluctuations of inventory are always reflected as a change in price in the real economy such that

$$\frac{dP}{dt} = \Psi \left(I_{nv}^{*} - I_{nv} \right) \tag{29}$$

where I_{nv}^{*} denotes desired inventory, which represents the amount of inventory stock that the economy as a whole desires to hold at any moment in time. This price adjustment process can be further specified as follows

$$\frac{dP}{dt} = \frac{P^{*} - P}{\text{Adjustment Time}} \tag{30}$$

where the desired price P^{*} is obtained as

$$P^{*} = \frac{P}{\left(I_{nv}/I_{nv}^{*} \right)^{e}} \tag{31}$$

where e is an inventory ratio elasticity of desired price. This elasticity can be changed as a parameter in our SD model so that users can try out different assumptions on the degree of price rigidity. The default value is set to 0, which assumes fixed price. We have set the price adjustment time to 4 (years) in the subsequent simulations. The stock-flow diagram in Figure 3 illustrates this price adjustment process already.

Expected Inflation Formation Process

With the introduction of price adjustment process above, the model can now be extended further to incorporate the formation of expected inflation as a psychological variable. Specifically the expected inflation rate can be modeled as

$$\frac{d\pi^{e}}{dt} = \frac{\pi - \pi^{e}}{\text{Adjustment Time}} \tag{32}$$

where the inflation rate is obtained as follows:

$$\pi = \frac{d(lnP(t))}{dt} \tag{33}$$

where $lnP(t)$ is a natural logarithm of price $P(t)$. The adjustment process of expected inflation above reflects the *adaptive expectation*. With the inclusion of the price adjustment and expected inflation rate, our extended IS-LM model with flexible price assumption is now completed.

3.5 Spending & Money Hypotheses under the Flexible Price

Let us now run simulations and test the spending and money hypothesis in this extended model. Specifically we allow the price to move flexibly by setting its elasticity to 0.2 at t = 0 from its default value of 0 (fixed price). The inflation expectation adjustment time is set to 10 (years).

[10] Yamaguchi (2013, Chapter 9) discusses the contrasting views on the role of price adjustment in the Neoclassical long-run equilibrium and Keynesian aggregate demand equilibrium of GDP with a causal loop diagram.

Figure 8 below shows the behavior of income (left) and price level (right). "Case 2" in the caption means that the simulation is run under flexible price assumption as shown in Table 1. Reductions in consumption, investment (spending hypothesis) and money stock (money hypothesis) are implemented in the same way as was done in case 1. Both hypotheses cause income to fall similar to case 1 simulations.

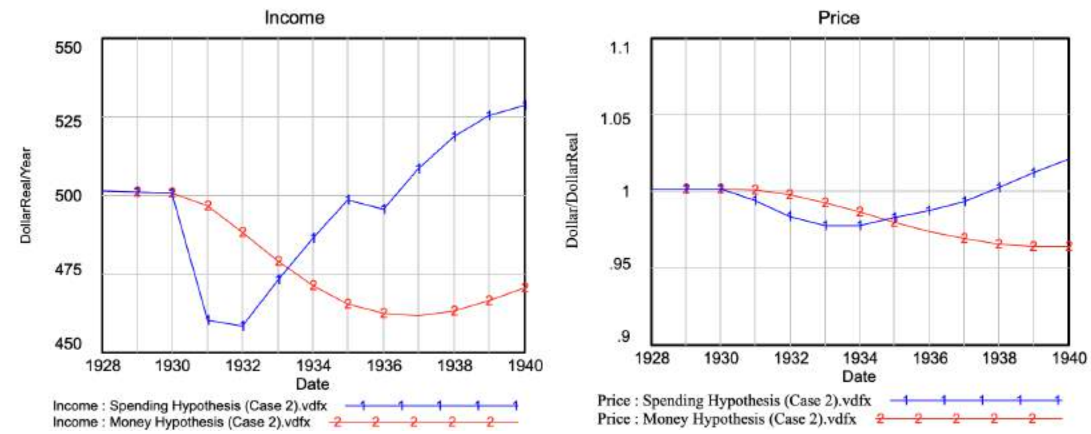

Figure 8: Income and Flexible Price under the Two Hypotheses (Case 2)

A left diagram in Figure 9 below shows nominal interest rate (line 1 in blue), *ex ante* real interest rate (line 2 in red) and *ex post* real interest rate (line 3 in green) under the spending hypotheses. The right diagram shows those of the money hypothesis. Spending hypothesis under flexible price (case 2) captures what Mankiw called the *destabilizing effects of deflation* on income, the fall in nominal interest rate as well as rise in real interest rate. Though the rise in *ex ante* real interest rate (line 2) under the spending hypothesis is not significant in our simulation, the decline in nominal interest rate causes the *ex ante* real interest rate to appear relatively higher. Moreover the spending hypothesis captures the sudden rise in *ex post* real interest rate (line 3), which is consistent with the data in Figures 5 and 19.

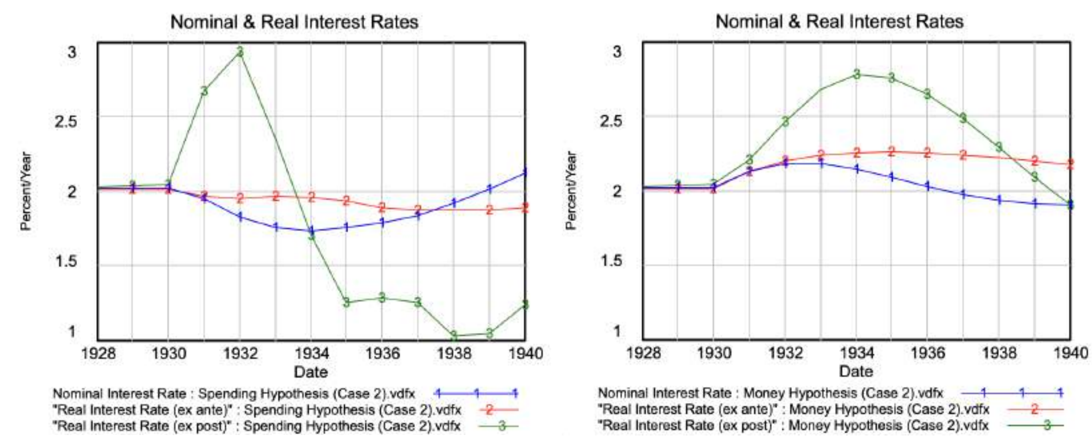

Figure 9: Nominal and Real Interest Rates under the Two Hypotheses (Case 2)

Case 2 analysis is what Mankiw's extended model of the IS-LM has attempted to implement, but he did not present a dynamic model. Our simulation results indeed confirms the validity of Mankiw's claim, and this is one of the contributions of this paper. However, the problem of spending hypothesis in case 2 is that it still treats money stock M^s as exogenously given, thus failing to explain the contraction of money as was discussed in case 1 also. To see this visually, Figure 10 below compares the behaviors of money stock (left) and real money balance (right) under the two hypotheses. From the graph on the right, we can observe that real

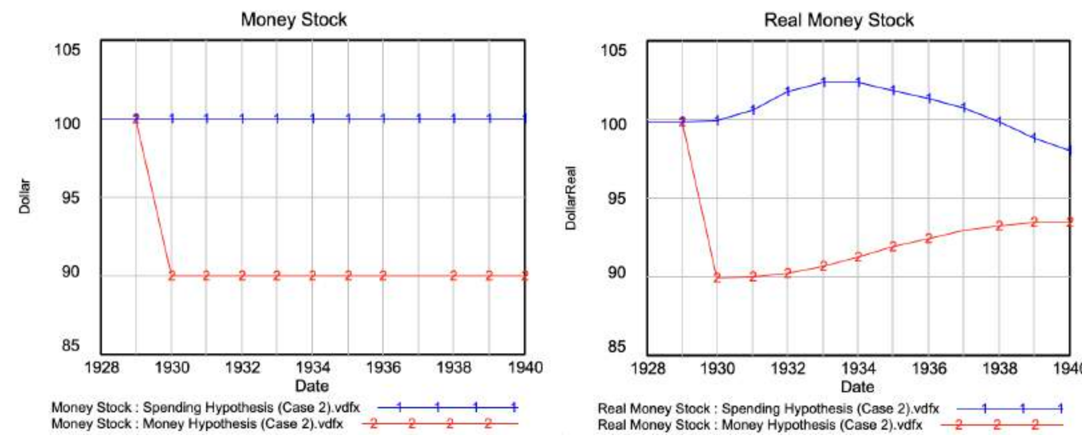

Figure 10: Money Stock and Real Money Balance under the Two Hypotheses (Case 2)

money stock under the spending hypothesis (line 1 in blue) increases whereas that of money hypothesis (line 2 in red) decreases initially and then rise. This seems to suggest that spending hypothesis explains the behavior of real money balance during the Depression better than the money hypothesis. Looking at the graph on the left, however, the spending hypothesis does not take into account the contraction of money in the first place. The rise in real money balance without contractions in money stock shows that the spending hypothesis in case 2 model does not explain the real money balance for the right reason. As far as our simulations suggest, therefore, we did not find a theoretical evidence which supports Mankiw's claim under the spending hypothesis in his extended IS-LM analysis.[11]

Money hypothesis in case 2, on the other hand, captures the money contraction, deflation, and rise in real money balance for the right reason. Also the rise in *ex post* real interest rate is consistent with the data. However, the nominal interest rate also rises under the money hypothesis, which is inconsistent with what was observed during the Great Depression.

Problems of Spending Hypothesis under the Flexible Price Model

In summary the spending hypothesis in the extended model still fails to explain the contraction of money, and thus the behavior of real money balance for the right reason. It does not take into account the fact that money stock contracted significantly during the Depression either. This anomaly alone should have prompted economists to question the validity of IS-LM

[11] Recall from the quotation above that Mankiw (2016, p.356) maintained: "if falling prices are destabilizing, then a contraction in the money supply can lead to a fall in income, even without a decrease in real money balances or a rise in nominal interest rates". One can see here that he presupposes the money contraction under the spending hypothesis in his extended analysis. This presumption, however, contradicts with his definition of spending hypothesis or with the exogenous money still assumed in his extended model of the short-run IS-LM.

model itself, rather than rejecting only the money hypothesis in favor of the other twice; that is, first in the standard IS-LM model and, again, in the extended model. Our simulations imply that the conventional IS-LM model, which is built upon the fixed price and exogenous money assumptions, fails to explain the causes of the Great Depression under both hypotheses. Should we abandon the IS-LM model, then? If so, the cause of the Great Depression becomes unexplainable again even in the undergraduate-level textbooks, which is a serious issue.

4 Endogenous Money Spending Hypothesis

What is wrong with the IS-LM analysis, then? As discussed so far, the problem lies in the assumption that money stock M^s is exogenously given and prices are fixed. Since the introduction of IS-LM model by Hicks (1937), it has been a norm among economists to assume that money is exogenously determined by the monetary authority; that is, money stock has been assumed to be put into circulation and can be controlled by the government and/or central bank. Empirical studies, on the contrary, show that the majority of money stock is created endogenously as interest-bearing debts of non-banking sectors under the current fractional reserve banking systems (Werner, 2016; Yamaguchi, 2021; Yamaguchi and Yamaguchi, 2021a).[12]

4.1 The Fisher's Debt-Deflation & 100% Money Theories

Have the economists been ignorant for such a long time so as to disregard the role of money and debts? No, they have not. Indeed, just as the same time when Keynes published the *General Theory* in 1936, Irving Fisher, who was the leading American economists and just became the first president of newly-founded Econometric Society in 1931, proposed that the main cause of the Depression is the structure of fractional reserve banking system itself where money is created and destructed endogenously. His main interest at the time was to elucidate the causes of business cycles. And, just like Keynes, he has been struggling in search for the remedies.[13]

The Debt-Deflation Theory – Fisher's Analysis of Booms and Depressions

Fisher's solution was the paper published in the first volume of Econometrica entitled "The Debt-Deflation Theory of Great Depressions" (Fisher, 1933), which was essentially a summary of his book "Booms and Depressions" (Fisher, 1932) published a year before. He analyzed that the crux of the Depression was the *over-indebtedness* ("debt disease"), which triggered the financial crisis initially, and the *deflation* ("price-level disease") that worsened the burden of debtors. In other words, he had a conviction that the central factors that precipitated the Depression were debt disease (bank loans) and dollar disease (increasing value of the dollar) rather than real economic factors such as over- or under-production, consumption, saving or investment. Let us first briefly revisit the debt-deflation theory based on his article.

Fisher focused on nine macroeconomic variables and described them as the "chain of consequences" that he considered characterized the dynamics of the Great Depression as follows:

> (1) *Debt liquidation* leads to *distress selling* and to (2) *Contraction of deposit currency*, as bank loans are paid off, and to a slowing down of velocity of circulation. This contraction of deposits and of their velocity, precipitated by distress selling,

[12]In the original article, Hicks (1937) simply assumed "Let M be the given quantity of money (p.148)". We do not know whether Hicks himself, and others who later followed the IS-LM framework, made such an assumption for the sake of mathematical simplicity or by the unfamiliarity with the fractional reserve banking. This was, however, and still is an over-simplification of the money and banking systems of the real world.

[13]Section 4.1 owes to Chapter 8 of Yamaguchi (2015) titled "What is the Chicago Plan (Monetary Reform)?".

causes (3) *A fall in the level of prices*, in other words, a swelling of the value of the dollar. Assuming, as above stated, that this fall of prices is not interfered with by reflation or otherwise, there must be (4) *A still greater fall in the net worths of business*, precipitating bankruptcies and (5) *A like fall in profits*, which, in a "capitalistic," that is, a private-profit society, leads the concerns which are running at a loss to make (6) *A reduction in output, in trade, and in employment* of labor. These losses, bankruptcies, and unemployment, lead to (7) *Pessimism and loss of confidence*, which in turn lead to (8) *Hoarding and slowing down still more the velocity of circulation*. The above eight changes cause (9) *Complicated disturbances in the rate of interest*, in particular, a fall in the nominal, or money, rates and a rise in the real, or commodity, rates of interest. (Fisher, 1933, p.342; emphasis original).

Evidently Fisher pointed out the contraction of money stock and a fall in nominal or a rise in real interest rates in the debt-deflation theory. Furthermore practitioners of system dynamics can easily notice that his line of thought is inherently a causal loop analysis.[14]

Figure 11 below illustrates a causal loop diagram of the debt-deflation theory.[15] Numbers in parenthesis show the sequence in the original exposition by Fisher. The starting point of his

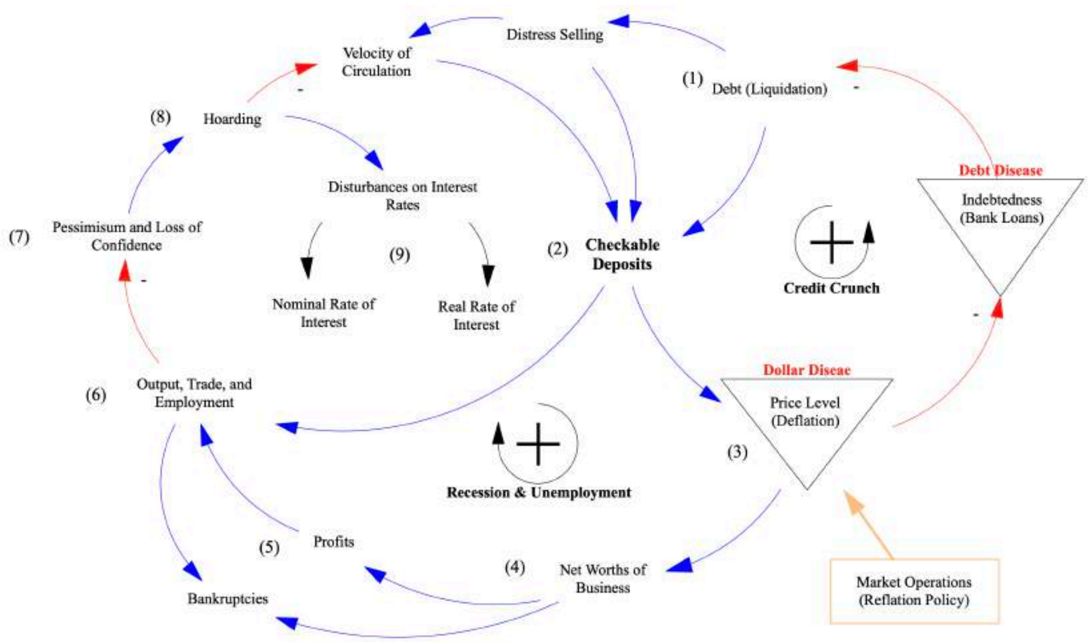

Figure 11: The Debt-Deflation Theory in A Causal Loop Diagram

analysis is the occurrence of over-indebtedness and insolvency upon the burst of the bubble. Companies and individuals repay bank loans in order to reduce their debts (1). Demand deposits will decrease as a result (2). Distress selling on margin calls causes the stock market

[14]Fisher uses the term "logical order" as opposed to "chronological order". The former is generally called the 'causal (loop) analysis' and the latter 'behavior analysis (over time)' in system dynamics. Fisher is known to have also explained systematically the importance of stock-flow distinction and a need for the strict adherence to it in economic theory and analysis (Fisher, 1906), not to mention his contribution to fundamental concepts underlying the macroeconomics including the Fisher equation (Fisher, 1930).

[15]Adopted from Yamaguchi (2015, Figure 8.1, p.177) with minor modifications and translation from Japanese. Blue arrows indicate the causal relationship changes in the same direction whereas red indicate the opposite.

to crash, and sales in both real and financial markets become sluggish in the process of debt repayments. The velocity of money slows down. As a result of the declines in investment and consumption, price levels will fall (3). Then, net assets of business corporations begin to decrease further (4), and bankruptcies increase. At the same time profits will decrease (5) and corporate losses increase. Levels of production will decrease in this way (6), which in turn decrease employment. In addition, the recession makes corporate managers pessimistic and reduce confidence in their businesses as losses and bankruptcies become more evident (7). They then decrease expenditures and stop spending money. Money begins to be hoarded and its velocity of circulation slows down further (8). As a result, recession will accelerate decline in prices (3). All of the above turmoils affect interest rates, lowering nominal interest rates as demand for money and loans plunge, while raising real interest rates (9). This causal loop is referred to as "recession and unemployment loop" in the causal digram.

Fisher called this effects of excess debts and insolvency "debt disease", and effects of deflation on the economy "dollar disease". He then analyzed that debt disease results in the contraction of money stock, lower prices, and bring about the dollar disease. Compounding effects of debt and dollar diseases bring about the so-called fallacy of composition; "*the very effort of individuals to lessen their burden of debts increases it, because of the mass effect of the stampede to liquidate in swelling each dollar owed* (...) *the more the debtors pay, the more they owe.* (Fisher, 1933, p.344; emphasis in original)". This feedback loop is referred to as "credit crunch loop". When we focus on the dynamics around the falling prices, this is a deflationary spiral. As we have just seen, the debt (bank loan) and money always occupy the central roles in Fisher's analysis.

Note that Fisher's causal analysis stops at the interest rates (9) as is illustrated in Figure 11. However, under our integrated hypothesis applied in the flexible price IS-LM model, which we will discuss in the next Section 4.2, the *ex ante* real interest rate affects the level of investment I such as described in the equation (24). Accordingly the feedback loop will be closed in our case 4 model with flexible price and endogenous money assumptions.

Reflation Policy – Fisher's Initial Prescription

How do we get out of the Depression, then? In system dynamics the question becomes: which dominant loops to break? The Fisher's answer was straightforward. He came to a conclusion that price level should be stabilized and the economy will be reflated. More specifically he considered prices P would naturally rise if the Federal Reserve conducts open market operations and increases the amount of money M. Using the causal diagram in Figure 11, this policy can be thought of as breaking the credit crunch loop through monetary policy. Keynes's analysis, on the other hand, put more emphasis on the real economic variables such as aggregate demand. Thus, the Keynesian policies can be thought of as breaking the 'recession and unemployment loop'. Behind this logic Fisher had the quantity theory of money (Fisher, 1920) in mind:

$$MV = PT \tag{34}$$

where T denotes Trade or Transaction Volumes (not to be confused with Tax Revenues in equation 5). Notice how the quantity theory is embedded in the causal analysis of Figure 11. Based on this equation of exchange, Fisher argued that the increase in money M will eventually lead to increases in prices P or transaction volumes T (or income Y), if the money velocity V remains constant (or increases). Specifically he contended that, as long as the velocity V keeps its pace with T, which had already been observed statistically by Dr. Carl Snyder (a statistician at the Federal Reserve Bank of New York) according to Fisher, the price level P can be kept steady along with the steady progress of T in the long-run. Let us call such a policy *reflation policy.* Fisher (1932, Chapter X) conveyed that the reflation policy causes prices to rise moderately, and the economy would eventually recover from the dollar disease as illustrated at the bottom right corner of Figure 11. For this reflation policy to be effective, Fisher (1932) stated "[w]e need only to assume that an increase in the quantity of the circulating medium has *some* tendency to raise the price level, and *vice versa* (p.124; emphasis in original)".

Fisher himself seemed very pleased at the time that his theory was highly regarded by experts as "both new and important (Fisher, 1933, p.337)". As a matter of fact, he was convinced that the reflation policy, though it was not a panacea, could have escaped the Depression as follows:

> In fact, in my opinion, this [prevention of the Depression] would have been done had governor Strong of the Federal Reserve Bank of New York lived, or had his policies been embraced by other banks and the federal reserve board and pursued consistently after his death. (Fisher, 1933, p.347)

The reflation policy continued to have influences on economists even today and it became the rationale of large scale asset purchase programs known as Quantitative Easing (QE).

From The Debt-Deflation to 100% Money Theory – The Fisher's Conversion

In march of 1933, the same year as he published the debt-deflation paper, Fisher received a proposal called "The Chicago Plan for Banking Reform" proposed by the eight economists at the University of Chicago.[16] With his debt-deflation theory published in October, Fisher had full hopes for the reflation policy by the Federal Reserve as explained above. In fact, as if to support his expectations and confidence in his theory, Fisher (1945) confessed that he "had not at the time of stating them [conclusions of the Booms and Depressions] given attention to the 100% system (p.119)". However, from around 1934, Fisher began to devote himself with the monetary reform envisioned by the Chicago Plan to the extent he abandoned his own reflation theory. Undoubtedly Fisher must have been in a hurry to publish *100% Money* at the time. Due to the demanding publication schedule, he simply reproduced the original section titled "THE ROLES OF DEBT AND DEFLATION" from the Econometrica article into Chapter 7 of his new book with the section titled "BOOMS and DEPRESSIONS". In doing so, he took the insight he gained after the publication of the debt-deflation theory and slipped the following sentence into his new book published two years later in March of 1935:

[16] They were: G. V. Cox, Aaron Director, Paul H. Douglas, Albert G. Hart, Frank H. Knight, Lloyd W. Mints, Henry Schultz, and Henry C. Simons. Phillips (1995) provides a detail account of the background, thesis and outcomes of monetary and banking reform proposals in the 1930s. The proposals, in principle, consisted of (1) requiring 100% reserve ratio on checkable deposits and (2) establishing and authorizing the "Currency Commission" *à la* Fisher (1945, p.119) to provide money banks would need for the 100% reserve ratio, and to manage total money stock towards the price stability objective. Banks will accordingly become the true financial intermediaries of existing funds between savers and borrowers. The former arrangement structurally increases resiliency, safety and stability of the domestic financial system by making all M_1 backed by legal tender, thus achieving $M_0 = M_1$. Note that deposits are merely promises by private banks to refurnish currency, i.e. legal money, on demand under the current fractional reserve banking system. As a by-product of the reform, national debts will also be liquidated. See further Yamaguchi (2010, 2011, 2013) for Accounting System Dynamics (ASD) model-based studies and Benes and Kumhof (2012) for DSGE model-based study on the topic. According to Zarlenga (2002), the proposal of 100% reserve banking originates from Soddy (1926). Frederick Soddy, who won the Nobel prize in 1921 for his research in radioactive decay and formulation of the isotopes theory, was the Dr. Lee's Professor of Chemistry at Oxford (1919-1936). He was deeply concerned with the persistent inequality in the era of technological progress after the industrial revolution, and came to a conclusion that the fractional reserve banking system was the root cause of the prevailing economic injustice. According to Phillips (1995, p.45), Frank Knight encountered with the Soddy's idea and, together with aforementioned Chicago school economists, refined the proposal into the banking reform plan. Concerning the role of government in monetary system, Frank Knight once 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 (*ibid.*)".

> It should be noted that *all the events listed occur through a contraction of check-book money.* (Fisher, 1945, p.123; emphasis in original)

All the events listed imply the nine events he listed in the original debt-deflation paper, and *check-book money* implies demand deposits. So, what was the insight he gained after the publication of the debt-deflation theory? Fisher realized, upon receiving the Chicago plan, that money stock was not an exogenous policy variable. Instead he realized bank loans create deposits under the fractional reserve banking system or "the 10% system" *à la* Fisher (1945).

Specifically he observed this endogenous expansion and contraction of bank deposits as shown in Table 2.[17] First, from 1926 to 1929, the money stock increased by 1 billion dollars from 26 to 27 billion dollars. This reflects the economic booms of the time (the Roaring 20s). Then, from 1929 to 1933, cash holdings increased by 1 billion dollars from 4 billion to 5 billion dollars. This is the result of depositors flooding banks and withdrawing cash. In other words, depositors raised the cash ratio from 17.4% in 1929 to 33.3% in 1933, reducing bank reserves by 1 billion dollars. As a result, demand deposits have fallen by as much as 8 billion dollars from 23 billion in 1929 to 15 billion dollars in 1933. In summary cash increased by 1 billion over the period of four years, while demand deposits decreased by 8 billion, resulting in the destruction of 7 billion dollars of money stock. This contraction in the money stock can also be confirmed in Figure 5 above. At that time, instability caused by bank runs in the U.S. developed into a systemic scale, forcing at least more than 10,000 banks to close operations. Observing this, Fisher likened the money stock to highways for business activities, describing that the 23 billion miles (dollars) of highways needed for daily business operations were suddenly destroyed by 8 billion miles (dollars).[18]

	1926	1929	1933
Money Stock (M^s)	26	27	20
Cash	4	4	5
Deposits	22	23	15
Cash-Deposit Ratio	4/22	4/23	5/15
($= \frac{Cash}{Deposits}$)	(= 18.2%)	(= 17.4%)	(= 33.3%)

Table 2: Deposits Contraction during the Great Depression & Changes in Money Stock during 1926-1933 (in billions)

As a result, the supply of money is endogenously determined, and the quantity equation (34) is not an equation but merely an identity that always holds. In other words, the quantity theory as an identity must be accurately expressed, considering that money stock is a function of transactions T under the fractional reserve banking systems, as follows:

$$M(T)V \equiv PT \tag{35}$$

Expressed in this way, the causal inference that money stock M^s affects prices P and the real economy is no longer convincing and discernible.[19] On the contrary, the relationship between money and economic activities becomes clear. Changes in money stock occur endogenously and M should not be treated as an exogenous policy variable. Thus the reflation policy initially envisioned by Fisher himself is only effective up to the stage where base money (M_0) can

[17] Prepared by the authors based on descriptions by Fisher (1945, pp.5-6). Numbers were rounded. Hence the cash-deposit ratios do not precisely correspond to the values calculated using numbers in the table.

[18] Yamaguchi and Yamaguchi (2021b, Chapter 1) observed that almost the same ratio of money stock M_1 was potentially destroyed during the burst of the Japanese bubble in the 1990s. It was 'potentially' because during the post-bubble period, the Japanese government, following the Keynesian fiscal policy, increased deficit spendings through bond issuance, which increased the money stock. Recall that fiscal expenditures financed by bonds underwritten by banks will result in increase in money stock (Yamaguchi and Yamaguchi, 2021a).

[19] Fisher proposed the quantity theory as an identity. However it was somehow transformed later into an equation that determines price P and income-related variables by the monetarists. This is also noticeable from the Mankiw's interpretation and explanation of the money hypothesis originally put forward by Fisher.

be increased through rediscounting and open market operations by central banks. The asset purchase programs, however, do not increase money stock M^s (such as $M_{1,2,3}$) per se, which consists of currency and deposits. This means that another assumption of the reflation policy, as described below, will not be guaranteed under the fractional reserve banking system:

$$M_1 = mM_0 \Longrightarrow (\text{if } m \text{ is stable}) \Longrightarrow \Delta M_1 = \Delta M_0 \tag{36}$$

where m is the money multiplier.[20] In other words, Fisher realized further that the money multiplier m cannot be assumed to be stable. This means that the two major assumptions of reflation policy, i.e., the stable velocity V and money multiplier m, do not hold simply because m cannot be controlled by the central bank nor by the government under the fractional reserve system. This was the reason why he emphasized in italics that the Great Depression, as analyzed in the debt-deflation paper, "*occur through a contraction of deposits*". Upon receiving and studying the Chicago plan carefully, he was convinced that the fundamental cause of the Depression lies in the structure of fractional reserve banking system itself. Under this system, money is created through bank loans, driving speculative investments and financial bubbles. When the bubble bursts, the $8 billion dollars of "check-book money" disappeared during the financial turmoil. He then continued the analysis and concluded as follows:

> Booms and depressions can doubtless, to some extent, be cured and prevented without recourse to the 100% system, but, if my analysis is correct, not so surely, quickly, and easily as under 100% system; for an underlying cause (or precondition) of great booms and depressions is the 10% system itself (Fisher, 1945, p.120)

In this way Fisher buried his own reflation theory with his own hands and replaced it with 100% money theory where he contended the effectiveness of stabilization policy and other socio-economic benefits.[21] Under the 100% reserve system, demand deposits will not disappear from circulation even if debts (bank loans) are repaid. Additionally the money velocity will not be affected. That is, the causal arrow pointing from "Debt (Liquidation)" towards "Checkable Deposits" disappears, and the credit crunch loop is eliminated. As a result, there will be no debt disease or dollar disease that causes the depression. The reflation policy may eliminate the effects of dollar disease as Fisher initially hoped, but they could not eliminate the effects of debt disease. He was theoretically convinced that, even if these illnesses occurred, they would not cause economic fluctuations to be as severe as the Great Depression under the *100% system*. After the World War II and until his death in 1947, Fisher continued to advocate the monetary reform, collaborating with other economists, informing members of the American Economic Association (AEA) where he was the past president in 1918, and engaging with members of the Congress and Senators to enact a bill that will establish the *100% system* in the United States and at international level (Phillips, 1995). However, the Fisher's endogenous money analysis was gradually forgotten, and later disappeared completely from textbooks as if it were a *taboo*.

[20] If the cash-deposit ratio (α_c), legally required reserve ratio (β_r), and excess reserve ratio (β_e) are defined, then the money multiplier (m) is obtained as

$$m = \frac{\alpha_c + 1}{\alpha_c + \beta_r + \beta_e} \tag{37}$$

The cash-deposit ratio is a value determined by the liquidity preference of non-banking private sectors such as households and producers, and excess reserve ratio is determined by the lending of deposits (assuming the financial intermediation theory of banking). If the cash-deposit ratio or excess reserve ratio rises due to some external factors, then the money multiplier would fall and money stock M^s will also be out of control since the central bank can only control the required reserve ratio. See Yamaguchi and Yamguchi (2016) further.

[21] See Fisher (1945, pp.10-14) further. All of them still applies even today as the basic structure of the debt money system remains the same as was in the 1930s, except the gold standard was abolished in 1971.

4.2 The SD Model of Endogenous Money IS-LM

Empirical results show that the majority of money supply are created by bank loans. That is, money stock M^s exists as interest-bearing debts of non-banking sectors under the current *debt money system*.[22] Accordingly money stock needs to be reincorporated as an endogenous variable into the IS-LM model. This has prompted us to revise the 'exogenous money' assumption of the conventional IS-LM analysis. How can we revise our IS-LM model, then, into the one in which money is endogenously created and destroyed? More specifically, how can we integrate the spending hypothesis by Keynes and money hypothesis by Fisher within the IS-LM framework?

Endogenous Money Spending Hypothesis

The conventional IS-LM model assumes money stock is exogenously given and controlled by the monetary authority. However, as shown in equation (35) above, money must be a function of transactions in terms of the Fisher's quantity theory such that

$$M = M(T) \tag{38}$$

Since the IS-LM model analyzes this transaction volume in a narrower sense as transactions related to the income, money stock must be a function of income, i.e. $M = M\ (Y)$. Income in turn is determined by effective demand such as consumption, investment and government spending within the IS-LM framework. Under the current debt money system, debts by private sector and government (borrowings) precede investment and spending, since money stock is only put into circulation when banks grant loans by creating deposits on their books. If the private sector increase investments or the government issues debt securities, then the amount of money in the economy will increase endogenously. That is, money stock M^s in the LM curve must be a function of investment (I) and government debt (D_G) such that

$$M = M(I, D_G) \tag{39}$$

If effective demand is determined by investment and government spending and *IS* curve is drawn, then the money stock would also change simultaneously. Therefore *LM* curve also have to be drawn again in conjunction with it.

Based on this insight of endogenous debt money, we propose an alternative integrated hypothesis for the causes of the Great Depression; that is, *Endogenous Money Spending Hypothesis*. Specifically, we have assumed that economic recessions under the debt money system are generally caused by a combination of spending and money hypotheses as follows:

(a) Aggregate demand falls (the real sector is assumed to trigger recessions here).

(b) Declines in demand for loans follow, including forced debt repayments (credit crunch).

(c) Money stock contracts as a result, followed by deflation, which increases debt burdens of borrowers and real interest rate, which brings the causality back to (a).

[22] Yamaguchi (2021) examined the money-debt relationship, as suggested by the deposit creation theory of banking, in the case of United States Dollar (USD) and found that total debts from banks approximate total money stock M_2 of the U.S. during 1945-2020, following the previous case observed in Japanese Yen (JPY) during 1980-2019 (Yamaguchi and Yamaguchi, 2021a,b). As a reference, Yamaguchi (2021, p.16, Fig.9) reports that the correlation coefficient between total debts and M_2 of the U.S. is 0.998 during the period between 1945-2020 and 0.996 during the period between 1980-2020. The money-debt relationship in the USD case was observed more precisely than it did in JPY case where the correlation coefficient between total debts and M_3 is 0.987 during 1980-2019. Furthermore the correlation coefficient between total debts and nominal GDP of the U.S. is reported to be 0.987 during the period between 1945-2020 and 0.978 during 1980-2020 respectively.

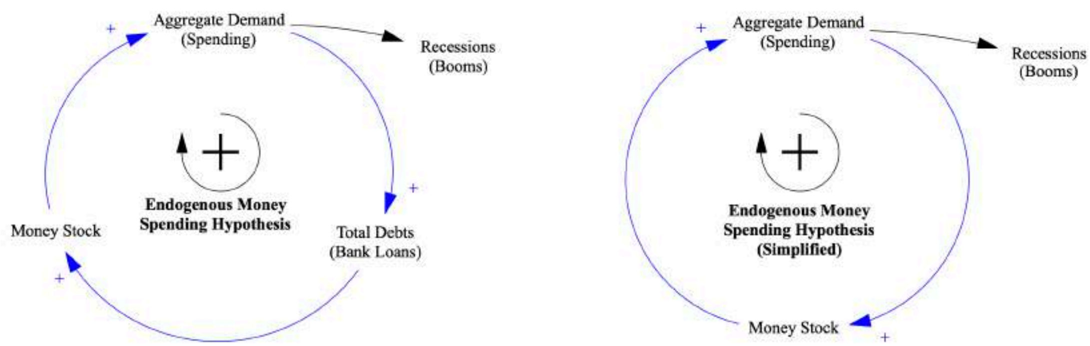

Figure 12: Endogenous Money Spending Hypothesis as A Positive Feedback Loop

The left diagram of Figure 12 above illustrates the above three events as a positive feedback loop of our endogenous money spending hypothesis. It can cover the case of recessions as well as economic booms. One can visualize the case of booms by simply reversing the causal direction in events (a), (b) and (c) in the same feedback loop. This causal loop diagram can compactly capture how economic booms and recessions are triggered and intensified under the debt money system. This is our revised model of endogenous money IS-LM where debts from banks play a central role in the overall macroeconomic dynamics. To incorporate this feedback loop into the SD model, however, we need to bring the analyses of budget equations additionally.

Endogenous Money IS-LM Model

To avoid such complexity in this paper, the right diagram of Figure 12 illustrates a simplified feedback loop of our endogenous money IS-LM model where money is increased or decreased endogenously and proportionately with growth rate of income (this causal relationship from income to money stock is omitted for simplification in the figure) such that

$$\Delta M^s = \Delta Y \tag{40}$$

This is a straightforward approach to incorporate endogenous money without modeling the complex inter-sector transactions, which will be undertaken in the next paper (Part II) by incorporating budget equations and balance sheets of macroeconomic sectors. We have employed this simple approach in this paper (Part I) without losing a generality of the debt money system. This mechanism is already included in the stock-flow diagram in Figure 3 as "Money Stock (Endogenous)". Users can switch between exogenous and endogenous money mode by turning on-off the "Switch (Money)" shown on the upper left of "Money Stock". In our subsequent simulations we assume that money stock increases or decreases endogenously by 70% of the income growth rate. This ratio can be changed by a variable called "Endogenous Money Fraction" so that users can try different assumptions on the degree of money endogeneity. The default value is set to 0.7. By setting the endogenous money fraction = 0, the growth rate of money stock becomes zero and the model will also run under the exogenous money mode.

4.3 Endogenous Money Spending Hypothesis under the Flexible Price

Now we are in a position to examine how this revised model of IS-LM analysis behave under the endogenous money spending hypothesis. We have run simulation by switching the model to endogenous money mode and applying the same spending hypothesis implemented in case 1 and case 2. We have set the money stock adjustment time to 4, which is the same value for price adjustment time explained in Section 3.4.

Figure 13 shows behaviors of nominal and real interest rates on the left, and inflation and expected inflation rates on the right diagram. "Case 4" in the caption means the simulation is ran under the flexible price and endogenous money assumptions.[23] Because the case 4 model assumes endogenous money, the spending hypothesis now becomes the endogenous money spending hypothesis. Note, however, that each legend shown below the graphs only says "Spending Hypothesis (Case 4)". Figure 14 compares behaviors of money stock (left)

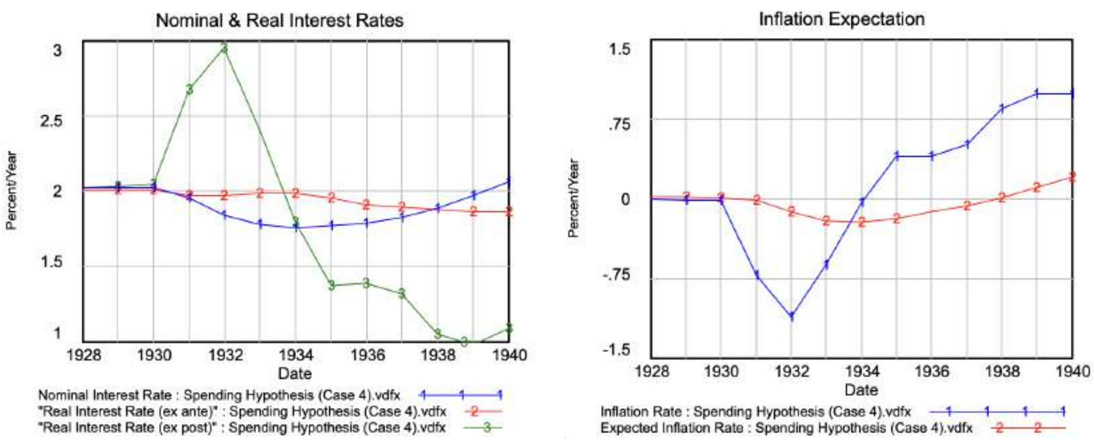

Figure 13: Interests and Inflation under Endogenous Money Spending Hypothesis (Case 4)

and real money balance (right) under the spending hypothesis in case 2 (line 1 in blue) and the endogenous money spending hypothesis (line 2 in red). Our simulation shows endogenous

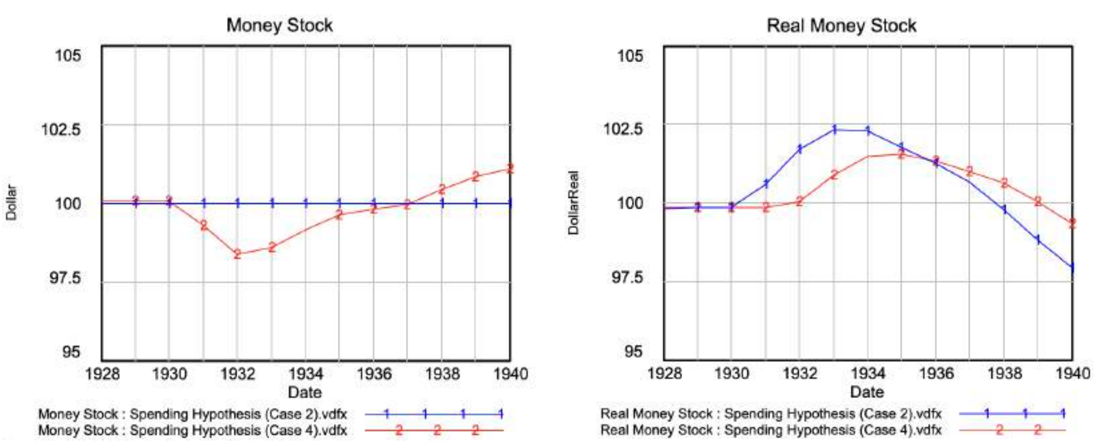

Figure 14: Money Stock under Endogenous Money Spending Hypothesis (Case 4)

money spending hypothesis, which was the original analysis on the causes of the Depression by Fisher, captures the behaviors of nominal and real interest rates already explained under the

[23]Simulation results under the spending hypothesis in case 3 model (fixed price, endogenous money) will be discussed in the next Section 5 where we summarize simulation results under all cases from 1 through 4.

spending hypothesis in case 2, but also the contraction of money stock, which was unexplained under the previous case 2 model. Accordingly the rise in real money balance is now explained for the right reason. As explained already, the current model is not optimized for reference data. Consequently the initial rise in real money balance in the data is not replicated precisely. The direction of change in real money balance is determined by the changes in price level and money stock. It is therefore a matter of calibration, which is not the purpose of this paper.

5 Evaluation of Endogenous Money Spending Hypothesis

5.1 Simulation Results: Cases 1 through 4

Figure 20 and 21 in the Appendix show all simulation results obtained from case 1 through 4. The underlying assumptions in each case is summarized in Table 1. Simulation under the spending hypothesis in case 1 is shown by line 1 (blue) and money hypothesis is shown by line 2 (red). Spending hypothesis in case 2 is shown by line 3 (green) and money hypothesis is shown by line 4 (pink). Spending hypothesis in case 3 model is shown by line 5 (light blue) while spending hypothesis in case 4 is shown by the thick line 6 (orange). To summarize in the exact order as presented in this paper, line 1 and 2 (case 1) are the simulation results discussed in Section 3.2. Line 3 and 4 (case 2) corresponds to the simulations discussed in Section 3.5. Line 6 (case 4) is the simulation under the endogenous money spending hypothesis discussed in Section 4.3. Note that behaviors of nominal and real interest rates are identical in each case 1 and 3 since price is fixed under both cases. Also, cases 3 and 4 assume the endogenous money. Therefore simulations are run only under the spending hypothesis in both cases.

5.2 Qualitative Evaluation of the Hypotheses

Evaluation of Hypotheses under the Conventional IS-LM Analysis

A table shown at the top of the Figure 15 (next page) summarizes the qualitative evaluations of spending and money hypothesis applied on the standard IS-LM model as the comparative statics. Arrows indicate the implied direction of changes in each macroeconomic variable shown in columns. There are three types of arrows in our qualitative evaluation. Arrows pointing upward imply an increase or rise in each variable. Similarly, arrows pointing rightward imply no change or 'fixed', and downward arrows imply a decrease or reduction. Arrows in blue indicate that the simulation under a certain hypothesis is consistent with the data observed during the Great Depression, which is shown on the second row of the table. Specifically, we have evaluated both hypothesis by comparing the implied direction of changes in each variable against the data indicated by the blue arrows. Black arrows, on the other hand, indicate that the simulation result is not consistent with the data. By applying this evaluation criteria, the top table summarizes results of the spending and money hypothesis applied under the conventional IS-LM analysis explained in standard textbooks. The second row of the table shows the direction of changes observed from the data during the initial period between 1929-1933. The third row shows the spending hypothesis and the fourth row the money hypothesis.

As discussed in Section 3.2, Mankiw pointed out that money hypothesis cannot explain the rise in real money balances $\frac{M^s}{P}$ ("the first problem") and decline in nominal interest rate i ("the second problem") observed in the data, and then argued that these problems are sufficient to reject the money hypothesis. However, we discussed that spending hypothesis does not explain the contraction of money in the first place. It was further pointed out that, when i and P declined during the Great Depression, the real interest rate r must have risen, which is what

	M^s	P	$\frac{M^s}{P}$	i	r
The Great Depression (1929-1933)	↓	↓	↑	↓	↑
Spending Hypothesis	→	→	→	↓	↓
Money Hypothesis	↓	→	↓	↑	↑

Exogenous Money

Fixed Price

	M^s	P	$\frac{M^s}{P}$	i $(=r)$
Spending Hypothesis (Case 1)	→	→	→	↓
Money Hypothesis (Case 1)	↓	→	↓	↑

Flexible Price

	M^s	P	$\frac{M^s}{P}$	i	r_{ante}	r_{post}
Spending Hypothesis (Case 2)	→	↓	↑	↓	↓↑	↑
Money Hypothesis (Case 2)	↓	↓	↓↑	↑	↑	↑

Endogenous Money

Fixed Price

	M^s	P	$\frac{M^s}{P}$	i $(=r)$
Spending Hypothesis (Case 3)	↓	→	↓	↑

Flexible Price

	M^s	P	$\frac{M^s}{P}$	i	r_{ante}	r_{post}
Spending Hypothesis (Case 4)	↓	↓	↑	↓	↓↑	↑

Figure 15: Qualitative Evaluations of Spending, Money, and Endogenous Money Spending Hypothesis

money hypothesis correctly implies. Accordingly one may similarly counter-argue that money hypothesis performs better than spending hypothesis when it comes to explaining the behavior of (*ex post*) real interest rate, even though the data is absent in the original Table 12-1 in Mankiw (2016). We then discussed further that the fundamental issue of his analysis is the fixed price assumption. As long as price level P is fixed, there is no theoretical distinction between nominal and real interest rates, or between *ex ante* and *ex post* real interest rates. This means one cannot evaluate the behavior of interest rate in the conventional IS-LM model against the real world data correctly, and cannot reject either one of hypotheses accordingly.

Evaluation of Hypotheses under Cases 1 through 4

Shown at the bottom of Figure 15 is a table summarizing the qualitative evaluations of simulation results under all cases using the same criteria. The arrangement of cases corresponds to the sequence explained in Table 1 where case 1 is shown at the top left corner, and the endogenous money spending hypothesis (case 4) is shown at the bottom right.

Case 1 model (fixed price, exogenous money) was discussed in Section 3.2, and corresponds to the conventional short-run IS-LM analysis explained in standard textbooks. Case 1 model can be alternatively interpreted as what Mankiw's extended model actually analyzed because his model only introduced the expected inflation rate, not the flexible price itself. Spending hypothesis under the case 1 (line 1 in blue in Figures 20 and 21) captures the reduction in nominal interest rate i but not other variables. Since M^s and P is assumed to be fixed, real money balance $\frac{M^s}{P}$ is also fixed. Money hypothesis in case 1 (line 2 in red), on the other hand, accounts for the contraction of M^s, but not for the decline in i. As discussed above, Mankiw interpreted the interest rate in short-run IS-LM model as showing the nominal interest rate i and compares it with that of the data to reject the money hypothesis falsely.

Case 2 model (flexible price, exogenous money) is the model discussed in Section 3.5. Spending hypothesis in case 2 (line 3 in green in Figures 20 and 21) captures what Mankiw called the destabilizing effects of deflation on income, the fall in nominal interest rate i as well as the sudden rise in *ex post* real interest rate in the data. Case 2 analysis is what the extended analysis in Mankiw (2016) has attempted, but he did not present a working model. Our simulation results corroborate Mankiw's claim. However, the problem of spending hypothesis in case 2 model is that it still treats M^s as an exogenous policy variable, thus failing to explain its contraction during the Depression. This meant that behavior of real money balance is not explained under spending hypothesis for the right reason. For the behavior of *ex ante* real interest rate, our simulation suggests that it rises relative to nominal interest rate and then fluctuate, as it is affected by multiple factors including inflation and the nominal interest rate, which in turn is affected by various factors even in our simple model. Money hypothesis in case 2 (line 4 in pink), on the other hand, captures the money contraction, deflation, and rise in real money balance for the right reason. Also the rise in *ex post* real interest rate is consistent with the data. However, the nominal interest rate i rises, which is inconsistent with the data.

Spending hypothesis in case 3 (line 5 in Figures 20 and 21) captures the endogenous contraction of M^s. Decrease in real money balance $\frac{M^s}{P}$, however, contradicts with the data. This contradicted behavior under the spending hypothesis is not mentioned at all in Mankiw's analysis. Recall that the decrease in real money balance under the money hypothesis was the main reason why Mankiw rejected it in the standard IS-LM (case 1) model. We cannot fully evaluate the behavior of interest rates for the same reason as in case 1 (no theoretical distinction between the nominal and real interest rates under the fixed price assumption).

Case 4 model (flexible price, endogenous money) was discussed in Section 4.3 where the endogenous money spending hypothesis was examined. It captures the data already explained in case 2 as well as the endogenous contraction of money stock, which was unexplained in case 2. Accordingly the rise in real money balance is explained for the right reason under the endogenous money spending hypothesis. As a result, arrows are all in blue, indicating that the direction of changes in all variables are consistent with the data except the *ex ante* real interest rate. The *ex ante* real interest rate is shown in black as we have no data in Figure 5.

In this paper we began our analysis by first translating the conventional IS-LM framework of the comparative statics into a system dynamics model. Figure 15 illustrates how the behaviors of the Great Depression unexplained by the traditional IS-LM analysis are now fully captured by our endogenous money IS-LM model. A wide green arrow represents a *methodological* paradigm shift from comparative statics to system dynamics simulation. A wide orange arrow represents a *theoretical* paradigm shift from exogenous money to endogenous money analysis.

6 Endogenous Money IS-LM Model As Paradigm Shift

Using the conventional IS-LM model, Mankiw (2016) tried to explain the causes of the Great Depression and rejected the money hypothesis. We have rejected both of them under the standard IS-LM model with exogenous money assumption, and proposed an alternative endogenous money spending hypothesis. The revised model was able to explain the Depression successfully. In this section we explore this hypothesis further to see if it can explain other cases of recession.

6.1 Recessions by the Endogenous Money Spending Hypothesis

In Figure 16 we have produced behaviors of the three hypotheses as a more general case of economic recessions. To illustrate comparative analysis between exogenous and endogenous

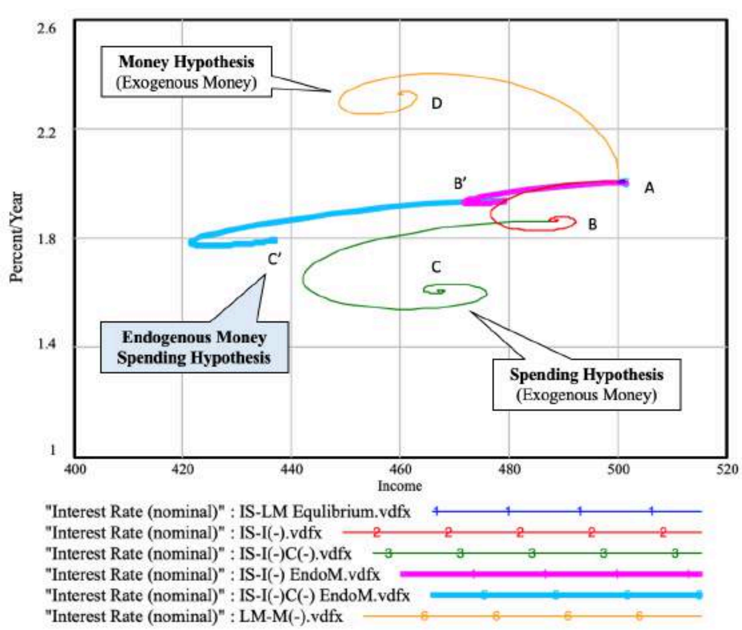

Figure 16: Joint Shifts of IS-LM Curves under Endogenous Money Spending Hypothesis

money clearly, fixed price is assumed here. Furthermore STEP function is used to implement reductions in aggregate demand components.[24] Behaviors of spending hypothesis around points B and C and money hypothesis around point D under the exogenous money are the same as shown in Figure 4. On the other hand, behaviors around points B' and C' under the endogenous money spending hypothesis are newly shown as the movement from points B and C. They share similar behaviors as those under the spending hypothesis. For instance, nominal interest rate taken on the vertical axis continues to fall. That is, a rise in nominal interest rate at point D, which Mankiw called the second problem of money hypothesis, does not occur under the endogenous money spending hypothesis. Yet, these points no longer move along the *LM* curve in contrast to the case of spending hypothesis under the exogenous money (case 1) as discussed in Section 2.3. Consequently, the endogenous money spending hypothesis can be said to be a better prospect for the analysis of economic recessions in general. Not only that, it also provides the unified view of Fisher's and Keynes's analyses on the causes of the Great Depression.

6.2 Joint Shifts of IS-LM Curves under Endogenous Money

Our endogenous money IS-LM model further provides a new finding that the point C' attained under the endogenous money spending hypothesis is the combination of shifts in both *IS* and *LM* curves, which have been applied separately under the exogenous money assumption. Specifically, a line 6 (orange) in Figure 17 illustrates shows how the point C' can be attained as a combination of independent shifts in the *IS* curve caused, firstly, by the spending hypothesis (point A $\rightarrow$ B by $\Delta I = -20$ at t = 8; and point B $\rightarrow$ C by $\Delta C = -20$ at t = 24), and in *LM* curve caused, secondly, by the money hypothesis (point C $\rightarrow$ C' by $\Delta M = -14$ at t = 8). The

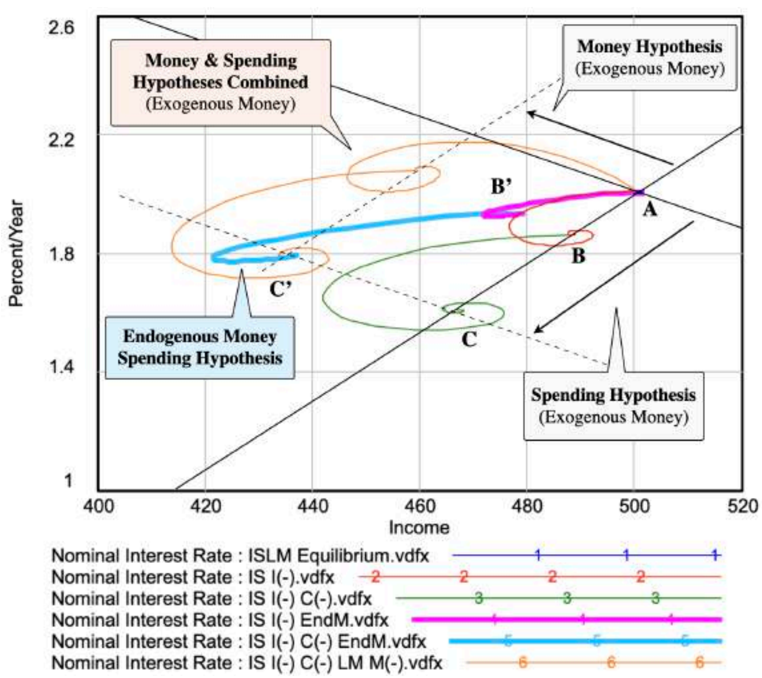

Figure 17: Analysis of the Joint Shifts of IS-LM Curves under Endogenous Money

point C' can be attained irrespective of the combination orders among $\Delta I, \Delta C$ and ΔM. Yet

[24] For the analysis of the Great Depression discussed in Section 3.2, recall that we used PULSE function to simulate the behaviors of data without calibrating the model parameters for formal data fittings.

the exogenous and endogenous money models show different paths to point C'. This implies that the traditional comparative static analysis of shifting either IS or LM curve separately and observing its impact on the economy, as we have been thoroughly taught in macroeconomic textbooks, is no longer applicable to the analysis of recessions under the current debt money system. For the analysis of recessions, both IS and LM curves must be jointly shifted all the time. Economists must now abandon the traditional IS-LM analysis in the textbooks and adopt dynamic analysis along the endogenous money IS-LM model presented here. This is the paradigm shift in macroeconomics we emphasized in this paper.

6.3 Japan's Lost 30 Years as Unpredictable Shifts of IS-LM Curves

Monetary policy explained in the traditional exogenous money IS-LM model, which is to control money stock M^s as discussed in Section 2.3, is no longer available in the endogenous money IS-LM model, simply because the central bank cannot control money stock that is endogenously created. Furthermore, it cannot control real interest rate either because money stock and price are not under its control. Central bank can only change base money M_0 through its market operations to guide nominal interest rates as its policy target. In this sense, we have been falsely taught in textbooks that central banks in the real world somehow exercise a direct control over money stock as its policy instrument. Indeed, monetary policy turned out to be far less effective in the real economy. This is why the series of QE policies that have been implemented during Japan's post-bubble period turned out to be ineffective. As discussed in Section 4.1, they were destined to fail at a theoretical level as Irving Fisher, the original advocate of the reflation policy, had already predicted and warned against in the 1930s.

How about fiscal policy by the government, then? In Figure 18 (next page) we implemented a fiscal policy of increasing government spending by $\Delta G = 40$ at t = 35 to get out of the recession at point C'. As a result, the model attained the point F' with the higher level of income. This movement from point $C' \rightarrow F'$ seems predictable since the government expenditure G is increased in the same fashion as was done in the exogenous money IS-LM model, which moves a new equilibrium point toward F (point C → F) along the LM curve (dotted line).

Driven by this expectation on the fiscal policy, the Japanese government has increased its debt and spent 595 trillion yen to stimulate the post-bubble economy during the last 30 years; that is, its cumulative amount of expenditure became larger than its nominal GDP. On average it implemented roughly 20 trillion yen of deficit spending per yer. Yet, her GDP only increased by 60 trillion yen in total during the same period, that is, an increase in 2 trillion yen per year on average. This expansionary fiscal expenditure of 20 trillion yen only ended with an increase in GDP by 2 trillion yen per year.

This poor performance is in stark contrast with the textbook explanation of fiscal multiplier effect implied by the Keynesian theory. By substituting the parameter values[25] into the simple IS-LM equilibrium in equation (13), the fiscal multiplier can be obtained as follows:

$$\frac{\Delta Y}{\Delta G} = \frac{1}{1 - c(1-t) + \alpha(a/b)} = 2.427 \tag{41}$$

If we use this multiplier for the calculation purpose only, then Japan's nominal GDP should have increased by 48.5 trillion yen ($= 2.427 \times 20$) every year instead of the 2 trillion yen that was actually realized. The Japanese policy makers seemed to have been fooled by this illusion of fiscal multiplier taught by the standard textbooks.[26] They might have expected that the

[25]Parameter values are as follows: $c = 0.76$, $t = 0.1$, $\alpha = 8$, $a = 0.3$, $b = 25$. Note that these are the same values used in all simulations presented throughout this paper.

[26]IS-LM analysis is a popular subject in the recruitment test for government officials of Japan.

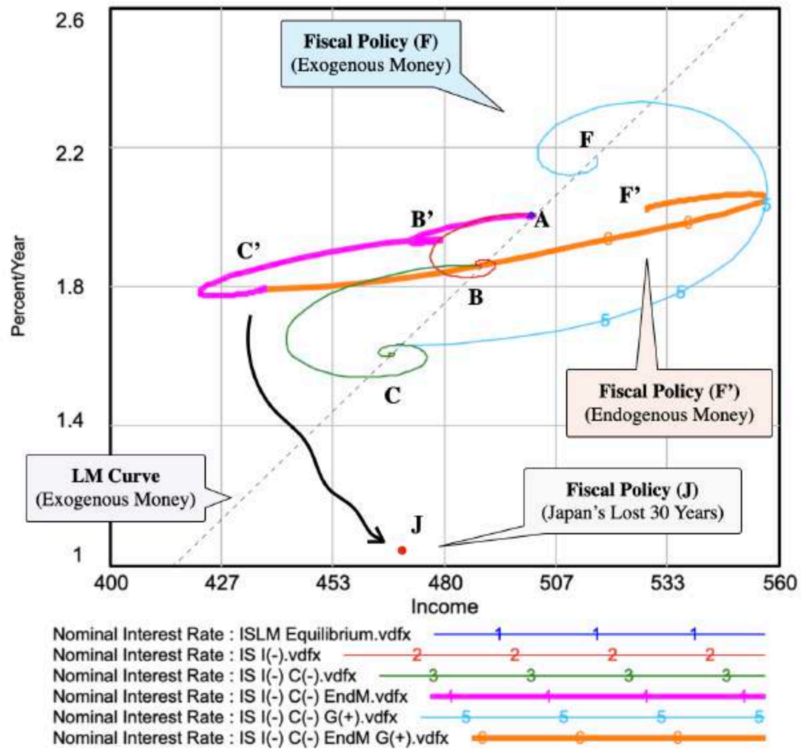

Figure 18: Fiscal Policy under the Endogenous Money IS-LM & Japan's Lost 30 Years

economy would move, say, from the point C to the point F in Figure 18. This is another example of the flawed interpretation and application of Keynesian comparative static analysis. The conventional IS-LM analysis gives an impression that one-time government spending brings the economy into a new equilibrium with higher level of income. However, if we examine the effects of fiscal policy in a dynamic model, we could easily learn that it is not the case.[27] Hence the correct interpretation and application of fiscal multiplier should be that the government needs to continue spending by either raising taxes or borrowing money by issuing treasury bonds, until a new (comparative static) equilibrium is attained and sustained at such points.

Based on the historical data in Japan, the effect of its fiscal policy must be shown to have moved its equilibrium point from point C' to, say, a point J, which is manually drawn (its real scales of income and interest rate are neglected here). This was how fiscal policy failed to stimulate the economy contrary to what the conventional IS-LM analysis would have predicted. So long as we use the revised IS-LM model, however, we are still led to expect that the economy will move toward north-east direction such as the point F'. In other words, there is no way to end up with the point J as long as government expenditure is increased even in the endogenous money IS-LM model. Accordingly, the point J such as observed in the Japanese case becomes entirely unpredictable even under the revised IS-LM model. In this sense, its inability to explain the point J becomes its limitation. Can we analyze the case of point J with the endogenous money IS-LM model, then? This challenge will be addressed in our next paper (part II).

[27] See Chapter 9 of Yamaguchi (2013) further for simulation analyses.

7 Discussions

In Section 4.1 we discussed how Irving Fisher, upon his realization of the significance of endogenous money under the current debt money system, incorporated it into his debt-deflation theory and proposed the *100% Money*. As the original proponent of reflation policy, Fisher immediately came to the conclusion that the very structure of the debt money system itself was what was preventing the economy from not only recovering as quickly as possible, but has been the root cause of the Great Depression. As the proponent of spending hypothesis, what was the Keynes position on the endogenous money, then? As the final analysis of this paper, let us briefly examine how the original proponents of the spending and money hypothesis incorporated endogenous money analysis into their theories of the Depression and policy proposals.[28]

7.1 Irving Fisher and John M. Keynes on Endogenous Money

The subject of money and banking seems to have been a confusing topic even for Keynes. Werner (2005, p.189), for instance, observed that Schumpeter (1954) had been curious as to why Keynes, who initially recognized banks as creators of new deposits in his Treatise (Keynes, 1930), failed to incorporate such a significant role of banks in the *General Theory* as follows:

> The deposit-creating bank loan and its role in the financing of investment *without any previous saving up of the sums thus lent* have practically disappeared in the analytic schema of the General Theory, where it is again the saving public that holds the scene. Orthodox Keynesianism has in fact reverted to the old view according to which the central facts about the money market are analytically rendered by means of the public's propensity to save coupled with its liquidity preference. I cannot do more than advert to this fact. Whether this spells progress or retrogression, every economist must decide for himself. (Schumpeter, 1954, p.1115; Italics in original)

Keynes began his research on monetary theory from the treatise on money. But since he was in the U.K., it might be possible that he was simply not aware of the Chicago plan nor the *100% Money* by Fisher. Perhaps he was busy writing the *General Theory* at the time and didn't consider it as deeply as Fisher did. Or had he have to ignore it because he thought the *General Theory* would not complete unless he assumed that investment comes from savings and that the supply of money was determined exogenously?[29] The answer seems to be the latter. Keynes was, in fact, one of the 40 people that Henry C. Simons and other original proponents of the Chicago plan selected to privately forward the memorandum that laid out the money and banking system reform. Keynes replied to Simons on March 31st of 1933, stating "Much interested by the memorandum which you kindly send me" (Phillips, 1995, p.51).

Eleven years later, in July 1944, delegates from forty-four nations gathered in Bretton Woods, New Hampshire to discuss the post-war international monetary system. Keynes, then

[28] This section owes to Section 8.4.2 of Yamaguchi (2015, p.204-206) titled "Keynes and the Chicago Plan".

[29] Readers of the *General Theory* immediately find the following reflection by Keynes in its preface:

> The relation between this book and my *Treatise on Money*, which I published five years ago, is probably clearer to myself than it will be to others; and what in my own mind is a natural evolution in a line of thought which I have been pursuing for several years, may sometimes strike the reader as a confusing change of view. (...) This book, on the other hand, has evolved into what is primarily a study of the forces which determine changes in the scale of output and employment as a whole; and, whilst it is found that money enters into the economic scheme in an essential and peculiar manner, technical monetary detail falls into the background. (...) The difficulty lies, not in the new ideas, but in escaping from the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds. (Keynes, 1936, preface; Emphasis in original)

adviser to the British Treasury, participated in the Bretton Woods negotiations and proposed a global central bank called the Clearing Union and to create a new supranational currency called Bancor to facilitate clearing of imbalances in international settlements. The U.S. delegate Harry Dexter White, the then chief international economist at the Treasury Department, proposed a Stabilization Fund plan such as the establishment of the IMF and what became the World Bank Group. Meanwhile Fisher sent a letter to Keynes on July 4th, 1944, asking him to informally take up the 100% reserve banking system in the Bretton Woods negotiations as follows:

> I think it's quite possible it could, after the war, be put over for Americans and other countries, as the best *national* plan to interlock with the *international* plan you are now trying to put over. We could then avoid great inflation and deflation in future over a wide area. (Allen, 1993, p.715; Emphasis in original)

Namely it was a proposal by Fisher to integrate the 100% reserve plan with Keynes's international monetary stabilization scheme. Three days later, on July 7th, Keynes replied to Fisher that he was "one of my earliest teachers on these matters," but expressed his "considerable reservations" about "the 100 per cent money," and declined being "an advocate." (Allen, 1993, p.715). He then continued as follows:

> In my judgment deflation is in the near future a much more dangerous risk than inflation. I am afraid of your formula because I think it would, certainly in England, have a highly deflationary suggestion to a great many people. Apart from that, I am satisfied that in British conditions anyhow ... we can obtain complete control over the quantity of money by means much less capable of exciting unfavorable comment and opposition. (*ibid.*)

As is now clear from his reply to Fisher, Keynes was fully aware that the 100% money proposal excited "unfavorable comment and opposition" in the U.S. We can also see Keynes had still believed money stock could be controlled, and that he was opposed to the analysis of the Great Depression by Fisher and the Chicago economists. Keynes knew the money stock would be expanded and destroyed endogenously by loans of private banks, but did not think they were the causes of the Depression. When Fisher received the Chicago plan, he immediately noticed a theoretical flaw in his debt-deflation theory and pointed out the potential inefficacy of reflation policy under the fractional reserve banking system. As Schumpeter observed, Keynes initially emphasized the role of deposit creation in his treatise. Yet, he later categorically denied the need for incorporating the endogenous money into his theory and policy proposals upon the suggestion by Fisher. These flaws in the treatment of money and banking in the Keynesian theory have led to the government debt crisis such as in Japan as discussed in Section 6.3.

7.2 Macroeconomic Textbooks Must Incorporate Endogenous Money

The subject of money and banking was a confusing topic for Keynes himself, and Mankiw's popular textbook is no exception. As we saw in Section 3.1, Mankiw merely refers Friedman and Schwartz (1963) as the advocate of money hypothesis despite the fact that Milton Friedman himself was a student of Henry C. Simons and Lloyd W. Mints, by whom the Chicago Plan was proposed in 1933.[30] Mankiw (2016), however, introduced the money hypothesis in a way as if its

[30]It is well-known that Friedman later confessed himself as a persistent and strong advocate of the 100% reserve system (Friedman, 1992, pp.65-66). He recommended, in addition to the original Chicago plan, that interests should be paid on those 100% reserves so as to "render the system less subject to the difficulties of avoidance that were the bug-a-boo of the earlier proposals." The Friedman's idea can be implemented alternatively as the service charges depositors pay to banks for keeping their funds safe. *Loans for consumption* contract still apply.

proponents analyzed that the contraction of money stock M^s alone caused the Great Depression. That is, the money hypothesis does not take into account the reductions in aggregate demand, and thus, fails to explain the decline in nominal interest rate i. He then extended his argument that spending hypothesis is sufficient to explain the Depression based on his extended IS-LM analysis as we discussed in Section 3.3. However, when we objectively assess the money hypothesis as proposed by the Chicago economists and Irving Fisher, it can be observed that such interpretation of the money hypothesis itself is mistaken and a sheer misrepresentation of the original money hypothesis. It is clear Fisher considered factors underlying the spending hypothesis in his debt-deflation theory and 100% Money. It therefore remains mystery as to why Mankiw refers to the debt-deflation theory but not in its entirety, leaving the most essential part of Fisher's conclusion on the causes of the Depression and boom-bust cycles in general.

When it comes to the explanations on money and banking, economics textbooks remain confusing even today. Focusing our attention specifically on the Mankiw's textbook, readers would still find an obscurantism as to how the fractional reserve banking system works in reality. For instance, Mankiw first introduces 'exogenous money' view in Chapter 4 titled "The Monetary System: What It Is and How It Works". Then, on different pages in the same chapter, he seems to emphasize the 'endogenous money' view while explaining the usual but flawed money multiplier model, which reflects the financial intermediation theory as opposed to deposit creation theory of banking practiced in the real world. The following quotations from Mankiw (2016, Chapter 4) show his popular textbook remains to be confusingly on both sides.

> In an economy that uses fiat money, such as most economies today, the government controls the supply of money: legal restrictions give the government a monopoly on the printing of money. Just as the level of taxation and the level of government purchases are policy instruments of the government, so is the quantity of money. (p.86)
>
> *If banks hold 100% of deposits in reserve, the banking system does not affect the supply of money.* (p.89; Emphasis in original)
>
> Many institutions in the economy act as financial intermediaries ... . Yet, of these financial institutions, only banks have the legal authority to create assets (checking accounts) that are part of the money supply. Therefore, banks are the only financial institutions that directly influence the money supply. (p.91)
>
> The Fed controls the money supply indirectly using a variety of instruments. (p.95)

Such ambiguity seems to reflect the Mankiw's flawed application of the standard IS-LM model on the case of the Great Depression. Application of the flawed model only serves to confuse, or even mislead at worst, the students and general readers. Despite the persistent confusion among the economics profession, however, the empirical studies confirm the veracity of deposit creation theory under the fractional reserve banking systems (Werner, 2005, 2016; Yamaguchi, 2021). Should economic theories be grounded on the exogenous money or endogenous money? The answer is clear as this paper have demonstrated. If the macroeconomics is to be saved from the century-old confusion and obscurantism, a new generation of economists must incorporate the paradigm shift of dynamic endogenous money analysis.

Conclusion

The Keynesian short-run IS-LM model, which is built on the exogenous money and fixed price assumptions, is shown to be no longer applicable to explain economic recessions such as the Great Depression, simply because our economy is operating under the fractional reserve banking system where money is created and destroyed endogenously against private bank loans. It is then demonstrated that the endogenous money IS-LM model of the debt money system is shown to produce behaviors consistent with the data observed during the Depression. Specifically, the endogenous money spending hypothesis, which integrates the spending hypothesis as proposed by Keynes and money hypothesis as originally proposed by Fisher is shown to capture the previously unexplained behaviors of the Great Depression. Macroeconomic theories must be rebuilt on this integrated framework that allows the endogenous money analysis. A shift from the old paradigm that has dominated the field for nearly a century is emphasized accordingly.

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Appendix 1: The Great Depression Data in Graphs

Figure 19 below shows the time-series from Figure 5 in graphs. As explained in Section 3.2, the real interest rate (red line) is obtained from the nominal interest rate and inflation data based on the Fisher equation. Accordingly the real interest rate shown in Figure 19 corresponds to *ex post* rather than *ex ante* real interest rate.

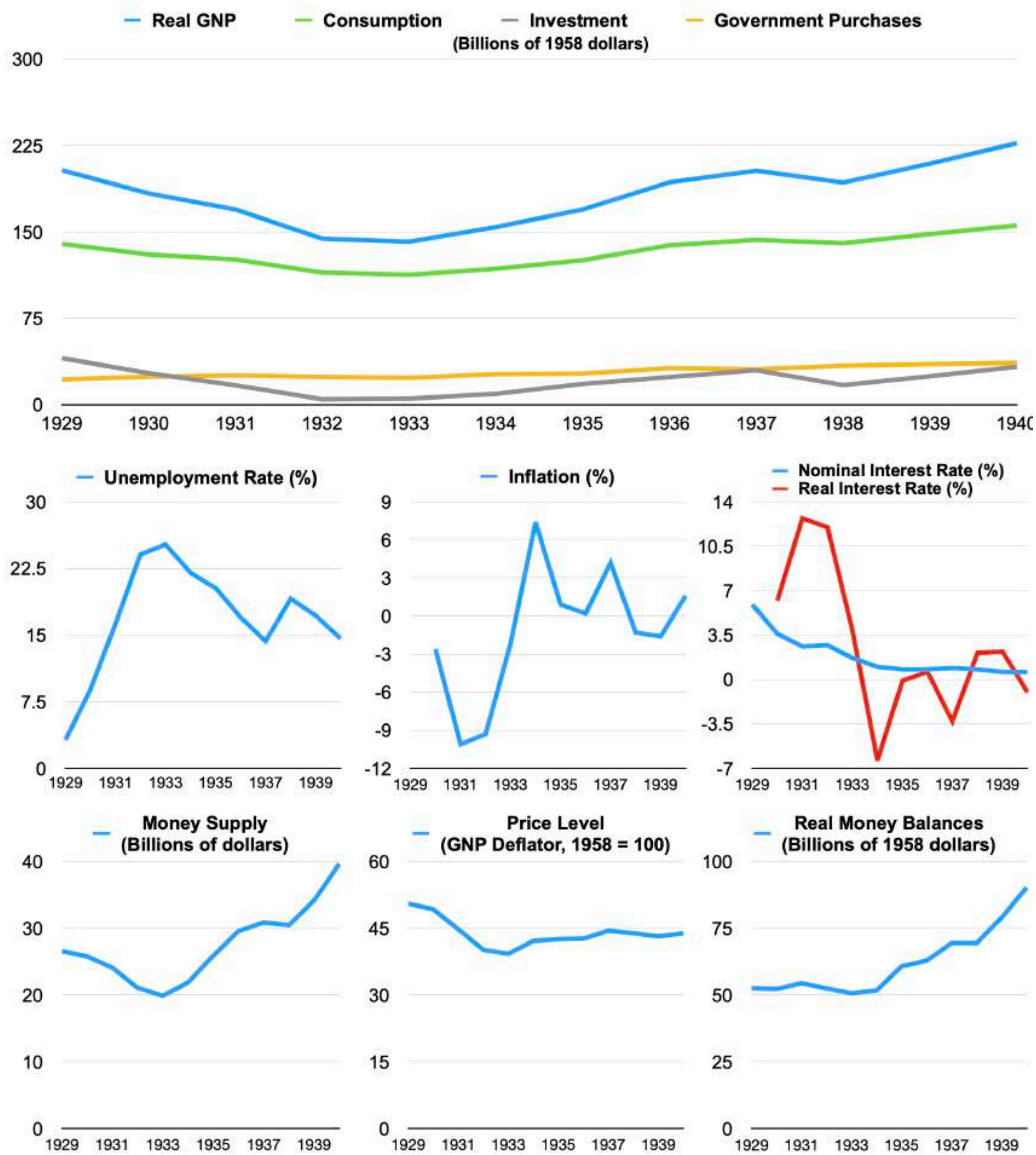

Figure 19: Key Macroeconomic Variables during the Great Depression (1929–1940) in Graphs

Appendix 2: Simulation Results – All Cases

Figure 20 and 21 show the results of all simulations from the case 1 (fixed price, exogenous money) to case 4 (flexible price, endogenous money) model. Spending hypothesis under case

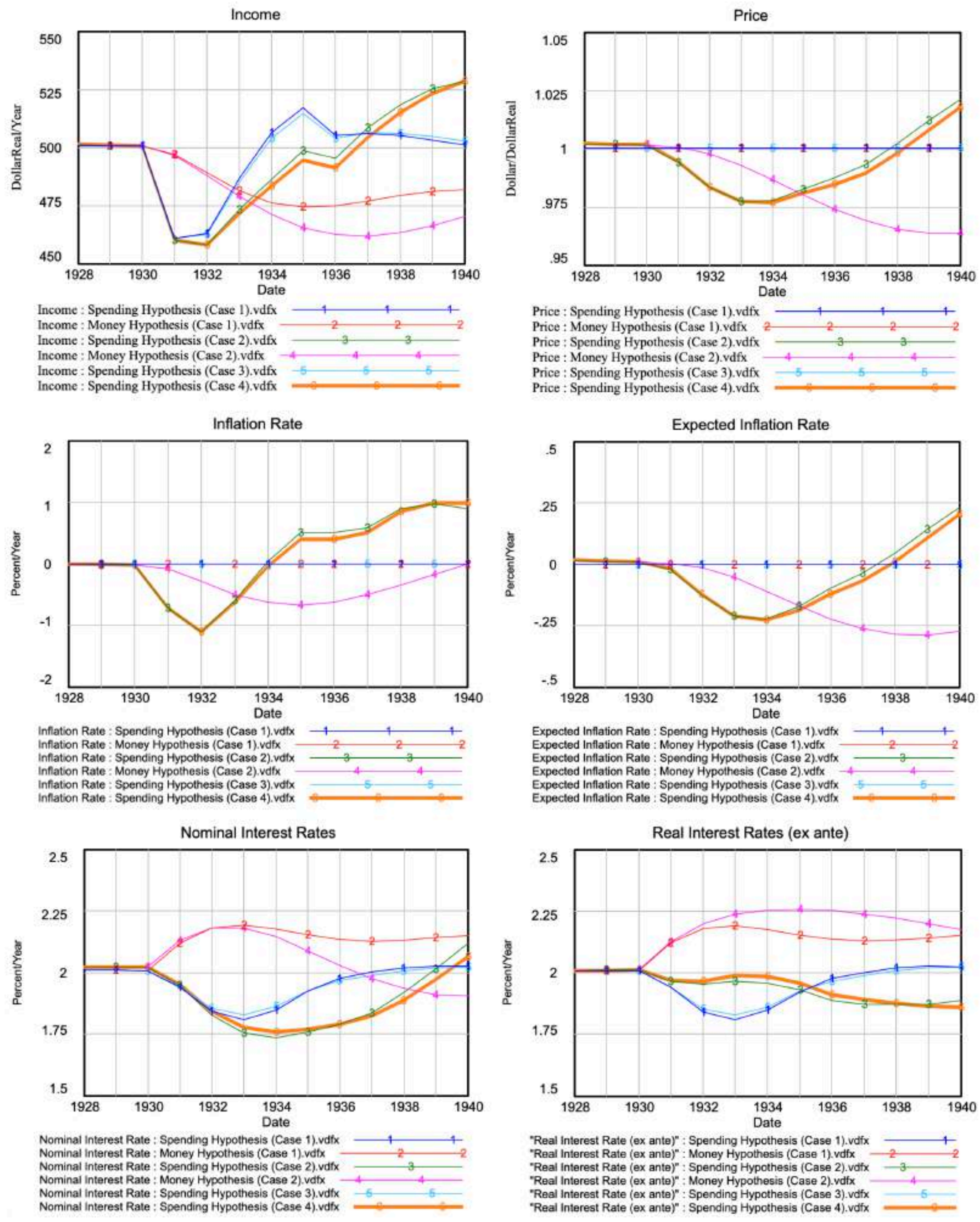

Figure 20: Simulation Results of IS-LM Case Analysis on the Great Depression (1 of 2)

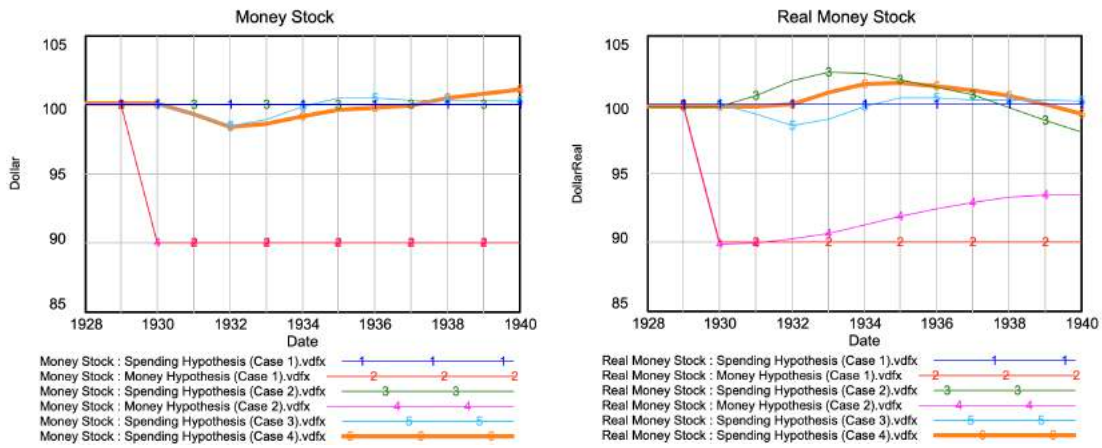

Figure 21: Simulation Results of IS-LM Case Analysis on the Great Depression (2 of 2)

1 is shown by line 1 (blue). Money hypothesis in case 1 is shown by line 2 (red). Spending hypothesis in case 2 is shown by line 3 (green). Money hypothesis in case 2 is shown by line 4 (pink). Spending hypothesis in case 3 is shown by line 5 (light blue). And the spending hypothesis in case 4 is shown by thick line 6 (orange).

Line 1 and 2 (case 1) are discussed in the Section 3.2. Line 3 and 4 (case 2) corresponds to the simulations discussed in Section 3.5. Line 5 (case 3) was discussed in the Section 5 and line 6 (case 4) is discussed in the Section 4.3. Note that behaviors of nominal and real interest rates are identical in case 1 and 3 since price level P is assumed to be fixed in both cases.

Figure 22 below (next page) captures a simulation panel where users can implement customized scenarios with different parameter assumptions by moving sliders. The model was developed by the authors of the current paper and will be published by Japan Futures Research Center as an open source model for educational purposes. The copyrights belong to the developers accordingly.

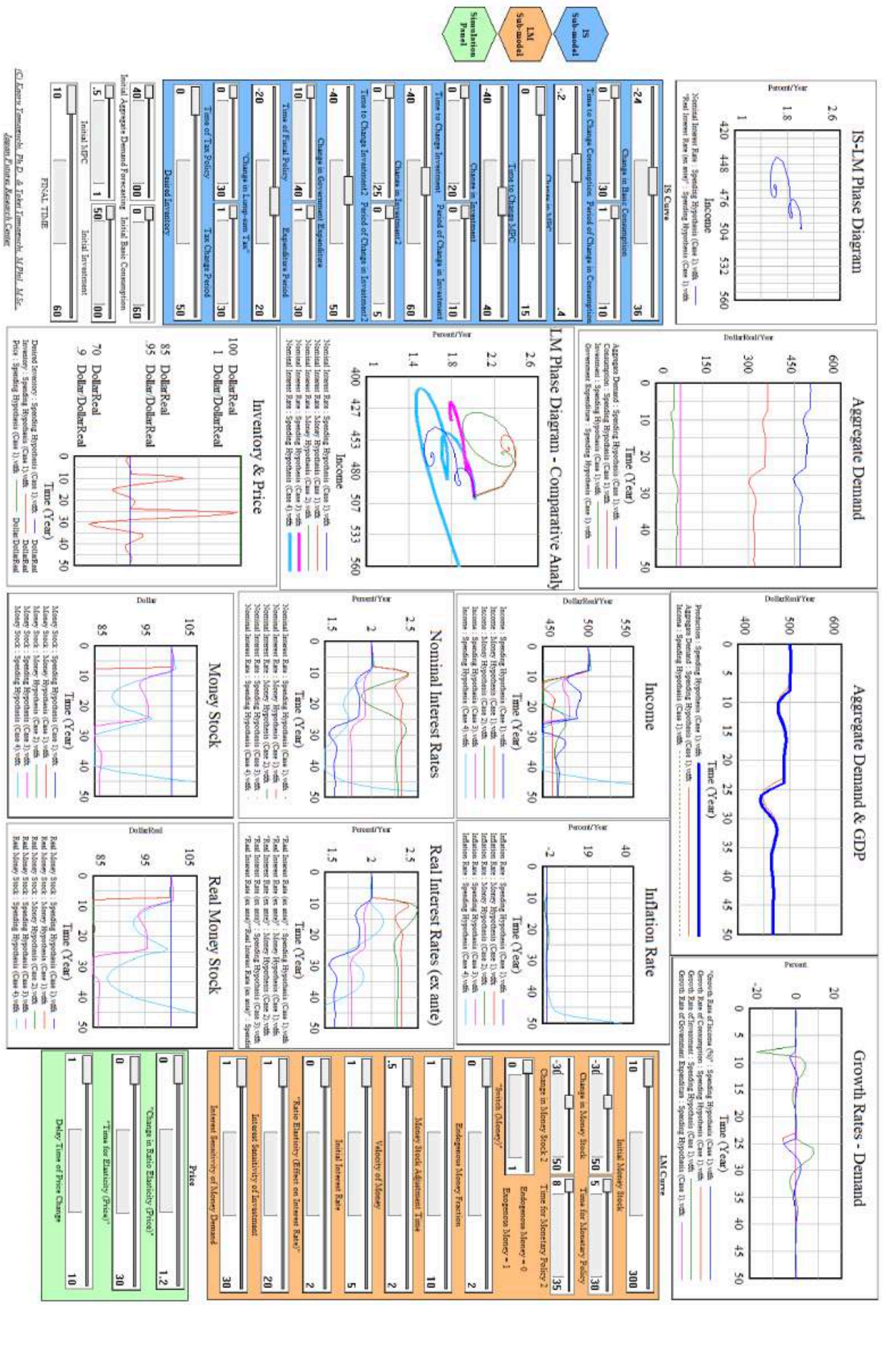

Figure 22: A Simulation Panel View of the Endogenous Money IS-LM Model