

Watanabe, Toshio

Article

Bank credit, expected inflation rate, and financial dynamics

European Journal of Economics and Economic Policies: Intervention (EJEEP)

Provided in Cooperation with:

Edward Elgar Publishing

Suggested Citation: Watanabe, Toshio (2025) : Bank credit, expected inflation rate, and financial dynamics, European Journal of Economics and Economic Policies: Intervention (EJEEP), ISSN 2052-7772, Edward Elgar Publishing, Cheltenham, Vol. 22, Iss. 1, pp. 9-31, <https://doi.org/10.4337/ejeep.2024.0130>

This Version is available at:

<https://hdl.handle.net/10419/315659>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

Bank credit, expected inflation rate, and financial dynamics

Toshio Watanabe

Faculty of Economics, Fukui Prefectural University, Japan
toshio@fpu.ac.jp

We investigate the effects of debt–capital ratio and expected inflation rate on the stability of the economy using a Minsky model and reconsidering Fisher’s debt-deflation theory. We have developed static and dynamic models that formalize an inflation-targeting policy. The static model reveals that an increase in the debt–capital ratio may negatively impact the profit rate and that the Fisher proposition is invalid. Our dynamic model indicates that the economy can become endogenously unstable. When the debt–capital ratio is high and the sensitivity of nominal wage rate to the profit rate is higher than that of bank lending, it may lead to debt-deflation. Finally, we demonstrate that the central bank alone can make only a limited contribution to economic stability.

Keywords: *financial instability hypothesis, debt-deflation theory, bank behavior, portfolio selection, inflation-targeting policy*

JEL codes: *E12, E44, E52*

1 INTRODUCTION

Economic recession may cause deflation, which may lead to depression. The Japanese economy has experienced long-term deflationary depression in the 1990s and 2000s following a bubble economy period in the 1980s. However, Japan is still struggling to break away from deflationary situation. Additionally, the global financial crisis triggered by the subprime mortgage crisis led to significant threats of deflation in certain regions of the world.

Fisher (1933) developed the debt-deflation theory, which suggests that recessions are caused by a significant rise in the real debt balance associated with deflation. Fisher’s theory has been adopted by Minsky (1975), who proposed the novel financial instability hypothesis. Minsky (1986) also noticed the relevance of balance sheet variables and emphasized the commercial banking sector, which accelerates booms or crises through credit expansion or contraction. Furthermore, he highlighted the importance of stabilizing an unstable economy through suitable government and central bank policies.

In this study, we develop an extended financial dynamic model and investigate the effects of the expected rate of inflation on the economy through stock variables. Our analysis follows that of Ryoo (2013b) and Watanabe (2021), who construct Minsky models with bank behaviors, and highlights the reconsideration of Fisher’s debt-deflation theory. We reveal the mechanism of debt-deflation and the limitations of inflation-targeting policy.

Minsky’s ideas led to the development of various mathematical models. Regarding the post-Keynesian theoretical literature, Lavoie (1995) and Ryoo (2013a) apply a Kaleckian

Received 16 October 2021, accepted 20 March 2023

investment function with firm's debt and consider the validity of Minsky's hypothesis. Ryoo (2013b) stresses that the leverage structure of banks introduces instability to the economy.

Although several studies, including the studies cited above, have followed Keynes's and Minsky's theories, they have assumed that interest is exogenous and goods prices are constant. In studies such as those by Asada (1999, 2001), Charles (2008a, 2008b, 2016), and Lima/Meirelles (2007), the interest rate is endogenous. Chiarella et al. (2013), Asada (2014), and Parui (2021) have already explored the impact of inflation and price dynamics. However, from the perspective of conventional Keynesian theory, they disregard the structure of financial markets stress by Minsky and make some simple assumptions regarding the interest rate and the markup in firms' pricing. Furthermore, they do not incorporate each agent's behavior in their macrodynamic models.¹ Watanabe (2021) builds upon Minsky's model and includes some microeconomic foundations that formalize economic agents' behaviors and reveal the factors that cause instability while assuming that goods prices are constant.

Based on the reasoning of Watanabe (2021), this study attempts to fill the gaps in the existing literature and construct a new financial instability model to investigate the effects of expected inflation. Our model has the following features.

First, we distinguish financial assets and endogenize the bank lending rate and equity price. We assume that a bank seeks profits and a firm determines the optimal combination of borrowing from the bank and issuing equity to minimize financing costs. The interest rate and equity price are endogenously determined by bank lending and equity markets, respectively.² Regarding microeconomic foundations, we assume that each agent solves optimization problems subject to the current state and future expectations based on their confidence. Our approach differs from neoclassical dynamic models in which economic agents solve their own intertemporal optimization problem.

Second, we formulate the process of adaptive inflation expectation in wage bargaining and analyze the stabilizing effects of monetary policy on the economy. In the studies by Lavoie (1995) and Hein (2007), there is no central bank controlling the money supply, but the interest rate is treated as exogenous. There is also no inflation. In contrast, we assume that the monetary authority adopts an active policy, namely an inflation-targeting policy,³ which is a type of Taylor (1993) rule. The central bank adjusts the interbank rate to realize the target inflation rate.⁴ Following Hicks (1956), we assume that the interbank rate is exogenously defined in the short term. However, it endogenously varies in the long term in response to the economic scenario.⁵

1. Chiarella/Flaschel (2000) call their approach 'macro-foundations'. Based on this concept, Murakami/Asada (2018) examine the influence of expected inflation on the (in)stability of the economy in a Kaleckian model.

2. Lavoie (1997) characterizes Minsky's financial instability hypothesis as being inherited from classical economics based on the loanable funds approach.

3. Inflation targeting is anathema for many post-Keynesian economists (e.g., Arestis 2009). Hein/Stockhammer (2010) present a model that synthesizes several of the post-Keynesian criticisms of the New Consensus Model. They develop post-Keynesian alternative macroeconomic policies contrasting that proposed in the New Consensus Model. Setterfield (2006) and Lima et al. (2014) demonstrate that inflation targeting may be compatible with post-Keynesian economics.

4. Asada (2014) and Murakami/Asada (2018) also formulate a variant of the Taylor-rule-type monetary policy that considers both the rate of inflation and level of real output.

5. Hicks (1956) focuses on the distinction between single-period and continuation analysis. In our model, the former concept is applied to static analysis and the latter concept is applied to dynamic analysis.

Finally, we investigate the stability conditions of the economy.⁶ Unlike Asada (2001) and Charles (2008a, 2008b), we first construct a static model and then extend it to a dynamic model. We assume that the economy is stable in the short run. However, it may destabilize in the long run based on changes in stock variables.⁷ We examine how the economic shocks affect the dynamic economy through financial factors, such as the interest rate and debt–capital ratio. In particular, we explore the mechanism of debt–deflation.

The static model reveals that when bank lending excessively reacts to the debt–capital ratio, the increase in the debt–capital ratio may negatively impact the economy. Furthermore, the expected inflation rate increases the nominal interest rate. However, the real interest rate decreases. This indicates that the Fisher proposition is invalid in the short run of our model.⁸ In the dynamic model, the economy faces a constant risk of instability. When the increase in the debt–capital ratio reduces the profit rate, and the debt–capital ratio is high and the sensitivity of nominal wage rate to the profit rate is higher than that of bank lending, it may lead to the debt–deflation process, which can destabilize the economy. We assume that the central bank alone has limited capability to ensure economic stability. Appropriate regulations for financial asset holders and banks are crucial for economic stabilization.

The remaining paper is organized as follows. Section 2 discusses the investment and financing decisions of firms. Section 3 analyzes the bank behavior and household portfolio behavior. Section 4 analyzes the economy's short-run equilibrium. Section 5 investigates the stability properties of the economy in a dynamic system and considers the effectiveness of monetary policy. Section 6 summarizes our conclusions.

2 FIRM BEHAVIOR

2.1 Firm investment decisions

We consider an imperfectly competitive firm that has four categories of decisions to take.⁹ First, the firm decides its markup on costs. We assume that the firm makes markup pricing over labor costs at a constant rate. Second, it decides on the quantity of production. We assume that the firm fully adjusts supply to demand during each period.

We denote the markup, nominal wage rate, labor, output, and labor–output ratio as τ , ω , N , Y , and $n(= Y/N)$, respectively. The price level p is given by

$$p = (1 + \tau)\omega n. \quad (1)$$

The profit rate of firm r is

$$r = (pY - \omega nY)/pK = [\tau/(1 + \tau)] \cdot (Y/K), \quad (2)$$

6. Minsky (1986) describes instability as a scenario in which financial markets become dysfunctional after being hit hard by endogenous or exogenous shocks that disrupt an economic environment that had already accumulated high levels of financial fragility. In contrast, in our model, as well as many post-Keynesian models, the stability of the economy means that the economy follows the steady-state path. Similarly, Hein (2007) extends Lavoie's (1995) 'Minsky-Steindl' model and investigates the conditions of stability in the long run.

7. This approach follows that of Taylor/O'Connell (1985).

8. The Fisher proposition states that nominal interest rates should adjust such that real interest rates are unaffected by inflation. Also see Fisher (1930).

9. This assumption follows that presented by Lavoie/Godley (2001).

where K denotes the capital stock. For simplicity, we assume that τ and n are constant and consider a one-good economy.

The firm's third decision considers investment quantity. After deciding on investments, the firm determines how the investment will be financed. The fourth decision is the selection of funding methods.¹⁰

We now consider the firm's investment decisions. The firm cannot exactly know the returns over periods during which new equipment is installed. Therefore, its investment decisions are based on expected returns. Additionally, the firm cannot collect returns if it makes bad investments and goes bankrupt. We consider the borrower risk presented by Keynes and assume that the expected returns of investment are discounted by the expected real interest rate and borrower's risk premium.¹¹

We denote expected returns of investment I as $\{Q_t^e\}_{t=0}^\infty$, expected real interest rate during the current period as ρ , and borrower's risk premium as σ . The lifetime of capital goods is assumed to be infinite. Then, the capitalized value of expected earnings for investment PV is calculated as

$$PV = \int_{t=0}^{\infty} Q_t^e e^{-(\rho+\sigma)t} dt, \quad (3a)$$

$$\rho = i - \pi, \quad (3b)$$

where i denotes the nominal interest rate corresponding to the bank lending rate and π is the expected inflation rate.

For simplicity, we can assume that the sequence of expected returns from investment $\{Q_t^e\}$ is represented by a constant series $\{Q\}$ that satisfies

$$\int_{t=0}^{\infty} Q_t^e e^{-(\rho+\sigma)t} dt = \int_{t=0}^{\infty} Q e^{-(\rho+\sigma)t} dt = Q \int_{t=0}^{\infty} e^{-(\rho+\sigma)t} dt. \quad (3c)$$

Let Q be the average expected return. Then, the current value of expected returns from investment is rewritten as

$$PV = \frac{Q}{\rho + \sigma}. \quad (3d)$$

Under Keynes's investment theory, we make some assumptions regarding factors that determine Q . We consider the ratio of prospective investment yields to investment, which is denoted as Q/pI , and express it as ϕ , which corresponds to the marginal efficiency of capital. Because capital accumulation increases capital stock, the marginal efficiency of capital diminishes as the capital accumulation rate increases. However, when the current profit rate increases, the state of confidence improves and the expected prospective yields

10. Based on these assumptions, the firm's real and financial decisions are determined separately. Therefore, the budget constraint in equation (7a) plays no role in investment decisions. These assumptions have often been used in previous studies (e.g., Franke/Semmler 1991; Ryoo 2013a, 2013b).

11. Keynes (1936: 144) writes: 'Two types of risk affect the volume of investment which have not commonly been distinguished, but which it is important to distinguish. The first is the entrepreneur's or borrower's risk and arises out of doubts in his own mind as to the probability of his actually earning the prospective yield for which he hopes. If a man is venturing his own money, this is the only risk which is relevant'.

increase.¹² Considering these assumptions, we express the function ϕ in the following form:

$$Q/pI = \phi(k, r), \quad \phi_k < 0, \phi_r > 0, \quad \phi_{kr} > 0, \quad \eta = -k\phi_k/\phi < 1, \quad k = I/K. \quad (4a)$$

We express the elasticity of ϕ with respect to k as η and assume that it is constant.¹³

The risk premium σ corresponds to Minsky's terminology of the margin of safety. Based on Minsky's arguments, we assume that borrower risk is an increasing function of the debt–capital ratio l .¹⁴ However, borrower risk is subjective and does not appear on signed contracts.

$$\sigma = \sigma(l), \quad \sigma_l > 0, \quad l = L/pK, \quad (4b)$$

where L denotes a nominal level of debt.

Substituting equations (4a) and (4b) into equation (3d), the expected net cash flows from investment are

$$\Pi^f = \frac{Q(k, r)}{\rho + \sigma(l)} - pI = \{[k\phi(k, r)/(\rho + \sigma(l))] - k\}pK. \quad (5a)$$

Assuming that the firm determines the capital accumulation rate k to maximize Π^f , we have

$$\phi(k, r)(1 - \eta) = \rho + \sigma(l). \quad (5b)$$

The left-hand side of the equation (5b) represents the marginal efficiency of capital. The right-hand side represents marginal cost. Then, we have the following capital accumulation rate function:

$$k = k(r, \rho, l), \quad k_r > 0, \quad k_\rho < 0, \quad k_l < 0. \quad (5c)$$

Substituting equation (3b) into equation (5c), we get

$$k = k(r, i - \pi, l), \quad k_r > 0, \quad k_i = k_\rho < 0, \quad k_\pi = -k_\rho > 0, \quad k_l < 0. \quad (6)$$

The capital accumulation rate is a decreasing function of the expected real interest rate and debt–capital ratio, and an increasing function of the profit rate.¹⁵

12. Keynes (1936: 147) writes: ‘The considerations upon which expectations of prospective yields are based are partly existing facts which we can assume to be known more or less for certain, and partly future events which can only be forecasted with more or less confidence’.

13. This assumption ensures that the maximization problem has a meaningful solution.

14. Minsky (1975: 107) writes: ‘[T]he borrower sees the cash flows due to debts as certain and the prospective yields (Q') as uncertain, increasing the ratio of investment that is debt-financed decreases the margin of security and thus lowers the capitalization rate the borrower applies to the Q' ’. The difference is that we assume σ to depend on the ratio of capital that is debt-finance. In contrast, Kalecki (1937) presents the ‘principle of increasing risk’, where σ is assumed to be an increasing function of the amount of investment expenditure.

15. Asada (1999) demonstrates that the Kaleckian approach can be considered as a promising microeconomic foundation of the post-Keynesian theory of investment and finance. However, Asada's model simultaneously includes both the borrower risk and lender risk in investment decisions. In contrast, we formulate the lender risk as a component of bank behavior.

2.2 Investment financing

Let us consider a firm's financing plan. We assume that the sources of financing are retained earnings, bank loans, and equity shares. The budget constraint for new investment can be expressed as

$$pI = F + \dot{L}^d + q\dot{E}^s, \quad (7a)$$

where F denotes retained earnings, \dot{L}^d denotes new borrowing from the bank, q is the equity price, and \dot{E}^s represents new equity issues in the current period.

We assume that the firm has a constant ratio v of gross earnings as retained earnings. This is represented as

$$F = v(pY - \omega N). \quad (7b)^{16}$$

Substituting equation (7b) into equation (7a) and dividing the resultant expression by pK , we obtain

$$k = vr + l^d + qe^s, \quad (7c)$$

$$l^d = \dot{L}^d / pK, e^s = \dot{E}^s / pK.$$

After financing a part of the investment using retained earnings, firms choose between borrowing from the bank and issuing new equity for the remainder of the capital. We assume that firms choose an optimal combination to minimize financing costs. In debt-finance, the unit costs of borrowing from the bank, which involve subjective costs, can be represented as the sum of the bank lending rate and borrower risk $i + \sigma(l)$. In equity-finance, firms pay dividends to shareholders and transaction costs on new equity issues. We suppose that the firm takes the medium- and long-term perspective and decides dividends z that vary with the profit rate and debt–capital ratio. We define the dividends paid per unit of equity evaluated at the market price as γ and express them as

$$\gamma = \frac{z(r, l)}{q}, \quad \gamma_r > 0, \quad \gamma_q < 0, \quad \gamma_l < 0. \quad (8a)$$

Furthermore, we assume that transaction costs depend on the volume of equity issues and are expressed as a homogenous function of degree one as

$$\Psi = \Psi(\dot{E}^s) = \psi(e^s)pK, \quad \psi_{e^s} > 0. \quad (8b)$$

Based on these assumptions, the costs of funding for new investment become

$$CF = [i + \sigma(l)]\dot{L}^d + \gamma q\dot{E}^s + \Psi(\dot{E}^s) = \{[i + \sigma(l)]l^d + z(r, l)e^s + \psi(e^s)\}pK. \quad (9a)$$

We assume that firms determine l^d and e^s to minimize CF subject to equation (7c). The optimal condition is given by

$$\frac{z(r, l) + \psi_{e^s}}{q} = i + \sigma(l). \quad (9b)$$

16. The profit $pY - \omega N$ is divided into the retained earnings, interest payment, and dividends. In our model, the dividend is the surplus after deducting the interest payment from the constant gross profit rate $1 - v$.

Then, the ratio of equity issues to capital stock is given by

$$e^s = e^s(r, i, q, l), \quad e_r^s < 0, \quad e_i^s > 0, \quad e_q^s > 0, \quad e_l^s > 0. \quad (9c)$$

We can rewrite equation (9c) evaluated at the market price as

$$\begin{aligned} qe^s &= q \cdot e^s(r, i, q, l) = f(r, i, q, l), \\ f_r &= qe_r^s < 0, \quad f_i = qe_i^s > 0, \quad f_q = e^s + qe_q^s > 0, \quad f_l = qe_l^s > 0. \end{aligned} \quad (9d)$$

Based on equations (6) and (9d), we can solve equation (7c) with respect to borrowing from the bank as follows:

$$\begin{aligned} l^d &= l^d(r, i, q, l, \pi) = k(r, i - \pi, l) - vr - f(r, i, q, l), \\ l_r^d &\leq 0, \quad l_i^d < 0, \quad l_q^d < 0, \quad l_\pi^d < 0, \quad l_\pi^d > 0. \end{aligned} \quad (9e)$$

An increase in the profit rate reduces equity issues. However, the effect on bank borrowing is not clearly determined because the increase in the profit rate increases investment and retained earnings. When investment significantly increases with respect to the profit rate, bank borrowing increases. An increase in the bank lending rate, debt–capital ratio, and equity price reduces bank borrowing and increases equity issues. Finally, an increase in the expected inflation rate increases bank borrowing and does not affect equity issues.

3 BEHAVIOR OF BANKS AND HOUSEHOLDS

3.1 Bank behavior and lending

Banks and firms both seek profits. A bank collects new deposits from households and borrows from the call market. The bank uses these funds to issue loans to firms and maintain its reserves. From a bank's balance sheet, we have

$$\dot{L}^s + \dot{R} = \dot{D}^d + \dot{A}, \quad (10a)$$

where \dot{L}^s , \dot{R} , \dot{D}^d , and \dot{A} represent new bank loans, bank reserves, deposits from households, and borrowing from the call market, respectively.

The bank must satisfy reserve requirements

$$\dot{R} = \theta \dot{D}^d, \quad (10b)$$

where θ denotes the legal reserve rate that is kept constant.¹⁷ Substituting equation (10b) into equation (10a) and dividing the resultant expression by pK , we obtain

$$\begin{aligned} l^s &= (1 - \theta)d^d + a, \\ l^s &= \dot{L}^s / pK, \quad d^d = \dot{D}^d / pK, \quad a = \dot{A} / pK. \end{aligned} \quad (10c)$$

17. The bank does not hold excess reserves because they do not yield interest.

Next, we consider the bank's profit. We assume that the deposit rate is exogenous and the bank accepts all deposits made by households.¹⁸ The central bank supplies the call loans requested by the bank under the existing interbank rate. Additionally, the bank bears the operating costs and default risk. We assume that the transaction costs include these costs. Considering the revenue by loan, we can represent the bank's profit per unit of capital π^b as

$$\pi^b = il^s - i^d d^d - i^a a - g, \quad (11a)$$

$$\pi^b = \Pi^b / pK, \quad g = G / pK,$$

where Π^b , i^d , i^a , and G denote bank profit, deposit rate, interbank rate, and transaction costs, respectively.

Regarding transaction costs, the losses caused by corporate bankruptcies are reasonably dependent on a lender's subjective risk.¹⁹ It increases when the bank estimates that the likelihood of firm bankruptcy is high. We assume that the lender's risk premium depends on the bank's subjective evaluation of the firm's debt–capital ratio and profit rate. For a high debt–capital ratio and low profit rate, the bank's subjective evaluation becomes negative and the transaction costs increase. We express the subjective evaluation ϵ^b as

$$\epsilon^b = \epsilon^b(r, l), \quad \epsilon_r^b > 0, \quad \epsilon_l^b < 0. \quad (11b)$$

Additionally, the bank's operating costs increase as bank lending increases. We assume that the transaction cost g is an increasing function of the ratio of bank lending to capital. Then, the cost function g becomes

$$g = g(l^s, \epsilon^b) = g(l^s, \epsilon^b(r, l)), \quad (11c)$$

$$g_{l^s} > 0, \quad g_r < 0, \quad g_l > 0, \quad g_{l^s l^s} > 0, \quad g_{l^s r} < 0, \quad g_{l^s l} > 0.$$

We assume that the marginal cost of bank lending changes in the same direction as the total transaction cost in response to changes in each variable. Substituting equations (11b) and (11c) into equation (11a), we get

$$\pi^b = il^s - i^d d^d - i^a a - g(l^s, \epsilon^b(r, l)). \quad (11d)$$

We assume that the bank maximizes profit π^b subject to the constraints in equation (10c). The bank controls bank lending l^s and borrowing from the call market a . Then, the first-order condition is given by

$$i = g_{l^s}(l^s, \epsilon^b(r, l)) + i^d. \quad (11e)$$

Solving equation (11e) with respect to l^s , we can express the bank lending function as

$$l^s = l^s(r, i, l, i^d), \quad l_r^s > 0, \quad l_i^s > 0, \quad l_l^s < 0, \quad l_{i^d}^s < 0. \quad (12)$$

18. The deposit rate is closely tied to the interbank rate. It can be represented as $i^d = \delta i^a$, where δ is constant. We assume that the loan rate exceeds the deposit rate (i.e., $i > i^d$).

19. Keynes (1936: 144) writes: 'But where a system of borrowing and lending exists, by which I mean the ranting of loans with a margin of real or personal security, a second type of risk is relevant which we may call the lender's risk'. In our model, lender risk has an indirect influence on bank lending and the interest rate according to the bank's cost function.

Bank lending is an increasing function of the profit rate and bank lending rate, and a decreasing function of the debt–capital ratio and interbank rate.

3.2 Household portfolio behavior

We now formulate a household's portfolio behavior. First, we consider the source of funds. The gross income of a firm is distributed as profits and wages. From profits, the firm pays interest for borrowing and dividends. The remainder of the profits is the retained earnings. The household earns wages and dividends from the firm. We assume that the bank's profit is distributed to the household through factors including the bank's wage bill. The household can also receive interest from deposits. Finally, we assume that the bank's transaction costs and central bank's revenue also belong to the household. Eventually, the bank and central bank will have no retained earnings and the household will obtain the entire national income, excluding the retained earnings of the firm. Table 1 presents a flow matrix describing the transactions among the four sectors.²⁰

First, we can express the household income pY^h in the current period as

$$pY^h = pY - v(pY - \omega N). \quad (13a)$$

Table 1 Transaction matrix

| | Households | Firms | | Banks | Central Bank | Row total |
|---|-----------------|---------|-------------|------------|--------------|-----------|
| | | Present | Capital | | | |
| Consumption | $-PC$ | $+PC$ | | | | 0 |
| Investment | | $+PI$ | $-PI$ | | | 0 |
| Wage | $+wN + G$ | $-wN$ | | $-G$ | | 0 |
| Net profit | | $-F$ | $+F$ | | | 0 |
| Interest on loans | | $-iL$ | | $+iL$ | | 0 |
| Interest on deposits | $+i^d D$ | | | $-i^d D$ | | 0 |
| Interest on call loans from central bank | | | | $-i^a A$ | $+i^a A$ | 0 |
| Dividends | $+Div$ | $-Div$ | | | | 0 |
| Transfers | $\Pi^b + i^a A$ | | | $-\Pi^b$ | $-i^a A$ | 0 |
| Loans | | | $+\dot{L}$ | $-\dot{L}$ | | 0 |
| Deposits | $-\dot{D}$ | | | $+\dot{D}$ | | 0 |
| Currency | $-\dot{J}$ | | | | $+\dot{J}$ | 0 |
| Issue of equities | $-q\dot{E}$ | | $+q\dot{E}$ | | | 0 |
| Call loans from the central bank | | | | $+\dot{A}$ | $-\dot{A}$ | 0 |
| Bank reserves | | | | $-\dot{R}$ | $+\dot{R}$ | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 |

20. Symbols with plus signs describe sources of funds and those with negative signs indicate uses of funds.

The household uses revenue to consume pC and hold new equity $q\dot{E}^d$, deposits \dot{D}^d , and cash currency \dot{J}^d . We can express the household budget constraint as

$$pC + q\dot{E}^d + \dot{D}^d + \dot{J}^d = pY - v(pY - \omega N). \quad (13b)$$

We adopt a conventional specification of consumption pC as a function of flow income pY^b . We express the propensity for consumption as c and assume that it is constant.

$$pC = c[pY - v(pY - \omega N)], \quad 0 < c < 1. \quad (13c)$$

Based on equations (13a) and (13c), the household saving function is

$$pS^b = s[pY - v(pY - \omega N)], \quad (13d)$$

$$s = (1 - c), \quad 0 < s < 1,$$

where s denotes the propensity to save out of the income of the household. Substituting equations (1) and (2) into equation (13d) and dividing the resultant expression by pK , we have

$$s^b = \frac{pS^b}{pK} = s \left(\frac{1}{\tau} + 1 - v \right) r, \quad (13e)$$

where s^b represents the household savings per unit of capital. For simplicity, we define the new money demand \dot{M}^d in the current period as the sum of new deposits and cash currency as follows:

$$\dot{M}^d = \dot{D}^d + \dot{J}^d. \quad (14a)$$

Finally, substituting equation (13c) into equation (13b) and considering equations (13d) and (14a), equation (13b) becomes

$$\dot{M}^d + q\dot{E}^d = pS^b. \quad (14b)$$

This indicates that the household allocates savings pS^b to holding equity $q\dot{E}^d$ and money \dot{M}^d .

We assume that the portfolio behavior function follows that described by Tobin (1969) and that the household allocates money to deposits and cash currency at a constant rate.²¹ Expressing the ratio of new equity demand to the household's savings as μ , we can represent the demand functions of each asset as

$$qe^d = \mu \cdot s^b, \quad (14c)$$

$$m^d = (1 - \mu) \cdot s^b, \quad (14d)$$

$$e^d = \dot{E}^d / pK, m^d = \dot{M}^d / pK, \quad 0 < \mu < 1.$$

We assume that equity demand moves with the anticipated dividends paid per unit of equity evaluated at the market price γ . We express μ as an increasing function of γ as follows:

$$\mu = \mu(\gamma) = \mu \left(\frac{z(r, l)}{q} \right) = \mu(r, q, l), \quad (14e)$$

21. We can express the demand for deposits as $\dot{D}^d = \lambda \dot{M}^d$, where λ is constant.

$$\mu_\gamma > 0, \mu_r = \mu_\gamma \frac{z_r}{q} > 0, \mu_q = -\mu_\gamma \frac{z}{q^2} < 0, \mu_l = \mu_\gamma \frac{z_l}{q} < 0.$$

An increase in the debt–capital ratio and equity price reduces the anticipated dividend yields. Additionally, an increase in the profit rate increases them. Substituting equation (14e) into equations (14a) and (14b), we obtain

$$qe^d = \mu(r, q, l) \cdot s \left(\frac{1}{\tau} + 1 - v \right) r, \quad (15a)$$

$$qe_r^d > 0, qe_q^d < 0, qe_l^d < 0,$$

$$m_t^d = [1 - \mu(r, q, l)] \cdot s \left(\frac{1}{\tau} + 1 - v \right) r. \quad (15b)$$

$$m_r^d \geq 0, m_q^d > 0, m_l^d > 0.$$

An increase in the profit rate increases equity demand. However, the effect on money demand is ambiguous. An increase in the debt–capital ratio and equity price reduces the equity demand.

4 EQUILIBRIUM OF MARKETS

An economic system consists of six markets: commodities, bank lending, equity, deposits, cash currency, and call loans. We assume that the deposit rate is exogenous and the bank accepts all household deposits. Similarly, we assume that the interbank rate is exogenously determined and the central bank supplies call loans requested by the bank. However, using Walras's law, we eliminate the analysis of the cash currency market. Therefore, we consider equilibrium in three markets.

First, we consider the commodity market. The total national savings pS^t are equal to the sum of household savings pS^h and the firm's retained earnings F .

$$\begin{aligned} pS^t &= pS^h + F \\ &= s[pY - v(pY - \omega N)] + v(pY - \omega N). \end{aligned} \quad (16a)$$

Dividing this equation by pK and considering equations (1) and (2), we have

$$s^t = \frac{pS^t}{pK} = \left[s \left(\frac{1}{\tau} + 1 - v \right) + v \right] r, \quad (16b)$$

where s^t represents the total national savings per unit of capital. Based on equations (6) and (16b), the balance equation for the commodity market becomes

$$k(r, i - \pi, l) = \left[s \left(\frac{1}{\tau} + 1 - v \right) + v \right] r. \quad (17a)$$

When there is excess demand in the commodity market, the profit rate increases. This adjustment process is represented as

$$\dot{r} = k(r, i - \pi, l) - \left[s \left(\frac{1}{\tau} + 1 - v \right) + v \right] r. \quad (17b)$$

We consider the bank lending market and equity market as financial markets. Based on equations (9d), (9e), (12), and (15a), we derive the balance equations for the bank lending market and equity market as follows:

$$k(r, i - \pi, l) - vr - f(r, i, q, l) = l^s(r, i, l, i^a), \quad (17c)$$

$$\mu(r, q, l) \left[s \left(\frac{1}{\tau} + 1 - v \right) r \right] = f(r, i, q, l). \quad (17d)$$

We assume that the bank lending rate increases when there is excess demand in the bank lending market and the equity price increases when there is excess demand in the equity market, which can be represented as

$$\dot{i} = k(r, i - \pi, l) - vr - f(r, i, q, l) - l^s(r, i, l, i^a), \quad (17e)$$

$$\dot{q} = \mu(r, q, l) \left[s \left(\frac{1}{\tau} + 1 - v \right) r \right] - f(r, i, q, l). \quad (17f)$$

We now consider a short-run equilibrium. The system comprises equations (17a), (17c), and (17d), and determines the profit rate, bank lending rate, and equity price. Considering equations (17b), (17e), and (17f), we can derive the Jacobian matrix M^s of the system evaluated at the short-run equilibrium as

$$M^s = \begin{pmatrix} a_{11} & a_{12} & 0 \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}, \quad (18a)$$

$$a_{11} = k_r - s \left(\frac{1}{\tau} + 1 - v \right) - v \leq 0,$$

$$a_{12} = k_p < 0,$$

$$a_{21} = k_r - v - f_r - l_r^s \leq 0$$

$$a_{22} = k_p - f_i - l_i^s < 0,$$

$$a_{23} = -f_q < 0,$$

$$a_{31} = \mu_r s \left(\frac{1}{\tau} + 1 - v \right) r + \mu s \left(\frac{1}{\tau} + 1 - v \right) - f_r > 0,$$

$$a_{32} = -f_i < 0,$$

$$a_{33} = \mu_q s \left(\frac{1}{\tau} + 1 - v \right) r - f_q < 0.$$

We assume that the economy is stable after considering the interaction between the commodity market and financial markets. We assume that the following conditions are satisfied according to the Routh–Hurwitz conditions for stability:

$$a_{11} = k_r - s \left(\frac{1}{\tau} + 1 - v \right) - v < 0, \quad (18b)$$

$$a_{21} > a_{31}. \quad (18c)^{22}$$

Equation (18b) indicates that the sensitivity of investment to changes in the profit rate is lower than that of aggregate savings. This requirement is typically referred to as ‘the Keynesian stability condition’. Equation (18c) indicates that when the profit rate increases, the sensitivity of excess demand in the bank lending market is higher than that in the equity market.²³ Then, the short-run equilibrium can be represented as follows:²⁴

$$r = r(l, \pi, i^a), \quad (19a)$$

$$r_l \leq 0, r_\pi > 0, r_{i^a} < 0,$$

$$i = i(l, \pi, i^a), \quad (19b)$$

$$i_l \leq 0, i_\pi > 0, i_{i^a} > 0,$$

$$q = q(l, \pi, i^a), \quad (19c)$$

$$q_l \leq 0, q_\pi \leq 0, q_{i^a} < 0.$$

The effects of the debt–capital ratio on the system are ambiguous because these effects on the bank lending market are undetermined. The mathematical result of the effects on the profit rate is expressed as

$$\frac{dr}{dl} = \frac{c_{1l}(M_{11}^s - M_{21}^s) - c_{2l}M_{21}^s + c_{3l}M_{31}^s}{\Delta^s} \leq 0, \quad (19d)$$

$$c_{1l} = -k_l, c_{2l} = f_l + l_l^s, c_{3l} = -\mu_l s^b + f_l,$$

$$\Delta^s = a_{11}M_{11}^s - a_{12}M_{12}^s < 0, M_{11}^s - M_{21}^s > 0, M_{21}^s > 0, M_{31}^s > 0,$$

where M_{ij}^s is a cofactor of the respective a_{ij} .

22. Appendix 1 outlines the derivation of the stability conditions.

23. In contrast to the stability conditions, in a real economy, the reaction of the equity market may be larger than that of the bank lending market when realized profits differ from expected profits. In this scenario, the rise in the profit rate significantly increases the equity price and in some cases, it may reduce the interest rate and the economy may deviate from the equilibrium. The short-run equilibrium is likely to become unstable. When the short-run equilibrium becomes unstable, the economy also becomes unstable in the long term. However, we assume that in the short term, stock variables remain constant and the economy is stable. In Section 5, we demonstrate that the long-term economy may be destabilized by changes in the stock variables. Our approach is similar to that of Taylor/O’Connell (1985).

24. Appendix 2 presents the mathematical results of comparative statics.

Specifically, when the sensitivity of bank lending to the debt–capital ratio l_i^s is higher than that of the equity issue of the firm f_i and the substitution effect of the household portfolio selection μ_i is large, the profit rate decreases. The former indicates that the bank significantly reduces loans in response to an increase in the debt–capital ratio. In this scenario, the bank lending rate and equity price are positive and negative, respectively. Therefore, the effects of the debt–capital ratio largely depend on financial factors such as bank behavior and household portfolio behavior. This result is different from that presented by Ryoo (2013b), who stresses the role of the bank in the economy and indicates that an increase in the debt–capital ratio increases the profit rate.

Next, let us consider the effects of the expected inflation rate. It increases both the profit rate and bank lending rate. Its effects on the banking rate are expressed as

$$0 < \frac{di}{d\pi} = \frac{-k_p(M_{12}^s - M_{22}^s)}{\Delta^s} < 1. \quad (19e)$$

This result indicates that the expected inflation rate increases the nominal interest rate. However, the positive change in the nominal interest is small and accordingly, an increase in the expected inflation rate reduces the real interest rate. This suggests that the Fisher proposition does not hold for our model. Furthermore, the effect on the equity price remains undetermined. Particularly, when the ratio of new equity demand to the household savings μ is high, an increase in the expected inflation rate may increase the equity price.

Finally, regarding the effect of the interbank rate, an increase in the interbank rate reduces the profit rate and equity price, and increases the bank lending rate.

The analysis presented in this section can be summarized by the following two propositions.

Proposition 1 *The effects of the debt–capital ratio on the economy are ambiguous. When the sensitivity of bank lending to the debt–capital ratio is higher than that of the equity issue of the firm and the substitution effect of the household portfolio selection is large, the profit rate decreases and the nominal interest rate increases.*

Proposition 2 *An increase in the expected inflation rate increases the nominal interest rate. However, because the positive effect is small, the real interest rate decreases. Therefore, the Fisher proposition is not valid in our model.*

5 DYNAMIC MODEL

5.1 Dynamic model and the steady state

We now present a dynamic model for analyzing economic stability. Thus far, the debt–capital ratio l , expected inflation rate π , and interbank rate i^a were treated as exogenous variables. We now present the dynamics of the debt–capital ratio and investigate the debt–deflation process. Additionally, we formalize the inflation-targeting policy and examine the effectiveness of monetary policy to ensure economic stabilization.

Taking the logarithmic derivative of the debt–capital ratio from the definition of l , we have

$$\frac{\dot{l}}{l} = \frac{\dot{L}}{pK} \cdot \frac{pK}{L} - \frac{\dot{p}}{p} - \frac{\dot{I}}{K}. \quad (20a)$$

The inflation rate can be set equal to the rate of change in the nominal wage rate according to equation (1) as follows:²⁵

$$\frac{\dot{p}}{p} = \frac{\dot{\omega}}{\omega}. \quad (20b)$$

We assume that wage bargaining influences the nominal wage rate. The nominal wage rate is adjusted to fill the gap between the actual and normal profit rates. We define the normal profit rate r_n as the profit rate when the capacity utilization rate is equal to the normal rate. The normal capacity utilization rate corresponds to the long-term capacity utilization rate, which is the average of past and expected cyclical fluctuations. This rate depends on the conventions, historical experience, and long-term strategic considerations of a firm. We assume that the normal profit rate is kept constant and when the actual profit rate is larger than the normal profit rate, the nominal wage rate increases.²⁶ The wage inflation function h is represented as²⁷

$$\frac{\dot{\omega}}{\omega} = h(r - r_n) + \pi, \quad h_r > 0. \quad (20c)$$

Next, we assume that the expected inflation rate is revised adaptively. We formulate the dynamics of π as

$$\dot{\pi} = \alpha \left(\frac{\dot{p}}{p} - \pi \right), \quad \alpha > 0, \quad (20d)$$

where α denotes the adjustment speed of the expected inflation rate to the actual inflation rate.

Finally, we formalize the monetary policy rule. We assume that the central bank implements inflation-targeting policy and adjusts the interbank rate toward the target inflation rate p_f . Then, the dynamics of the interbank rate is given by

$$\dot{i}_a = \beta \left(\frac{\dot{p}}{p} - p_f \right), \quad \beta > 0, \quad (20e)$$

where β denotes the adjustment speed of the interbank rate, which indicates the degree of willingness of the monetary authority to achieve the target inflation rate.²⁸

Considering equations (20a) to (20e), and the other results of our static analysis, we have the following dynamic model:

$$\begin{aligned} \dot{l} &= T(l, \pi, i^a) \\ &= l^s(r(l, \pi, i^a), i(l, \pi, i^a), l, i^a) - [h(r - r_n) + \pi + k(r(l, \pi, i^a), i(l, \pi, i^a) - \pi, l)]l, \end{aligned} \quad (21a)$$

25. The labor–output ratio n remains unchanged. From equation (1), the ratio of employment to capital is expressed as $\frac{N}{K} = n \frac{Y}{K} = n \frac{(1+\tau)}{\tau} r$. Because τ and n are constant, it depends on the profit rate.

26. We assume that firms keep the level of normal output below potential output to meet unexpected demand. Additionally, we assume that workers and capitalists maintain the common normal profit rate.

27. Equation (20c) can be confirmed to be consistent with an expectations-augmented wage Phillips curve.

28. α and β are parameters.

$$\dot{\pi} = \alpha[h(r - r_n)], \quad (21b)$$

$$\dot{i}_a = \beta[h(r - r_n) + \pi - p_f]. \quad (21c)$$

We define the steady state as $\dot{l} = \dot{\pi} = \dot{i}_a = 0$ and assume that the capital accumulation rate is positive. Therefore, we have the following steady-state relationships:

$$l^s(r(l^*, \pi^*, i^{a*}), i(l^*, \pi^*, i^{a*}), l^*, i^{a*}) = [\pi^* + k(r(l^*, \pi^*, i^{a*}), i(l^*, \pi^*, i^{a*}) - \pi^*, l^*)]l^*, \quad (22a)$$

$$r(l^*, \pi^*, i^{a*}) = r_n, \quad (22b)$$

$$\pi^* = p_f, \quad (22c)$$

where l^* , π^* , and i^{a*} represent the steady-state values of l , π , and i^a , respectively. At the steady state, the debt–capital ratio l^* remains constant, the actual profit rate is equal to the normal rate, and the expected rate of inflation is equal to the target inflation rate set by the central bank.

5.2 Stability of the steady state

We focus on equations (21a) to (21c) to analyze economic stability. We derive the Jacobian matrix M^d of the dynamic system evaluated at the steady state as²⁹

$$M^d = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix},$$

$$b_{11} = \left\{ l_r^s - \left[h_r + s \left(\frac{1}{\tau} + 1 - v \right) + v \right] l^* \right\} r_l + l_i^s \cdot i_l + l_l^s - (p_f + k^*) \lesseqgtr 0, \quad (23a)$$

$$b_{12} = \left\{ l_r^s - \left[h_r + s \left(\frac{1}{\tau} + 1 - v \right) + v \right] l^* \right\} r_\pi + l_i^s \cdot i_\pi - l^* \lesseqgtr 0, \quad (23b)$$

$$b_{13} = \left\{ l_r^s - \left[h_r + s \left(\frac{1}{\tau} + 1 - v \right) + v \right] l^* \right\} r_{i^a} + l_i^s \cdot i_{i^a} + l_{i^a}^s \lesseqgtr 0, \quad (23c)$$

$$b_{21} = \alpha h_r r_l \lesseqgtr 0, \quad (23d)$$

$$b_{22} = \alpha h_r r_\pi > 0, \quad (23e)$$

$$b_{23} = \alpha h_r r_{i^a} < 0, \quad (23f)$$

$$b_{31} = \beta h_r r_l \lesseqgtr 0, \quad (23g)$$

$$b_{32} = \beta(h_r r_\pi + 1) > 0, \quad (23h)$$

$$b_{33} = \beta h_r r_{i^a} < 0. \quad (23i)$$

29. From the equations of short-run equilibrium, the following equation is satisfied at the steady state: $k_r \cdot r_l + k_p \cdot i_l + k_l = s \left(\frac{1}{\tau} + 1 - v \right) r_l$. Considering this equation, we have equation (23a). Similarly, we can derive equations (23b) and (23c).

According to the Routh–Hurwitz conditions, the steady state is stable if and only if the following conditions are satisfied:

$$M_1^d = -(b_{11} + b_{22} + b_{33}) > 0, \quad (24a)$$

$$M_2^d = M_{11}^d + M_{22}^d + M_{33}^d > 0, \quad (24b)$$

$$M_3^d = -(\text{determinant } M^d) = -(b_{11}M_{11}^d + b_{22}M_{22}^d + b_{33}M_{33}^d) > 0, \quad (24c)$$

$$M_1^d M_2^d - M_3^d > 0. \quad (24d)$$

where M_{ij}^d is a cofactor of the respective b_{ij} .

We now analyze the stability of the economy. For simplicity, we assume that an increase in the debt–capital ratio decreases the profit rate and that the value of the determinant of M^d is negative ($M_3^d > 0$). The first assumption indicates that the substitution effect of household portfolio selection in response to the debt–capital ratio is large.³⁰ These two assumptions are expressed as

$$r_l < 0, \quad (25a)$$

$$b_{11}r_{i^u} - b_{13}r_l > 0. \quad (25b)$$

Substituting the values of each element in the matrix M^d into equations (24a), (24b), and (24d), we get

$$M_1^d = -b_{11} - \alpha b_r r_\pi - \beta b_r r_{i^u} > 0, \quad (26a)$$

$$\beta(b_{11}r_{i^u} - b_{13}r_l) - \alpha(\beta r_{i^u} - b_{11}r_\pi + b_{12}r_l) > 0, \quad (26b)$$

$$\beta(b_{11}r_{i^u} - b_{13}r_l)(M_1^d - \alpha) - \alpha M_1^d(\beta r_{i^u} - b_{11}r_\pi + b_{12}r_l) > 0. \quad (26c)$$

When conditions (26a) to (26c) are satisfied, the steady state becomes stable. However, there is no guarantee that the actual economy satisfies these conditions. Therefore, a modern capitalist economy faces the risk of becoming unstable endogenously. To ensure economic stabilization, the following three conditions must be satisfied:

- (1) The sign of element b_{11} in Jacobian matrix M^d is negative;
- (2) The adjustment speed of the expected inflation rate α is sufficiently low;
- (3) The adjustment speed of the interbank rate β is sufficiently high.

Condition (1) is most important for achieving stability. It can be demonstrated that $l_r^s - [b_r + s(\frac{1}{\tau} + 1 - \nu) + \nu]l^*$ is positive. This value depends on the level of the debt–capital ratio l and relative magnitudes of the sensitivity of bank lending and nominal wage rate to the profit rate. When l is high and the volatility of the nominal wage rate to the profit rate b_r is higher than that of bank lending l_r^s , b_{11} may be positive. In this case, the economy may be unstable. An increase in debt–capital ratio causes serious deflation and further increases the debt–capital ratio. This is a deflationary spiral process argued by Fisher (1933). Fisher investigated the interaction between price fluctuation and the interest rate. In contrast, we focus on the effect of the profit rate on bank behavior and nominal wage rate movement.

30. See the results of the short-run analysis for detail.

Condition (2) indicates that the expected inflation rate remains stable. Amplification of the expected inflation rate makes investment unstable and leads to economic instability. Condition (3) indicates that the central bank should actively adjust the interbank rate to the gap between the actual and target inflation rates. Although monetary authority contributes significantly to the stability of the economy, the central bank alone can make only a limited contribution.

The stability conditions depend on economic agents' behaviors and monetary policy. In a capitalist economy, because each agent acts without having accurate information, financial instability may occur endogenously. In other words, monetary policy alone cannot ensure economic stabilization. To ensure economic stabilization, the central bank and government must implement regulations to prevent excessive reactions of the expected inflation rate and nominal wage rate to the profit rate.

The main points discussed above can be summarized by the following proposition.

Proposition 3 *When an increase in the debt–capital ratio reduces the profit rate (e.g., $r_l < 0$), the following conditions must be satisfied to stabilize the economy: (1) the debt–capital ratio is low and the sensitivity of the nominal wage rate to the profit rate is lower than that of bank lending; (2) the volatility of the expected inflation rate is low; and (3) the central bank adjusts the interbank rate actively in response to the profit rate.*

5.3 Debt-deflation process and the effectiveness of inflation-targeting policy

We now examine the dynamics of the economy. First, we describe the debt-deflation process. We assume that firms are heavily in debt and the economy is in a recession. An increase in the debt–capital ratio reduces the profit rate, thereby reducing the nominal wage rate and expected inflation rate. Accordingly, the price inflation rate continues to decline. Because the decrease in the expected inflation rate increases the real interest rate, the investment and the profit rate decrease more rapidly. Furthermore, the equity demand decreases and the equity price drops significantly. In an unstable economy, the sensitivity of the nominal wage rate to the profit rate is higher than that of bank lending and a decrease in the profit rate further increases the debt–capital ratio. As a result, debt-deflation occurs in the economy. To improve this negative situation, the central bank may reduce the interbank rate. However, because the adjustment speed is slow, the profit rate and expected inflation rate are not guaranteed to improve. Therefore, the recession may intensify and the economy may not be able to re-stabilize.

In contrast, we now consider a stable economy. In such an economy, a decrease in the profit rate also reduces the nominal wage rate and expected inflation rate. However, because the effect of the profit rate on the nominal wage and inflation rate is small, a severe increase in the debt–capital ratio cannot occur. Furthermore, the effects of the expected inflation on the real interest rate and investment remain stable. Additionally, because the central bank actively responds to the economic scenario, its monetary policy is very effective. It reduces the nominal interest rate and increases investment. Therefore, the economy reverses. The price inflation rate and equity price increase, and the economy converges to a steady state.

Finally, we consider the effects of inflation-targeting policy on the steady state in a stable economy. Assuming that $l_r^s - [b_r + s(\frac{1}{\tau} + 1 - \nu) + \nu]l^*$ is positive, we derive

$$b_{12} > 0, b_{13} < 0. \quad (27a)$$

In this case, regarding the effect of the target inflation rate p_f on the steady state, we obtain

$$\frac{dl^*}{dp_f} > 0, \frac{d\pi^*}{dp_f} = 1 > 0, \frac{di_a^*}{dp_f} < 0. \quad (27b)$$

When the target inflation rate increases, the debt–capital ratio and expected inflation rate increase, and the interbank rate decreases. These findings can be summarized by the following proposition.

Proposition 4 *In a long-run stable economy, an increase in the target inflation rate p_f increases the expected inflation rate and debt–capital ratio and decreases the interbank rate.*

6 CONCLUSION

Our dynamic macroeconomic model indicates that when the debt–capital ratio is high and the volatility of the nominal wage rate in response to the profit rate is higher than that of bank lending, the economy may experience the debt-deflation process. Furthermore, even if debt-deflation does not occur, when the volatility of the expected inflation is high and the adjustment speed of the interbank rate to profit is slow, the economy may destabilize. A capitalist economy is not necessarily self-correcting and does not always satisfy stable conditions. Once the economy becomes unstable, it is difficult for it to re-stabilize. This result is in agreement with Fisher's and Minsky's theories. To ensure economic stabilization, the central bank and government must implement regulations to make the movement of the expected inflation rate and nominal wage rate stable. Furthermore, the central bank must actively implement monetary policy to adjust the interbank rate to an appropriate level.

Several challenges are remaining for future research. First, we must quantitatively analyze financial dynamics to identify the stable region of parameters using numerical methods. Second, as monetary policies, the zero-interest policy and quantitative easing have been implemented in actual economies. Considering these policies, we must analyze a more comprehensive set of macroeconomic policies that can contribute to economic stability. Finally, in a modern capitalist economy, many issues transcend national boundaries. Therefore, we must extend our model to an open economy model.

ACKNOWLEDGEMENTS

We wish to thank the editors of *EJEEP*, two anonymous referees, and Shin Imoto (Onomichi City University) for their helpful comments and suggestions. Responsibility for any errors and/or omissions that may remain rests solely with the authors. This work was supported by JSPS KAKENHI Grant Number JP21K01443.

REFERENCES

- Arestis, P. (2009): New consensus macroeconomics and Keynesian critique, in: Hein, E., Niechoj, T., Stockhammer, E. (eds), *Macroeconomic Policies on Shaky Foundations: Whither Mainstream Economics?*, Marburg: Metropolis-Verlag, 165–186.

- Asada, T. (1999): Investment and finance: a theoretical approach, in: *Annals of Operations Research*, 89, 75–87.
- Asada, T. (2001): Nonlinear dynamics of debt and capital: a post-Keynesian analysis, in: Japan Association for Evolutionary Economics, Aruka, Y. (eds), *Evolutionary Controversies in Economics: A New Transdisciplinary Approach*, Tokyo: Springer, 73–87.
- Asada, T. (2014): Mathematical modeling of financial instability and macroeconomic stabilization policies, in: Dieci, R., He, X., Hommes, C. (eds), *Nonlinear Economic Dynamics and Financial Modelling: Essays in Honour of Carl Chiarella*, Cham, Switzerland: Springer, 41–63.
- Charles, S. (2008a): A post-Keynesian model of accumulation with a Minskyan financial structure, in: *Review of Political Economy*, 20(3), 319–331.
- Charles, S. (2008b): Teaching Minsky's financial instability hypothesis: a manageable suggestion, in: *Journal of Post Keynesian Economics*, 31(1), 125–138.
- Charles, S. (2016): Is Minsky's financial instability hypothesis valid?, in: *Cambridge Journal of Economics*, 40(2), 427–436.
- Chiarella, C., Flaschel, P. (2000): *The Dynamics of Keynesian Monetary Growth: Macro Foundation*, Cambridge, UK: Cambridge University Press.
- Chiarella, C., Flaschel, P., Semmler, W. (2013): *Reconstructing Keynesian Macroeconomics*, Volume 2, New York: Routledge.
- Fisher, I. (1930): *The Theory of Interest*, London: Macmillan.
- Fisher, I. (1933): The debt-deflation theory of Great Depressions, in: *Econometrica*, 1(4), 337–357.
- Franke, R., Semmler, W. (1991): A dynamical macroeconomic growth model with external financing of firms: a numerical stability analysis, in: Nell, E., Semmler, W. (eds), *Nicholas Kaldor and Mainstream Economics*, London: Macmillan, 335–359.
- Hein, E. (2007): Interest rate, debt, distribution and capital accumulation in a post-Kaleckian model, in: *Metroeconomica*, 58(2), 310–339.
- Hein, E., Stockhammer, E. (2010): Macroeconomic policy mix, employment and inflation in a post-Keynesian alternative to the New Consensus Model, in: *Review of Political Economy*, 22(3), 317–354.
- Hicks, J.R. (1956): Methods of dynamic analysis, in: *25 Economic Essays in Honor of Erik Lindahl*, Stockholm: Ekonomisk Tidskrift. (Reprinted in Hicks, J. (1982), *Money, Interest, and Wage: Collected Essays on Economic Theory of John Hicks*, Volume 2, Oxford, UK: Clarendon Press.)
- Kalecki, M. (1937): The principle of increasing risk, in: *Economica*, 14, 440–447.
- Keynes, J.M. (1936): *The General Theory of Employment, Interest, and Money*, London: Macmillan.
- Lavoie, M. (1995): Interest rates on post-Keynesian models of growth and distribution, in: *Metroeconomica*, 46(2), 146–177.
- Lavoie, M. (1997): Loanable funds, endogenous money, and Minsky's financial fragility hypothesis, in: Cohen, A., Hagemann, H., Smithin, J. (eds), *Money, Financial Institutions and Macroeconomics*, Boston: Kluwer Academic, 67–82.
- Lavoie, M., Godley, W. (2001): Kaleckian models of growth in a coherent stock-flow monetary framework: a Kaldorian view, in: *Journal of Post Keynesian Economics*, 24(2), 277–311.
- Lima, G.T., Meirelles, A.J. (2007): Macrodynamics of debt regimes, financial instability and growth, in: *Cambridge Journal of Economics*, 31, 563–580.
- Lima, G.T., Setterfield, M., Silveira, J.J. (2014): Inflation targeting and macroeconomic stability with heterogeneous inflation expectations, in: *Journal of Post Keynesian Economics*, 37(2), 255–279.
- Minsky, H.P. (1975): *John Maynard Keynes*, New York: Columbia University Press.
- Minsky, H.P. (1986): *Stabilizing an Unstable Economy*, New Haven: Yale University Press.
- Murakami, H., Asada, T. (2018): Inflation-deflation expectations and economic stability in a Kaleckian system, in: *Journal of Economic Dynamics and Control*, 92, 183–201.
- Parui, P. (2021): Financialization and endogenous technological change: a post-Kaleckian perspective, in: *Structural Change and Economic Dynamics*, 58(4), 221–244.
- Ryoo, S. (2013a): The paradox of debt and Minsky's financial instability hypothesis, in: *Metroeconomica*, 64(1), 1–24.
- Ryoo, S. (2013b): Bank profitability, leverage and financial instability: Minsky-Harrod model, in: *Cambridge Journal of Economics*, 37(5), 1127–1160.

- Setterfield, M. (2006): Is inflation targeting compatible with Post Keynesian economics?, in: *Journal of Post Keynesian Economics*, 28(4), 653–671.
- Taylor, J. (1993): Discretion versus policy rules in practice, in: *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.
- Taylor, L., O'Connell, S.A. (1985): A Minsky crisis, in: *Quarterly Journal of Economics*, 100(5), 871–885.
- Tobin, J. (1969): A general equilibrium approach to monetary theory, in: *Journal of Money, Credit and Banking*, 1(1), 15–29.
- Watanabe, T. (2021): Reconsideration of the IS–LM model and limitations of monetary policy: a Tobin–Minsky model, in: *Evolutionary and Institutional Economics Review*, 18(1), 103–129.

APPENDIX 1 STABILITY CONDITIONS FOR SHORT-RUN EQUILIBRIUM

For the matrix M^s , we know that

$$a_{12} < 0, a_{22} < 0, a_{23} < 0, a_{31} > 0, a_{32} < 0, a_{33} < 0, M_{11}^s > 0, M_{21}^s > 0, M_{31}^s > 0,$$

where M_{ij}^s is a cofactor of the respective a_{ij} .

Furthermore, we define M_1^s , M_2^s , and M_3^s as

$$M_1^s = -(\text{trace } M^s) = -(a_{11} + a_{22} + a_{33}), \quad (\text{a1})$$

$$M_2^s = M_{11}^s + M_{22}^s + M_{33}^s, \quad (\text{a2})$$

$$M_3^s = -(\text{determinant } M^s) = -\Delta^s = -(a_{11}M_{11}^s - a_{12}M_{12}^s), \quad (\text{a3})$$

where M_2^s is the sum of the second minor determinants of matrix M^s .

According to the Routh–Hurwitz conditions, the short-run equilibrium is stable if and only if the following conditions are satisfied:

$$M_1^s > 0, \quad (\text{a4})$$

$$M_2^s > 0, \quad (\text{a5})$$

$$M_3^s > 0, \quad (\text{a6})$$

$$M_1^s M_2^s - M_3^s > 0. \quad (\text{a7})$$

In our model, equation (a7) can be expressed as

$$M_1^s M_2^s - M_3^s = M_4^s + (a_{12}a_{23}a_{31} - a_{11}a_{22}a_{33}), \quad (\text{a8})$$

$$M_4^s = -a_{11}(a_{11}a_{33} + M_{33}^s) - a_{22}M_2^s - a_{33}(a_{11}a_{33} + M_{11}^s). \quad (\text{a9})$$

When $a_{11} < 0$ and $a_{21} > a_{31}$, the following conditions hold:

$$M_{12}^s < 0, \quad (\text{a10})$$

$$M_{22}^s > 0, \quad (\text{a11})$$

$$M_{23}^s > 0, \quad (\text{a12})$$

$$M_{32}^s > 0, \quad (\text{a13})$$

$$M_{33}^s > 0. \quad (\text{a14})$$

These conditions are sufficient to satisfy the Routh–Hurwitz conditions. It should be noted that when $a_{11} < 0$ and $a_{21} > a_{31}$, the short-run equilibrium becomes stable.

APPENDIX 2 MATHEMATICAL RESULTS OF COMPARATIVE STATICS

When the system satisfies equations (17a), (17c), and (17d), the mathematical results of comparative statics in the short-run model are expressed as

$$\frac{di}{dl} = \frac{-c_{1l}(M_{12}^s - M_{22}^s) + c_{2l}M_{22}^s - c_{3l}M_{32}^s}{\Delta^s} \leq 0, \quad (\text{a15})$$

$$\frac{dq}{dl} = \frac{c_{1l}(M_{13}^s - M_{23}^s) - c_{2l}M_{23}^s + c_{3l}M_{33}^s}{\Delta^s} \leq 0, \quad (\text{a16})$$

$$\frac{dr}{d\pi} = \frac{k_p(M_{11}^s - M_{21}^s)}{\Delta^s} > 0, \quad (\text{a17})$$

$$\frac{dq}{d\pi} = \frac{k_p(M_{13}^s - M_{23}^s)}{\Delta^s} \leq 0, \quad (\text{a18})$$

$$\frac{dr}{di^a} = \frac{-l_{ia}^s M_{21}^s}{\Delta^s} < 0, \quad (\text{a19})$$

$$\frac{di}{di^a} = \frac{l_{ia}^s M_{22}^s}{\Delta^s} > 0, \quad (\text{a20})$$

$$\frac{dq}{di^a} = \frac{-l_{ia}^s M_{23}^s}{\Delta^s} < 0, \quad (\text{a21})$$

$$M_{11}^s - M_{21}^s > 0, \quad M_{12}^s - M_{22}^s < 0,$$

$$M_{13}^s - M_{23}^s = f_i \left[l_r^s + \mu_r s \left(\frac{1}{\tau} + 1 - v \right) r + (\mu - 1)s \left(\frac{1}{\tau} + 1 - v \right) \right] + l_i^s \cdot a_{31} \leq 0.$$