A Theory of the Credit-to-GDP Gap: Using Credit Gaps to Predict Financial Crises

Harashima, Taiji

Kanazawa Seiryo University

21 April 2022

A Theory of the Credit-to-GDP Gap: Using Credit Gaps to Predict Financial Crises

HARASHIMA Taiji*

February 2022

Abstract

The credit-to-GDP gap (credit gap) is thought to be a promising leading indicator of financial crises, but the trend of the credit-output ratio must be appropriately estimated before credit gaps can be used for this purpose. To appropriately estimate this ratio, it is necessary to know the mechanism by which it is generated, but this mechanism has not necessarily been sufficiently explained. In this paper, I examine the mechanisms underlying the creation of credit-output ratios and credit gaps, and show that the credit-output ratio has an exponentially increasing upward trend. A log-linear trend of the credit-output ratio therefore should be estimated when using the credit gap to predict financial crises. Estimates of log-linear trends of the credit-output ratio and credit gap of the U.S. indicate that the financial crises in 2008 and 1990 can be predicted if the credit gaps are well estimated and considered as an important leading indicator of financial crisis, even in "real time" (i.e., from the perspective of those years, not the present).

JEL Classification: E32, E37, E41, E44, G01, G10

Keywords: Credit gap; Credit-output ratio; Capital-output ratio; Financial crisis; Leading indicator; Demand for Money

---

*Correspondence: HARASHIMA (Family name) Taiji (First name), Kanazawa Seiryo University, 10-1 Goshomachi-Ushi, Kanazawa, Ishikawa, 920-8620, Japan.

Email: harashim@seiryo-u.ac.jp or t-harashima@mve.biglobe.ne.jp.

1 INTRODUCTION

The credit-to-GDP gap (credit gap) indicates the deviation of the credit-output (or credit-GDP) ratio from its long-term trend. The credit gap is thought to be an important indicator because it likely contains important information to predict financial crises. The most widely used estimates of the credit-output ratio and credit gap are those published for many countries by the Bank for International Settlements (BIS). BIS estimates of the U.S. credit gap show a notable increase in the size of the credit gaps before the financial crisis and Great Recession in 2008. This coincidence of events—an increase in the size of the credit gap and the occurrence of a financial crisis—enhanced the reputation of credit gaps as a promising leading indicator of financial crises. The Basel Committee for Banking Supervision of the BIS recommends using credit gaps when determining countercyclical regulatory capital buffers.

Although it may be difficult to clearly define "financial crisis," the serious turbulence in financial markets that accompanies a recession seems to have been called a financial crisis. Many studies have examined the predictability of financial crises by using credit gaps, and most of them concluded that credit gaps are a good predictor or leading indicator of a financial crisis (Borio and Lowe, 2002; Borio and Drehmann, 2009; Drehmann and Juselius, 2014; Beltran et al., 2021; Greenwood et al., 2021). In addition, many studies emphasize the importance of credit booms in predicting a financial crisis (Schularick and Taylor, 2012; Greenwood and Hanson, 2013; Baron and Wei, 2017; Krishnamurthy and Muir, 2017; López-Salido et al., 2017; Mian et al., 2017).

However, the use of credit gaps as a leading indicator of a financial crisis has a weak point: the trend of the credit-output ratio must be appropriately estimated beforehand. Credit gaps can be properly calculated and used only if the trend of the credit-output ratio is appropriately estimated, but it is not necessarily easy to appropriately estimate this trend because there are many possible types of trends (e.g., additively or exponentially increasing) and estimation methods. The calculated credit gaps will differ greatly depending on which types of trend and estimation method are used.

To appropriately estimate the trend, it is first necessary to know how credit-output ratios are generated (i.e., the underlying mechanism). The BIS estimates the trend of credit-output ratio simply by applying an Hodrick-Prescott (HP) Filter to unprocessed data related to the credit-output ratio without considering any underlying mechanism. It is doubtful therefore whether the trend estimated by the BIS is appropriate, and it may be significantly biased.

In this paper, I examine how credit-output ratios are generated. Credits consist roughly of financial instruments used as money, for investments in capital for production, and for other purposes. These three types of financial instruments are determined by different mechanisms, and I examine each one separately.

First, I examine the mechanism of financial instruments used as money (I call this “conceptual money”) on the basis of a money-in-utility function and the inflation model presented by Harashima (2004b, 2007a, 2007b[1], 2007c[2], 2008[3], 2013b). I show that the ratio of conceptual money to output can have an exponentially increasing upward trend because both conceptual money and output grow exponentially on a balanced growth path. Next, I examine financial instruments for investments in capital for production (I call these “capital for steady state”), and show that its ratio to output is kept constant on a balanced growth path.

Finally, I examine the mechanism of financial instruments for other purposes. These instruments likely consist mostly of those used for speculative purposes, and there will be “good” and “bad” speculations. Good speculations are beneficial to society because they are used for investments in technologies to create innovations, and bad speculations are harmful because they are roughly equivalent to gambling or Ponzi schemes. I first show that the ratio of good speculation to output is constant, and then I construct a model of bad speculation. On the basis of the model, I show that the ratio of the trend of bad speculation to output can have an exponentially increasing upward trend.

The credit-output ratio mechanism shown in this paper indicates that the trend of the credit-output ratio should be estimated as a log-linear trend because the ratios of conceptual money and bad speculation to output have exponentially increasing upward trends. I estimate log-linear trends of the U.S. credit-output ratio for several estimation periods and estimate credit gaps by using these estimated trends.

The model of bad speculation indicates that credit gaps mostly reflect fluctuations of the amount of bad speculation. This means that it is most likely that financial crises are generated by an excessive amount of bad speculation. If that is true, the credit gap will be a very important tool to predict financial crises. The present and real-time credit gaps of the U.S. calculated on the basis of the log-linear trend of the credit-output ratio estimated in this paper strongly imply that the financial crises in 2008 and 1990 could have been anticipated if the credit gap had been appropriately calculated and considered as an important leading indicator of these financial crises.

However, the usefulness of credit gaps remains uncertain because there are several limitations to this analysis, including difficulties in estimating trends and a small number of samples to study.

2 NATURE OF CREDIT

[1] Harashima (2007b) is also available in Japanese as Harashima (2013a).
[2] Harashima (2007c) is also available in Japanese as Harashima (2018a).
[3] Harashima (2008) is also available in Japanese as Harashima (2020a).

2.1 Components of credits

The BIS defines credit in its statistics as the financial instruments that comprise currency, deposits, loans, and debt securities. Roughly speaking, credits consist of the following three types of financial instruments: those used (1) as money, (2) for investments in capital for production, and (3) for other purposes.

Type (1) financial instruments are conceptually a kind of goods and services that function as a medium of exchange, measure of value, and store of value. This type of instrument does not generate interest but gives utility to people by providing these three functions. In addition, type (1) financial instruments can be regarded to be highly liquid financial assets. Because of their high liquidity and the utility gained from these assets, people are willing to hold them even if they do not generate any interest. As noted in the Introduction, I refer to type (1) financial instruments as "conceptual money".

Conceptually, the amount of type (2) financial instruments should be almost equal to that of capital at steady state. In theory, capital is accumulated up to a unique steady state level that is determined by the structure of an economy (e.g., by the economy's level of technology and rate of time preference [RTP]). Many of these instruments (i.e., the capital) are actualized through loans and debt securities. Here, I refer to type (2) financial instruments as "capital for steady state". Type (3) financial instruments can be considered to be almost equivalent to speculative investments or what I call "speculations". The nature of type (3) instruments is examined in detail in Section 5.

An important point is that these three components of credit are highly likely to behave differently and have different underlying mechanisms. The movement of credit therefore represents the combined movement of these three moving components. Hence, to examine the nature of the credit-output ratio, we should first examine the natures of these three components separately.

2.2 Credit-output ratio

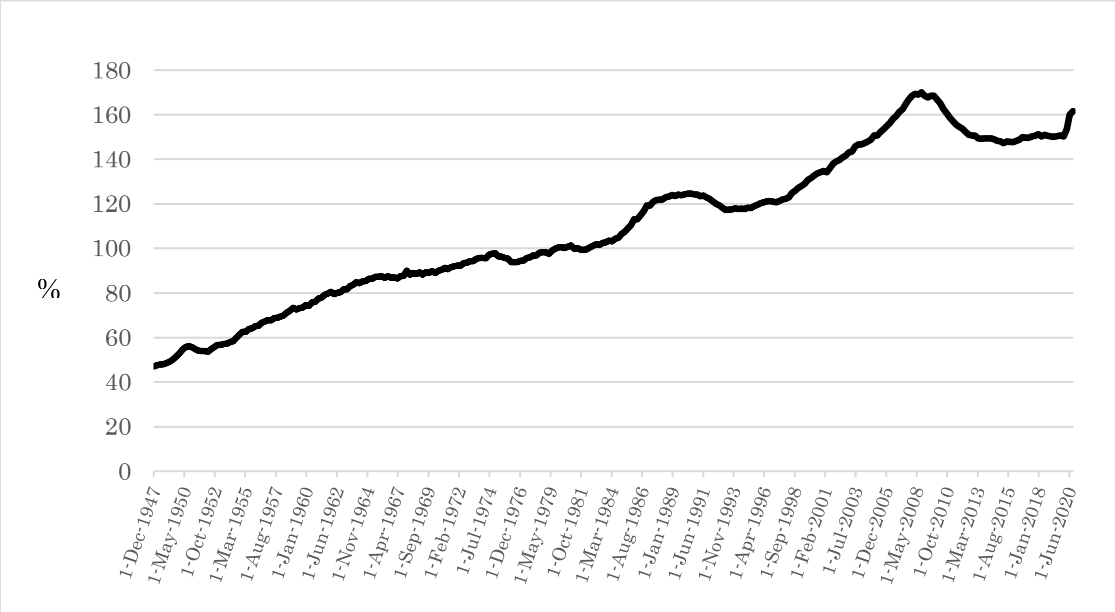
2.2.1 Upward trend of the credit-output ratio

Figure 1 shows the U.S. credit-output (GDP) ratio for the past 70 years estimated and published by the BIS. An upward trend can clearly be recognized, and upward trends are also observed in the BIS's estimates of credit-output ratio in many other countries. The BIS is well aware of the existence of the trend and therefore publishes data of trends of credit-output ratios estimated using an HP filter.

2.2.2 Mechanism of the upward trend

Because an upward trend in credit-output ratios exists, it must be estimated before the credit gap concept can be applied to predict financial crises. However, estimating this trend is not an easy task. Indeed, there are various trend models and estimation methods, and the estimates differ largely depending on the model and estimation method used.

Figure 1: U.S. credit-to-GDP ratio since 1947



Source: BIS.

To choose an appropriate trend model and estimation method, we need to know how the trend is generated; that is, we need to know the mechanism underlying it. To the best of my knowledge, no economic theory has been presented that explains this mechanism. Nevertheless, the mechanism is important and has to be uncovered because the usefulness of credit gaps in predicting financial crises crucially depends on whether the estimated trend is appropriate.

3 CONCEPTUAL MONEY AND THE CREDIT-OUTPUT RATIO TREND

3.1 Conceptual money and money defined by a central bank

Usually, each country's "official" money is defined by its central bank. However, money defined as such is not necessarily equivalent to conceptual money. The reason for this difference is that the kinds of deposits are included in (or regarded as a part of) each country's money is determined ad hoc by each central bank because the degrees of liquidity of various types of deposits cannot be easily and correctly measured.

Roughly speaking, if the interest of a type of deposit is less than the return obtained from capital at the steady state, it indicates that people desire it because it provides some degree of liquidity in addition to the interest. In addition, the interest may decrease as the value of the liquidity the deposit provides increases. Nevertheless, it is difficult to measure any deposit's exact degree of liquidity. Therefore, a central bank has to define money by ad hoc selecting deposits from among many types of deposits, and consequently, the definition is not entirely accurate. As a result, the amounts of conceptual money and official money as defined by a central bank usually differ.

In addition, the amount of money defined by the central bank is probably influenced and controlled through the manipulation of the central bank, which may make the amount deviate even more from the amount of conceptual money. Therefore, in this paper, I do not use the money statistics published by central banks, but instead refer to and use only the idea of conceptual money.

3.2 Money-in-the-utility function

Consider a model based on Sidrauski (1967)'s well-known money-in-the-utility function such that the representative household maximizes its expected utility

$$E\int_0^\infty u_P(c_t, m_t)\exp(-\theta_P t)dt \tag{1}$$

subject to the budget constraint

$$\dot{a}_t = (r_t a_t + w_t + \sigma_t) - [c_t + (\pi_t + r_t)m_t] - g_t \ , \tag{2}$$

where u_P and θ_P are the utility function and RTP of a household, respectively, r_t is the real interest rate, π_t is the inflation rate, c_t is real consumption, w_t is the real wage, σ_t is lump-sum real government transfers, m_t is real money, a_t is wealth, g_t is government expenditure in period t, $a_t = k_t + m_t$, and k_t is real capital. All variables are expressed in per capita terms, and E is the expectation operator.

The term $(\pi_t + r_t)m_t$ in equation (2) indicates the interest that the household has foregone because it held m_t. Therefore, m_t is an element that does not generate any interest; rather, it represents the economic value that arises from its functions as a medium of exchange, measure of value, and store of value. That is, the money described in the money-in-the-utility function is identical to conceptual money (i.e., a type (1) financial instrument). On the other hand, k_t is clearly identical to capital for steady state (i.e., a type (2) financial instrument). Hence, wealth ($a_t = k_t + m_t$) consists of capital for steady state and conceptual money.

3.3 The law of motion for inflation and conceptual money

In this section, I examine the nature of conceptual money based on a model that consists of a money-in-the-utility function, in particular, on the model of inflation presented by Harashima (2007b).

3.3.1 The model

3.3.1.1 The government budget constraint

The budget constraint of a government is

$$\dot{B}_t = B_t R_t + G_t - X_t - S_t \ ,$$

where B_t is accumulated nominal government bonds, R_t is the nominal interest rate for government bonds, G_t is nominal government expenditure, X_t is nominal tax revenue, and S_t is the nominal amount of seigniorage at time t. The tax is assumed to be lump sum. All variables are expressed in per capita terms. The government bonds are long term, and the returns on the bonds, R_t, are realized only after the bonds are held during a unit period (e.g., one year). Government bonds are redeemed in a unit period, and the government successively refinances the bonds by issuing new ones at each time. R_t is composed of the real interest rate r_t and the expected change of the bonds' price by inflation $\pi^e_{b,t}$ such that

$$R_t = r_t + \pi^e_{b,t} \ .$$

Let $b_t = \frac{B_t}{p_t}$, $g_t = \frac{G_t}{p_t}$, $x_t = \frac{X_t}{p_t}$, and $s_t = \frac{S_t}{p_t}$, where p_t is the price level at time t. Here $\pi_t = \frac{\dot{p}_t}{p_t}$. By dividing by p_t, the budget constraint is transformed to

$$\frac{\dot{B}_t}{p_t} = b_t R_t + g_t - x_t - s_t$$

which is equivalent to

$$\dot{b}_t = b_t(R_t - \pi_t) + g_t - x_t - s_t \ . \tag{3}$$

3.3.1.2 Optimization of government

A government maximizes its expected utility

$$E_0 \int_0^\infty u_G \left(g_t, x_t\right) \exp(-\theta_G t) dt$$

subject to its budget constraint (i.e., equation (3)), where u_G and θ_G are the utility function and RTP of government, respectively. The government maximizes its expected utility considering the behavior of the representative household that is reflected in R_t in its budget constraint.

3.3.1.3 Optimization of the representative household

The representative household also simultaneously maximizes its expected utility (i.e., equation (1)) subject to its budget constraint (i.e., equation (2)). It is assumed that $r_t = f'(k_t)$, $w_t = f(k_t) - k_t f'(k_t)$, $\frac{\partial u_P(c_t, m_t)}{\partial c_t} > 0$, $\frac{\partial^2 u_P(c_t, m_t)}{\partial c_t^2} < 0$, $\frac{\partial u_P(c_t, m_t)}{\partial m_t} > 0$, and $\frac{\partial^2 u_P(c_t, m_t)}{\partial m_t^2} < 0$, where $f(\cdot)$ is the production function. Population is assumed to be constant.

3.3.1.4 The law of motion for inflation

Combining the optimality conditions of the representative household and government yields the law of motion for inflation that is described by

$$\pi_{b,t}^e = \pi_t + \theta_G - \theta_P$$

or

$$\int_{t-1}^{t} \int_{i}^{i+1} \pi_j dj di = \pi_t + \theta_G - \theta_P$$

at steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$, and $\dot{k}_t = 0$, and

$$\lim_{t \to \infty} \pi_t = \pi_0 + 6(\theta_G - \theta_P) t^2$$

(see Harashima, 2004b, 2007a, 2007b, 2007c, 2008, 2013b).

3.3.2 The optimal quantity of conceptual money

The Friedman rule requires that money is supplied until the supply reaches the representative household's saturation point. The saturation point is a point such that

$$\frac{\partial u_P(c^*, m_t)}{\partial m_t} = 0 \ , \tag{4}$$

and therefore,

$$\pi_t + \theta_P = \pi_t + r_t = 0 \tag{5}$$

(see Harashima, 2004b, 2007a, 2007b, 2007c, 2008, 2013b). However, the model in Section 3.3.1 indicates that the real quantity of conceptual money (m_t) is supplied up to the point that satisfies

$$\frac{\partial u_P(c^*, m_t)}{\partial m_t} = [\pi_0 + r_t + 6(\theta_G - \theta_P)t^2] \frac{\partial u_P(c^*, m_t)}{\partial c^*} \tag{6}$$

at steady state, where c^* is c_t at steady state (Harashima, 2007b). That is, conceptual money (m_t) and consumption at steady state (c^*) are connected by equation (6). Note that $\theta_P = r_t$ at steady state.

Equation (6) indicates that, in general,

$$\frac{\partial u_P(c^*, m_t)}{\partial m_t} \neq 0$$

because

$$\frac{\partial u_P(c^*, m_t)}{\partial c^*} > 0 \ ,$$

and $\pi_0 + r_t + 6(\theta_G - \theta_P)t^2 \neq 0$. Equations (4) and (5) (i.e., the Friedman rule) are satisfied only if $\theta_G = \theta_P$ and $\pi_0 + r_t = 0$, which is the world the Friedman rule assumes.

3.4 Upward trend mechanism

3.4.1 Relation between conceptual money and consumption (output)

If an economy grows endogenously, the value of c^* will have an upward trend because technological progress is continuous, particularly on a balanced growth path. Let c_t^* be c^* in period *t* on a balanced growth path in an endogenously growing economy (i.e., c^* increases constantly). Hence, on a balanced growth path, equation (6) is changed to

$$\frac{\partial u_P(c_t^*, m_t)}{\partial m_t} = [\pi_0 + r_t + 6(\theta_G - \theta_P)t^2]\frac{\partial u_P(c_t^*, m_t)}{\partial c_t^*} \ . \tag{7}$$

It is highly likely that the term $\pi_0 + r_t + 6(\theta_G - \theta_P)t^2$ in equations (6) and (7) has neither an upward nor downward trend in the long run if the central bank is sufficiently independent because an independent central bank basically keeps $\theta_G = \theta_P$ (see Harashima, 2004b, 2007a, 2007b, 2007c, 2008, 2013b). Therefore, here, it is assumed that $\theta_G = \theta_P$. In this case, inflation is neither accelerating nor decelerating and

$$\frac{\partial u_P(c_t^*, m_t)}{\partial m_t} = (\pi_0 + r_t)\frac{\partial u_P(c_t^*, m_t)}{\partial c_t^*} \tag{8}$$

on a balanced growth path by equation (7). Note that equations (7) and (8) mean that if $\theta_G - \theta_P \neq 0$ (i.e., inflation is accelerating or decelerating), the interest that a household forewent because it held m_t is not $(\pi_t + r_t)m_t$; rather, it is $[\pi_0 + r_t + 6(\theta_G - \theta_P)t^2]m_t$.

As c_t^* increases due to endogenous economic growth, the marginal utility of consumption $\frac{\partial u_P(c_t^*, m_t)}{\partial c^*}$ decreases because $\frac{\partial^2 u_P(c_t, m_t)}{\partial c_t^2} < 0$, and by equation (8), that of conceptual money $\frac{\partial u_P(c_t^*, m_t)}{\partial m_t}$ also decreases. As a result, as an economy grows (i.e., as consumption and output increase), m_t increases. Therefore, both c_t^* and m_t have upward trends in a growing economy.

If the upward trend of m_t is steeper than that of c_t^*, the ratio of m_t to output (or consumption) will also have an upward trend, and consequently, the credit-output ratio can also have an upward trend.

3.4.2 Conceptual money as an origin of the upward-trending credit-output ratio

Suppose for simplicity that m_t and c_t^* are additively separable in a utility function such that

$$u_P(c_t^*, m_t) = u_{P,c}(c_t^*) + u_{P,m}(m_t) \ , \tag{9}$$

where $u_{P,c}$ and $u_{P,m}$ are utility functions with regard to consumption and conceptual money, respectively. Hence, by equation (9),

$$\frac{\partial u_P(c_t^*, m_t)}{\partial m_t} = \frac{d u_{P,m}(m_t)}{d m_t} \tag{10}$$

and

$$\frac{\partial u_P(c_t^*, m_t)}{\partial c_t^*} = \frac{du_{P,c}(c_t^*)}{dc_t^*} \ . \tag{11}$$

The utility function with regard to consumption is assumed to be a constant relative risk aversion utility function such that

$$u_{P,c}(c_t^*) = \frac{{c_t^*}^{1-\mu}}{1-\mu} \ , \tag{12}$$

where μ is a positive constant. Because the economy is on a balanced growth path,

$$\frac{\frac{dc_t^*}{dt}}{c_t^*} = \eta = \text{a positive constant} \ ,$$

and therefore,

$$c_t^* = c_0^* e^{\eta t} \ . \tag{13}$$

Hence, by equations (12) and (13),

$$\frac{du_{P,c}(c_t^*)}{dc_t^*} = {c_0^*}^{-\mu} e^{-\mu\eta t} \ . \tag{14}$$

By equations (7), (10), (11), and (14),

$$\frac{du_{P,m}(m_t)}{dm_t} = \lambda {c_0^*}^{-\mu} e^{-\mu\eta t} \tag{15}$$

on the balanced growth path where

$$\lambda = \pi_0 + r_t + 6(\theta_G - \theta_P)t^2 = \pi_0 + 6(\theta_G - \theta_P)t^2 + \theta_P \ . \tag{16}$$

Because $\theta_G = \theta_P$, as assumed above, then by equation (16), λ is a constant such that

$$\lambda = \pi_0 + \theta_P = \text{constant} \ .$$

On the other hand, the utility function with regard to conceptual money is also assumed to be a constant relative risk aversion utility function such that

$$u_{P,m}(m_t) = \frac{{m_t}^{1-\zeta}}{1-\zeta} , \tag{17}$$

where ζ is a positive constant. Therefore, by equation (17),

$$\frac{du_{P,m}(m_t)}{dm_t} = {m_t}^{-\zeta} . \tag{18}$$

Hence, by equations (15) and (18),

$$m_t = \lambda^{-\frac{1}{\zeta}} c_0^{*\frac{\mu}{\zeta}} e^{\frac{\mu}{\zeta}\eta t} . \tag{19}$$

Therefore, by equations (13) and (19),

$$\frac{m_t}{c_t^*} = \lambda^{-\frac{1}{\zeta}} c_0^{*\left(\frac{\mu}{\zeta}-1\right)} e^{\frac{\mu-\zeta}{\zeta}\eta t} . \tag{20}$$

Because consumption and output grow at the same rate on a balanced growth path, equation (20) indicates that, if $\mu > \zeta$, both the conceptual money-consumption ratio ($\frac{m_t}{c_t^*}$) and the conceptual money-output ratio have upward trends and increase exponentially. In addition, if $\mu < \zeta$, they have downward trends, and if $\mu = \zeta$, there is no trend. Because conceptual money is a component of credits, then the credit-output ratio will have an upward trend if $\mu > \zeta$, a downward trend if $\mu < \zeta$, and no trend if $\mu = \zeta$.

Whether $\mu > \zeta$, $\mu < \zeta$, or $\mu = \zeta$ is an empirical question. Equations (12) and (17) indicate that, if $\mu > \zeta$, the degree of disturbance or deviation aversion (or risk aversion) with respect to consumption is higher than that with respect to conceptual money. A household will therefore accept or allow (or feel less uncomfortable from) a greater magnitude of disturbance or deviation in the amount of conceptual money it holds than in the amount of its consumption. In other words, households care less about deviations in the amount of conceptual money than in the amount of consumption. Equation (20) indicates that the credit-output ratio has an upward trend if people actually have such preferences.

3.4.3 Direction of causality

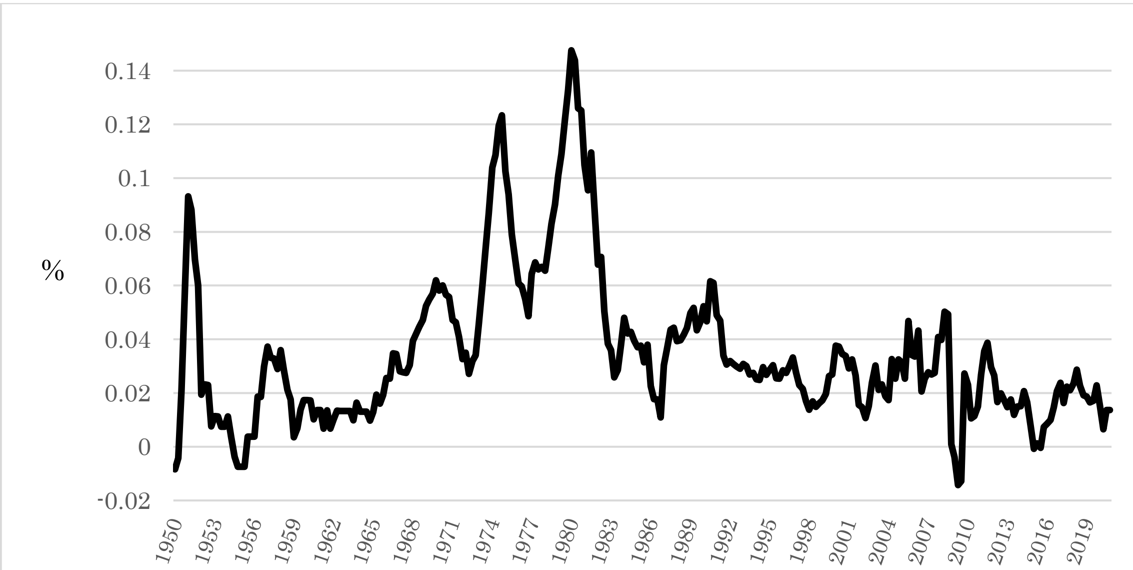
Equations (7) and (8) indicate the existence of a long-run relationship between conceptual money and consumption (and equivalently output), but it does not show which way the causality runs. Nevertheless, it is highly likely that the causality runs from consumption (output) to conceptual money in the long run because long-run economic growth is basically determined by increases in total factor productivity, which are independent of conceptual money. Therefore, it is also highly likely that the trends of conceptual money and the credit-output ratio are basically determined by the consumption (GDP) trend.

Note, however, that it is still possible that conceptual money causes short-run fluctuations of consumption and output.

3.4.4 Effect of inflation

Equation (7) indicates that an increase in $\lambda = \pi_0 + r_t + 6(\theta_G - \theta_P)t^2$ makes m_t decrease. If the central bank is sufficiently independent, $\theta_G = \theta_P$ is kept and therefore λ is kept constant. If it is not sufficiently independent, λ is changeable. This means that, if inflation accelerates because the central bank is not sufficiently independent, the effect of c_t^* on m_t diminishes in the sense that an increase in c_t^* causes a smaller increase in the amount of m_t than before the acceleration of inflation. As a result, the trend of credit-output ratio will shift downwards. For example, during the period of the Great Inflation in the 1970s (Figure 2), the trend of the credit-output ratio may have been shifted downward by inflation acceleration.

Figure 2: U.S. consumer price index

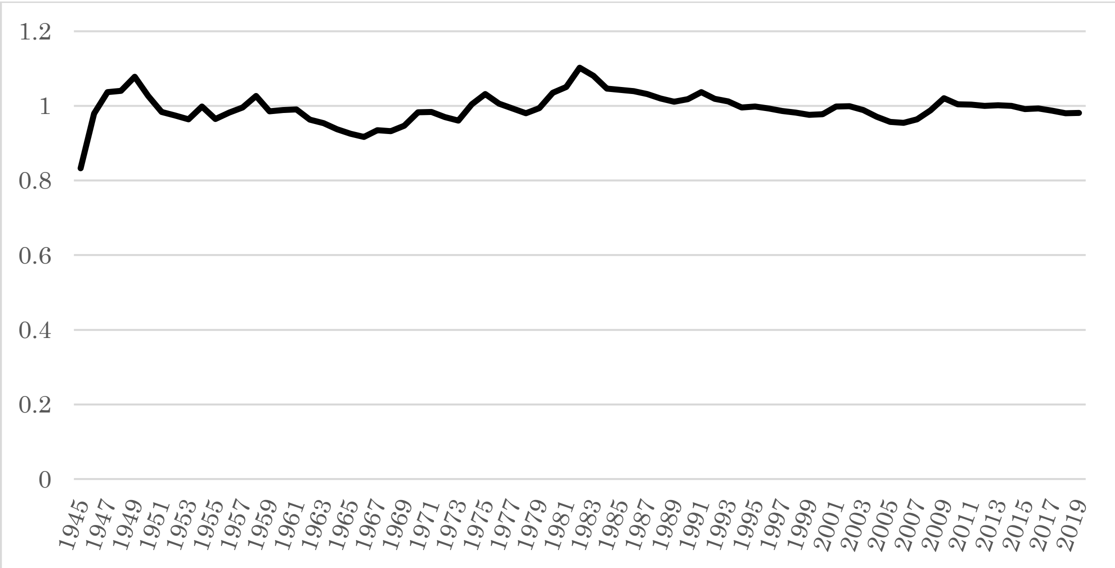


Source: "CPI for all urban consumers (CPI-U)" (U.S. Bureau of Labor Statistics).

4 CAPITAL FOR STEADY STATE AND THE CREDIT-OUTPUT RATIO TREND

One of Kaldor's (1957) six facts is that the capital-output ratio will be roughly constant over time, and unlike the credit-output ratio, the capital-output ratio $\left(\frac{K}{Y}\right)$ has been observed to be roughly constant over long periods of time, where K is capital and Y is output. For example, Figure 3 shows that the capital-output ratio of the U.S. has been roughly constant in the period after WWII.

Figure 3: U.S. capital-output ratio



Sources: "Real GDP" for output and "private nonresidential fixed assets" for real capital (U.S. Bureau of Labor Statistics).

This constancy is quite natural, and most economic theories require it. In most economic growth models, the output-capital ratio (i.e., the reciprocal of capital-output ratio) is also kept equal to a pre-determined unique constant value (i.e., RTP $\times$ [$1 -$ labor share]) at steady state.

Furthermore, Harashima (2018b[4], 2019b, 2021a) showed that an economy's functioning depends on a constant capital-output ratio, and its invariance is essential because each household unconsciously detects (or feels) its own intrinsic capital-wage ratio (CWR) at its "maximum degree of comfortability" (MDC) and behaves so as to keep it constant. In other words, households behave in such a way as to reach steady state on the basis of their perceived CWR at MDC (hereafter, the MDC-based procedure). The

[4] Harashima (2018b) is also available in Japanese as Harashima (2019a).

MDC-based procedure can completely substitute for the conventionally assumed procedure to reach steady state under which rational expectations are generated with RTP (hereafter, the RTP-based procedure). The MDC-based procedure is very simple. A household has only to act on its feelings about whether the combination of its labor income and capital (wealth) is comfortable or not. The steady state that is reached under the MDC-based procedure can be interpreted to be equivalent to the one reached under the RTP-based procedure. Because the MDC-based procedure is far easier for households to use than the RTP-based procedure and leads households to the same steady state, it is much more likely that households actually behave under the MDC-based procedure rather than the RTP-based procedure.

Although the expected CWR at MDC (or RTP) of a representative household may occasionally change to a large extent (Harashima, 2004a, 2009[5], 2014a, 2016[6], 2019c), the intrinsic CWRs at MDC (or equivalently RTP) of households will not largely fluctuate because CWR at MDC is a kind of preference, similar to RTP. In any case, it is highly likely that CWRs at MDC (or RTP) have neither an upward nor downward trend in the long run. Because households behave to maintain their own CWRs at MDC and CWR is directly correlated to the capital-output ratio, the capital-output ratio (unlike the credit-output ratio) will also not have an upward or downward trend in the long run.

The capital used in the capital-output ratio is almost identical to capital for steady state. Therefore, capital for steady state is basically irrelevant to the upward trend of the credit-output ratio.

5 SPECULATION AND THE CREDIT-OUTPUT RATIO TREND

In this section, I examine the mechanism underlying how type (3) financial instruments (i.e., financial instruments used for the other purposes) are generated.

5.1 Risk

Similar to conceptual money and capital for steady state, type (3) financial instruments must also provide utility or some type of return to people because people would otherwise never use them. The question arises, however, what kinds of utility or returns does it provide? Among the various elements that make up credit, an important element that I have not yet considered is risk. Of course, conceptual money and capital for steady state do involve some element of risk, but their main sources of utility and returns are not based

5 Harashima (2009) is also available in Japanese as Harashima (2018c).

6 Harashima (2016) is also available in Japanese as Harashima (2021c).

on risk-taking. The main source of utility from conceptual money is from the three functions of money, and the main source of utility or returns from capital for steady state is the marginal productivity of capital. Risks (uncertainties) about the three functions of money and the marginal productivity of capital are small.

However, taking risks can provide another kind of reward—innovations—and this reward is very important for the whole economy. Creating innovations is a risky business, but innovations are an essential element for technological progress and economic growth. If nobody engages in risk-taking, few innovations will be created and economic growth will be slow. Most risk-taking requires the use of credit, so that taking risk is most likely the main source of gaining rewards from type (3) financial instruments.

Taking risks can be interpreted as "speculation" because success is not guaranteed, and many speculations will end in failure. Hence, for the purpose of this analysis, I consider type (3) financial instruments to be almost equivalent to speculation.

5.2 "Good" and "bad" speculations

Although some type (3) financial instruments (speculations) are used for creating innovations, some are not. For the purpose of this discussion, consider that there are two kinds of speculation: "good" and "bad". Good speculations are those undertaken to help generate innovations and technological progress.

On the other hand, bad speculations are those undertaken even if there is no intention to create innovations. Instead, they may be used to exploit other people's economic resources by confusing them, intentionally misleading them, or even deceiving them. By speculatively manipulating financial markets, some people can take (or exploit or even steal) other people's economic resources, for example, through market manipulation.

Most kinds of market manipulation are prohibited or strictly regulated in many countries, but gray areas exist and are never completely removed. Furthermore, new, unnoticed, and more complicated methods of market manipulation are created constantly, similar to many other unlawful activities (e.g., tax avoidance) because huge amounts of economic resources can be obtained by such conduct even though it is risky. Harashima (2015, 2018d) showed that bluffs in financial markets are one of such kind of speculation.

The important point is that bad speculations basically do not increase output in the economy in the long run because they do not promote technological progress and increase total factor productivity. They do not generate any new economic value because they exist to exploit (or steal) other people's economic resources (i.e., economic value that has already been generated by other people). They are in essence similar to gambling, through which no new goods and services are produced, except for the joy and excitement (or increased utility) of the people who gamble.

Indeed, bad speculations are not an essential and necessary element for an economy, but rather are an element that should be removed. Nevertheless, because they are not essential and therefore are not anchored to real economic activities, they may occasionally fluctuate greatly.

5.3 Difficulty discerning good and bad speculations

Discerning good and bad speculations is difficult, in part, because they are both risky and involve uncertainty. Before knowing the eventual future consequences of speculations, it is difficult to discern whether they are good or bad because the eventual results, whether good or bad, are quite uncertain in the present.

In addition, even after the eventual consequences are known, it can still be difficult to distinguish good from bad because it is difficult to know the intention or motivation behind the speculations. If a person sincerely undertakes a highly risky project with the intention of creating new technology, this speculation is considered to be good, but how can that person prove good intentions to other people if the project eventually fails? On the other hand, a malicious person may undertake a risky project without any intention to create new technologies but rather to exploit other people's economic resources. After that project eventually fails, the malicious person may insist that the project failed only because of bad luck or some other reason. It may not be easy to prove that the malicious person is lying because the project was known to be very risky from the beginning. Unless the malicious person confesses his or her own malicious intent, this question could remain unsolved forever.

Furthermore, bad speculations are generally undertaken under the guise that they are good speculations because bad speculators know that their true natures have to be concealed. Hence, bad speculations usually appear to be good speculations. In this sense, bad speculations are not only malicious, they are also disguised and misrepresented.

Governments and financial authorities work hard to eliminate bad speculations and even to return ill-gotten gains if possible. However, as noted above, it is not easy to eliminate them because it is difficult to distinguish good and bad speculations. If all kinds of speculation (or risk-taking activities) were banned, bad speculations could be eliminated, but such a ban would be hazardous to the economy because a complete ban would also eliminate good speculations. Without good speculations, few innovations would be generated and economic growth would be slow.

5.4 Generation mechanism of good speculation

Good speculations will always exist on a large scale and not fluctuate largely because they are investments in technologies and therefore indispensable to proceed on a balanced growth path. Good speculations are a necessity for an economy to grow constantly because, on a balanced growth path, investments in technologies as well as technologies themselves increase at the same rate as output (GDP), as indicated in Harashima (2013c, 2019d). Therefore, the ratio of good speculations to output will basically remain constant.

5.5 Generation mechanism of bad speculation

Next, I examine the mechanism by which bad speculations are generated. To the best of my knowledge, no economic model of bad speculation has yet been presented, in which the mechanism of bad speculations is well described quantitatively on the basis of economic theories.

5.5.1 The representative household

It is highly likely that bad speculations are undertaken by the people who take more risks than the average person and whose degrees of risk aversion are lower than the average. I call these people "bad speculators". This means that households are heterogeneous, and therefore, as Harashima (2014b) showed, the representative household cannot be defined simply as being equal to the average household. Hence, according to Harashima (2014b), I use the representative household that is defined to be consistent with sustainable heterogeneity (SH), which is the state in which all optimality conditions of all heterogeneous households are simultaneously satisfied through, for example, government intervention to redistribute incomes among households (Harashima, 2010[7], 2012[8], 2014c).

5.5.2 The model of bad speculation

5.5.2.1 Utilities from bad speculations

Bad speculators obtain utility not only from consumption and conceptual money but also from bad speculations. That is, undertaking a risky project itself makes a bad speculator happy. Bad speculators simply enjoy bad speculations themselves, in much the same way a gambler enjoys playing games in a casino.

Let β_t be the real amount of per capita bad speculation in an economy in period t. Suppose for simplicity that m_t, c_t^*, and β_t are additively separable in the utility function. Hence, the utility function of the representative household is changed from equation (9) to

$$u_P(c_t^*, m_t, \beta_t) = u_{P,c}(c_t^*) + u_{P,m}(m_t) + u_{P,\beta}(\beta_t) \ , \tag{21}$$

where $u_{P,\beta}$ is the utility function with regard to bad speculation and is assumed to be a

[7] Harashima (2010) is also available in Japanese as Harashima (2017).
[8] Harashima (2012) is also available in Japanese as Harashima (2020b).

constant relative risk aversion utility function such that

$$u_{P,\beta}(\beta_t) = \frac{\beta_t^{1-\rho}}{1-\rho} \ , \tag{22}$$

where ρ is a positive constant. By equations (21) and (22),

$$\frac{\partial u_P(c_t^*, m_t, \beta_t)}{\partial \beta_t} = \beta_t^{-\rho} \ . \tag{23}$$

5.5.2.2 Costs for enjoying bad speculations

Bad speculations not only give utilities but also incur costs. Because bad speculations do not contribute to production activities in an economy and, moreover, disturb economic activities and generate inefficiencies. Harashima (2021b) showed that the levels and growth rates of production and consumption decrease as the success rate of investment decreases; that is, bad speculations will reduce production and consumption at steady state or on a balanced growth path. Due to the inefficiency caused by bad speculations, the level of utility of households also decreases. In addition, Harashima (2021b) showed that the amount of capital at steady state decreases as the success rate of investment decreases.

Let $q\beta_t$ be the cost of bad speculation, where $q(0 < q < 1)$ is a constant and represents the degree of inefficiency generated in an economy because of bad speculations. The cost $q\beta_t$ is analogous to the interest ($(\pi_t + r_t)m_t$) foregone when holding conceptual money. Therefore, in addition to $(\pi_t + r_t)m_t$, the cost $q\beta_t$ has to be subtracted from the amount of capital in each period in the budget constraint of the representative household (which includes bad speculators), as shown in equation (26).

I assumed that q is constant because a government must tolerate bad speculations to some extent, but there is an upper limit for the reasons discussed in Section 5.3. The value of q therefore indicates the government's limit of tolerance for bad speculations in the long run. In other words, a government tolerates bad speculations as long as the unit cost of bad speculation (the degree of inefficiency in economy generated by a unit of bad speculation in the long run) is lower than q. Bad speculators may be aware of the government's tolerance limit and therefore may undertake bad speculations such that they keep the unit cost of bad speculations equal to q in the long run. Bad speculators may desire a much higher value of q (e.g., bad speculations with higher risks and higher returns), and therefore they may occasionally undertake bad speculations whose costs greatly exceed q in the short run.

5.5.2.3 The trend of bad speculation

Bad speculations probably fluctuate greatly as discussed in Section 5.2. Let $\bar{\beta}_t$ be the trend of β_t in period *t*, and it is assumed that

$$\beta_t = (1 + \varepsilon_t)\bar{\beta}_t \geq 0 , \quad (24)$$

where ε_t is a stationary random variable with zero mean in period t (e.g., a Markov process). $\bar{\beta}_t$ and ε_t are independent of each other and determined differently. The determination of $\bar{\beta}_t$ is discussed in Section 5.6.

Because the future results of speculations are quite uncertain in the present and the nature of bad speculations are often disguised or misrepresented as discussed in Section 5.3, the effects of bad speculations continue to exist for a relatively long period. Hence, if large-scale bad speculations are occasionally and stochastically undertaken, each of their effects persists for a long while; therefore, large-scale low frequency movements will dominate the movement of ε_t.

5.5.2.4 The optimization problem

Because the additional utility from bad speculations must be included in the utility function, the optimization problem of the representative household described by equations (1) and (2) must be changed. Including, the effects of bad speculations, the representative household maximizes expected utility

$$Max \ \ E_0 \int_0^{\infty} u_P \left(c_t, m_t, \beta_t\right) \exp(-\theta_P t) dt \quad (25)$$

subject to

$$\dot{a}_t = (r_t a_t + w_t + z_t) - [c_t + (\pi_t + r_t) m_t + q\beta_t] - g_t \ . \quad (26)$$

5.6 Mechanism underlying the upward trend due to bad speculations

5.6.1 Relation between bad speculation and consumption

As the result of optimization, that is, by equations (25) and (26),

$$\frac{\partial u_P\left(c_t^*, m_t, \bar{\beta}_t\right)}{\partial \bar{\beta}_t} = q \frac{\partial u_P\left(c_t^*, m_t, \bar{\beta}_t\right)}{\partial c_t^*} \quad (27)$$

is held on a balanced growth path. Equation (27), which describes the relation between c_t^* and $\bar{\beta}_t$, is analogous to equation (7) or (8), which describes the relation between c_t^* and m_t. Because c_t^* and m_t compete with each other as the source of utility, consumption (c_t^*) and bad speculation (β_t) also compete with each other from the perspective of the representative household as the source of utility. Of course, β_t competes with not only c_t^* but also m_t, and therefore, by equations (8) and (27),

$$\frac{\partial u_P(c_t^*, m_t, \bar{\beta}_t)}{\partial c_t^*} = (\pi_0 + r_t)^{-1} \frac{\partial u_P(c_t^*, m_t)}{\partial m_t} = q^{-1} \frac{\partial u_P(c_t^*, m_t, \bar{\beta}_t)}{\partial \bar{\beta}_t}$$

holds on a balanced growth path for $\theta_G = \theta_P$.

In addition, equation (27) indicates that the trend of bad speculations ($\bar{\beta}_t$) is not a free variable. It is subject to preferences μ and ρ, parameter q, and variable c_t^*. In particular, the trend of bad speculation is anchored by consumption (c_t^*); therefore, it will not diverge largely from the consumption trend. That said, as shown in the previous sections, bad speculations will fluctuate largely around their trend because of ε_t in equation (24).

5.6.2 Mechanism of the upward trend

By equations (13), (14), and (23),

$$\bar{\beta}_t = q^{-\frac{1}{\rho}} c_0^{*\frac{\mu}{\rho}} e^{\frac{\mu\eta}{\rho}t} . \tag{28}$$

Therefore, by equations (13) and (28),

$$\frac{\bar{\beta}_t}{c_t^*} = q^{-\frac{1}{\rho}} c_0^{*\left(\frac{\mu}{\rho}-1\right)} e^{\frac{\mu-\rho}{\rho}\eta t} . \tag{29}$$

Equation (29) indicates that, if $\rho < \mu$, the trend of the ratio of bad speculation to consumption ($\frac{\bar{\beta}_t}{c_t^*}$; equivalently, the trend of ratio of bad speculation to output) and therefore the credit-output ratio have upward trends and increase exponentially. If $\rho > \mu$, they trend downward, and if $\rho = \mu$, they trend neither upward nor downward.

Whether $\rho = \mu$, $\rho < \mu$, or $\rho > \mu$ is an empirical question, similar to the case of ζ and μ, but the possibility of $\rho < \mu$ (i.e., an upward trend) cannot be denied *a priori.*

5.7 Fluctuations around the trend

Conceptual money, capital for steady state, and good speculation do not contain stochastic elements that have a large variance, as discussed in the previous sections. Hence, they are highly unlikely to be the main source of fluctuations in the credit-output ratio.

On the other hand, equation (24) indicates that bad speculation is a stochastic variable with a large variance and can generate large-scale fluctuations around its trend; that is, ε_t can largely vary. Bad speculations therefore are probably the main source of fluctuations in the credit-output ratio.

Note that credit-output ratios below the trend do not indicate “negative amounts” of bad speculations. Rather, they indicate smaller amounts of bad speculations than usual because bad speculations have a positive trend ($\bar{\beta}_t$), and therefore, the total amount of bad speculations will always be non-negative.

6 ESTIMATES OF A LOG-LINEAR TREND

6.1 The need to estimate a log-linear trend of the credit-output ratio

The discussion in the previous sections indicates that conceptual money and bad speculation are most likely the origin of the upward trend in the credit-output ratio. In addition, the conceptual money-consumption ratio and the trend of the ratio of bad speculation to consumption increase exponentially as indicated by equations (20) and (29). This means that the trend of credit-output ratio should be estimated as a log-linear trend.

As shown in the previous sections, the trend of the credit-output ratio is the sum of (1) two constant parts (the ratios of capital for steady state and good speculation to output) and (2) two exponentially increasing parts (the conceptual money-consumption ratio and the trend of the ratio of bad speculation to consumption).

Here, by Maclaurin series, if $|\chi|$ and $|\omega|$ are sufficiently smaller than unity,

$$\ln(a + be^{\chi t} + ce^{\omega t}) \cong \ln(a + b + c) + \frac{b\chi + c\omega}{a + b + c} t \ , \tag{30}$$

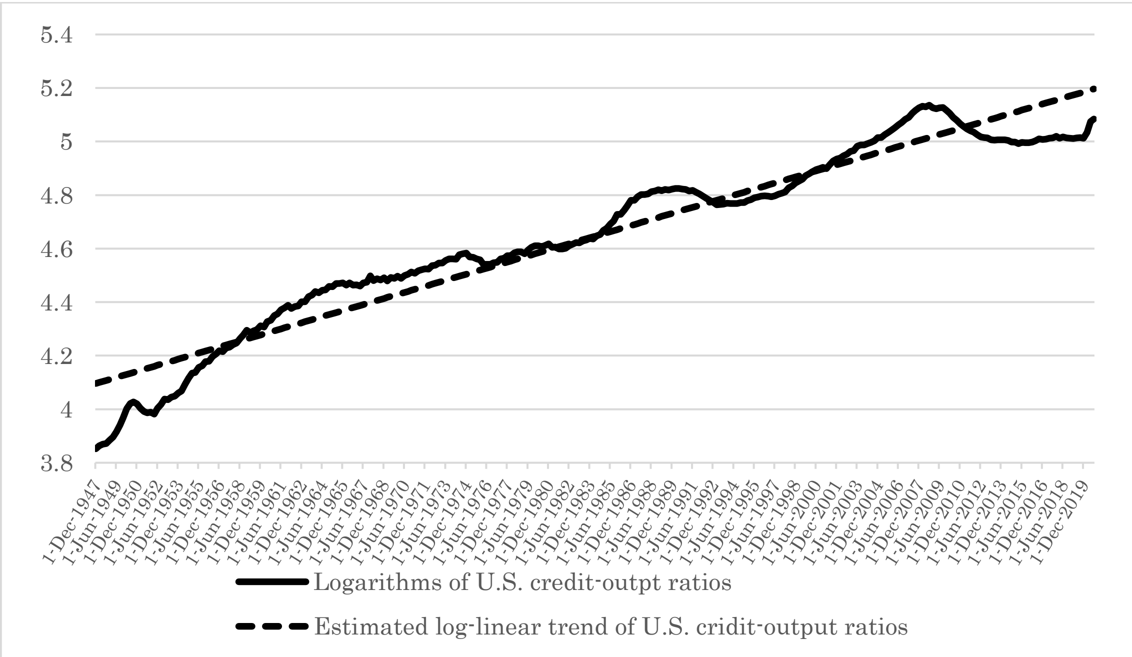
where $a(>0)$, $b(>0)$, $c(>0)$, χ, and ω are constants. The two exponentially increasing parts in the trend of the credit-output ratio (the conceptual money-consumption ratio and the trend of the ratio of bad speculation to consumption) correspond to $be^{\chi t}$ and $ce^{\omega t}$ in equation (30), respectively, and the sum of the two constant parts corresponds to a in equation (30). By equations (20) and (29), if $\left|\frac{\mu-\zeta}{\zeta}\eta\right|$ and $\left|\frac{\mu-\rho}{\rho}\eta\right|$ are sufficiently smaller than unity, the trend of the credit-output ratio can be approximately described as a log-linear trend, as indicated by equation (30). Because the economic growth rate η is basically far smaller than unity and positive, and both $\left|\frac{\mu-\zeta}{\zeta}\right|$ and $\left|\frac{\mu-\rho}{\rho}\right|$ will be less than unity (or at least not far larger than unity), the condition for the approximation will usually be satisfied. This means that the trend of the credit-output ratio should be estimated as a log-linear trend to calculate credit gaps.

6.2 Estimates

6.2.1 Trend without considering inflation

I ran a linear regression on logarithms of the yearly credit-output ratios of the U.S. (published by the BIS) using data starting in 1947 (Figure 4). An upward trend is clearly apparent.

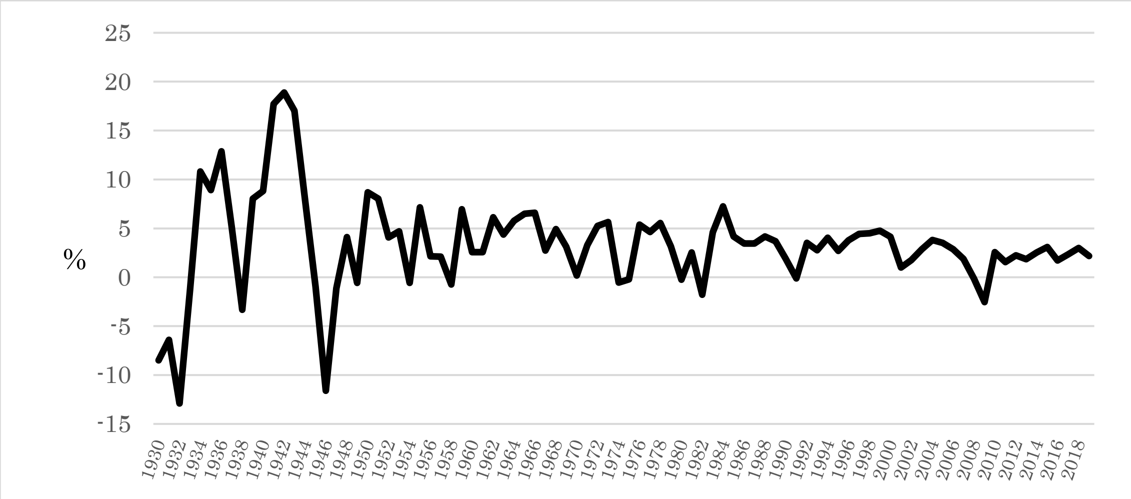
Figure 4: Estimated log-linear trend of the U.S. credit-output ratio since 1947



However, data during the period immediately after WWII seem to be significantly biased by the impacts of the Great Depression and WWII and their aftermath. A similar kind of bias can also be seen in the growth rate (Figure 5), where GDP clearly showed abnormal fluctuations during the Great Depression and WWII.

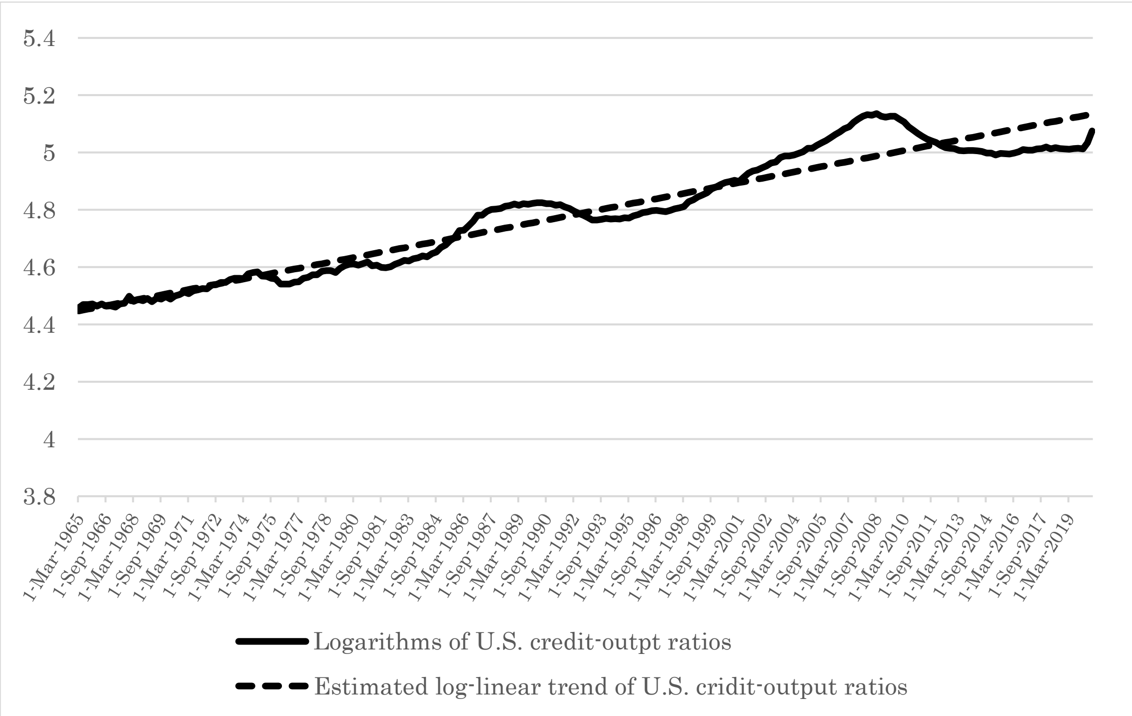
Figure 5 nevertheless indicates that it is likely that η (the growth rate of real GDP) was almost constant since the mid-1960s. Hence, I estimated a log-linear trend for 1965 to 2020 (Figure 6). The estimated trend shown in Figure 6 is very similar to that in Figure 4, but it appears to have a better fit with the data.

Figure 5: The growth rate of real GDP in the U.S.



Source: U.S. Bureau of Economic Analysis.

Figure 6: Estimated log-linear trend of the U.S. credit-output ratio since 1965



6.2.2 Trend after removing the effect of inflation

As shown in Section 3.4.4, increases of inflation will shift the credit-output ratio trend downwards. Because inflation was relatively high during the period of the Great Inflation in the 1970s (Figure 2), the credit-output ratio may have shifted lower in this period because of high inflation.

There are various methods to adjust or eliminate the effects of inflation in estimating the trend, but I simply removed the data from this period from the estimation. Specifically, from the 1965 to 2020 dataset, I excluded credit-output ratio data from the second quarter of 1973 to the third quarter of 1982.

Figure 7: Estimated log-linear trend of the credit-output gap of the U.S. (since 1965 excluding the period of the Great Inflation)

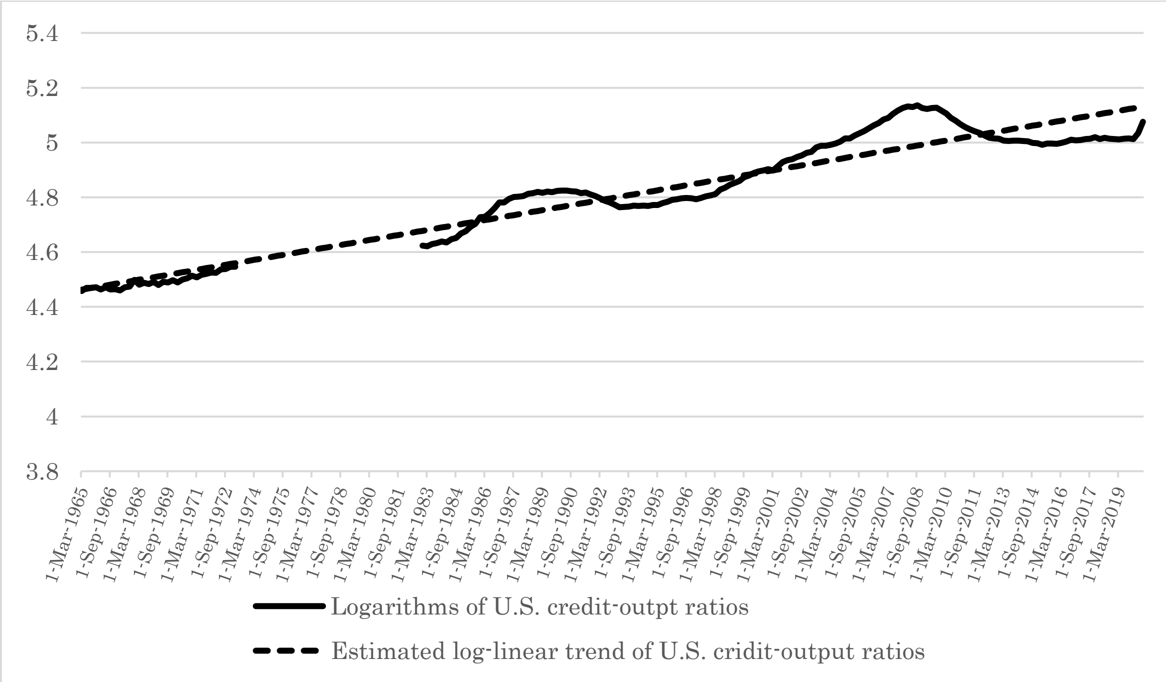


Figure 7 shows the estimated trend using the adjusted data. The estimated trend is very similar to the unadjusted trend (Figure 6), but it is shifted slightly upward from the unadjusted one. In this sense, the effect of the Great Inflation may be considered to be small.

7 THE CREDIT GAP

7.1 Credit gaps

Credit gaps indicate deviations of credit-output ratios from the trend. Specifically, I define the credit gap as the ratio of the deviation of the credit-output ratio to the exponential of the estimated log-linear trend. Let the credit-output ratio in a period be X_1 and the exponential of the value of the estimated log-linear trend be X_2 in that period. The value of the credit gap in that period (X_3) is defined as

$$X_3 = \frac{X_1}{X_2} - 1 .$$

In Section 6.1.1, I concluded that the trend of the credit-output ratio should be estimated as a log-linear trend. Therefore, to calculate credit gaps, I used the log-linear trends of the U.S. credit-output ratios estimated in Section 6.2, using data since 1965, with and without adjusting for the Great Inflation.

7.2 Credit gaps and information about a financial crisis

As discussed in Section 3.4.3, the trend of the credit-output ratio will generally be determined by output (GDP), but fluctuations of the credit-output ratio will not. As discussed in Section 5.7, of the elements that make up credits, only bad speculations can largely fluctuate, as indicated by ε_t in equation (24). Therefore, it is probable that the credit-output ratio fluctuates mostly in response to fluctuations in bad speculations and that credit gaps mostly reflect deviations of bad speculation from the trend. That is, a credit gap primarily originates in fluctuations of bad speculation.

Therefore, credit gaps seem to highly likely contain important information about financial crises because financial crises seem to be highly likely closely related to bad speculations.

7.3 Estimates

Figure 8 shows the estimated U.S. credit gaps based on the estimated log-linear trend of the credit-output ratio using data since 1965 with no adjustment for the Great Inflation (i.e., using the same data for Figure 7), and Figure 9 shows the same thing with the adjustment (i.e., using the same data for Figure 6).

Figure 8: Estimated U.S. credit gaps since 1965

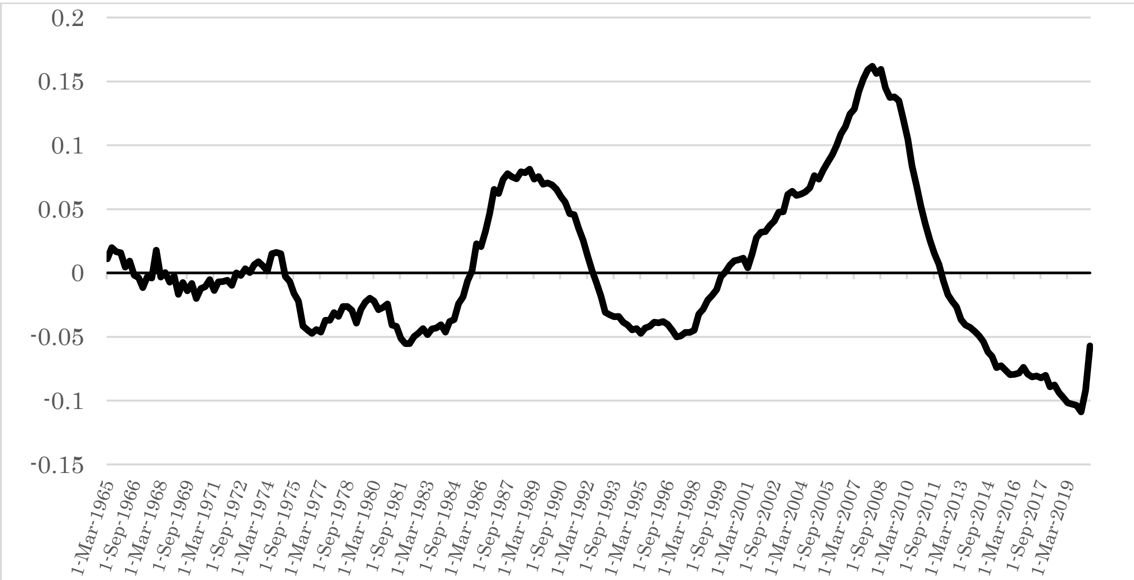
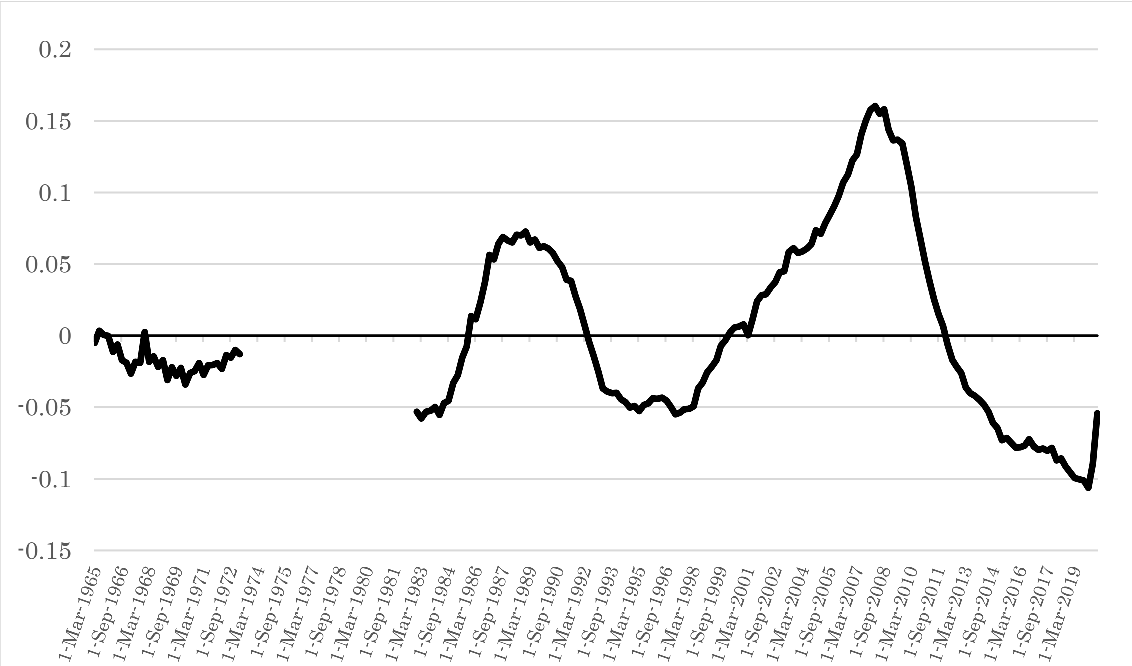


Figure 9: Estimated U.S. credit gaps since 1965 excluding the period of the Great Inflation



Figures 8 and 9 look similar in the periods before 1973 and after 1983, which indicates that the impact of the Great Inflation on credit-output ratios was small. They commonly indicate that two peaks in the credit gaps, one around 1988 and another around 2008. The latter peak (about a 16% deviation from the trend) is roughly two times higher than the former (about 8%).

7.3.1 Real-time estimates

As interesting as they are, Figures 8 and 9 only show the credit gaps estimated *ex post*. The real-time estimates (i.e., the credit gap in a period estimated in that period) would be far more helpful to predict a financial crisis. Therefore, I also estimated real-time credit gaps.

Figures 10 and 11 show real-time estimates based on the estimated log-linear trends of credit-output ratios, using data since 1980 without adjusting for the period of the Great Inflation and since 1983 with adjusting for it, respectively. In these figures, the credit gap value of a given year indicates the credit gap that would be estimated for that year using data from 1965 to that year.

Figures 10 and 11 commonly indicate that the real-time estimates of the U.S. credit gap again have two peaks: one in around 1988 and the other in about 2008. The difference between the figures is again small, showing the small effect of the Great Inflation. The main difference between the real-time estimates (Figures 10 and 11) and the present-day estimates (Figures 8 and 9) is that the real-time peaks are almost the same size (about a 10% deviation from the trend). Hence, a similar level of alarm or warning of a financial crisis could be felt in real time in those periods.

Figure 10: Estimated real-time credit gaps in the U.S. since 1980 without adjustment for the Great Inflation

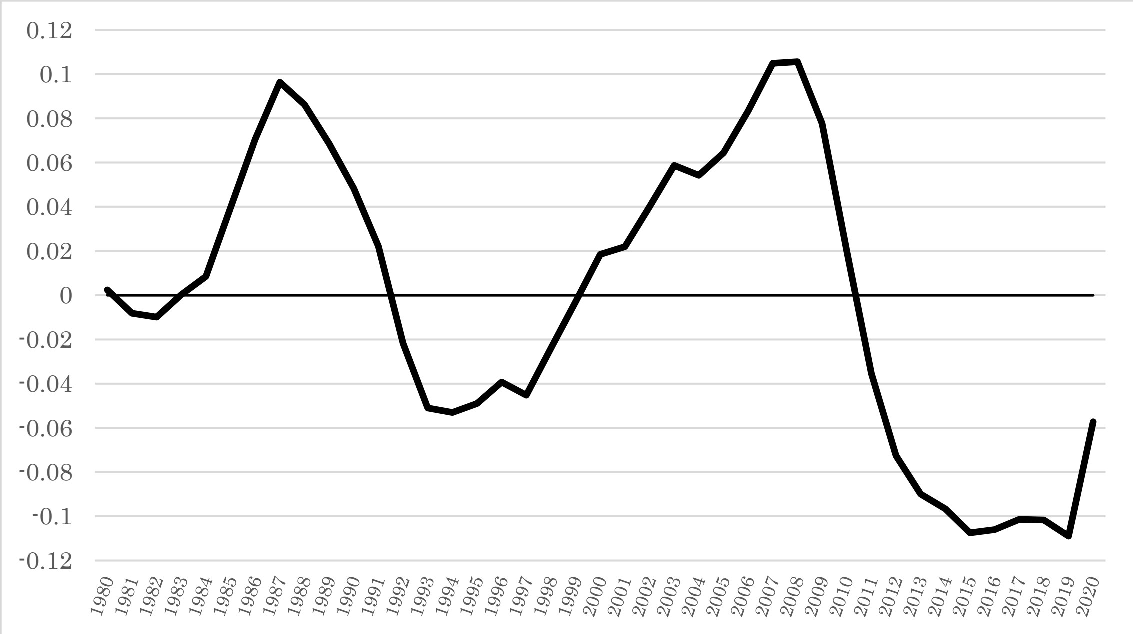
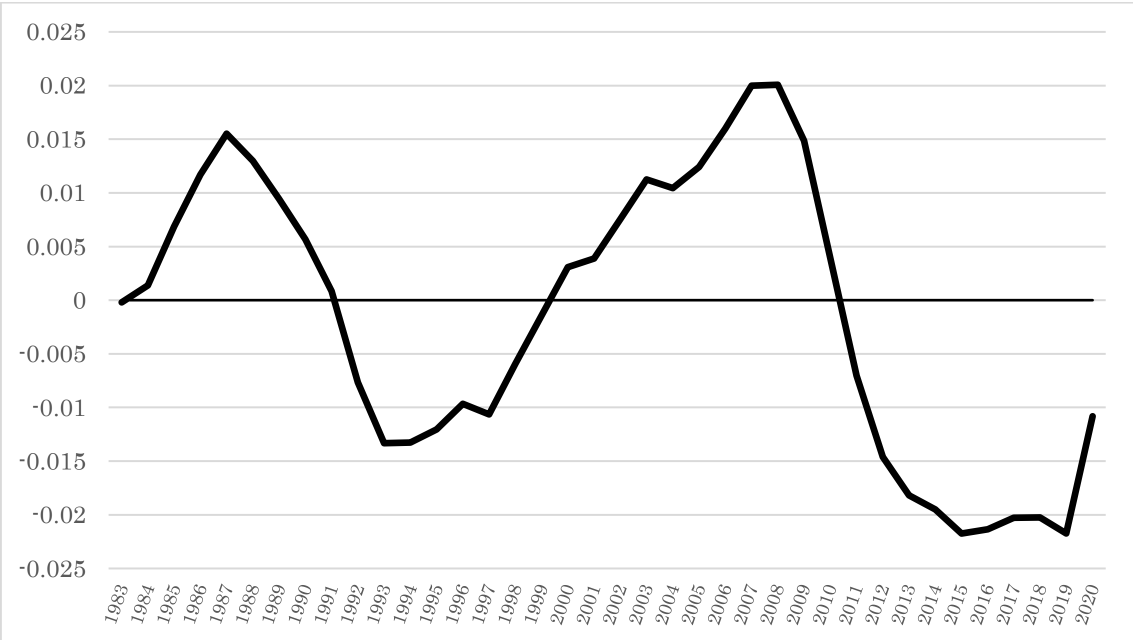


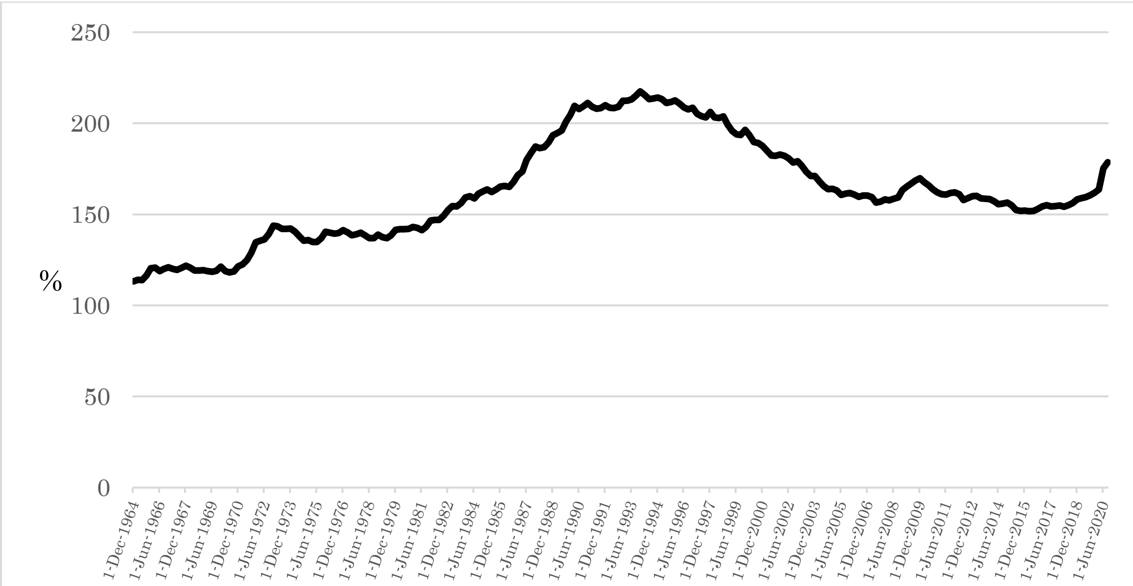
Figure 11: Estimated real-time credit gaps in the U.S. since 1983 with adjustment for the Great Inflation



7.4 Credit gaps of Japan

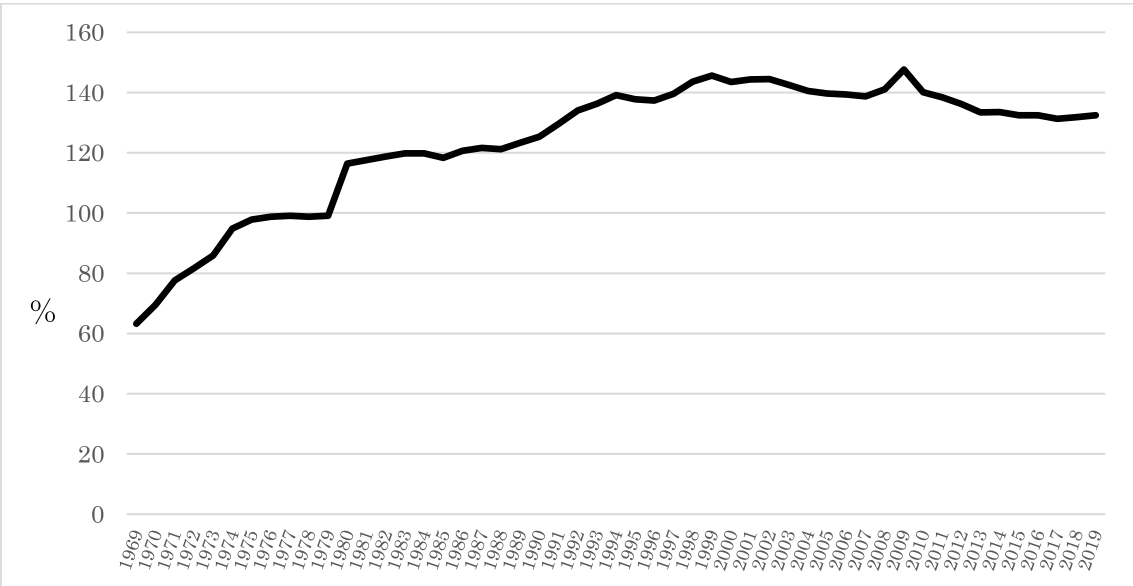
For comparison, I also examined credit-output gaps for Japan. Figure 12 shows Japan's credit-output (GDP) ratio since 1964. It appears to have an upward trend, but the trend is not as clearly recognizable compared as that of the U.S. The trend is somewhat ambiguous in Japan for the following two reasons.

Figure 12: Credit-to-GDP ratios of Japan since 1964



Source: The BIS

Figure 13: Estimated capital-output ratios of Japan



Source: "Real GDP," "Private non-residential fixed assets," and "Gross capital stock (incorporated enterprises)," in SNA (National Accounts of Japan) published by the Economic and Social Research Institute, Cabinet Office, the Government of Japan.

First, as shown in Figure 13, until the 1990s, the Japanese economy seems to have proceeded on a saddle point path (in a Ramsey-type growth model) because the capital-output ratio of Japan gradually increased until that point. Since then, however, the ratio has been almost constant or slightly decreasing. This means that Japan was accumulating capital in the earlier period to reach the steady state level; therefore, the capital-output ratio continued to increase in those periods. In other words, until the 1990s, Japan was in the process of catching-up to the developed economies. Accordingly, before the 1990s, the credit-output ratio of Japan increased more rapidly than that of an economy that is already at steady state (or on a balanced growth path). That is, it is highly likely the credit-output ratio of Japan was largely affected by this process of catching up.

Second, Harashima (2004a, 2016) showed that it is highly likely that Japan experienced a large-scale upward shift in CWR at MDC (RTP) in 1990. This large-scale shift resulted in a severe recession as the so-called “bubble economy” burst and an accompanying severe financial crisis, which made the amount of credit and the credit-output ratio decrease markedly. This sudden and significant change in economic conditions in 1990 makes the credit-output ratio trend of Japan unclear and ambiguous.

These two factors are closely related. The so-called “bubble economy” in the second half of 1980s that preceded the upward shift in CWR at MDC (RTP) in 1990 may have been generated because the Japanese were not well aware that the end of the “catching-up” process was approaching at that time, and therefore, they may have been too optimistic and still expected high economic growth rates. In addition, because Japan’s economy had been proceeding on a saddle point path (i.e., on the path of catching-up), the expected CWR at MDC (RTP) of the representative household had a relatively larger variance than usual (or than expected at steady state or on a balanced growth path), and therefore, it seems likely that bad speculators could spread misinformation (e.g., about the true CWR at MDC (RTP) of the representative household) and that many people in Japan in the 1980s believed it. However, this bad speculation eventually failed (or was revealed) in 1990, and people suddenly raised the expected CWR at MDC (RTP) of the representative household. As a result, the output-capital ratio (the reciprocal of the capital-output ratio) has increased since 1990s to match the level that corresponds to the higher expected CWR at MDC (RTP) of the representative household (i.e., the capital-output ratio has decreased, as Figure 13 indicates).

Because of these special and unique factors, it is difficult to correctly estimate Japan’s credit-output ratio trend. This means that it also would have been difficult to predict the financial crisis in Japan in the 1990s at that time. On the other hand, because the U.S. did not have such special factors, the U.S. may have been able to more easily predict the financial crisis in 2008 at that time if credit gaps were properly calculated, monitored, and considered.

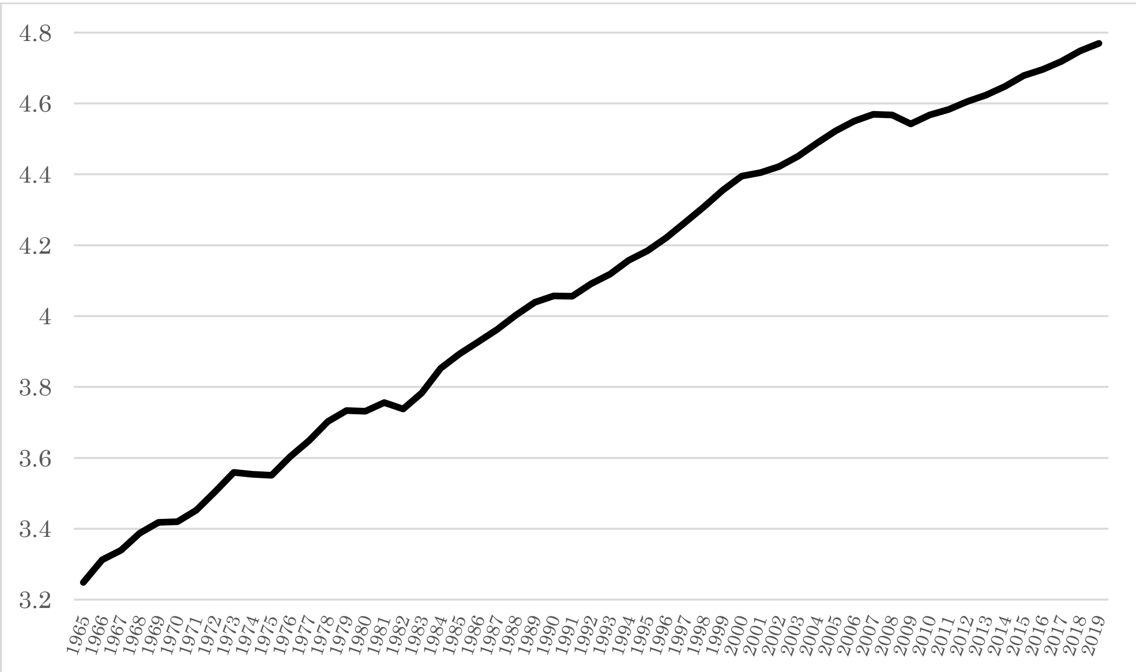
8 PREDICTABILITY OF FINANCIAL CRISES BY CREDIT GAPS

8.1 Predictability of financial crises

The serious turbulence in financial markets that sometimes accompanies a recession is often called a financial crisis. Although the term is not properly defined, the recessions in 2008 and 1990 in the U.S. are commonly regarded as financial crises that have accompanied recessions. In this section, therefore, I examine the relation between these two episodes and credit gaps.

As discussed in Section 7.2, it is highly likely that credit gaps contain important information about financial crises. To examine whether credit gaps actually contain such important information, I compared the estimated credit gaps and the movement of real GDP in the U.S. (Figure 14).

Figure 14: Logarithm of real GDP of the U.S. since 1965



Source: U.S. Bureau of Economic Analysis

Figure 14 indicates that real GDP decreased around 2008 and 1990 as well as in 1982, 1973, and 1969, whereas the estimated credit gaps in Figures 8, 9, 10, and 11 indicate two peaks around 2008 and 1988. The two credit gap peaks therefore can be judged to have preceded the decreases in real GDP in 2008 and 1990. This match suggests that real-time credit gaps could be used to predict the decreases in real GDP and the ensuing financial crises in 2008 and 1990. This conclusion matches the conclusions in many works on the predictability of financial crisis by credit gaps (e.g., Borio and Lowe, 2002; Borio and Drehmann, 2009; Drehmann and Juselius, 2014; Greenwood et al., 2021; Beltran et al., 2021).

It is unclear whether credit gaps could also be used to predict the recessions (as defined by the National Bureau of Economic Research) that began in 2001, 1981, 1980, 1973, and 1969.

8.2 Excessive bad speculations

The existence of the trend component in β_t (i.e., $\bar{\beta}_t$) means that bad speculations always exist in an economy to some extent. This means that the occurrence of financial crises cannot be fully explained only by the existence of bad speculations. It is possible that only excessive bad speculations (amounts far larger than $\bar{\beta}_t$) can generate financial crises, and if they are not excessive, no crisis will be generated.

As discussed in Section 7.4 and Harashima (2004a, 2016), the financial crisis since 1990 in Japan highly likely accompanied a significant increase in CWR at MDC (RTP). In addition, Harashima (2016) showed that the Great Recession in 2008 also highly likely accompanied a significant increase in CWR at MDC (RTP) in the U.S. These episodes imply that if bad speculations become excessive, they can affect and change fundamental elements (parameters) in an economy. Unlike the case of a "normal" level of bad speculations (i.e., that of $\bar{\beta}$), excessive bad speculations may influence not only the behaviors of people who are directly concerned but also those of many other ordinary people in an economy. In particular, they may have the power to make the expected preferences of the representative household change.

8.3 Limitations

8.3.1 Necessity to estimate the trend

If there were no upward or downward trend in the credit-output ratio (i.e., it is constant), deviations would be easily and clearly recognized and measured. However, if an upward trend exists, deviations are harder to clearly judge and measure, as discussed in previous sections. Unfortunately, an upward trends does actually exist. The necessity of appropriately estimating the trend of the credit-output ratio greatly constrains our ability to predict financial crises on that basis.

8.3.2 Shortage of samples

Only two episodes were available as samples of financial crises (Section 7), that is, those around 2008 and 1988. The number of available samples is too small. Furthermore, because of the lack of samples, it is very difficult to show which deviations from the trend are large enough to certainly cause a financial crisis and even more difficult to show the probability of occurrence of a financial crisis based on credit gaps.

Moreover, although the recession in 2001 is regarded to have been caused by the collapse of the speculative dot-com bubble, and therefore, credit gaps would seem to have been able to predict it, they failed, as shown in Figures 8, 9, 10, and 11. This means that only two of three cases studied could be successfully predicted, which makes it difficult to draw a clear conclusion on the predictability.

8.3.3 Various causes of recessions

Recessions occurred not only in 2008 and 1990 in the U.S., but also in 2001, 1981, 1980, 1973, and 1969, but credit gaps did not predict them because the trend deviations were not sufficiently large in those periods. A possible reason for these failures is that many of these recessions were not related to a financial crisis. For example, the recession in 1973 was generated because of the first oil crisis, that in 1980 because of the Reagan–Volcker disinflation policy, and that in 1981 because of the second oil crisis. Credit gaps will only be able to predict recessions resulting from excessive bad speculations (i.e., those that are accompanied by a financial crisis).

8.3.4 Inflation

Because the credit-output ratio is affected by inflation, as shown in Section 3.4.4, inflation is a factor that constrains the power to predict financial crises. Nevertheless, as indicated in Sections 6.2.2 and 7.3, the effect of inflation may not be large if the scale of inflation is less than or similar to that of the Great Inflation in 1970s. If much higher inflation (e.g., hyperinflation) is generated, however, its effect on credit-output ratios may not be negligible, and therefore, prediction of financial crisis may become even more difficult with credit gaps.

8.3.5 Low frequency of fluctuation of bad speculation

Figures 6 and 7 indicate that there is a notable low-frequency fluctuation of credit-output ratios. This type of fluctuation means that very long-term data of credit-output ratios are needed to appropriately estimate their trend for useful and meaningful prediction of financial crises. However, many kinds of irregular incidents will occur during a long period (e.g., wars, epidemics, and oil crises), and therefore, it may not be easy to obtain unbiased long-term data to appropriately estimate the trend.

8.3.6 Breaks of GDP trend

Figure 14 indicates that the trend of real GDP in the U.S. has had several breaks during the last half century. For example, the trend shifted downwards after 2008. Equations (7) and (8) indicate that, if the trend of real GDP breaks, the trend of the credit-output ratio will also break. However, if the trend of real GDP shifts downwards/upwards, those of conceptual money and bad speculation will also shift downwards/upwards. That is, effects of a GDP trend break on credit-output ratios will be canceled out to some extent. Hence, the effect of a trend break for real GDP is unclear. Nevertheless, if the magnitude of trend break of real GDP is sufficiently large, such a break may become an important factor constraining predictions.

9 CONCLUDING REMARKS

U.S. credit gaps increased significantly before the Great Recession. This coincidence of events enhanced the reputation of credit gaps as an important leading indicator of financial crisis. The Basel Committee for Banking Supervision of the BIS recommended using credit gaps for determining countercyclical regulatory capital buffers. Many studies have examined the predictability of credit gaps and concluded that credit gaps are a good predictor or leading indicator of financial crises.

However, before a credit gap can be used as a leading indicator of a financial crisis, the trend of the credit-output ratio must be appropriately estimated, but it is not necessarily easy to do so. To estimate the credit-output ratio appropriately, it is necessary to understand the mechanism by which credit-output ratios are generated.

Credits consist roughly of three types of financial instruments: conceptual money, capital for steady state, and good and bad speculations. On the basis of the money-in-utility function, I showed that the ratio of conceptual money to output can have an exponentially increasing upward trend. Furthermore, I constructed a model of bad speculation, and on the basis of the model, I showed that the ratio of the trend of bad speculation to output can also have an exponentially increasing upward trend. On the other hand, the ratios of capital for steady state and good speculation to output basically remain constant. Therefore, the trend of credit-output ratio should be estimated as a log-linear trend. I estimated log-linear trends of the credit-output ratio of the U.S. for several estimation periods to calculate credit gaps.

The model of bad speculation indicates that credit gaps are mostly generated due to fluctuations of bad speculations, and therefore, credit gaps will contain very important information about the occurrence of financial crises. The present and real-time U.S. credit gaps estimated in this paper both strongly imply that the financial crises around 2008 and 1990 could be anticipated if credit gaps were appropriately calculated and considered as an important leading indicator of financial crises at those times.

It still remains unclear whether credit gaps are useful in predicting financial crises because of several limitations, including difficulties in estimating trends, a small number of samples to study, and varying economic and social conditions over a long period of time (recession, inflation, GDP, etc.). Nevertheless, even with this uncertainty, when credit gaps are observed to be largely increasing, governments should at least begin to monitor economic conditions more carefully and in more detail than usual and prepare for a potential crisis.

References

Baron, Matthew and Wei Xiong (2017) "Credit Expansion and Neglected Crash Risk," *Quarterly Journal of Economics*, Vol. 132, pp. 713-764.

Beltran, Daniel O., Mohammad R. Jahan-Parvar and Fiona A. Paine (2021) "Optimizing Credit Gaps for Predicting Financial Crises: Modelling Choices and Tradeoffs," *Board of Governors of the Federal Reserve System, International Finance Discussion Papers*, No. 1307.

Borio, Claudio and Mathias Drehmann (2009) "Assessing the Risk of Banking Crises – Revisited," *BIS Quarterly Review*.

Borio, Claudio and Philip Lowe (2002) "Asset Prices, Financial and Monetary Stability: Exploring the Nexus," *BIS Working Papers* (114).

Drehmann, Mathias and Mikael Juselius (2014) "Evaluating Early Warning Indicators of Banking Crises: Satisfying Policy Requirements," *International Journal of Forecasting*, Vol. 30, No. 3, pp. 759-780.

Greenwood, Robin and Samuel G. Hanson (2013) "Issuer Quality and Corporate Bond Returns," *Review of Financial Studies*, Vol. 26, No. 6, pp. 1483-1525.

Greenwood, Robin, Samuel G. Hanson, Andrei Shleifer, and Jakob Ahm Sørensen (2021) "Predictable Financial Crises," *Harvard Business School Working Paper* 20-130

Harashima, Taiji (2004a) "A More Realistic Endogenous Time Preference Model and the Slump in Japan," *EconWPA Working Papers*, ewp-mac0402015.

Harashima, Taiji (2004b) "The Ultimate Source of Inflation: A Microfoundation of the Fiscal Theory of the Price Level," *EconWPA Working Papers*, ewp-mac/ 0409018.

Harashima, Taiji (2007a) "Why should central banks be independent?" *MPRA* (*The Munich Personal RePEc Archive*) *Paper*, No. 1481.

Harashima, Taiji (2007b) "The Optimal Quantity of Money Consistent with Positive Nominal Interest Rates," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 1504.

Harashima, Taiji (2007c) "Hyperinflation, Disinflation, Deflation, etc.: A Unified and Micro-founded Explanation for Inflation," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 3836.

Harashima, Taiji (2008) "A Microfounded Mechanism of Observed Substantial Inflation Persistence," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 10668.

Harashima, Taiji (2009) "Depression as a Nash Equilibrium Consisting of Strategies of Choosing a Pareto Inefficient Transition Path," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 18987.

Harashima, Taiji (2010) "Sustainable Heterogeneity: Inequality, Growth, and Social Welfare in a Heterogeneous Population," *MPRA* (*The Munich Personal RePEc*

Archive) *Paper* No. 24233.

Harashima, Taiji (2012) "Sustainable Heterogeneity as the Unique Socially Optimal Allocation for Almost All Social Welfare Functions," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 40938.

Harashima, Taiji (2013a) "The Optimal Quantity of Money Consistent with Positive Nominal Interest Rates," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 46, No. 2, pp. 27 - 36.（原嶋　耐治「正の名目金利と整合的な最適貨幣量」『金沢星稜大学論集』第 46 巻第 2 号 27-36 頁）.

Harashima, Taiji (2013b) "The Phillips Curve and a Micro-foundation of Trend Inflation," *Theoretical and Practical Research in Economic Fields*, Vol. 4, No. 2, pp. 153-182.

Harashima, Taiji (2013c) "An Asymptotically Non-Scale Endogenous Growth Model," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 44393.

Harashima, Taiji (2014a) "Time Preference Shocks," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 60205.

Harashima, Taiji (2014b) "The Representative Household Assumption Requires Sustainable Heterogeneity in Dynamic Models," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 57520.

Harashima, Taiji (2014c) "Sustainable Heterogeneity in Exogenous Growth Models: The Socially Optimal Distribution by Government's Intervention," *Theoretical and Practical Research in Economic Fields*, Vol. 5, No. 1, pp. 73-100.

Harashima, Taiji (2015) "Bubbles, Bluffs, and Greed," (2015) *Theoretical and Practical Research in Economic Fields*, Vol. 6, No. 1, pp. 29-56.

Harashima, Taiji (2016) "The Cause of the Great Recession: What Caused the Downward Shift of the GDP Trend in the United States?" *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 69215.

Harashima, Taiji (2017) "Sustainable Heterogeneity: Inequality, Growth, and Social Welfare in a Heterogeneous Population," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 51, No. 1, pp. 31 - 80.（原嶋　耐治「持続可能な非均質性—均質ではない構成員からなる経済における不平等、経済成長及び社会的厚生—」『金沢星稜大学論集』第 51 巻第 1 号 31～80 頁）.

Harashima, Taiji (2018a) "Hyperinflation, Disinflation, Deflation, etc.: A Unified and Micro-founded Explanation for Inflation," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 52, No. 1, pp. 41 - 68.（原嶋　耐治「ミクロ的基礎に立つインフレーションの統一的説明—超インフレーション、ディスインフレーション、デフレーション等—」『金沢星稜大学論集』第 52 巻第 1 号 41～68 頁）.

Harashima, Taiji (2018b) "Do Households Actually Generate Rational Expectations? "Invisible Hand" for Steady State," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 88822.

Harashima, Taiji (2018c) "Depression as a Nash Equilibrium Consisting of Strategies of Choosing a Pareto Inefficient Transition Path," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 51, No. 2, pp. 71 - 101.（原嶋 耐治「パレート非効率な移行経路を選択する戦略からなるナッシュ均衡としての恐慌」『金沢星稜大学論集』第51 巻第 2 号 71～101 頁）.

Harashima, Taiji (2018d) "Bubbles and Bluffs: Risk Lovers Can Survive Economically," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 83615.

Harashima, Taiji (2019a) "Do Households Actually Generate Rational Expectations? "Invisible Hand" for Steady State," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 52, No. 2, pp. 49 - 70.（原嶋 耐治「家計は実際に合理的期待を形成して行動しているのか―定常状態への「見えざる手」―」、『金沢星稜大学論集』第 52 巻第 2 号 49～70 頁）.

Harashima, Taiji (2019b) "A Theory of Inflation: The Law of Motion for Inflation under the MDC-based Procedure," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 94100.

Harashima, Taiji (2019c) "A Pareto Inefficient Path to Steady State in Recession" *Journal of Applied Economic Sciences,* Vol. 14, No. 3. pp. 842-850.

Harashima, Taiji (2019d) "An Asymptotically Non-Scale Endogenous Growth Model," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 52, No. 2, pp. 71 - 86.（原嶋 耐治「漸近的に規模効果が消失する内生的経済成長モデル」『金沢星稜大学論集』第 52 巻第 2 号 71～86 頁）.

Harashima, Taiji (2020a) "A Microfounded Mechanism of Observed Substantial Inflation Persistence," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 53, No. 2, pp. 83 - 110.（原嶋 耐治「物価上昇率に顕著な持続性が観察される機序のミクロ的基礎付け」『金沢星稜大学論集』 第 53 巻第 2 号 83-110 頁）.

Harashima, Taiji (2020b) "Sustainable Heterogeneity as the Unique Socially Optimal Allocation for Almost All Social Welfare Functions," in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 54, No. 1, pp. 71 - 95.（原嶋 耐治「殆ど全ての社会的厚生関数に対して唯一の社会的に最適な配分をもたらすものとしての持続可能な非均質性」『金沢星稜大学論集』 第 54 巻第 1 号 71～95 頁）.

Harashima, Taiji (2021a) "Consequence of Heterogeneous Economic Rents under the MDC-based Procedure," *Journal of Applied Economic Sciences,* Vol. 16, No. 2. pp. 185-190.

Harashima, Taiji (2021b) "Economic Inequality and Heterogeneous Success Rates of Investment," *MPRA* (*The Munich Personal RePEc Archive*) *Paper* No. 110688.

Harashima, Taiji (2021c) "The Cause of the Great Recession: What Caused the Downward Shift of the GDP Trend in the United States?" in Japanese, *Journal of Kanazawa Seiryo University*, Vol. 54, No. 2, pp. 55-67.（原嶋 耐治「世界同時不

況の原因―米国のGDP傾向変動の下方移動は何故生じたのかー」『金沢星稜大学論集』第54巻第2号55～67頁）.

Kaldor, Nicholas (1957) “A Model of Economic Growth,” *The Economic Journal*, Vol. 67, pp. 591–624.

Krishnamurthy, Arvind and Tyler Muir (2017) “How Credit Cycles across a Financial Crisis,” *NBER Working Papers* 23850

López-Salido, David, Jeremy C. Stein and Egon Zakrajšek (2017) “Credit-Market Sentiment and the Business Cycle,” *The Quarterly Journal of Economics*, Vol. 132, No. 3, pp. 1373-1426.

Mian, Atif, Amir Sufi and Emil Verner (2017) “ Household Debt and Business Cycles Worldwide,” *The Quarterly Journal of Economics*, Vol. 132, No. 4, pp. 1755-1817.

Schularick, Moritz and Alan M. Taylor, (2012) “Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008,” *American Economic Review*, Vol. 102, pp. 1029-1061.

Sidrauski, Miguel. (1967) “Rational Choice and Patterns of Growth in a Monetary Economy,” *American Economic Review*, Vol. 57, No. 2, pp. 387–393.