Bubbles and Global Imbalance

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Abstract

We provide a simple model of overlapping-generations with imperfect pledgeability to explain the coexistence of the historically low real interest rate, asset bubbles, and capital under-accumulation, all of which have prevailed in the recent world economy. In addition, we divide the world economy into two regions with the difference in financial development to explain the greater imbalance of current account in the bubbly economy and the investment boom in the deficit region.

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1. Introduction

Over the past decade, the world economy has been featured by the historically low real interest rate and asset bubbles. At the same time, the deficit of the current account of the United State has been remarkably increasing at the same period when bubbles have emerged. Additionally, the economy of the United State has experienced the economic boom with the comovement between investment in capital and bubbles.

Bubbles and current account imbalances have been argued independently. The enormous literature has attempted to explain the “global imbalance”, including Obstfeld and Rogoff (2005a, 2005b), Blanchard et al (2005), Edward (2005), Engel and Rogers (2006), Choi et al (2008), Cooper (2008), and others. However, all the literature relied on the intertemporal approach proposed by Obstfeld and Rogoff (1996) and hence is silent on bubbles.

Recently, a number of papers have recently investigated the impacts of bubbles on economic activities, including Kray and Ventura (2006), Caballero and Krishnamurthy (2006), Caballero et al (2008a), and Farhi and Tirole (2008). However, there are few papers that link bubbles and current account imbalances. To our small knowledge, the exceptions are Kray and Ventura (2006) and Caballero et al (2008b). Kray and Ventura (2006) develop a story in which the large current account deficit of the US is closely related to an increase in the outstanding stock of government debt that has replaced bubbles in firm equities. Caballero et al (2008b) develop a story that interconnects the global imbalance, the subprime crisis, and asset bubbles.

The purpose of this paper is twofold. First, we develop a model that explains the coexistence of the historically low real interest rate, asset bubbles, and capital under-accumulation, all of which have emerged in the recent world economy. Second, we divide

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1 Caballero et al (2006) explained capital inflows as one of major sources of funding investment boom in United States, but did not give an argument linking the current account imbalance to bubbles.
the world economy into two regions with the difference in financial development to explain the
greater imbalance of current account in the bubbly economy and the investment boom in the
deficit region.

The starting point of the argument is Tirole (1985) that develops the theory of rational
bubbles in the growth model of overlapping generations. However, his argument has a critical
drawback to explain the recent observations on how bubbles impact on economic activities. In
Tirole (1985), bubbles arise and develop so as to eliminate capital over-accumulation. But we
find no evidence for capital over-accumulation, but rather for capital under-accumulation (e.g.,

Imperfect pledgeability in financial contracts is a central notion to solve this difficulty. The
poor working of capital markets brought about by imperfect pledgeability gives rise to the
wedge between the rate of return to capital and the real interest rate [e.g., Stiglitz and Weiss
(1981), Gale and Hellwig (1985), Williamson (1986), and others]. The weak ability of supplying
financial assets becomes the source of the low real interest rate that calls for asset bubbles,
which in turn reinforces the investment slump. Asset bubbles move the capital stock to the
smaller level than the Golden Rule, and hence coexist with capital under-accumulation.

At the next step, we divide the world economy into two regions with the difference in the
extent of imperfection of pledgeability, in other words, financial development. The difference in
financial development becomes the source of current account imbalances, shifting capital from
the financially less-developed to the financially developed region. Remarkably, the supply curve
of financial assets is subject to decreasing returns to capital when financing capital, but not
downwardly-sloped but flat when financing bubbles. International bubbles promote further
reallocation of capital, and enlarges the current account imbalance. Then the deficit region
enjoys the investment boom, and at the same time supplies greater bubbles in the international
market. Not only the difference in financial development but also the asymmetry in the ability of supplying international bubbles that will also be related to institutional quality is one of determinants of current account imbalance.

The model predicts an interesting story on the emergence of the global bubbles and the greater imbalance of current account. Asian emerging countries grew faster than other regions over this decade and increased output share in the world economy despite their weak financial systems [e.g., Caballero et al, 2008a]. The deterioration of the world-wide “average” institutional quality led to the low interest rate and global bubbles. Noteworthy, the global saving rate has been almost constant at 22-23 percent past twenty years (see Figure 5 below) so that emerging Asian countries should not be responsible primarily for bubbles.

Caballero et al (2008b), most closely related to ours, develop a story that links the current account imbalance and bubbles to explain the current financial crisis of the United States. They show that the country with developed financial markets runs the greater current account deficit when bubbles emerge, but their Lucas (1978) exchange economy is silent to the interconnection among the reallocation of capital, bubbles, and the global imbalance.

This paper is also related to the recent literature that explains the comovement between investment in capital and bubbles. The literature includes Ventura (2003), Caballero and Krishnamurthy (2006), Caballero et al (2006), and Farhi and Tirole (2008).2 In our model, the

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Caballero et al (2006) develop their argument for the growth-saving feedback so as to explain the high correlation between investment and stock prices, and bubbles. Farhi and Tirole (2008) develop a model of imperfect pledgeability where the bubbly steady state features more investment than the bubbleless steady state. Ventura (2003) provides a setting in which entrepreneurs issue debt and also equity to finance investment, where equity takes the form of bubble creation. Caballero and Krishnamurthy (2006) develop a small-open economy in which asset bubbles used for collateral for financing productive investment promote investment in capital.
region with high institutional quality can exploits the decline in the real interest rate first by increasing investment in capital, and secondly by issuing bubbles in the international market.

This paper is also related to the literature that emphasizes the difference in the institutional quality as one primary determinant of capital flows or/and the current account. Boyd and Smith (1997) and Matsuyama (2004) show that the difference in financial frictions brought about by borrowers’ balance-sheets influences capital flows. Sakuragawa and Hamada (2001) demonstrate that the difference in pledgeability to financial assets determines capital flows. Caballero et al (2008a) show that the difference in financial development measured specifically by the capital income share determines capital flows.

This paper also contributes to the arguments on dynamic efficiency/inefficiency, capital over/under accumulation, and sustainability of asset bubbles. Bubbles do not necessarily work as means of enhancing efficiency dynamically in an economy with imperfect pledgeability. This feature arises from the fact that the initial bubbleless economy is Pareto sub-optimal. In the presence of wedge between social and private returns to capital, the one-to-one relationship between dynamic efficiency/inefficiency and bubbles break down (e.g., Saint-Paul (1992), Grossman and Yanagawa (1993) and Femminis (2002)). Bubbles can arise even when the bubbleless economy is dynamic efficient. In addition, even capital over-accumulation is not always a source of dynamic inefficiency. Bubbles may bring the overly-capitalized economy down to a situation of scarce capital.

This paper is organized as follows. Section 2 gives the overview. Section 3 sets up the model and studies the benchmark economy. Section 4 analyzes the world economy when there are frictions in financial markets. Section 5 investigates the two-region version of the model so as to exploit arguments on the great imbalance.
2. Overview of the Recent World Economy

The coexistence of the historically low real interest rate, asset bubbles, and weak investment demand relative to great savings, in other words, capital under-accumulation is a dominant feature of the world economy over this decade. This phenomenon is seemingly casual, but unusual from economic theories. Investigating interest rates versus economic growth rates will give a hint to solve this puzzle.

Figure 1 illustrates several interest rates and the economic growth rate averaged over G7 countries (U.S., U.K., Japan, Germany, France, Canada, and Italy). Until the end of 1990s, all the interest rates except for the deposit rate were greater than the economic growth rate, but this situation has changed around 2000. Some of interest rates began to be smaller than the economic growth rates, and since 2004, all the interest rates are smaller than the economic growth rates.

The recent observation for the greater economic growth rates than interest rates is consistent with economic theories on bubbles. Diamond (1965), Ihori (1978), and Tirole (1985) explain the sustainability of asset bubbles in the model of finitely-lived agents, and show that asset bubbles exists when capital is overly accumulated in the bubbleless economy, put differently, when the rate of return to capital is smaller than economic growth rate. Since the late 1990s, we have witnessed several bubbles, including the dot-com bubbles, real estate booms, stock market booms, and recently appreciations in gold and oil. Their story explains the coexistence of bubbles and low interest rates, but cannot explain why capital-under accumulation that coexists

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3 Each of interest rates and the economic growth rate is a simple average of G-7 countries (source: IFS). We exclude the 1991 data of German in calculating averages. Money market rate, treasury bills, treasury bills: 3 years or longer, deposit rate, and max overdraft reflect call rate, short-term rate of the government bond, long-term rate of the government bond, short-term deposit interest rate, and loan interest, respectively.

4 Additionally, behind asset bubbles in China that have been sustained for more than two decades is the far higher economic growth rate than the interest rates.
with bubbles.

We check capital under- or over-accumulation by the criterion proposed by Abel et al. (1989) that compare capital income and the aggregate investment, not relying on rates of returns to capital that are often unobservable in actual economies. According to their criterion, the economy is dynamically efficient (inefficient) if and only if capital income is greater (smaller) than investment.

Table 1 describes gross capital income less gross investment divided by GDP over G7 countries for the sample of 1990-2004 (source: *National Accounts of OECD Countries*). Every figure is positive in every country so that we can safely conclude that all the listed countries have been dynamically efficient and experienced capital under-accumulation. This tendency for capital under-accumulation is not specific to advanced countries. The observation in the recent international capital mobility suggests the world-wide stagnant investment. Capital does not flow from OECD to non-OECD countries, but flows from non-OECD to OECD countries (e.g., Prasad et al. (2007)), suggesting the evidence of stagnant investment in emerging economies.

3. Basic Model

Looking at these observations, we are tempted to describe a dynamic model that explains the coexistence of the low real interest rate, asset bubbles, and capital under-accumulation.

Let us consider an economy of overlapping generations that lasts for infinity. At each period \( t = 0, 1, 2, \ldots, \infty \), the economy is populated by a continuum of *ex ante* identical agents that live for two periods and supplies one unit of labor when young. There is no population growth. The technology level grows at an exogenous rate \( g \), satisfying \( A_{t+1} = (1 + g)A_t \). At each period the final good is produced by firms that use labor and capital as inputs according to the
constant-returns-to-scale technology described as \( Y_t = F(K_t, A_t N_t) \), where \( K_t \) and \( N_t \) are aggregate supplies of capital and labor. The labor force is constant over time and normalized unity. Letting \( k_t(= K_t/A_t) \) denote capital per effective worker, the output per effective worker is described as \( y_t \equiv Y_t/A_t = F(K_t/A_t, 1) \equiv f(k_t) \), where \( f(.) \) is thrice continuously differentiable, increasing, concave, satisfying \( f(0) = 0 \), and \( \lim_{k_t \to 0} f'(k_t) = +\infty \). Since the production technology is homogeneous of degree one, output of the final good can be described in terms of the action of a single, aggregate, price-taking firm. From the profit-maximizing behavior of that firm, output is exhausted by the payment to two inputs and each input is paid its marginal product. The rate of return to capital \( R_t \) and the wage rate \( W_t \) are determined to satisfy \( R_t = f'(k_t) \) and \( w_t = f(k_t) - k_t f'(k_t) = W(k_t) \), respectively. The final good is numeraire. Assume that capital depreciates fully after one period. The price of capital is then equal to \( R_t \).

Each of \( \text{ex ante} \) identical agents born at \( t \) maximizes \( \log c^f_t + \beta E_t \log c^{o}_{t+1} \), where \( c^f_t (c^{o}_{t+1}) \) is consumption in the first (second ) period of life, and \( E_t \) is the expectation operator.

At the first period of life, each of them supplies one unit of time inelastically in the labor market. Having received the wage repayment from the firm, each agent discovers his/her type. With probability \( \alpha (0 < \alpha < 1) \), he is an “entrepreneur”, while with probability \( 1 - \alpha \), he turns out to be an “investor”.

Each of entrepreneurs has access to one linear capital investment technology that transforms one unit of the final good into one unit of capital after one period. On the other hand, any investor cannot have access to the capital investment technology and earns the second-period income only by investing the first-period income in lending to others or holding assets.

Assume that there is no enforcement mechanism to fulfill financial contracts between...
debtors and creditors and hence to enforce on borrowers to repay their debt. When debtors breach the contract and refuse to make their repayment, a portion $\lambda (0 < \lambda < 1)$ of their earnings are assumed to be forfeited by the creditor. Put differently, a portion $\lambda$ of borrowers’ assets are pledgeable. The parameter $\lambda$ represents pledgeability, and thus captures the efficiency of the broadly defined financial system. A low $\lambda$ is interpreted to capture weak bankruptcy procedure, poor bank monitoring, and low contract enforcement, and will be associated with poor financial development. A low $\lambda$ is interpreted to capture weak bankruptcy procedure, poor bank monitoring, and low contract enforcement, and will be associated with poorly developed financial markets. Much literature on economic growth has argued the importance of institutional quality (e.g., North (1981), Hall and Jones(1999), Acemoglu et al(2001) and others). La Porta et al (1997, 1998), Beck et al(2000), and Levine et al(2000) have linked economic and financial developments by using various indicators of investor rights and protection, and legal enforcement as instrumental variables for financial development. The parameter $\lambda$ is thus interpreted to capture the efficiency of the broadly defined financial system.

First of all, we investigate an economy under perfect capital market with $\lambda = 1$. Letting $I_t$ denote the amount of investment, $X_t$ denote the amount of saving, and $r_{t+1}$ denote the interest rate prevailing at $t+1$, any of entrepreneurs earns $f'(k_{t+1})I_t - (1 + r_{t+1})(I_t - X_t)$ by implementing own project, while $(1 + r_{t+1})X_t$ by supplying his first-period income to others. Entrepreneurs are willing to start their own projects if

\[
(2-1) \quad f'(k_{t+1}) \geq 1 + r_{t+1}.
\]

We call this inequality the **profitability constraint**. The “AK” structure of the investment project makes the inequality bind with equality. Eventually,

\[
(2-2) \quad f'(k_{t+1}) = 1 + r_{t+1}
\]

is only sustainable in equilibrium. Entrepreneurs and investors then earns $1 + r_{t+1}$ per unit
equally, and the uncertainty about his/her type is irrelevant. The aggregate capital is defined as
the population of entrepreneurs $\alpha$ multiplied by the individual investment size $I$, so
that $K_{t+1} = \alpha I$, and hence we have
\begin{equation}
(1 + g)k_{t+1} = \alpha I_t / A_t.
\end{equation}
Both entrepreneurs and investors save a fraction $s \equiv \beta / (1 + \beta)$ of the first-period income. Let
$B$ denote units of aggregate bubbles, and $p_t$ denote the price of each unit of bubbles. The
aggregate savings $sAW_t$ are used for financing investment in capital $\alpha I_t$ and purchasing
bubbles $p_tB_t$, and its relation is described by
\begin{equation}
sAW(k_t) = \alpha I_t + p_tB_t.
\end{equation}
Letting $b_t(\equiv p_tB_t / A_t)$ denote bubbles per effective worker at time $t$, and using (2-3), (2-4) is
expressed by
\begin{equation}
sW(k_t) = (1 + g)k_{t+1} + b_t.
\end{equation}
Under perfect foresight, bubbles have to earn the same rate of return as that on capital to satisfy
$p_{t+1} / p_t = 1 + r_{t+1}$. Given that the net supply of nominal bubbles is zero, the aggregate bubbles
per effective worker thus grow to satisfy
\begin{equation}
\frac{b_{t+1}}{b_t} = \frac{1 + r_{t+1}}{1 + g}.
\end{equation}
Finally we exclude negative bubbles;
\begin{equation}
b_t \geq 0.
\end{equation}
We define two kinds of equilibria. A bubbleless economy is defined as an equilibrium in which
$b_t = 0$ for any $t$ or $b_t$ converges to zero if $b_t > 0$ for any $t$. A bubbly economy is defined as
an equilibrium in which $b_t$ does not converge to zero.

First of all, we examine the analysis of steady states. The steady state of a bubbleless
economy is characterized by a pair $\{k, \bar{F}\}$, satisfying $(1 + g)\bar{k} = sW(\bar{k})$, and $1 + \bar{F} = f'(\bar{k})$.
On the other hand, the steady state of a bubbly economy is characterized by a
pair \( \{ k_{GR}, r_{GR}, b_{GR}\} \), satisfying \( (1 + g)k_{GR} + b_{GR} = sW(k_{GR}), \) \( 1 + r_{GR} = f'(k_{GR}), \) and \( r_{GR} = g, \) with \( b_{GR} > 0. \)

We briefly summarize the properties of the economy under perfect financial markets. If \( \bar{\gamma} > g \), there exists a unique bubbleless economy and the interest rate converges to \( \bar{\gamma} \), while otherwise, there exists an asymptotically bubbly economy and the interest rate converges to \( g \) [Tirole (1985, Proposition 1)]. Ihori (1978) demonstrates that the government bond, which is intrinsically valueless, carries the long-run capital level to the Golden Rule level of capital when \( \bar{\gamma} < g. \)

### 4. The World Economy with Financial Market Imperfections

We now introduce the financial market friction into the benchmark model. The financial market is competitive in the sense that both borrowers and lenders take the equilibrium rate \( r_{t+1} \) as given. If any of entrepreneurs borrows \( (I_t - X_t) \) and repays \( (1 + r_{t+1})(I_t - X_t) \) honestly, his earnings will be \( f'(k_{t+1})I_t - (1 + r_{t+1})(I_t - X_t), \) while if he breaches the promise for repayment, a portion \( \lambda \) of his earning is forfeited, and his earning would be \( (1 - \lambda)f'(k_{t+1})I_t. \) The incentive compatibility constraint that induces entrepreneurs to commit the truthful behavior is given by

\[
(3-1) \quad (1 + r_{t+1})(I_t - X_t) \leq \lambda f'(k_{t+1})I_t. \tag{3-1}
\]

Equation (3-1) implies that entrepreneurs can borrow the amount up to some fraction of the project revenue so that it will be called the “borrowing constraint”. 

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5 Implicit in (3-1) is that entrepreneurs do not use the borrowed fund to buy bubbles. Entrepreneurs will borrow only for capital investment because the rate of return from capital is greater than the one from holding bubbles when (3-1) binds with equality, as argued below.

6 A number of other incentive considerations allow one to derive the similar borrowing constraint. For example, the literature on credit rationing (e.g., Stiglitz and Weiss (1981), Williamson (1986), Aghion and Bolton (1997), and others) leads eventually to the same
When the borrowing constraint binds with equality, the rate of return that entrepreneurs earn will be different from that investors earn. Letting \( z_{t+1} \) denote the rate of return from implementing own project, each of agents that save the amount of \( X_t \) earns \( z_{t+1}X_t \) if he/she is an entrepreneur, while \( (1 + r_{t+1})X_t \) if he/she is an investor.\(^7\) Any agent that is ex ante identical choose the saving \( sA_w \) to maximize
\[
\log(A_w - X_t) + \beta \log X_t + \beta (1 - \alpha) \log(1 + r_{t+1}) + \beta \alpha \log z_{t+1}.
\]

The market clearing in the capital market is given by
\[
\alpha (I_t - sA_w) = (1 - \alpha)sA_w - p_i B_i,
\]
where the L.H.S. is the aggregate demand for funds by entrepreneurs, and the R.H.S. is the aggregate supply of fund by investors, except for holding bubbles. This equation is finally expressed as
\[
(3-2) \quad sW(k_t) = (1 + g)k_{t+1} + b_t,
\]
which is the same as (2-5).

The determination of the real interest rate requires careful analysis. Either the profitability constraint or the borrowing constraint, should bind with equality. If the borrowing constraint is not binding, the profitability constraint should bind with equality, whereas if the borrowing constraint is binding with equality, the profitability constraint may not be binding. The above argument is summarized by the following;
\[
(3-3) \quad 1 + r_{t+1} = \min \{f'(k_{t+1}), \frac{\lambda f'(k_{t+1})}{I_t - sA_w} \}.
\]
Without loss of generality, we confine attention on symmetric equilibria in which all entrepreneurs choose the same amount of investment.

\(^7\) Strictly, we have \( z_{t+1} = \frac{(1 + g)k_{t+1}}{\alpha W(k_t)} f'(k_{t+1}) + \left\{1 - \frac{(1 + g)k_{t+1}}{\alpha W(k_t)}(1 + r_{t+1}) \right\}.\)
When the borrowing constraint binds with equality, (3-3) is replaced by

\[ 1 + r_{t+1} = \frac{\hat{\lambda} f'(k_{t+1})}{(1 + g) k_{t+1}} \frac{(1 + g) k_{t+1}}{(1 + g) k_{t+1} - \alpha W(k_t)}. \]

When the borrowing constraint is binding with equality, (2-6), (3-2), and (3-4) define a bubbly economy with \( b_t > 0 \) for \( t \to \infty \). The steady state is expressed as a pair \( \{\tilde{k}_b, \tilde{b}, \tilde{r}_b\} \), satisfying

\[ sW(\tilde{k}_b) = (1 + g)\tilde{k}_b + \tilde{b} \]

\[ 1 + \tilde{r}_b = \frac{\hat{\lambda} f'(\tilde{k}_b)}{(1 + g)\tilde{k}_b - \alpha W(\tilde{k}_b)}, \]

\[ \tilde{r}_b = g. \]

Before proceeding to the analysis of the bubbly economy, it is useful to study the bubbleless economy. Equation (3-3) then reduces to

\[ 1 + r_{t+1} = \min\{f'(k_{t+1}), \frac{\hat{\lambda}}{1 - \alpha} f'(k_{t+1})\}. \]

It is straightforward to see that the borrowing constraint is binding only if \( \alpha + \hat{\lambda} < 1 \), and then we have \( 1 + r_{t+1} = \frac{\hat{\lambda} f'(k_{t+1})}{1 - \alpha} \). Hereafter we impose the following in order to focus on an interesting case.

**Assumption 1** \( \alpha + \hat{\lambda} < 1 \).

Assumption 1 is intended to describe an economy when financial market imperfections are serious.\(^8\) Under Assumption 1, we obtain \( 1 + r_{t+1} < f'(k_{t+1}) \).

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\(^8\) The fraction of entrepreneurs \( \alpha \) is a measure of separation between creditors and debtors, and matters when the borrowing constraint is crucial. As \( \alpha \to 1 \), outside funds are negligible, and all investment is carried out directly by entrepreneurs, while as \( \alpha \to 0 \), outside funds are more important, and each of entrepreneurs has to borrow the greater amount from investors. Another parameter \( \hat{\lambda} \) capture the development of the contract enforcement mechanism as argued above. As \( \hat{\lambda} \to 1 \), the incentive compatibility constraint is always satisfied, and
The steady state of an economy with the binding borrowing constraint is characterized by the pair \( \{ \tilde{k}, \tilde{r} \} \), satisfying \((1 + g)\tilde{k} = sW(\tilde{k})\), and \(1 + \tilde{r} = \frac{\lambda}{1 - \alpha} f'(\tilde{k})\). Comparing between two bubbleless economies, the steady-state stocks of capital are the same. The difference lies in the real interest rate. The weak demand for investment that is brought about by the borrowing constraint should drive the interest rate down to equal the predetermined aggregate savings.\(^9\)

We go back to the bubbly economy. When there are financial market imperfections, we derive an interesting feature that is useful for the analysis. We obtain the following.

**Proposition 1**

If the borrowing constraint is binding with equality, the stock of capital is smaller than the Golden Rule at the bubbly steady state.

*Proof.* The steady-state link between \( k \) and \( r \) leads to

\[
1 + r = \min\{f'(k), \lambda f'(k) \frac{(1 + g)k}{(1 + g)k - \alpha s W(k)}\} = \min\{f'(k), \Lambda(k)\}.
\]

In Figure 2, we illustrate the case when \( \Lambda(k) \) is always below \( f'(k) \). When the borrowing constraint is binding, capital should be smaller than otherwise for any given \( r \). It is easily verified to have \( \tilde{k}_B < k_{GR} \) for \( r = g \). Q.E.D.

Bubbles move the capital stock to the smaller level than the Golden Rule, and hence are coexistent with capital under-accumulation. This finding directly suggests that capital entrepreneurs would be able to borrow as much as possible, taking \( r_{t+1} \) as given. As \( \lambda \to 0 \), entrepreneurs would be able to borrow nothing and hence have to self-finance their investment entirely.

\(^9\) A number of models with finitely-lived agents, including Azariadis and Smith (1993), Boyd and Smith (1997), Sakuragawa and Hamada (2001), Matsuyama (2004), and others, have shown that the introduction of the borrowing constraint, regardless of whether it is either endogenously derived as a response to the incentive problem or exogenously imposed, leads to a decline in the equilibrium interest rate.
over-accumulation is not necessary in the bubbleless economy for bubbles to emerge.

The economy is a two-dimensional dynamic system that is characterized by the two loci, \( k_{t+1} = k_t \) and \( b_{t+1} = b_t \). We demonstrate dynamic properties using a phase diagram. The derivation of the curve \( k_{t+1} = k_t \) is conventional, and given by

\[
(3-10) \quad b_t = sW(k_t) - (1 + g)k_t.
\]

The curve \( b_{t+1} = b_t \) follows from (3-2) and (3-4), and we have

\[
(3-11) \quad (1 + g)(1 - \alpha)sW(k_t) - b_t = \lambda f'(\frac{sW(k_t) - b_t}{1 + g})sW(k_t) - b_t.
\]

There exists a continuously differentiable function \( b_t = \Phi(k_t) \), satisfying (3-10), with the positive derivative;

\[
\Phi'(k_t) = -\frac{\lambda f''(k_{t+1})}{(1 + g)} + \alpha s(1 + g)b_tW'(k_t)/sW(k_t) - b_t > 0 \quad \text{so that the curve } b_{t+1} = b_t \text{ is upward sloping.}
\]

Figure 3 illustrates a typical phase diagram representing the dynamics of the economy. The bubbly steady state is attained at \( W \), and features less investment than the bubbleless steady state.

When the curve \( b_{t+1} = b_t \) crosses the curve \( k_{t+1} = k_t \) from below, dynamic properties are qualitatively the same as those developed by Tirole (1985) and Weil (1987). There exists an upwardly sloping saddle path to the bubbly steady state. Given \( k_0 \), all dynamic paths originating from below \( b_0 \) converge toward the bubbleless steady state. Trajectories starting above \( b_0 \) are infeasible as they all lead to the resource constraint being violated in finite periods. The properties of equilibria are summarized as follows.

**Proposition 2**

(a) If \( \tilde{r} > g \), the economy is bubbleless and the interest rate converges to \( \tilde{r} \).

(b) If \( f'(\tilde{k}) > 1 + g > 1 + \tilde{r} \), there exists a unique bubbly economy with initial bubble \( b_0 \).

Bubbles per effective worker converges to \( \tilde{b} \) and the interest rate converges to \( g \). In the
bubbly economy, the steady-state capital per effective worker, denoted $\tilde{k}_{GR}$, satisfies
\[ f'(\tilde{k}_{GR}) > 1 + g = f'(k_{GR}), \quad \text{with} \quad \tilde{k}_{GR} < \tilde{k} < k_{GR}. \]

(c) If $1 + g > f'(\tilde{k}) > 1 + \tilde{r}$, there exists a unique bubbly economy with initial bubble $b_0$.

Bubbles per effective worker converge to $\tilde{b}$ and the interest rate converges to $g$. In the bubbly economy, the steady-state capital per effective worker capital satisfies
\[ f'(\tilde{k}_{GR}) > 1 + g = f'(k_{GR}), \quad \text{with} \quad \tilde{k}_{GR} < k_{GR} < \tilde{k}. \]

A heuristic proof of Proposition 2 is as follows. Agents require that, at the stationary state, the rate of return on bubbles, $1 + g$, be at least equal to the rate of return on lending, $1 + \tilde{r}$, so that it must be the case that $g \geq \tilde{r}$ if $\tilde{b} > 0$. On the other hand, at the stationary state, the presence of bubbles decreases the capital stock relative to the bubbleless equilibrium, so that we must have $\tilde{k}_{GR} < \tilde{k}$ and hence $\tilde{r} > \tilde{r}$ if $\tilde{b} > 0$. Therefore, the necessary condition for bubbles to be sustainable is $g > \tilde{r}$. Conversely, if $g > \tilde{r}$, bubbles absorb the aggregate savings and reduces the capital stock until the interest rate $1 + \tilde{r}$ is pushed up to $1 + g$. Finally, if $\tilde{r} > g$, it must be the case that $\tilde{r} = \frac{\lambda}{1 - \alpha} f'(\tilde{k}_{GR}) - 1 > \tilde{r}$, but then it follows from (2-5) that the aggregate bubbles per-effective-worker should grow indefinitely, which is infeasible.

Bubbles can arise even if the rate of return to capital is greater than the growth rate (Proposition 2(b)). What determines the sustainability of asset bubbles is the relation between the real interest rate and the growth rate. The rate of return to capital is irrelevant to the condition for the viability of asset bubbles. To check this, it is useful to examine what happens if the bubbleless economy realizes the Golden Rule. The rate of return to capital is equal to the
growth rate, but so that asset bubbles can arise because the growth rate is greater than the interest rate.

The case of Proposition 2(b) is relevant for the current observation of the world economy. The borrowing constraint brought about by the weak financial system gives rise to the weak demand for investment. The weak ability of supplying financial assets becomes the source of the low real interest rate that calls for asset bubbles, which in turn reinforces the investment slump. This model explains the coexistence of the low real interest rate, asset bubbles, and capital under-accumulation.

4. Bubbles and Dynamic Efficiency

We now turn to the question of dynamic efficiency. We use the dynamic efficiency criterion by Cass (1972) who defines that the economy is dynamically efficient if there does not exist another feasible sequence of capital which provides at least as much aggregate consumption at all dates and strictly higher aggregate consumption in at least one date. We should note that our economy is Pareto sub-optimal in the sense that some intra-generational transfer of income can make all agents better off.10

As Proposition 2 demonstrates, bubbles arise if \( \tilde{r} < g \). We first consider the case for \( f'(\tilde{k}) > 1 + g > 1 + \tilde{r} \), where the per-effective-worker aggregate consumption is less than the Golden Rule at the bubbleless steady state. The aggregate consumption declines since bubbles are

---

10 If an intra-generational transfer of income would be permitted between investors and entrepreneurs through government intervention at the first period of their lives, an appropriate tax-subsidy scheme will move the economy substantially to the Diamond-Tirole model. In this economy, the efficiency result is then standard. The bubbleless equilibrium is dynamically efficient if \( \tilde{r} > g \), while otherwise, it is dynamically inefficient and the asymptotically bubbly equilibrium is dynamically efficient [Tirole (1985, Proposition 2)].
move the capital stock down to an even smaller level than the Golden Rule. We secondly consider the case of capital over-accumulation at the bubbleless steady state, with

$$1 + g > f'(\tilde{k}) > 1 + \tilde{r}.$$  

Bubbles then move the economy into the region of capital under-accumulation so that the direction of the aggregate consumption is not clear. Since the aggregate consumption  

$$C(k) \equiv f(k) - (1 + g)k \text{ is increasing first, reaches the maximum at } k_{GR}, \text{ and later decreasing, there here exists a } k^* \text{, less than } k_{GR}, \text{ under which the aggregate consumption is the same as the one at } \tilde{k}. \text{ We have different welfare implications according to where the bubbly steady state } \tilde{k}_B \text{ lies relative to } \tilde{k}. \text{ We summarize as the following.}

**Proposition 3**

(a) If \( \tilde{r} > g \), the bubbleless economy is dynamically efficient.

(b) If \( f'(\tilde{k}) > 1 + g > 1 + \tilde{r} \), the bubbly economy does not improve efficiency, and dynamically efficient.

(c) If \( 1 + g > f'(\tilde{k}) > 1 + \tilde{r} \), the bubbly economy may or may not improve efficiency. If \( \tilde{k}_B < k \), the bubbly economy does not improve efficiency, and the bubbleless economy is dynamically efficient, while if \( \tilde{k}_B > k \), it improves efficiency so that the bubbleless economy is dynamically inefficient.

Proposition 3(a) and 3(b) say that \( f'(\tilde{k}) > 1 + g \) is a sufficient condition under which the bubbleless economy is dynamic efficient. Combined with Proposition 2(b), it turns out that bubbles can arise even when the bubbleless economy is dynamic efficient. On the other hand, Proposition 3(c) says that \( f'(\tilde{k}) > 1 + g \) is not necessary for dynamic efficiency. Put differently,
\[ f'(\tilde{k}) < 1 + g \] is not a sufficient condition under which the bubbleless economy is dynamic inefficient. Since \( f'(.) \) has a natural interpretation of the “average” rate of return to capital in our model, \( f'(\tilde{k}) > 1 + g \) coincides with the criterion for dynamic efficiency proposed by Able et al (1989). Our finding suggests that the Abel criterion is sufficient but not necessary for dynamic efficiency.¹¹

The mechanism under which asset bubbles arise even when the bubbleless economy is dynamically efficient is closely related to the fact that the bubbleless economy is Pareto sub-optimal. Several other papers have demonstrated that, in the presence of wedge between social and private returns to capital, bubbles can arise even when the bubbleless economy is dynamic efficient (e.g., Saint-Paul (1992), Grossman and Yanagawa (1993) and Femminis (2002)).¹²

There is another strand of literature that studies the low interest rate relative to growth rate. Abel et al (1989), Zilcha (1992), and Bohn (1995) investigate dynamic efficiency in stochastic models with infinitely-lived agents. Their implication is that dynamic efficiency depends on the relation between the growth rate and the rate of return on “risky” capital, not the “safe” interest rate. In theirs, even when the interest rate is below the growth rate, the Non-Ponzi condition is satisfied and so sustainable bubbles are excluded.

5. Two-Region Model and the Global Imbalance

Having thus far investigated the world economy, we turn to the two-region economy so as

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¹¹ Kray and Ventura (2006) give an example in which the Abel criterion is not even a sufficient condition when there are multiple investments that differ in the rate of return.

¹² Saint-Paul (1992), Grossman and Yanagawa (1993) provide endogenous growth models in which bubbles arise even when the private return to capital falls short of the growth rate, and bubbles are not Pareto-improving but rather lowers the growth rate by crowding out capital accumulation.
to study the impacts of bubbles on the capital reallocation and the current account balance. As a matter of fact, the deficit of the current account of the United State is remarkably increasing within this decade that has been coincident with the period when bubbles have emerged. Here we propose a story that links with current account imbalances.

Now divide the world economy into two regions that consist of regions “A” and “R”. Two regions are the same except for the pledgeability $\lambda_j \ (j = A, R)$. We suppose that region A is financially more developed, such that $\lambda_R < \lambda_A$. We have already investigated the dynamic properties so that here we examine the steady state analysis to focus on the effects of bubbles on capital flows across regions.

To begin with, the equilibrium of regional economies is described as four variables $\{\tilde{k}_A, \tilde{k}_R, \tilde{r}_A, \tilde{r}_R\}$, satisfying

\[
(1 + g)\tilde{k}_A = sW(\tilde{k}_A), \quad 1 + \tilde{r}_A = \Lambda(\tilde{k}_A, \tilde{r}_A),
\]
\[
(1 + g)\tilde{k}_R = sW(\tilde{k}_R), \quad 1 + \tilde{r}_R = \Lambda(\tilde{k}_R, \tilde{r}_R).
\]

Obviously we have $\tilde{r}_R < \tilde{r}_A$. Region A with developed financial markets realizes the higher interest rate than other region with less developed one.\(^{14}\)

We consider a world economy when integration occurs in financial markets. The equilibrium of the bubbleless world economy is described as $\{k_A, k_R, r_w\}$, satisfying

\[
(5-1) \quad (1 + g)k_A + (1 + g)k_R = sW(k_A) + sW(k_R),
\]
\[
(5-2) \quad 1 + r_w = \Lambda(k_A, \lambda_A),
\]

and

\(^{13}\) Without loss of generality, we go on the analysis by assuming that at least Region R is borrowing-constrained.

\(^{14}\) Caballero et al (2007) construct a finitely-lived-agent, multi-country model that exploits model’s implications of the difference in real interest rates across countries, explaining the sustained rise in the current account deficit of one country and the rise in share of assets in global portfolio of one country.
In Figure 4A, the integration of financial markets realizes the equilibrium at $E_{W}$, where two downwardly sloped investment demand functions intersect with each other. The market clearing requires $r_{r} < r_{w} < r_{A}$ so that $k_{U}$ rises and $k_{A}$ falls, with reallocating capital from Region R to U. The magnitude of the net capital flow is expressed as the distance $E_{W}F$. Region A runs the current account deficit $g\{sW(k_{A})-(1+g)k_{A}\}$ at the steady state. The difference in the development of financial markets becomes the source of the current account imbalance (e.g., Sakuragawa and Hamada (2001)).

We turn to the bubbly economy. Let $b$ denote the aggregate bubbles that are supportable in the world. The bubbly equilibrium arises if $r_{w} < g$, and then is described as $\{k_{A}, k_{R}, b, r_{w}\}$, satisfying (5-2), (5-3),

\begin{equation}
(1+g)k_{A} + (1+g)k_{R} + b = sW(k_{A}) + sW(k_{R}),
\end{equation}

and

\begin{equation}
r_{w} = g.
\end{equation}

As Propositions 2 and 3 have demonstrated, bubbles arise even when both regions are featured by capital under-accumulation in the bubbleless economy, but then efficiency does not generally improve.

In Figure 4B, the equilibrium is characterized by two points, $E_{U}$ and $E_{A}$, where each of the regional investment demand functions intersects with the vertical line $1 + g$. The comparison between Figures 4A and 4B suggest that the magnitude of net capital flows depends on whether bubbles arise and furthermore on which region creates bubbles. Notably, countries with better developed financial markets will issue more “bubble” assets in the international market. The US government bond or “AAA”-ranked security instruments are traded

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15 The difference in the time preference and hence the saving rate becomes other source of the current account imbalance (e.g., Buiter (1981)).
internationally, but sovereign bonds issued by Asian emerging countries are difficult to be priced. Financial assets supplied by countries of weak financial system are not credible to foreign investors.

Typically, Region A create the share $\delta_A (>0.5)$ of the aggregate bubbles, and Region R does the share $1-\delta_A$. The current account of Region A is then \( g \{ sW(k_A) - (1 + g)k_A - \delta_A b \} \). As an extreme but interesting case, let us illustrate the case when Region A only creates bubbles in the international market. In Figure 4B, Region A funds investment in capital and bubbles by foreign capital. Then the magnitude of net capital inflows, expressed as the distance $E_A F$, tends to be greater than the bubbleless economy. We define the elasticity of substitution between capital and labor as $\sigma(k) = \frac{f'(k)W(k)}{f(k)W'(k)}$. We have the following.

**Proposition 4:** Suppose that $\Lambda(\ldots, \lambda) \ldots$ is decreasing at the steady state. A sufficient condition under which the current account deficit as a proportion of GDP of Region A is larger in the bubbly economy than the bubbleless one is that the capital level of Region R is large to satisfy

\[
f'(k_A) \leq \frac{\sigma(1 + g)}{s(1 - \sigma)}.
\]

**Proof:** We define the current account deficit as a proportion of GDP of Region A as

\[
g \{ sW(k_A) - (1 + g)k_A - \delta_A b \} / f(k_A) \ldots. Since $k_U$ increases by integration and $\delta_A b$ emerges, it is sufficient to check that \( \{ sW(k_A) - (1 + g)k_A \} / f(k_A) \) is non-increasing. By calculation, we have \( \{ sW(k_A) - (1 + g)k_A \} / f(k_A) \) is non-increasing if $f'(k_A) \leq \frac{\sigma(1 + g)}{s(1 - \sigma)}$. That establishes proposition. Q.E.D.

We check to what extent the condition is not restrictive. Whenever $\sigma \geq 1$, the inequality is always met, and hence the Cobb-Douglas form satisfies this inequality. Even when $\sigma$ is small,
the inequality is likely to be met. Suppose that $\sigma = 0.5$. If $s = 0.5$, for example, unless $f'(k_a)$ is twice greater than $1 + g$, the inequality is satisfied.

The assumption of $\partial \Lambda(., \lambda_j)/\partial k_j > 0$ is not restrictive. If $\Lambda(., \lambda_j)$ is increasing, the steady state will be unstable, but then there are other steady states that will be stable, with $\Lambda(., \lambda_j)$ being decreasing.

International bubbles can support the greater current account imbalance. The demand function of capital, in other words, the supply curve of financial assets, is always downward-sloping in the bubbleless economy, but in the bubbly economy it is first downward-sloping, and flat beyond point $E_{eq}$. The rate of return of bubbles does not decline when the supply of bubbles increases. The large part of current account deficit has been financed by Asian emerging countries that purchased US government bonds, which could be interpreted as bubbles in the environment of the recent world economy with low interest rates relative to growth rates.

Region A enjoys the decline in the interest rate by promoting investment in capital and issue government bonds in the international market. As a result, Region A enjoys the complementarity between investment in capital and bubbles at the sacrifice of the shrink of investment of other region. This model explains the coexistence of the global imbalance, the “speculative growth” in the U.S. economy, and the “exports” of bubbles from Asian countries.

Caballero et al (2008b), most closely related to ours, develop a model that explains the interconnection between bubbles and current account imbalances. They also demonstrate that the country with developed financial markets runs the greater current account deficit when bubbles emerge, but their Lucas (1978) exchange economy is silent to the interconnection among the reallocation of capital, bubbles, and the global imbalance. Kray and Ventura (2005)

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16 Caballero et al (2008a) explained capital inflows as one of major sources of funding investment boom in United States, but do not provide a rigorous study to link capital in flows with bubbles.
argue that the large current account deficit of the US is closely related to an increase in the outstanding stock of government debt that has replaced bubbles in firm equities, but do not argue that the international bubbles can support the greater current account imbalance.

Finally, we discuss some stories why global bubbles emerges at the late 1990’s when Asian financial crisis ended. One commonly-recognized story is investment slump in Asian countries. After experiencing Asian crisis, Asian emerging countries degraded the profitability of their investment opportunities. The downward shift of the Region R’s demand curve for capital leads to a decline in the world interest rate, being the source of global bubbles.

The model predicts an alternative interesting story on the emergence of the global bubbles and the greater imbalance of current account. Asian emerging countries grew faster than other regions over this decade and increased output share in the world economy despite their weak financial systems [e.g., Caballero et al, 2008a]. The deterioration of the world-wide “average” institutional quality led to the low interest rate and global bubbles. Noteworthy, as Figure 5 illustrates, the global saving rate has been almost constant at 22-23 percent past twenty years. Although Bernanke (2005), in his speech of the “saving glut”, criticized Asian countries for the reason that the added world saving net of investment was gave rise to bubbles, Asian countries should not be responsible primarily for bubbles.

In response to Asian crises, Asian emerging countries shrank their investment.

**Conclusion**

Imperfect pledgeability is a central notion that explains the coexistence of the historically low real interest rate, asset bubbles, and capital under-accumulation. In addition, its cross-country difference can explain the greater imbalance of current account in the bubbly
economy and the investment boom in the deficit country. As is well known, the high saving and the cross-country difference in savings can also explain bubbles and the greater imbalance. Which of the story between pledgeability and savings are relevant to explain the current bubbles and global imbalances? Taking into account the fact that the global saving rate has been almost constant past twenty years, current debates have been too biased toward the saving story. The more balanced discussions are expected to be made for future research and policy debates.
Appendix

The Proof of Proposition 3(c)

The proof of the former part of (c) is similar to that of (b), and is omitted. I make the proof of the latter. By the introduction of bubbles, \( k \) monotonically decline from \( \tilde{k} \) to \( \tilde{k}_b \).

Letting \( C_T \) denote the per-effective-worker aggregate consumption at period \( T \) at
\[
k_T = \tilde{k}, C_T(1 + g)^{-1} = f(\tilde{k}) - (1 + g)\tilde{k}.
\]
The per-effective-worker aggregate consumption at period at period \( T + 1 \) becomes
\[
C_{T+1}(1 + g)^{-1} = f(\tilde{k}) - (1 + g)k_{T+1} > C_T(1 + g)^{-1}
\]
so long as \( k_{GR} < k_{T+1} < \tilde{k} \). Furthermore,
\[
C_{T+2}(1 + g)^{-1} = f(k_{T+1}) - (1 + g)k_{T+2} > f(k_{T+1}) - (1 + g)k_{T+1}.
\]

This process continues so long as \( k_{T+N} > k_{GR} \) for \( N = 1,2,\ldots \).

The introduction of bubbles makes the equilibrium path of capital monotonically decline.

There exists some period \( T + \hat{N} \) when \( k_{T+\hat{N}} \) is less than \( k_{GR} \). For any \( k_s \), satisfying
\[
k_{S+1} < k_s < \ldots < k_s < \ldots < k_{GR},
\]
the followings are obtained:
\[
C(1 + g)^{-1} = f(k) - (1 + g)k < f(k_s) - (1 + g)k_s < f(k_{s+1}) - (1 + g)k_{s+1} = C_s(1 + g)^{-1}.
\]
Over the whole process from the bubbleless steady state toward the new steady state, the aggregate consumption is greater than the one in the bubbleless steady state so long as \( \tilde{k}_b > \tilde{k} \). Q.E.D.
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Figure 2  Capital under-Accumulation

\[ f'(k) \]

\[ \Lambda(k) \]

1 + r

1 + g

\[ \tilde{k}_B \quad k_{GR} \quad k \]
Figure 3  Equilibrium Dynamics with Bubbles

\[ b_t = b_{t+1} \]

\[ k_t = k_{t+1} \]
Figure 4A  Bubbleless Equilibrium in the Two-Region Economy

\[ 1 + r \]

\[ 1 + r_w \]

\[ \Lambda(k_A, \lambda_A) \]

\[ \Lambda(k_R, \lambda_R) \]

\[ F \]

\[ E_W \]

\[ k_A \]

\[ sW(k_A) \]

\[ k_R \]

\[ sW(k_R) \]
Figure 4B  Bubbly Equilibrium in the Two-Region Economy
Figure 1  Real Interest Rates and Real Growth Rate in G7 countries
(excluding the data for German in 1991)
Figure 5: Saving Rates in the World

0.0% 10.0% 20.0% 30.0% 40.0% 50.0% 60.0%


USA OECD (Japan, Russia) Asia Oil China Asia-China ROW World
Table 1  Test for Dynamic Efficiency

<table>
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<th>Year</th>
<th>Japan</th>
<th>Canada</th>
<th>France</th>
<th>German</th>
<th>Italia</th>
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