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Credit-driven Asset Inflation and Intergenerational Wealth Transfers

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Abstract - Credit-driven asset price inflation is shown to implement the optimal social security plan for an overlapping-generations economy. A simple asset-credit scheme of intergenerational financial trade provides wealth transfers between generations that replicate optimal social security transfers. The optimal rate of asset price inflation outpaces the stationary growth rate of GDP. I demonstrate a close link between the asset-credit scheme and the Friedman rule of optimal monetary dynamic.

Keywords - Overlapping generations, Credit expansion, Asset inflation, Welfare function

JEL numbers: E 31, E 51, E 58

1. Introduction

For several decades the United States and other advanced economies have experienced credit expansion and asset inflation of unprecedented scale and duration. The American financial system's assets have inflated at an annual average rate that in real terms exceeds the long-term rate of economic growth by 2.5 percentage points. The long-term tendency of credit growth and asset inflation has sustained several boom and bust cycles and has led to the volume of the financial system's assets being four times the economy's annual output. It is important to understand the fundamental economic factors underlying this striking phenomenon.

On hindsight one can see that the credit expansion and asset inflation in the United States were the consequences of the monetary policy conducted by the Federal Reserve after the transition from the gold-backed dollar to fiat money in 1971 and of the rapid development of new types of financial institutions after financial deregulation of the 1980s. In the three decades since the mid-1980s, the U.S. monetary policy has demonstrated a substantial shift toward credit easing, which facilitated the financial system's increase in the credit supply and fueled asset inflation. This policy of easing allowed the Fed to fulfill more or less successfully its mandates of ensuring economic growth, low inflation, and financial stability. The credit-fueled asset inflation provided short-term stimulus to aggregate expenditures and support to financial institutions while the rate of inflation of consumer prices remained quite low. Since the 1990s, asset inflation in the United States has also been fueled by the rapid accumulation of dollar-denominated official reserves by the central banks of some emerging-market economies via the creation of non-dollar fiat money. On the downside, the expansionist monetary policy conducted by the Federal Reserve and other central banks has led to a colossal debt overhang in the American economy that threatens long-term financial stability and undermines long-term economic growth (White, 2012).

It is possible to argue that these huge financial imbalances---the U.S. debt overhang and the global money glut---have resulted from myopic or even mistaken past policies on the part of the Fed. I do not dispute this point of view. In this paper, however, I attempt to explain the high rate of credit-fueled asset inflation for a *closed economy* by referring to the concept of long-term welfare maximization. I use as a theoretical framework the overlapping-generations (OLG) economy, in which one of the functions of credit is the creation of purchasing power to facilitate wealth exchange between generations of individuals. The principal argument I advance in this paper is that in theory the credit-driven asset trade can bring about transfers of wealth across generations that replicate optimal social security transfers. As will be shown, a long-term divergence of credit expansion and asset inflation from national income is necessary to ensure optimal wealth distribution among generations if the disruptive effects of debt on economic growth are not taken into account.

I examine the intergenerational wealth transfers induced by the credit expansion for a simple model of an OLG pure exchange economy with a two-period individual life cycle. The social planner in the basic model chooses wealth transfers to maximize an integral welfare function, which is the discounted sum of the utilities of all living and future generations. A first-best implementation of optimal transfers is possible through a credit-driven asset trade between generations. In any period, members of the younger generation buy a financial asset from the members of the older one using a loan. In the second period of life, they sell the asset to a new young generation and repay the loan. The credit is supplied by an authority, called here a "monetary authority", that maximizes the welfare function. This authority's control of the supply of credit is frictionless in any period.

For the sake of simplicity, I assume that the asset brings zero dividends and thus is intrinsically worthless, like fiat money in the early OLG monetary models by Wallace (1980), McCallum (1983) and others. The equilibrium asset price may be positive and may even inflate as a result of the expansion of credit, which supports an upward spiral of asset inflation. Asset price inflation is defined here as growth of the asset price measured in units of consumption good.

I show that optimal asset inflation outpaces the growth of GDP. This is possible because credit supply allows individuals to invest in an asset that is inflating at a rate greater than the growth rate of individual primary incomes. Moreover, only a *high-inflationary* asset can implement optimal intergenerational wealth distribution. The return on this asset must be higher than the social security return, which is equal to the GDP growth rate under a stationary growth regime. Unlike the social security return, the optimal rate of asset inflation depends on the time preference of the monetary authority measured by the discount rate in the welfare function. The higher this rate, the more rapid is the pace of credit expansion and asset price inflation.

In the OLG economy, which lacks credit, assets can only be *low-inflationary*, with long-term returns below or equal to the GDP growth rate. A trajectory for which the asset inflation rate is equal to the GDP growth rate is Pareto-optimal, but it is not a solution of the problem of integral welfare function maximization. If the asset inflation rate is below the GDP growth rate, intergenerational wealth distribution is suboptimal. The model without credit is, thus, a special case of Tirole's (1985) OLG model, with asset bubbles eliminating dynamic inefficiency from production investment.

I demonstrate a close link between credit-based asset inflation and the so-called optimal monetary dynamic. The optimum quantity of money rule first proposed by Milton Friedman (1969) implies consumer price deflation based on the contraction of the money supply at the rate of consumer utility discount. This rule was derived by Andrew Abel (1987) for a welfare maximization problem similar to the one discussed here. The "credit-based" and the "money-based" approaches both implement the same optimum by using different instruments. In practice, the monetary approach has never been applied under fiat money systems because of the destructive economic effects of deflation. In contrast to the Friedman rule, credit-fueled asset inflation has been facilitated by the monetary authorities of the United States and other countries since the early 1980s.

In the following exposition and discussion I avoid using the term "bubble" for the asset inflation presented in our model, although the type of asset we mean is unbacked by cash flow and is intrinsically useless. The fundamental value of this asset is based on the monetary authority's commitment to implement the policy that is optimal for all living and future generations.

This paper is organized as follows: Section 2 presents evidence regarding credit expansion, asset inflation, and monetary policy in the United States. Section 3 presents the basic optimal OLG model and its solution. Section 4 deals with the credit-based implementation of the optimal wealth distribution. In section 5 I discuss the model without credit and with a low-inflationary asset; in section 6 I discuss monetary implementation**;** in section 7 I discuss the results of the paper; and section 8 contains concluding remarks.

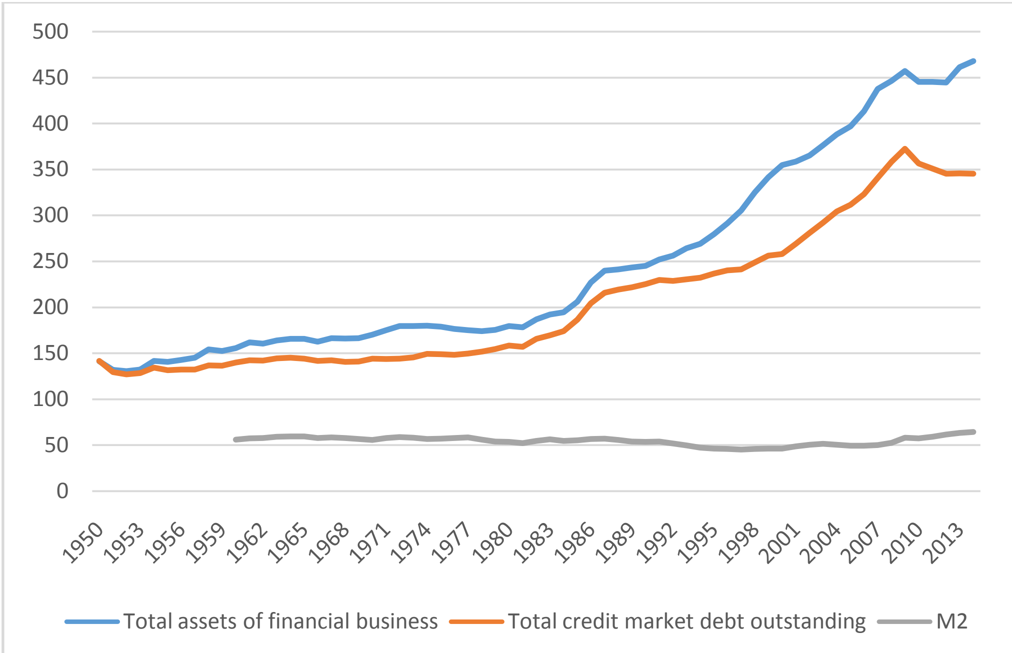
Table 1. Real Average Annual Growth Rates of Total Credit, Total Assets of Financial Business, M2, and GDP, 1970 to 2013

	Total Credit	**Total Assets of Financial Business**	**M2**	**GDP**
Growth rate (percent)	4.2	4.5	2.5	2.1
Gap to GDP growth (percentage points)	2.1	2.5	0.3	0

Source: Author's compilation, based on Federal Reserve Bank of St. Louis economic data ("Flow of Funds", http://research.stlouisfed.org/fred2/categories/32251)

2. Credit Expansion and Monetary Policy in the United States

Since the early 1980s there has been in the United States a strong tendency for credit and assets to grow much faster than GDP. Figure 1 shows the dynamics of the total U.S. credit market debt outstanding, total assets of financial business, and money supply M2 as percentages of GDP from 1950 to 2013. The ratio of total debt and total assets to GDP was below 150% in the 1950's; by the late 2000s total debt had increased to 350% of GDP, and total assets had increased to 450% of GDP. Table 1 presents the average annual growth rates of these indicators deflated by the consumer price index (CPI) for the period from 1970 to 2013. In real terms, the growth rate of total credit was 4.2% and of financial assets, 4.5%. The real M2 growth rate was only 2.5%. The growth rate of total credit was 2.1 percentage points greater than the growth rate of GDP. The financial assets growth rate was 2.5 percentage points greater than that for GDP, the M2 growth rate was just 0.3 percentage points greater.



Source: Author's compilation, based on Federal Reserve Bank of St. Louis economic data ("Flow of Funds", http://research.stlouisfed.org/fred2/categories/32251)

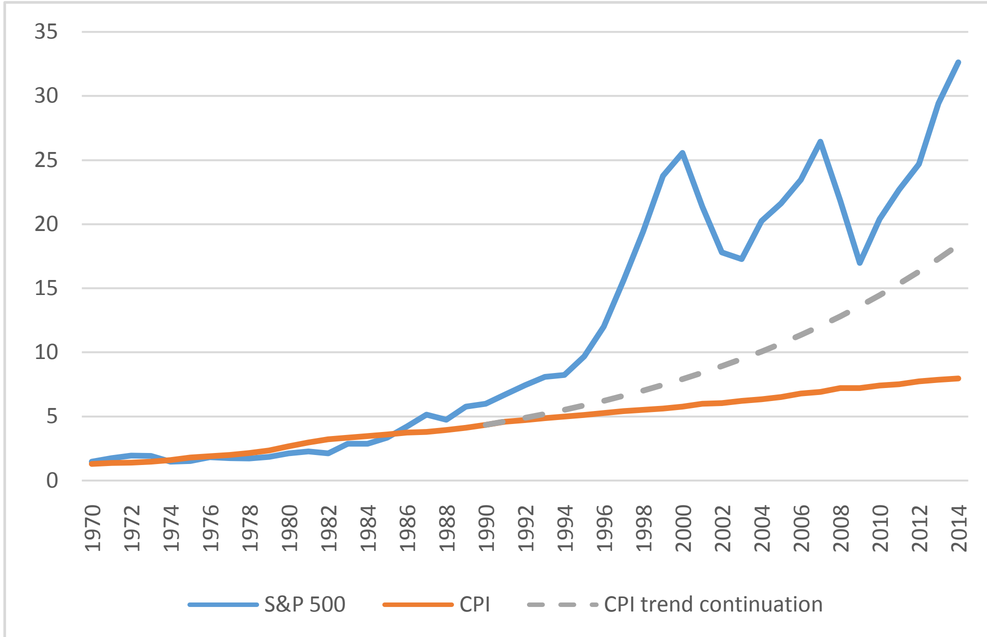
Figure 1. Total Assets of Financial Business, Total Credit Market Debt Outstanding, and M2, as Percentage of U.S. GDP 1950 to 2013

These processes resulted from monetary authority policies on the one hand—the transition to fiat money in 1971 and financial deregulation in the 1990s—and on the other, the Federal Reserve's dual mandate to control consumer price inflation and to stimulate economic growth.

The long-term credit expansion was initially encouraged by the U.S. Congress's passage of the Gold Reserve Requirement Elimination Act in 1968. Technically, issuing fiat money that had no intrinsic value gave unlimited power to the Federal Reserve—but even though it was not constrained in the issue of base money, it maintained quite a stable ratio of money supply to GDP, at least until the first round of quantitative easing in 2008 (Figure 1). Nevertheless, since the 1970s the Fed has been creating favorable conditions for long-term credit expansion. The supply of unbacked money increased the Fed's potential power as a creditor of last resort and diminished the need for reserve liquidity in the financial system. The ratio of banks' reserves and vault cash to their total assets sank from 12% in 1945 to 0.6% in 2007 (Duncan 2012, p. 8), thus facilitating credit creation.

The financial deregulation that has taken place since the 1980s has led to the emergence and rapid growth of non-bank financial institutions. The percentage of these institutions that were free of any reserve requirements in the American credit market went from 1% to 32% in the same period (Duncan, 2012, p. 10). Acting outside the framework of bank regulation, these non-bank institutions fueled asset inflation via the proliferation of collateralized credit instruments. The booming asset markets inflated the value of collateral, thus spurring a further increase in the credit supply. Banks reinforced the spiraling credit supply by replacing their traditional business with "shadow banking," based on a collateralized market system and wholesale funding.

The unconstrained creation of credit could have caused an upsurge of inflation in prices of both assets and goods, but since the 1980s the Fed has made substantial efforts to suppress consumer price inflation. To a considerable extent the inflation-suppression policy was supported by the labor cost deflation that resulted from globalization and prevented a domestic wage spiral. The S&P 500 stock index and the CPI have diverged since the mid-1980s (Figure 2). The average annual growth rates of these indicators, 7.2% and 6.2%, were close to each other from 1970 to the late 1980s, but then started to diverge; the average annual CPI inflation rate dropped to 2.6% between 1991 and 2013 (Table 2). The broken line in Figure 2 shows a trend continuation for the CPI after 1990. It is important to note that the suppression of consumer price inflation accelerated the growth of real asset prices. Table 2 illustrates this point. Because of the strong disinflation the growth rate of the real S&P index deflated by CPI was 0.9% from 1970 to 1990 but increased to 4.6% between 1991 and 2013.



Source: Author's compilation, based on Federal Reserve Bank of St. Louis economic data ("Flow of Funds," http://research.stlouisfed.org/fred2/categories/32251)

Figure 2. Growth Rates of S&P 500 and CPI, 1970 to 2013, Indexed to 1970. 1970 = 1

Table 2. Average Annual Growth Rates of the S&P 500 and the CPI, 1970 to 1990 and 1991 to 2013, Percents

Period	Nominal S&P 500 Index	CPI	Real S&P 500 Index
1970 - 1990	7.2	6.2	0.9
1991 - 2013	7.3	2.6	4.6

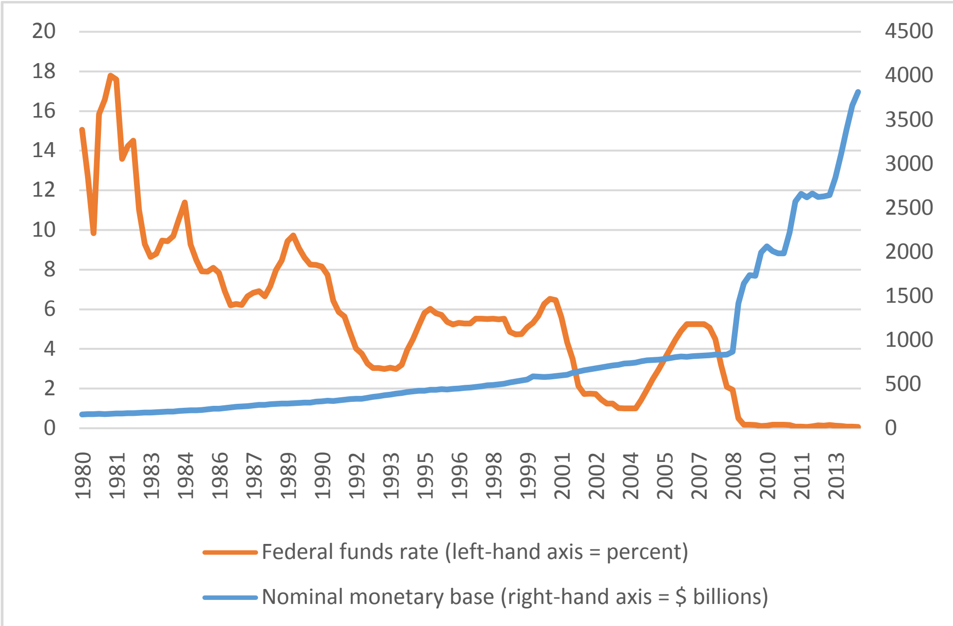
Source: Author's compilation, based on Federal Reserve Bank of St. Louis economic data ("Flow of Funds", http://research.stlouisfed.org/fred2/categories/32251)

The long-term processes of credit expansion and asset inflation allowed the Fed to exploit the credit channel of monetary policy to support economic growth. Expanding credit to households and businesses encouraged the growth of consumption and investment in production, while asset price inflation stimulated aggregate demand through the wealth effect.

To implement this policy, the Fed, instead of discouraging serial asset bubbles by preemptively tightening the monetary supply, chose preemptive easing each time after the bubbles burst.[1] The "Greenspan put option" was exercised, on an ever-increasing scale, after the stock market crash in 1987, the property and saving and loans crises in 1990--91, the Long Term Capital Management collapse in 1998, the bursting of the dot-com bubble in 2000, and the systemic financial crisis of 2008-2009. Figure 3 demonstrates a long-term tendency of the federal funds rate to decline to the zero lower bound that dictated the ultimate resort to quantitative easing. After 2008 the Fed fully accomplished its mission to become a creditor of last resort for banks, which was able to do thanks to the fiat money system created forty years earlier.

[1]. This strategy was usually justified by too high costs and risks of leaning against the bubbles. The Fed's officials also pointed out the difficulties in identifying asset bubbles and the inadequacy of monetary policy instruments for control of asset inflation.

What can support this view is the Fed's attempt to curb the booming stock market in 1928-1929 by raising the federal funds rate and its refusal to refinance the banking system after the 1929 stock market crash that led to a financial collapse (Bernanke, 2002).



Source: Author's compilation, based on Federal Reserve Bank of St. Louis economic data ("Flow of Funds", http://research.stlouisfed.org/fred2/categories/32251).

Figure 3. The Federal Funds Rate and the Nominal Monetary Base, 1980 to 2013

In what follows I do not concern myself with the issues of financial instability resulting from the monetary policy that encouraged asset inflation and the issues of non-sustainability of credit-driven economic growth in the long term. My focus here is only on the long-term welfare gains from the redistribution of wealth across generations brought about by credit-fueled asset inflation. We begin with a simple basic model of intergenerational wealth transfers.

3. Optimal Wealth Transfers

The basic problem is optimal income distribution within a social security system in a pure exchange economy with overlapping generations, each generation living in two periods. The individual life-cycle utility for a member of the generation born in period $t-1 \geq 1$ is:

$$v_{t-1} = u(c_{t-1}) + \beta u(x_t), \tag{1}$$

where c_{t-1}, x_t is consumption in periods $t-1$ and t, and $\beta \leq 1$ is the individual discount factor. The per-period utility is isoelastic: $u(c) = c^{1-1/\sigma}/(1-1/\sigma)$ for $\sigma > 0$, $\sigma \neq 1$ and $u(c) = \ln c$ for $\sigma = 1$, where σ is the intertemporal elasticity of substitution. For a member of the generation born in period 0 (generation 0), the life-cycle utility is defined as $v_0 = \beta u(x_1)$.

The member of generation $t-1$, born in period $t-1$, receives in the first and second periods of life primary incomes $y_{t-1}^{(1)}$ and $y_t^{(2)}$, which are exogenous variables of the model. In each period, primary incomes are redistributed through a lump-sum transfer from young to old generations. The individual chooses life-cycle consumption c_{t-1}, x_t subject to the per-period budget constraints:

$$c_{t-1} = y_{t-1}^{(1)} - \tau_{t-1}, \tag{2}$$

$$x_t = y_t^{(2)} + \delta_t, \tag{3}$$

where τ_{t-1} is the first-period lump-sum transfer and δ_t is the second-period bonus. In each period, the total bonus must be balanced with the total transfer,

$$n_{t-1}\delta_t = n_t \tau_t, \tag{4}$$

where n_t is the population number of generation t.

The social security system is managed by a social planner maximizing a Samuelson-Bentham welfare function (Samuelson, 1967), which is the weighted sum of life-cycle utilities of all generations:

$$V_0 = \sum_{t=0}^{\infty} \lambda^t n_t v_t, \tag{5}$$

subject to constraints (2) to (4). The objective function (5) relates to all individuals living in any time period. The social discount factor $\lambda < 1$ weights utilities of future generations and ensures convergence of (5).[2]

The social security system balance (4) implies $\delta_t = (n_t / n_{t-1})\tau_t$, which is inserted into the individual budget constraints (2) and (3). Inserting the consumption bundle c_{t-1}, x_t defined by these constraints into the objective function (5) and differentiating this function with respect to τ_t yields the first-order condition:

$$\beta u'(x_t) = \lambda u'(c_t) \quad (6)$$

or $x_t / c_t = (\beta / \lambda)^\sigma$, which implies optimal consumption based on the redistribution of national income $n_t y_t^{(1)} + n_{t-1} y_t^{(2)}$ between generations living in period t:[3]

$$c_t^* = \frac{n_t y_t^{(1)} + n_{t-1} y_t^{(2)}}{n_t + n_{t-1}(\beta / \lambda)^\sigma}, \quad (7)$$

$$x_t^* = \frac{n_t y_t^{(1)} + n_{t-1} y_t^{(2)}}{n_{t-1} + n_t(\lambda / \beta)^\sigma}. \quad (8)$$

Optimal consumption is thus defined by the average per capita income adjusted by factor $(\beta / \lambda)^\sigma$. Optimal transfer by the young is a share of the income differential adjusted by this factor:

$$\tau_t^* = y_t^{(1)} - c_t^* = \frac{(\beta / \lambda)^\sigma y_t^{(1)} - y_t^{(2)}}{g_t + (\beta / \lambda)^\sigma},$$

where $g_t = n_t / n_{t-1}$ is the rate of population growth.[4] The transfer is positive if

$$y_t^{(1)} / y_t^{(2)} \ge (\lambda / \beta)^\sigma, \quad (9)$$

which is the case if the relative primary income of the young is high or the ratio of discount factors λ / β is small. If the income distribution between coexisting generations is time-stationary, $y_t^{(2)} / y_t^{(1)} = const$, the social security return is equal to the GDP growth rate, $\delta_t / \tau_{t-1} = g_t \phi_t$, where $\phi_t = y_t^{(1)} / y_{t-1}^{(1)} = y_t^{(2)} / y_{t-1}^{(2)}$ is the growth rate of per capita income. The optimal social security return in this case does not depend on the social planner's time preference defined by the discount factor λ.

4. Credit-Based Implementation

Optimal intergenerational distribution of wealth can be implemented via financial instruments. Suppose a financial asset paying no dividends is traded in a competitive market. A member of generation $t-1$ invests in this asset by using credit to maximize the life-cycle utility (1), subject to the budget constraints:

$$c_{t-1} = y_{t-1}^{(1)} - P_{t-1} i_{t-1} + q_{t-1}, \quad (10)$$

$$x_t = y_t^{(2)} + P_t i_{t-1} - R_t q_{t-1}, \quad (11)$$

where P_{t-1} denotes the asset price denominated in consumption goods units, i_{t-1} is investment in the first period of life, and q_{t-1} is borrowing in the same period. In the second period the old sell their assets to the young at price P_t and repay credits at real interest rate R_t. At any period the asset supply is equal to 1 and the asset market is cleared:

$$i_t = 1 / n_t. \quad (12)$$

Suppose the credit is supplied by a "monetary authority" creating a purchasing power for investment in the asset. Let Q_t denote the credit supply and $Q_0 = 0$. At any period credit supply to the young generation is fully or partially covered by debt redemption by the old, implying that Q_t satisfies the dynamic equation

$$Q_t = R_t Q_{t-1} + \Delta_t, \quad (13)$$

where Δ_t indicates the net credit expansion in period t. The credit market is cleared in any period:

$$Q_t = n_t q_t. \quad (14)$$

The monetary authority maximizes the objective function (5) by setting the asset price in the first period P_1 and by choosing the sequence Q_t, Δ_t subject to conditions (10) to (14). The intertemporal balance constraint is absent in this problem and credit supply can grow indefinitely at an arbitrary rate. Therefore the no-Ponzi-scheme conditions are not imposed on variables Q_t and P_t. However, the net asset holding $P_t - Q_t$ must satisfy the transversality condition:

$$\lim_{t \to \infty} \lambda^t u'(c_t)(P_t - Q_t) = 0. \quad (15)$$

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2. My results do not change essentially if the objective function (5) excludes weighting by population numbers $V_0 = \sum_{t=0}^{\infty} \lambda^t v_t$. Abel (1987) provides arguments justifying this objective function based on the Bellman optimality principle.

3. This follows from combining the first-order condition (6) with the aggregate balance: $n_t c_t + n_{t-1} x_t = n_t y_t^{(1)} + n_{t-1} y_t^{(2)}$, implied by the balanced transfer condition (4).

4. From (7), (8): $y_t^{(1)} - c_t^* = y_t^{(1)} - \frac{n_t y_t^{(1)} + n_{t-1} y_t^{(2)}}{n_t + n_{t-1}(\beta / \lambda)^\sigma} =$

$$n_{t-1} \frac{(\beta / \lambda)^\sigma y_t^{(1)} - y_t^{(2)}}{n_t + n_{t-1}(\beta / \lambda)^\sigma} = \frac{(\beta / \lambda)^\sigma y_t^{(1)} - y_t^{(2)}}{g_t + (\beta / \lambda)^\sigma}.$$

It may be questionable to assume that the model entity solving this problem is a central bank and to match quantities and returns in the model to objects in the economy. More specifically, the assumption that this entity enjoys perfect control of credit supply is very strong. A real-world central bank can only indirectly influence financial institutions' supply of credit through various instruments of monetary policy and regulation of banks that are not considered in the model. However, considerations for imperfect controllability are relevant to any money aggregate and even to the base money, whereas in many theoretical models the nominal money supply is assumed to be a control variable.

Nevertheless, let us consider the solution of the monetary authority's problem. Individual investment i_{t-1} provides the maximum life-cycle utility for individuals (1) under the budget constraints (10) and (11), implying the first-order condition:

$$u'(c_{t-1}) = \beta(P_t / P_{t-1})u'(x_t)\,. \tag{16}$$

The same condition is fulfilled for borrowing q_{t-1}, since $R_t = P_t / P_{t-1}$ for risk-free instruments. Conditions of financial markets being cleared (12) and (14) imply consumption by young and old individuals:

$$c_t = y_t^{(1)} - P_t / n_t + Q_t / n_t\,,$$

$$x_t = y_t^{(2)} + P_t / n_{t-1} - R_t Q_{t-1} / n_{t-1}\,. \tag{17}$$

Inserting (13) and (17) into the objective function (5) and differentiating this function with respect to Q_t yields the first-order condition, which is the same as (6), $\beta u'(x_t) = \lambda u'(c_t)$, and implies optimal consumption (7) and (8).

Thus, credit-driven asset trade ensures optimal wealth distribution across generations. Consider the optimal rate of asset price growth in the stationary regime, under a constant rate of population growth, $g_t \equiv g$, and a constant growth rate of per capita incomes, $\phi_t \equiv \phi$. Combining (7) and (8) with (16) implies that the rate of asset inflation is equal to

$$P_t / P_{t-1} = \lambda^{-1}\phi^{1/\sigma} \text{ (see appendix).} \tag{18}$$

This rate is the product of the inverse of discount factor λ and the income growth rate raised to the power of $1/\sigma$. Inflation is positive under non-negative income growth: $P_t / P_{t-1} > 1$, if $\phi \geq 1$.

The discount factor λ must be sufficiently low to ensure that the asset inflation rate (18) exceeds the GDP growth rate:

$$\lambda^{-1}\phi^{1/\sigma} > g\phi\,. \tag{19}$$

Otherwise, if $\lambda g \phi^{1-1/\sigma} \geq 1$, the objective function (5) does not converge (since the stationary growth rate of consumption is equal to ϕ). Consequently, only a high-inflationary asset satisfying (19) implements the social security optimum. The return on this asset must be higher than the social security return in the stationary growth regime.[5]

The optimal net credit expansion is equal to the net life-cycle "transfer" to generation $t-1$:[6]

$$\Delta_t^* = (P_t / P_{t-1})\tau_{t-1}^* n_{t-1} - \tau_t^* n_t\,, \tag{20}$$

where τ_t^* is the individual transfer, which is equal to saving by the young: $\tau_t^* = y_t^{(1)} - c_t^* = \dfrac{(\beta/\lambda)^{\sigma} y_t^{(1)} - y_t^{(2)}}{g + (\beta/\lambda)^{\sigma}} > 0$. The individual transfer τ_t^* grows at rate ϕ along the stationary path, implying that $\Delta_t^* = (P_t / P_{t-1} - g\phi)\tau_{t-1}^* n_{t-1}$ $= (\lambda^{-1}\phi^{1/\sigma} - g\phi)\tau_{t-1}^* n_{t-1} > 0$, given condition (19). This and (13) imply $Q_t / Q_{t-1} > P_t / P_{t-1}$, that is, the rate of credit growth exceeds the rate of asset inflation.

One can treat equation (20) as a dynamic extension of the social security balance (4). A member of generation $t-1$ receives a "bonus" $\delta_t^* = x_t^* - y_t^{(2)} = (P_t / P_{t-1})\tau_{t-1}^*$ in the second period of life. Hence, according to (20), optimal credit expansion in period t covers a quasi-fiscal deficit measured as the gap between total bonus and transfer: $\Delta_t^* = \delta_t^* n_{t-1} - \tau_t^* n_t$. At any period, this deficit is positive because savings by generation $t-1$ are invested in the high-inflationary asset, bringing the revenue $(P_t / P_{t-1})\tau_{t-1}^* n_{t-1}$, which exceeds savings by generation t, $\tau_t^* n_t$.

The transversality condition (15) is fulfilled for high asset inflation. From (17), the net asset holding by generation t is equal to total savings by this generation: $P_t - Q_t = (y_t^{(1)} - c_t^*)n_t = \tau_t^* n_t$. The growth rate of the net asset holding is thus equal to the GDP growth rate $g\phi$ under stationary growth, while the growth rate of the dis-

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5. This conclusion holds for the problem with the objective function $V_0 = \sum_{t=0}^{\infty} \lambda^t v_t$ instead of (5) (see footnote 2). The first-order condition for this problem yields the optimal rate of asset inflation $P_t / P_{t-1} = \lambda^{-1} g \phi^{1/\sigma}$, while constraint (19) is replaced with $\lambda^{-1}\phi^{1/\sigma} > \phi$, implying that the optimal rate of inflation exceeds the GDP growth rate: $P_t / P_{t-1} > g\phi$.

6. Condition (17) implies that $P_t - Q_t = (y_t^{(1)} - c_t^*)n_t = \tau_t^* n_t$. From (13), $P_t - Q_t = (P_t / P_{t-1})(P_{t-1} - Q_{t-1}) - \Delta_t^* =$ $(P_t / P_{t-1})\tau_{t-1}^* n_{t-1} - \Delta_t^*$, which yields (20).

counted marginal consumption utility, $\lambda^t u'(c_t)$, is the inverse of the asset inflation rate $\lambda^{-1}\phi^{1/\sigma}$. Hence, due to (19), $\lim_{t\to\infty} \lambda^t u'(c_t)(P_t - Q_t) =$ $\lambda c_1^{-1/\sigma}(P_1 - Q_1)\cdot \lim_{t\to\infty}(\lambda g \phi^{1-1/\sigma})^{t-1} = 0$.

Consider the issue of asset price determination. Since members of generation 0 do not have debt, $Q_0 = 0$, the asset price in the first period is equal to the total transfer from generation 1, $P_1 = \tau_1^* n_1$. Members of generation 1 buy the asset at price P_1 without using credit, $Q_1 = 0$. The second-period asset price is $P_2 = \tau_1^* n_1 (P_2/P_1)$ $= \tau_1^* n_1 (\phi^{1/\sigma}/\lambda)$, and the credit for generation 2 is equal to $Q_2 = P_2 - \tau_2^* n_2$, according to equations (13) and (20). Growth of credit in subsequent periods is determined by these equations, and the asset price in period t is $P_t = \tau_1^* n_1 (\phi^{1/\sigma}/\lambda)^{t-1}$. As a result, the level of asset price is determined for all periods by the initial transfer to generation 0.

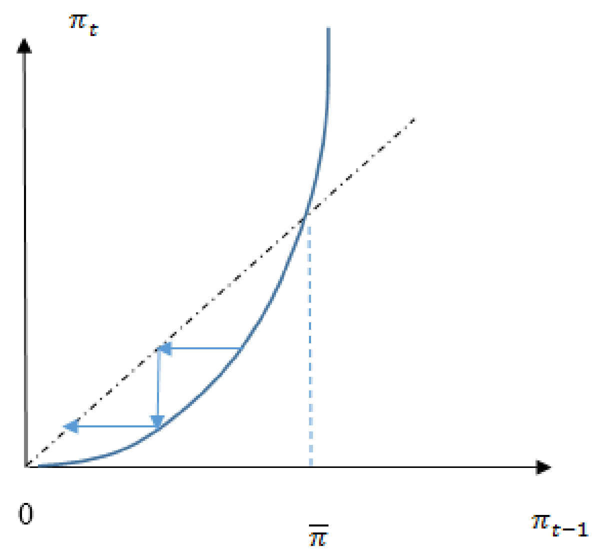
5. Asset Inflation without Credit

Asset trade between generations without credit does not guarantee optimality of wealth distribution. If credit is absent, the individual budget constraints (10) and (11) transform to $c_{t-1} = y_{t-1}^{(1)} - P_{t-1} i_{t-1}$, $x_t = y_t^{(2)} + P_t i_{t-1}$. Let, as above, $g_t \equiv g$ and $y_t^{(1)}/y_{t-1}^{(1)} = y_t^{(2)}/y_{t-1}^{(2)} \equiv \phi$ for all t. Then the first-order condition (16) for individual investment under market clearing, $i_{t-1} = 1/n_{t-1}$, is

$$\frac{g\beta\phi^{1-1/\sigma}\pi_t}{(\omega + g\pi_t)^{1/\sigma}} = \frac{\pi_{t-1}}{(1-\pi_{t-1})^{1/\sigma}}. \tag{21}$$

where $\pi_t = P_t / y_t^{(1)} n_t$ is the investment share in the first-period income of generation t, $\omega = y_t^{(2)}/y_t^{(1)}$ is the relative income of the old individual.[7]

We have obtained a difference equation on π_t with two steady states: 0 and $\bar{\pi} = \dfrac{(g\beta)^\sigma \phi^{\sigma-1} - \omega}{g + (g\beta)^\sigma \phi^{\sigma-1}} > 0$[8]. The steady states and non-stationary trajectories of this equation are drawn in Figure 4, where the curve depicts a locus for mapping (21). The steady state $\bar{\pi}$ is unstable, whereas the autarky steady state is stable: any path of π_t with $\pi_1 < \bar{\pi}$ converges monotonously to 0.[9] Trajectories with $\pi_1 > \bar{\pi}$ are not defined, because the investment share π_t for these trajectories becomes above 1 in a finite number of periods.



Source: Author

Figure 4. Dynamic of Investment Share of Income

The unstable steady state $\bar{\pi}$ corresponds to an asset price path, growing with the GDP growth rate: $P_t / P_{t-1} = g\phi$. For trajectories π_t converging to 0, the asset price grows more slowly than GDP: $P_t / P_{t-1} < g\phi$. For $\bar{\pi}$, the asset trade yields the intergenerational transfer:

$$\bar{\tau}_t = \bar{\pi} y_t^{(1)} = \frac{(\beta/\bar{\lambda})^\sigma y_t^{(1)} - y_t^{(2)}}{g + (\beta/\bar{\lambda})^\sigma},$$

where $\bar{\lambda} = g^{-1}\phi^{1/\sigma - 1}$ is a threshold discount factor, which is the upper bound of the interval of discount factors $(0, \bar{\lambda})$ that ensure convergence of the welfare function (5). This function is not defined for the discount factor $\bar{\lambda}$, so $\bar{\tau}_t$ cannot be a solution for the social planner problem with this objective function, although $\bar{\tau}_t$ coincides with τ_t^* for $\lambda = \bar{\lambda}$.

The steady state $\bar{\pi}$ is, nevertheless, Pareto-optimal, whereas any trajectory of (21) starting from $\pi_1 < \bar{\pi}$ and converging to 0 is not optimal. One can show this by

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[7]. The first-order condition is:
$$\frac{\beta P_t}{(y_t^{(2)} + P_t / n_{t-1})^{1/\sigma}} = \frac{P_{t-1}}{(y_{t-1}^{(1)} - P_{t-1}/n_{t-1})^{1/\sigma}}, \text{ implying (21).}$$

[8]. I assume that $(g\beta)^\sigma \phi^{\sigma-1} > \omega$, which is stronger than (9), given (19).

[9]. Oscillations around $\bar{\pi}$ are possible for $\sigma < 1$, but I do not consider such trajectories.

representing the per-period budget constraints of generation $t-1 \geq 1$ as $c_{t-1} = y_{t-1}^{(1)} - \pi_{t-1} y_{t-1}^{(1)}$, $x_t = y_t^{(2)} + g\phi \pi_t y_{t-1}^{(1)}$. Consider $\hat{x}_t = y_t^{(2)} + g\phi \pi_{t-1} y_{t-1}^{(1)}$, such that $\hat{x}_t > x_t$, because $\pi_{t-1} > \pi_t$. Inserting $c_{t-1}, \hat{x}_t$ into the consumer utility (1) and differentiating it with respect to π_{t-1} yields the first-order condition $u'(c_{t-1}) = \beta g\phi u'(\hat{x}_t)$, which is fulfilled only for $\pi_{t-1} = \bar{\pi}$. Consequently, the consumption bundle $c_{t-1}, \hat{x}_t$ is not optimal for $\pi_{t-1} < \bar{\pi}$, implying non-optimality of c_{t-1}, x_t. For generation 0, the state $\bar{\pi}$ is preferable, because for any $\pi_1 < \bar{\pi}$, $x_1 = y_1^{(2)} + g\pi_1 y_1^{(1)} < \bar{x}_1 = y_1^{(2)} + g\bar{\pi} y_1^{(1)}$.

As a result, the rate of asset inflation without credit cannot be above the rate of GDP growth in the long term. Coincidence of these rates implies Pareto-optimum, but does not provide a solution for the social planner problem with the Samuelson-Bentham welfare function. The intergenerational distribution of wealth is suboptimal if the asset inflation rate is below the GDP growth rate at any period. Thus, the absence of credit can lead to the dynamic inefficiency of investment, implying that a variation of the initial asset price can improve welfare of all generations.

6. Money-Based Implementation

Our inferences about the role of high asset inflation in intergenerational transfer of wealth closely relate to the earlier results of monetary theory based on the OLG models. In the 1970 and '80s, some macroeconomists viewed these models as a convenient framework to analyze the nature of money as a store of value used to facilitate exchange between generations. Their focus was on the nature of fiat money having no intrinsic value but serving as an instrument of optimal allocation of goods across generations.

To demonstrate a link between the monetary theory and our model, consider its simple modification with inclusion of monetary policy. This is essentially a simplified version of Abel's model of optimal monetary dynamic (Abel, 1987). Suppose that the monetary authority controls the nominal money supply M_t and maximizes the objective function (5). An individual born in period $t-1$ holds the nominal money balance m_{t-1} by the end of this period. The individual budget constraints are:

$$c_{t-1} = y_{t-1}^{(1)} - m_{t-1} / p_{t-1}, \tag{22}$$

$$x_t = y_t^{(2)} + \delta_t + m_{t-1} / p_t, \tag{23}$$

where p_{t-1} is the consumer goods price in the units of money, and δ_t is the bonus to the old. Money supply and demand are equated:

$$m_t n_t = M_t; \tag{24}$$

new money issue covers total payments to the old generation:

$$M_t - M_{t-1} = p_t n_{t-1} \delta_t; \tag{25}$$

and $M_0 = 0$.

The first-order condition related to money demand m_{t-1} is similar to (16):

$$u'(c_{t-1}) = \beta (p_{t-1} / p_t) u'(x_t). \tag{26}$$

From (24) and (25), consumption by individuals living in period t is $x_t = y_t^{(2)} + M_t / n_{t-1} p_t$, $c_t = y_t^{(1)} - M_t / n_t p_t$. Substituting these consumption functions into the objective function (5) and differentiating with respect to M_t implies optimality condition (6), which yields optimal consumption plans c_t^* and x_t^*, satisfying (7) and (8). Inserting c_{t-1}^* and x_t^* into equation (26), we obtain a consumer price equation, which is similar to (18) under the stationary growth regime ($g_t \equiv g$, $y_t^{(1)} / y_{t-1}^{(1)} = y_t^{(2)} / y_{t-1}^{(2)} \equiv \phi$):

$$p_t / p_{t-1} = \lambda \phi^{-1/\sigma}. \tag{27}$$

Optimal monetary policy is thus a consumer price deflation with the rate exceeding the rate of GDP growth: $p_{t-1} / p_t = \lambda^{-1} \phi^{1/\sigma} > g\phi$. This is again a consequence of condition (19) ensuring convergence of the welfare function (5). In the above model with credit this condition implied a high-rate asset inflation, whereas in the model with money it implies a high-rate deflation resulting in the contraction of nominal money supply under any rate of GDP growth: $M_t / M_{t-1} = \lambda g \phi^{1-1/\sigma} < 1$.[10]

Money contraction in period t is financed through a lump-sum payment by generation $t-1$, since $\delta_t < 0$ from (25). However, a member of this generation gains from deflation causing appreciation of real money holdings and receives the positive transfer in the second period of life, $\delta_t + m_{t-1} / p_t = g m_t / p_t$, as is seen from (24) and (25). The total transfer to the old generation in period t is thus equal to the volume of real money holdings by the young generation, M_t / p_t.[11] The real money holding plays the

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[10] For the threshold discount factor $\bar{\lambda} = g^{-1} \phi^{1/\sigma - 1}$, the Pareto-optimal quantity of money is constant.

[11]. In period 1, the old generation receives total transfer equal to total initial bonus: $M_1 / p_1 = n_0 \delta_1$, since $M_0 = 0$.

same role in the model with money that the net asset holding $P_t - Q_t$ plays in the model with credit-driven asset trade.

7. Discussion

I have demonstrated that asset price inflation and credit expansion implement optimal wealth distribution in the OLG economy. It has been shown that the optimal rate of asset inflation is higher than the rate of GDP growth, and the optimal rate of credit expansion is higher than the rate of asset inflation.

The optimal rate of asset price inflation in the model is above the GDP growth rate because the social discount factor in the welfare function (5) must be below the threshold level $\bar{\lambda}$ to ensure convergence of this function. A low discount factor implies a large transfer of wealth to the elderly, which is based on a large amount of net asset holdings by the young generation. These holdings require a high rate of asset inflation facilitated by a high-rate credit expansion.

Credit expands even more rapidly than the asset inflates to cover the quasi-fiscal deficit resulting in any time period from a gap between the net asset holdings by the young generation and the return on these holdings received by the old generation. The net asset holdings are equal to total savings and grow at the rate of GDP growth under the stationary regime; meanwhile the return on these holdings outpaces GDP growth because of the higher rate of asset inflation. Hence, the function of credit expansion is to finance the ever-expanding imbalances emerging in the sequence of intergenerational wealth transfers and resulting from the gap between the growth rates of asset price and GDP.

Although our model is too stylized for statistical testing on macroeconomic data series, its conclusions are relevant to the evidence on the long-term growth rates for the United States presented in Table 1. The growth rates of financial assets and total credit exceeded the growth rate of GDP in the period from 1970 to 2013. The real average growth rate of the financial system's assets in this period was 4.5% per annum, which was above the real growth rate of total credit 4.2%. However, the fast growth of financial assets was partly caused by the rapid development of financial institutions since the 1980s. The real average growth rate of the S&P 500 Index was only 2.9% in this period. This is above the GDP growth rate of 2.1% and below the growth rate of total credit as it is implied by the model.

One can also illustrate the equation on optimal asset inflation rate (18) with a simple numerical example. Let the social discount rate be 1% per annum and $1/\sigma = 1.5$. Then for the annual average per capita GDP growth rate of 1.2% for the period from 1970 to 2013, equation (18) yields the optimal annual rate of asset inflation, 2.8%. This is very close to the 2.9% average annual growth rate of the S&P 500 Index in the same period. Hence, the model implies quite a plausible estimate of long-term asset inflation for plausible parameter values.

In the closed-economy model we disregarded foreign trade imbalances and external reserves accumulation by the central banks of emerging market economies that contributed to U.S. asset inflation. By the end of 2013 the volume of global dollar-denominated exchange reserves reached $7.1 trillion, or 12.5% of the total U.S. credit market debt outstanding. The United States' trading partners funded their external reserves with fiat money creation to support exports and to insure themselves against financial and currency crises. However, foreign exchange reserves cannot expand ad infinitum at a constant rate, even if they are created with fiat money. Once a sufficient level of these reserves is reached, the pace of reserve accumulation slows down. The dynamic trade balance dictates reversals in foreign trade imbalances that consequently cannot drive a permanent asset inflation. The fundamental driving force of this process is unconstrained credit creation, which is a possible regime for the closed-economy model with overlapping generations.

An important implication of the model is the close theoretical link between the regime of high asset inflation and the modified Friedman rule of contracting money supply, which was a salient feature of the early OLG models of monetary theory. For instance, Neil Wallace (1980) shows, for an OLG model with a storable good that an optimal monetary equilibrium with a non-increasing quantity of money exists whenever the non-monetary equilibria, with money having no value, are non-optimal. However, the tenuousness of optimal monetary equilibria with non-increasing money supply sharply contrasted with the conduct of monetary policies in actual economies. This property resulted from the intrinsic uselessness and inconvertibility of fiat money and from the absence of the medium-of-exchange function in the OLG monetary models (McCallum, 1983).

Our focus here is on the explanation of credit-based asset inflation rather than on the nature of fiat money. We presented the OLG model with fiat money as a store of value to demonstrate that high deflation is optimal in this model for the same reason that high asset inflation is optimal in our model. The intrinsically useless asset in our model is merely a store of value that serves, along with credit, to facilitate wealth transfers between generations. Although one can ask to what extent credit-based asset trade facilitates distribution of wealth across generations in actual economies, our inference that the optimal asset inflation replacing optimal social security must be high is supported by empirical evidence.

Of course, the model does not capture many important aspects of this evidence. The model's most questionable assumption, of perfectly controlled credit supply by the monetary authority, implies the first-best optimality of credit-fueled asset inflation. A possible model extension may include financial intermediaries creating credit, aside from the monetary authority supplying the base money and setting a short-term interest rate to maximize the integral welfare function. In a second-best optimum, obstacles may arise in some time periods to expand credit because of imperfect information and constraints on incentives of financial intermediaries. Such an extension of the model may result in equilibria with credit cycles of the type examined by Azariadis and Smith (1998). In such a model setting, long-term asset inflation may take place in boom-bust regimes, in which periodic collapses of the asset price are caused by the binding constraints on credit growth.

Another possible way to extend the model is to take into account the detrimental effects of credit-fueled imbalances on financial stability and economic growth. A model extension including production and physical capital can capture the effects of excess indebtedness on balance sheets of production firms and financial intermediaries that undermine incentives to invest in capital and to supply loans. A welfare-maximizing monetary authority adopts decisions on credit expansion by taking into account the costs for the economy of further building up the debt, which are compared with the costs of deleveraging and asset deflation.

8. Conclusion

Overlapping-generations models provide a theoretical framework to explain the phenomenon of high and long-lasting asset inflation in advanced economies. Credit-fueled asset inflation has steadily outpaced the growth of fundamental macroeconomic indicators such as labor productivity and population size, and is largely irrelevant to the dynamics of these indicators. Consequently, I have considered a model with an intrinsically worthless asset that pays no dividends and delivers only capital gains to its holders. This asset value can inflate because in any period investors expect to sell it at a higher price to new entrants into the asset market in the future.

As has been shown, an ever-growing gap between the rate of the asset value inflation and the growth of GDP may result from the welfare-maximizing policy of credit supply. Like the role played by unbacked money in the dynamic monetary models, credit in our model is a device to facilitate a Pareto-improving exchange between generations. In our thought experiment, the credit-driven asset trade replaces the social security system as an instrument of optimal wealth distribution across generations. The rate of asset inflation that implements this distribution exceeds the social security return, which is equal to the GDP growth rate, and is defined by the discount factor in the objective function of the monetary authority that controls credit supply. As a result, one can explain a high rate of credit-fueled asset inflation by this authority's high rate of time preference.

The management of intergenerational wealth transfers is not an explicit goal of any monetary authority. Yet it is possible to view these transfers, at least in the context of the Federal Reserve, as an unintentional consequence of the Fed's fulfilling its key mandates to support economic growth and to control consumer price inflation. A combination of high asset price inflation as a stimulus for economic activity with low consumer price inflation as an explicit policy goal implies robustly high asset inflation in real terms. If pursued long-term, this combination tends to bring about the effects on wealth distribution across generations of the kind described in our highly stylized model. So far unanswered is the question of the extent to which the structure of inflation desirable for the monetary authority has resulted from deliberate policy measures and to what extent it has been influenced by external factors such as globalization.

Appendix

Inserting c_{t-1}^* and x_t^* into (16) implies

$$\beta P_t / P_{t-1} = \left(\frac{x_t^*}{c_{t-1}^*}\right)^{1/\sigma} = \left(\frac{n_t y_t^{(1)} + n_{t-1} y_t^{(2)}}{n_{t-1} + n_t (\lambda/\beta)^\sigma} : \frac{n_{t-1} y_{t-1}^{(1)} + n_{t-2} y_{t-1}^{(2)}}{n_{t-1} + n_{t-2} (\beta/\lambda)^\sigma}\right)^{1/\sigma} =$$

$$(\beta/\lambda)\left(\frac{n_{t-2} + n_{t-1}(\lambda/\beta)^\sigma}{n_{t-1} + n_t (\lambda/\beta)^\sigma} \cdot \frac{n_t y_t^{(1)} + n_{t-1} y_t^{(2)}}{n_{t-1} y_{t-1}^{(1)} + n_{t-2} y_{t-1}^{(2)}}\right)^{1/\sigma} = (\beta/\lambda)\left(\frac{1 + g(\lambda/\beta)^\sigma}{1 + g(\lambda/\beta)^\sigma} \cdot \frac{n_{t-2}}{n_{t-1}} \cdot \frac{g y_t^{(1)} + y_t^{(2)}}{g y_{t-1}^{(1)} + y_{t-1}^{(2)}} \cdot \frac{n_{t-1}}{n_{t-2}}\right)^{1/\sigma}$$

$$= (\beta/\lambda)\phi^{1/\sigma},$$

which yields (18).

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