THE OPTIMAL INFLATION RATE FOR JAPAN IN AN OVERLAPPING GENERATIONS ECONOMY

Manabu SHIMASAWA

and

Akira SADAHIRO

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Manabu SHIMASAWA*
Visiting Fellow, Institute for Research in Contemporary Political and Economic Affairs, Waseda University; Akita University

and

Akira SADAHIRO
School of Political Science and Economics, Waseda University

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* Corresponding author. 1-1 Tegata Gakuen-machi, Akita-city, Akita, 0108502, Japan. tel & fax +81-18-889-2657. e-mail: mshimasawa@ed.akita-u.ac.jp

1. Introduction

Japan, unlike most developed countries, is now experiencing prolonged deflation. Though the Japanese government was reluctant to recognize officially in March 2001 that the Japanese economy had been stuck in deflation since 1999, the statistical data, in fact, indicates that the deflationary situation of the Japanese economy has continued since 1994 (Figure 1).
Today, Japan is now one of the worst debtor countries in the world (Figure 2). Actually a remarkable increase in government debt stock was noted in Japan after the mid-1990s, when other advanced economies were reducing the public sector and government debt after the mid-90s. For instance, the debt-output ratio, which was about 34.8 percent in 1990, shot up to 107.9 percent in FY2002 (SNA basis), more than tripling. However, there are still no signs of fiscal collapse because of abnormally low interest rates, a situation supported by the bold measure for monetary ease that the Bank of Japan has implemented since February 1999 (Figure 3). But once a full-fledged economic recovery is achieved, the growth rate of prices will turn positive. A positive inflation rate makes the nominal interest rate increase, coupled with rising real interest rates. Under the enormous stock of government debt at present, we must prevent a sharp increase of inflation; it is highly possible that it could lead to a rise in the nominal interest rate, then to a rapid increase in government interest payments, and finally to fiscal catastrophe. To avoid such a consequence, the adoption of an inflation target may be needed. In fact, a number of developed countries have already adopted it to control inflation (Table 1).
Even if Japan adopts an inflation target, is any rate of inflation appropriate for the Japanese economy? For instance, is a 2-3 percent target zone suitable, like other countries that have already adopted the policy?
In this paper, we examine numerically the issue of the optimal rate of inflation in the context of a large-scale monetary growth overlapping generations (OLG) model calibrated for the Japanese economy to answer that question.
A number of papers written after the seminal study by Auerbach and Kotlikoff (1987), who extended the Diamond (1965) OLG model to a tractable simulation model, have studied a variety of questions regarding the future macroeconomic situation and the impacts of macroeconomic and intergenerational policy by using computable general equilibrium models with

scenarios, and their welfare implications. Section 5 concludes, summarizes the paper, and indicates some policy implications.

2. The Model Structure

In this section, we base our discussion on the monetary growth overlapping generations model with government debt and physical capital. Four sectors—household, production, government, and public pensions—compose this model. Before we approach the main subject, it is necessary first to point out some features of the economy from which we abstract. First, our model focuses on steady states. Second, uncertainty does not exist, i.e. we consider a non-stochastic world. Third, our modeled economy is a closed system. We abstract the interrelation with exterior world. And finally, there is no population growth and no technical change. Details of each sector follow.

(1) Household Sector

The overlapping generations model used in this paper is based on the lifecycle theory of consumptions/savings behavior with no bequest motive. We consider an economy in which every person lives for a fixed number of periods. We think of the first period of an agent's life as corresponding to the first year of an average Japanese working life—roughly age 21, so that each generation enters the labor market at age 21 (1^{st} period), retires and is granted a pension at age 65 (45^{th} period), and dies at age 80 (60^{th} period). The household supplies labor force inelasticity. These are rational, forward-looking agents. His/her instantaneous utility function may be specified thus:

$$v_{g,j} = \theta \frac{c_{g,j}^{1-\gamma}}{1-\gamma} + (1-\theta)\frac{m_{g,j+1}^{1-\gamma}}{1-\gamma} \tag{1}$$

where g refers to the g^{th} generation, j refers to the j^{th} period of life, γ is the inverse of the elasticity of intertemporal substitution, and θ is a distributional parameter denoting the intensity of the household's preference for consumption opposed to real money. The arguments of the utility function are the consumption per period ($c_{g,j}$) and the real money balances at the end of the period ($m_{g,j+1}$). It's obvious that we assume a money in utility (MIU) model, which is originally due to Sidrauski (1967), who extends the Ramsey growth model to allow both consumption and real money balances to enter the utility

$$c_{g,j} = \left\{\frac{1 + r_t(1 - \tau r_t)}{1 + \rho}\right\}^{\frac{1}{\gamma}} \left(\frac{1 + \tau c_{t-1}}{1 + \tau c_t}\right)^{\frac{1}{\gamma}} c_{g,j-1} \tag{4}$$

where τr denotes interest tax rate.

Maximizing with respect to the real money balances gives the following result:

$$m_{g,j} = \left\{\frac{1 + r_t(1 - \tau r_t)}{1 + \rho}\right\}^{\frac{1}{\gamma}} \left(\frac{\xi_{j-1}}{\xi_j}\right)^{\frac{1}{\gamma}} m_{g,j-1} \tag{5}$$

From the Euler equation for the real money balances, we notice that the household's intertemporal money demands depend not only on the real interest rate (r) but also on the marginal cost of holding money (ξ). Indeed, we easily show that the money demands depend negatively on the nominal interest rate. Thus, the higher the nominal interest rate, the smaller the demand for real money balances. Intuitively, a higher nominal interest rate means a higher opportunity cost of holding real money balances and a smaller demand for them.

We also obtain the amount assets held at age g by an individual born in year t:

$$\begin{cases} a_{g,j+1} = (1 - \tau w_t - \tau p_t)w_t - (1 + \tau c_t)c_{g,j} - m_{g,j+1} \quad at \quad j = 1 \\ a_{g,j+1} = (1 - \tau w_t - \tau p_t)w_t + \sigma_{g,j} + \{1 + (1 - \tau r_t)r_t\}a_{g,j} + \dfrac{m_{g,j}}{1 + \pi_t} \\ \qquad - (1 + \tau c_t)c_{g,j} - m_{g,j+1} \quad at \quad j = 2, \cdots, 44. \\ a_{g,j+1} = \sigma_{g,j} + \{1 + (1 - \tau r_t)r_t\}a_{g,j} + \dfrac{m_{g,j}}{1 + \pi_t} - (1 + \tau c_t)c_{g,j} - m_{g,j+1} + pen_{g,j} \\ \qquad at \quad j = 45, \cdots, 59. \end{cases} \tag{6}$$

$$PA_t = \sum_{g=j-58}^{j} a_{g,j} \tag{7}$$

where $a_{g,j}$ is physical wealth asset of generation g at age j, σ is government transfer to households, and PA_t is the aggregated private asset at period t.

(2) Production Sector

The input/output structure is represented by the Cobb-Douglas production function with constant return to scale. The firm yields a single good. The goods may be consumed or stored. The firm decides the demand for physical capital payments or to purchase goods and services[3]. In our model, seigniorage at time t equals to government transfers to households as mentioned previously. Moreover, the government is assumed to choose the rate of monetary creation (μ) and to follow the monetary rule:

$$M_{t+1} = (1 + \mu_t)M_t \tag{12}$$

where μ_t is the rate of monetary creation at time t.
The government decides the tax rate according to the budget constraints (Equation (10)). Here, the consumption tax rate is endogenously determined according to the difference of government revenues and government expenditures[4].

(4) Public Pension

Though the current public pension system of Japan is very complicated, we model it as a pay-as-you go pension system for tractability. The pension sector grants a pension to the retired generations while pension contributions are collected from the working generations.

$$b_t = \tau p_t w \tag{13}$$

where b stands for the pension contribution. The pension at time t is given by the product of the replacement rate and wage.

$$pen_t = \frac{1}{45}\beta\sum_{j=1}^{45} w_t(1 - \tau w_t - \tau p_t) \tag{14}$$

where pen is the pension benefit and β denotes replacement rate.
In our model, we give the time path of the pension contribution rate (τp) exogenously. As a result, the replacement rate (β) is determined endogenously.

(5) Equilibrium Conditions

To close the model structure, the following two market-equilibrium conditions must hold. The first condition is equilibrium in the money market. The aggregated money demands of all generations yield the economy's aggregate

[3] Though seigniorage can be a significant source of government finance, the inflation tax accounts for a very small fraction, even negative, of the real resources collected by the Japanese government because the inflation rate of Japan is very low, or even negative now.
[4] In the case that the inflation rate is endogenized, all tax rates are exogenized. Further discussion on this issue is provided in section 4.

calculated per capita GDP divided by capital-labor ratio k power to the capital income share α. We give two different values for inflation rate π: one is Consumer Price Index (CPI) excluding fresh food, and the other is GDP deflator. In the case CPI, π is set to 0.64 percent, the average annual growth rate during 1990–2003, and in the case GDP deflator, π is set to -0.25 percent, the average annual growth rate during 1990–2003. The consumption tax rate, wage income tax rate, and capital income tax rate are set at 7.5 percent, 9.5 percent, and 6.4 percent, which are estimated average marginal tax rate by using National Accounts' data. In addition, we assume the government expenditure output ratio of FY 2002, 21.5 percent, to be constant. It will be assumed that the government will maintain the present fiscal policy stance into the future. The pension tax rate is set at 0.138, according to the plan of the Ministry of Health, Labor and Welfare's. The sources of the parameter values are: Hamann (1992) and Auerbach and Kotlikoff (1987) for household preferences, Sadahiro and Shimasawa (2001) for production and the Cabinet Office (2004) for macroeconomic variables.

The model was solved numerically using the parameter values just above mentioned. The results are presented in Table 3. The following were verified: (i) in this simulation the CPI case and GDP deflator case deliver the same conclusion; (ii) both cases lead to money-output ratio similar to the historical value of the M2+CD-nominal GDP ratio for Japanese economy during 1967-2003: 95.3 percent; (iii) debt/GDP ratio is replicated under these parameters and initial value setting in both cases; (iv) it is necessary to raise the consumption tax rate to maintain the present level of government debt stock, up to about 20 percent; (v) the calculated steady state real interest rate is about 7.1 percent, which is fairly high the average real return on capital during the period 1985-2003: 3.5 percent; (vi) we obtain a reasonable interest elasticity of the demand for money (η), -0.50.

This baseline scenario constitutes our starting point of the policy change scenarios developed in the following section. For this reason, we conduct a sensitivity analysis for certain important assumed parameters to examine how robust the outcomes of baseline scenarios are. Here, we analyzed the sensitivity to marginal changes in values of the parameters—capital income share (α), distributional parameter (θ), pure rate of time preference (ρ), and intertemporal elasticity of substitution (γ)—holding all the other parameters at their baseline values. By doing two sensitivity checks on each parameter, in

γ as shown in Table 4[7]. Nevertheless, we think the results of these sensitivity analyses demonstrate that our findings are quite robust, in the sense that most of the parameters of our present model are empirically and plausibly parameterized.

4. Alternative Scenarios

To study the impacts of the change of inflation rate, those of the policy change against enormous amount of government debt stock, and those of pension reform, we simulate four alternative scenarios: 1) the "Tobin effect scenario," which examines the relationship between the inflation rate and capital formation, and furthermore to estimate the Tobin effect quantitatively; 2) the scenario to estimate the welfare maximizing inflation rate; 3) the first policy change scenario, in which we suppose that government debt is cut by a range from 30 percentage points to 90 percentage points compared to GDP, which means after-policy government debt to GDP enters a range from 20 percent to 80 percent by raising tax rates; and 4) the second policy change is pension reform. We suppose that the pay-as-you-go public pension system will be entirely abolished.

Tobin Effect Scenario

For an important feature of the relationship between the inflation rate and capital formation, as the higher inflation rate increases the nominal interest rate, the demand for real money balances is reduced. Intuitively, a higher nominal interest rate means a higher opportunity cost of real money balances holding. And it induces a recomposition of the individuals' portfolio away from money toward real assets, or capital. Thus we can easily imagine the positive correlation between the inflation rate and capital stock.

Before numerical analyses are done, let's look at Figure 4. This figure seems to indicate the positive relationship between two variables or the existing of "Tobin effect". Tobin (1965) insisted that as the higher inflation rate induces a portfolio revision from real money balances to capital, capital stock increases.

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[7] This problem is avoidable by allowing different elasticities of substitution for consumption and money in the utility function. Such a task, however, is left for future research.

percent, or is within a range from 0.5 percent to 1.5 percent under the present Japanese economic conditions and deep parameters[9].

And Figure 5 revealed another important feature that the opposite sign of inflation rate gives asymmetric effects on the welfare. Thus the negative inflation rates, *i.e.* deflation, have larger negative effects on individual welfare. Because Japan has been in a state of deflation for a few years (as seen in Figure 1), Japan's welfare loss amount to considerable.

Government debt cut Scenario

Generally, huge government debt stock, though it is 108 percent of GDP in Japan as of 2002—making it the worst among the advanced countries—makes inflation rise sharply. Now in Japan, partly because of the effect of the unprecedented monetary expansion implemented by the Bank of Japan, partly because of stagnation in the Japanese economy, inflation continues to be low or negative for years. However it is no small wonder when low or negative inflation turns into hyperinflation.

Here, we compute the inflation rate under the huge government debt stock endogenously. In this case, all tax rates are exogenized, and the difference between the government expenditure and tax revenue is balanced by seigniorage. Thus the inflation rate is endogenously determined according to the endogenous change of seigniorage[10]. Table 6 shows the result of this simulation. The huge amount of government debt stock raises the inflation rate up to about 12 percent in the long run. This level of steady state inflation rate is 13 percentage points high compared to the present inflation rate measured by CPI in Japan. Such high inflation, accompanied by a soaring nominal interest rate will bankrupt the Japanese government.

We next conducted the policy reform scenario, which is the case that government debt cut policy is implemented. We assume four scenarios: 1) that the government debt stock to GDP ratio is reduced from 108 percent to 80 percent, i.e., about a 30-percentage-point cut; 2) a 50-percentage point cut;

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[9] In this paper we limit our analysis to studying the steady state of the economy. However, those studies seem to be incomplete because the transitional dynamics is omitted. For example, transition from the non-optimal inflation rate to optimal inflation rate may hurt some generations, i.e., such regime switch may not be Pareto efficient. But this is an issue for future research.

[10] See equations (10), (11), and (12) in the previous section.

induces the rise of holding money balances, capital-labor ratio of this case is smaller than the previous four fiscal reconstruction cases. However, as the shrinking of government redistributes resources of consumption from the public sector to the private sector, individuals' lifetime utility levels become higher than in any other cases. For example, compared to the lifetime utility of the baseline endogenous inflation case, it is 11 percent larger.

5. Conclusion

In this paper, our purpose was to develop a computable multi-period monetary growth OLG model and to calibrate for the present Japanese economy to estimate the potential effects of changes of inflation rate and policy changes on individual welfare, output level, and inflation. Monetary growth arises in the model thanks to the individual's optimal choices between consumption and real money balances through money-in-the-utility. Our main conclusions are as follows.

First, we have shown the present negative inflation rate of Japan decreases the individual's welfare. Implementation of further policies against deflation are thus required. Second, the steady state welfare maximizing inflation rate for the Japanese economy is positive, and is calculated around 1.0 percent, or within a range from 0.5 percent to 1.5 percent. If the inflation target is to be adopted, it is necessary for the Bank of Japan to set the target inflation rate to around 1.0 percent. Third, our results suggest that the inflation rate in the long run is about 12 percent under the appropriate deep parameters and the world's worst-level government debt stock. Fiscal reconstruction needs to be implemented immediately. However, our numerical analysis revealed that even though fundamental fiscal reform is conducted, the optimal inflation rate may not be achieved. Additional drastic policy changes are required. Moreover, one such policy certainly does achieve a welfare maximizing inflation rate and improves individual welfare remarkably.

References

Auerbach, A.J. and L.J. Kotlikoff. *Dynamic Fiscal Policy*. Cambridge University

Table 1 Major Countries Adopted the Inflation Target

country	adoption year	target zone (%)
New Zealand	1990	0-3
Canada	1991	1-3
U.K.	1992	2.5
Sweden	1993	2±1
Finland	1993	2
Australia	1993	2-3
Spain	1994	3
Korea	1998	2.5-3.5

Source: Hayashi (2003)

Table 2 Values of Key Parameters, Initial Value, and Exogenous Variables

		CPI	GDP deflator
Capital income share	α	0.25	0.25
Intertemporal elast. of subst.	$1/\gamma$	2.0	2.0
Rate of time preference	ρ	0.015	0.015
Distributional parameter	θ	0.9387	0.9285
Initial capital labor ratio	k	190.2	190.2
Scale factor of production	A	18.2	18.2
Inflation rate	π	0.0064	-0.0025
Gov. Exp. to GDP ratio	$gexp$	0.215	0.215
Wage tax rate	τw	0.126	0.126
Interest tax rate	τr	0.074	0.074
Pension tax rate	τp	0.1358	0.1358

Table 3 Calibration Results

	CPI	GDP deflator
Capital-labor ratio	255.6	255.5
GDP per capita	72.6	72.6
Consumption tax rate (%)	19.9	21.0
Money-output ratio (%)	95.3	95.3
Debt-output ratio (%)	108.0	108.0
Real interest rate (%)	7.10	7.10
Interest elasticity of money demand	-0.50	-0.50

Table 5 (2) Tobin Effects in the Baseline Scenario (CPI)

(deviation from the former case %)

Change in π before		after	*k*	*y*	*r*[1)]	*w*	*c*	*m*
0	to	1.0	0.7	0.2	▲0.04	0.2	0.2	▲6.8
1.0	to	2.0	0.6	0.1	▲0.03	0.1	0.1	▲6.0
2.0	to	3.0	0.5	0.1	▲0.03	0.1	0.1	▲5.3
3.0	to	4.0	0.4	0.1	▲0.02	0.1	0.1	▲4.7
4.0	to	5.0	0.4	0.1	▲0.02	0.1	0.1	▲4.3
5.0	to	10.0	1.3	0.3	▲0.07	0.3	0.3	▲15.6
10.0	to	20.0	1.3	0.3	▲0.07	0.3	0.3	▲19.0

Notice 1) basis points

Table 6 Results of Endogenous Inflation Rate Scenario

k	*π(%)*	*y*	*i(%)*	*r(%)*	*c*	*m*
288.1	11.6	74.8	18.1	6.5	58.7	71.3

Table 7 Results of Fiscal Policy Reform Scenarios

	scenarios				
	Baseline	Case 1	Case 2	Case 3	Case 4
Capital-labor ratio	288.1	294.2	298.5	302.8	307.0
Inflation rate (%)	11.6	8.5	6.7	5.1	3.8
Per capita GDP	74.8	75.2	75.4	75.7	76.0
Nominal interest rate (%)	18.1	14.9	13.0	11.3	9.9
Real interest rate (%)	6.5	6.4	6.3	6.3	6.2
Consumption	58.7	59.0	59.2	59.4	59.6
Money demands	71.3	78.2	83.6	89.6	95.9

Notice: The policy reform here is the cut of government debt-output ratio.

Case 1: 30 percentage-point cut (debt output ratio 80 percent).

Case 2: 50 percentage-point cut (debt output ratio 60 percent).

Case 3: 70 percentage-point cut (debt output ratio 40 percent).

Case 4: 90 percentage point cut (debt output ratio 20 percent).

Figure 1 Deflation in Japan

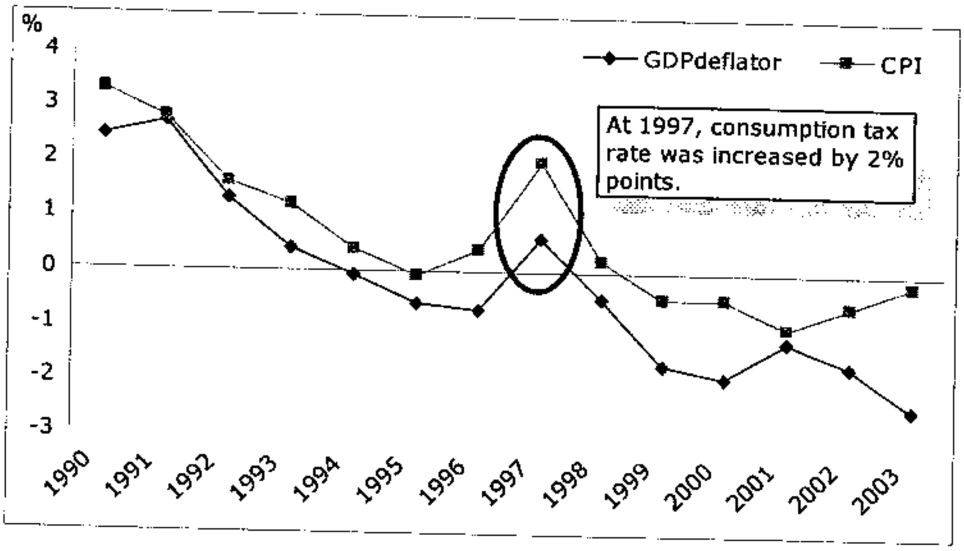
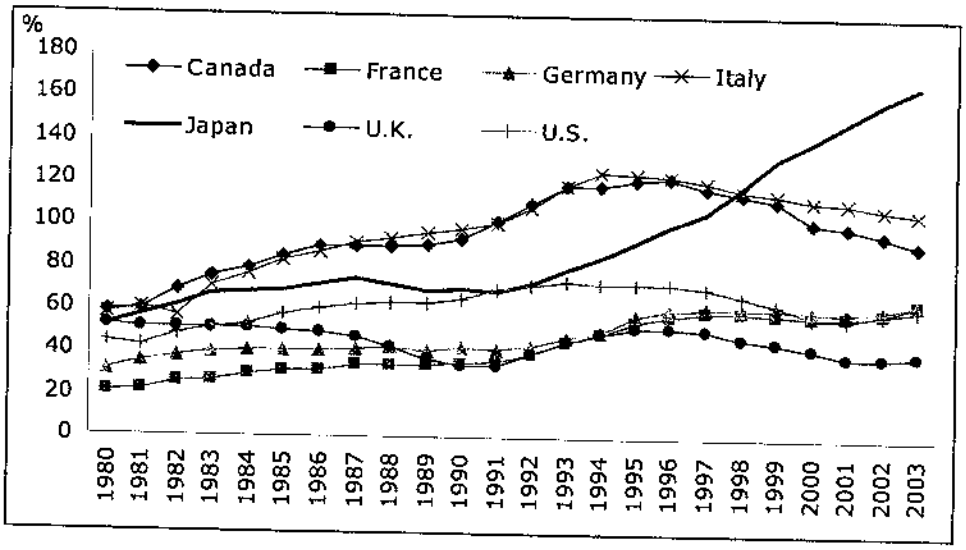


Figure 2 Government Debt/GDP Ratio



Source: IMF.

(2) GDP deflator and capital stock

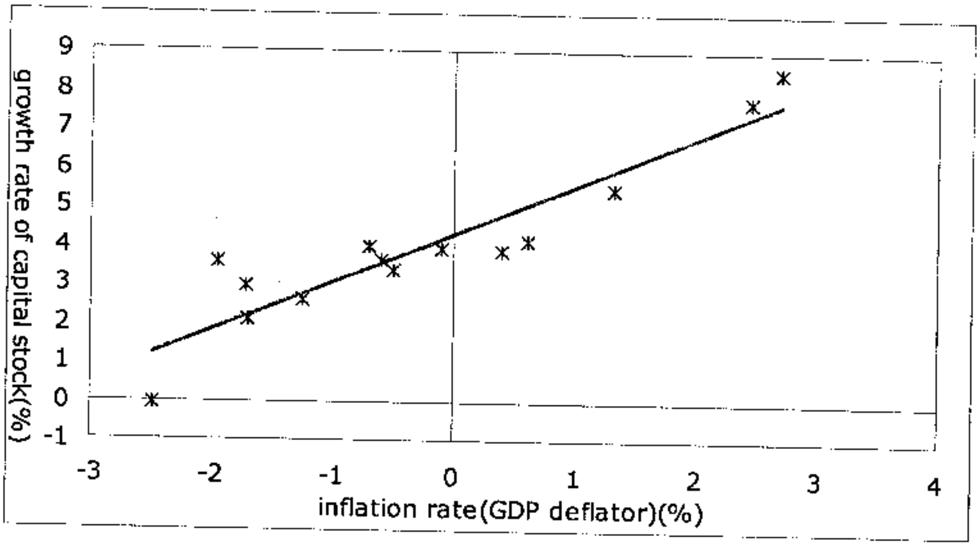


Figure 5 Welfare Maximizing Inflation Rate