The Ultimate Source of Inflation:

A Microfoundation of the Fiscal Theory of the Price Level

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March 2005
Version 1.2

Abstract

The paper explores a fundamental mechanism of inflation by explicitly including a government's optimization problem into a general equilibrium model assuming a Leviathan government. The result is clear-cut and beautiful: inflation is caused by the difference of the time preference rates between a government and households. This is an inevitable consequence of heterogeneity in time preference rates between a government and households. The model can be seen as a unified model that explains various types of inflation, e.g. hyperinflation, chronic inflation, disinflation and deflation, by this single mechanism. The model shows that inflation has the intrinsic nature of persistence, i.e. inflation rates have a unit root.

JEL Classification code: E31, E41

Keywords: Inflation; Deflation; The Fiscal Theory of the Price Level; Demand for Money

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I. INTRODUCTION

What is the ultimate source of inflation still remains as a central question for economists. It is reflected in the recent heated debate over the fiscal theory of the price level. Advocates of the FTPL are Leeper (1991), Sims (1994, 1997, 2001), Woodford (1995, 2001) or Chochrane (1998a, 1998b, 2000), and critics to the theory are Kocherlakota and Phelan (1999), McCallum (2001, 2003), Buiter (2002, 2004) or Niepelt (2004).[1] Although a theoretical literature, e.g. Sargent and Wallace (1981) and the literature of the FTPL, have predicted that fiscal deficits cause inflation, empirical evidence on the inflationary effects of fiscal deficits is inconclusive.[2] On the other hand, it is the stylized fact that the growth of money and inflation are closely related in the long-run, but causality may run from inflation to money.[3] Kocherlakota and Phelan (1999) argues that the FTPL is not falsifiable and the question whether the FTPL is correct can not be answered using data because the FTPL is about the behavior of a government for unobserved prices.

Kocherlakota and Phelan (1999) stresses that the key force behind the FTPL is that a government is fundamentally different from households. To find the true mechanism of inflation, therefore, we should make an investigation into government's behavior more extensively. How different are governments from households? What motives do governments have for expenditure, tax, seigniorage and borrowing? If there is fundamental heterogeneity in behavior between a government and households, it may be the key to the source of inflation. In the aforementioned literature, however, governments' behavior does not appear to be modeled sufficiently, and governments are often described *a priori*, e.g., as agents who are merely

[1] See also Carlstrom and Fuerst (2000), Christiano and Fitzgerald (2000) and Gordon and Leeper (2002).

[2] See e.g. Karras (1994), Darrat (2000), or Fischer, Sahay and Végh (2002).

[3] See e.g. Fischer, Sahay and Végh (2002).

obliged to commit themselves to budget constraints without maximizing anything.[4]

One of the reasons why many economists are skeptical about the FTPL may be that the concept of non-Ricardian policy is too general and non-Ricardian policies include too many fiscal policy rules, many of which may be unrealistic and absurd and lead to unfavorable and unacceptable consequences. To be too general may result in an impression that the FTPL is an extreme theory and merely a meaningless and useless gimmick. However, although most of the non-Ricardian policies may be meaningless and useless, there may be some non-Ricardian fiscal policy rules that play important roles in reality. Hence, it will be necessary to pin down such a non-Ricardian fiscal policy rule that may prevail in reality and, more importantly, is not an *ad hoc* exogenous fiscal policy rule but derived from optimization of government. We need, so to speak, a microfoundation of the Fiscal Theory of the Price Level. What do governments maximize in the process of expenditure and taxes if they are rational agents, while households maximize their expected utilities and firms maximizes their expected profits?[5] Inconclusiveness of the argument over the ultimate source of inflation may arise from this insufficient treatment of government's behavior in models. To model explicitly and clearly a government's maximization problem may be the key to solve the problem of the ultimate source of inflation.

In consideration of the above arguments, the paper examines the model that explicitly includes a government's maximization problem in the conventional general equilibrium framework. To do this, first it is necessary to examine preferences and objective/utility functions of governments. According to the literature of political economy, e.g. Downs (1957) and Alesina and Cukierman (1990), it will not be rare that government's preferences are not identical to those of a representative household. For example, governments are chosen by

[4] Of course, in most models regarding monetary policy, a monetary authority is assumed to maximize its loss function that consists of the rates of inflation and unemployment or output gaps as well as the target inflation rate.

[5] Cochrane (1998b) examines the case that a fiscal authority has an objective to minimize the volatility of inflation rate.

people not only from an economic point of view but from a political point of view, and in countries where income inequality is high, populist parties whose self senses of values are different from that of a representative household, will often win elections (more reasons are explained in the section II). More importantly, the paper adopts the Leviathan view of government, the most prominent reference of which is Brennan and Buchanan (1980). In this view, governments maximize their expected utilities with their own unique utility functions and rates of time preference, and the utility function of government consists of different factors from those of which the utility function of household consists.

The explicit inclusion of a government's maximization problem produces a simple, clear-cut and beautiful result: inflation is ultimately caused by the difference of the rates of time preference between a government and households. If the time preference rate of a government is higher than that of a representative household, the rate of inflation accelerates, and in reverse if the time preference rate of a government is lower than that of a representative household, the rate of disinflation and in some cases deflation accelerates. This is an inevitable consequence of heterogeneity in time preference rates between a government and households.[6] This simple mechanism bridges the gap between the real world and the nominal world. Without inflation, an economy can not be stable, and thus inflation plays a crucial role to stabilize an economy, i.e. to reconcile the contradiction in the time preference rates that will make rational agents confuse and unable to plan future economic activities rationally. The point is that if there is heterogeneity in time preference rates between a government and households, it will be impossible to construct a stable model without inflation, simply because there will be no other way to reconcile the contradiction in the time preference rates than inflation.

This clear-cut result sheds new light on various phenomena of inflation, e.g. persistence, hyperinflation, chronic inflation, disinflation, deflation and so on. For example, the model in the

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[6] Since Becker (1980), it has been well known that, if there is heterogeneity in time preference rates among households, a somber and extreme situation emerges, i.e., the most patient household owns all wealth.

paper has the intrinsic nature of persistence, i.e. inflation rates in the model have a unit root. Because the New Keynesian theory faces difficulties to explain the nature of persistence, the result that the model has the intrinsic nature of persistence will significantly enhance plausibility of the model.[7] For another example, the model in the paper can be seen as a unified model that explains various types of inflation, e.g. hyperinflation, chronic inflation, disinflation and deflation, by a single mechanism such that different combinations of the time preference rates of government and households generate various types of inflation.

This result also gives us new interpretations of the existing various inflation related models. For example, if money is included in the model, positive nominal interest rates are predicted, which is in sharp contrast to the Friedman rule. For another example, the paper predicts that the argument between the FTPL and the quantity theory will be infinitely inconclusive, because both theories equally correspond to a special case of the model in the paper, i.e. the utility of a government is constant in any time, and thus the optimality conditions of the government are reduced to only two equations, i.e. the budget constraint and the transversality condition, while five equations are necessary for a more general utility function of government. Hence, the model in the paper is different from the FTPL in the sense that the budget constraint is still a constraint of a government that is used when the government solves its optimization problem and also in the sense that inflation is caused not by deficits or accumulated government's debts but by the time preference rate of government. Nevertheless, in the sense that the price level is determined not by monetary factors but by fiscal factors, the conclusion in the paper is same as that of the FTPL and the model in the paper can be regarded as presenting a microfoundation of the FTPL.

The paper is organized as follows. In section II, first government's preferences are examined and the optimization problem of government that should be included in the model is specified. The model including the optimization problem of government produces a simple and

[7] See e.g. Holden and Driscoll (2003).

clear-cut result: inflation rates are determined by the difference of the time preference rates between a government and households. It is shown that inflation has the intrinsic nature of persistence, i.e. inflation rates have a unit root, and that the model can be seen as a unified model that explains various types of inflation, e.g. hyperinflation, chronic inflation, disinflation and deflation, by a single mechanism. In section III, the model is compared with the existing various models regarding inflation: the FTPL, the monetary policy rule, the Phillips curve, the optimal fiscal policy, and the theory of money. It is shown that the model in the paper can be regarded as presenting a microfoundation of the FTPL. Finally some concluding remarks are offered in section IV.

II. THE SOURCE OF INFLATION

1. The optimization problem of government

1.1 Heterogeneity in preferences between a government and households

Although households are modeled to maximize their expected utilities and firms are modeled to maximize their profits, it is neglected in many models what governments maximize. In the theory of optimal fiscal policy, a government is assumed to maximize households' expected utilities, but in many models governments are not assumed to maximize anything[8]. Probably, in democratic countries, a political party that has very different preferences from usual people may not win elections, therefore in the long run the averaged preferences of governments may be similar to those of a representative household. In addition, because politicians are generally motivated by a desire that they want to hold office as long as possible,

[8] The assumption in the theory of optimal fiscal policy that a government maximizes households' expected utilities is introduced for the purpose of normative analyses. Whether in reality governments behave according to the assumption is another question.

there will be complete policy convergence in two-party system.[9] However, it is not guaranteed that the preferences of a government are identical to those of a representative household in any time for several reasons. For example, the converged policy does not reflect the mean voter but the median voter.[10] Furthermore, and more importantly, as Alesina and Cukierman (1990) argues, there is the second motive: politicians have preferences over policy issues, thus complete policy convergence may not be the electoral equilibrium. The reasons why the preferences are different between a government and households are summed up as follows.

(i) Governments are chosen from among many political parties not only from an economic point of view but from a political point of view. Each political party has its own unique self sense of values regarding both economic and political points of view. Hence, it is not guaranteed that a political party, whose self sense of values regarding the economic point of view is identical to the representative households' preferences, wins an election, due to the self sense of values of the party regarding the political point of view.

(ii) A representative household's preferences are the aggregated preferences of all households. Hence it will be seen as the mean of households. However, governments are usually chosen by the median of households under proportional representation systems. This factor may particularly play an important role in developing countries where income inequality is very high and populist parties often win elections.[11]

(iii) When elections are held, people expect each party's self sense of values using only limited information. Hence, there will be errors in their expectations. Since only one party can win each election, then the law of large number can not be applied in each election, and thus, although

[9] See the literature of the policy convergence, most of which base upon Downs (1957).

[10] See the literature of the median voter theorem, e.g. also Downs (1957)

[11] See the literature of the delay in reforms, e.g. Rodrik (1996), Cukierman, Edwards, and Tabellini (1992), and Alesina and Drazen (1991).

households want to chose a party that has the same preferences as a representative household, those of the chosen party may be different from those of the representative household due to errors in expectations.[12] It was often seen that after an election, a party that won the election and formed a government raised tax rates although it appealed to constituents during the election that it would never raise tax rates.

(iv) Current voters can not bind the choices of future voters. If there is disagreement between current and future majorities, time inconsistency problem in choosing a party that forms a government will arise. If current voters aware this possibility, they may vote more myopically compared to their own rates of impatience in private economic activities.[13]

(v) When the preferences of a representative household changes, the preferences of a government and the household become different until the next election is held although initially those of the government and the household were identical.[14]

(vi) There is a possibility that a government changes its policy stance including its preferences, e.g. as a result of power struggles in a party that forms a government, although initially those of the government and a representative household were identical.

(vii) There is a possibility that the time preference rates of a government and a representative household *must* be different to control inflation rates. This possibility is examined in detail later.

Hence, it may be the usual situation that the preferences of a government are different from those of a representative household. If they are different, is it rational for a political party that forms a government not to maximize its own expected utility? Does the political party have an incentive not to maximize its expected utility? If we assume rationality of political parties and governments as we usually assume rationality of households and firms, we should assume

[12] See e.g. Alesina and Cukierman (1990).

[13] See e.g. Tabellini and Alesina (1990).

[14] See e.g. Harashima (2004a, c).

that the political party that forms a government maximizes its own expected utility in any time even though its preferences are different from those of a representative household.

Furthermore, there is a more important difference between a government and households regarding their utilities. If governments have only the first motive argued in Alesina and Cukierman (1990), i.e. to hold office as long as possible, only consumption and leisure hours of households may matter for governments. However, if governments have also the second ideological motive, i.e. to have preferences over policy issues, government expenditure and tax revenue that reflect policy achievements may play more important roles in their utilities. Governments will derive utility from expenditure that makes their ideological policies achievable and disutility from taxes that are costs necessary to achieve their ideological policies. This is the Leviathan view of government, the most prominent reference of which is Brennan and Buchanan (1980).[15] In this view, government expenditure is not a tool to maximize the private consumption of households, but is a tool to achieve policy objectives of the party that forms a government.[16] Governments are not presumed to be managed by politically neutral bureaucrats who are obliged to mechanically maximize the expected utility of a representative household in any time and under any political party that forms a government. Government's behavior assumed in the FTPL reflects an aspect of the Leviathan government that acts independently regardless of households' behavior.[17] The Leviathan view generally requires the explicit inclusion of government expenditure, tax revenue, or related government activities in

[15] There are two extremely different views regarding government's behavior. One is the Leviathan view and the other is the benevolent view. In the benevolent view, it is assumed that a government maximizes the expected utility of a representative household.

[16] It is in contrast to the models of the optimal fiscal policy that generally adopt the benevolent view, in which tax revenues are treated as a tool to maximize the private consumption of households.

[17] Christiano and Fitzgerald (2000) argues that non-Ricardian policies are corresponding to the type of policies contemplated in the Ramsey literature, in which governments are viewed as selecting their policies and committing themselves to those policies in advance before prices are determined in markets.

the utility function of government.[18] The paper adopts the Leviathan view firstly because the paper focuses on the second motive of government and secondly because the benevolent government can be seen as a special case of the Leviathan government, i.e. the benevolent government is a special case such that its preferences are coincident with those of a representative household although in general the preferences of a government are not identical to those of the household.

In addition, there is another difference between a government and households. Control variables for households are consumption and leisure hours, but control variables for governments are governments' expenditure and tax revenue. This important difference of nature also may require the explicit inclusion of government's expenditure and tax revenue in the utility function of government.

Taking the above arguments into account, the following environment is assumed in the paper. Each government is chosen from among political parties by elections under a proportional representation system for a finite term. Each political party has its own unique utility function and rate of time preference that are different from those of the other political parties. The utility function and the rate of time preference of a government are those of the chosen political party during its term. Hence, firstly government's preferences are not necessarily identical with those of a representative household, and secondly government's preferences in a country are time-variable.

1.2 The utility function of government

A Leviathan government derives utility from government's expenditure for its own purposes that are different from those of a representative household. Hence, the larger the expenditure the happier the Leviathan government will be. On the other hand, if the government thinks that raises of tax rates will provoke people's antipathy and will reduce its probability to

[18] See e.g. Edwards and Keen (1996).

be reelected, the Leviathan government will feel less happy, because the government expects that if it loses power it can not expend money for its purposes anymore. The Leviathan government may consider taxes as necessary costs to obtain freedom of expenditure for its own purposes. The expenditure and taxes in the utility function of government may be analogous to consumption and labor hours in the utility function of household. In addition, the consumption and labor hours are both control variables and similarly the government's expenditure and tax revenue are also both control variables.

Taking into the above arguments, the utility function of government can be expressed as $u^G(g_t, x_t)$,[19] where $g_t = \frac{G_t}{p_t}$ is the real government expenditure, $x_t = \frac{X_t}{p_t}$ is the real tax revenue of government in period t while G_t is nominal government expenditure, X_t is nominal tax revenue, and p_t is the price level in period t.[20] In addition, it can be assumed by the abovementioned arguments that $\frac{\partial u^G}{\partial g_t} > 0$, $\frac{\partial^2 u^G}{\partial g_t^2} < 0$, $\frac{\partial u^G}{\partial x_t} < 0$, and $\frac{\partial^2 u^G}{\partial x_t^2} > 0$.

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[19] It may be possible to assume that partially governments are benevolent. In this case the utility function of a government can be assumed to be $u^G(g_t, x_t, c_t, l_t)$ where c_t is the real consumption and l_t is the leisure hours of a representative household. However, in case of lump-sum tax, government's policies do not affect the steady state consumption and leisure hours. In this case the utility function can be assumed to be $u^G(g_t, x_t)$.

[20] Instead, it is possible to assume a loss function for a fiscal authority similar to that for a monetary authority, e.g. the Taylor rule. This kind of loss functions penalizes variations in output around its steady state level. Nonetheless, the paper does not adopt this kind of loss functions because it seems that this kind of loss functions can not deal with the fundamental difference between monetary and fiscal policies appropriately. Monetary authority's instrument, i.e. the nominal interest rate, has nothing to do with the utility of monetary authority. It is merely an instrument. However, a fiscal authority will derive utility from its instrument, i.e. government's expenditure as was discussed above if governments have the second motive argued in Alesina and Cukierman (1990). Hence, the level of government's expenditure should be directly included in the utility/loss function of fiscal authority.

2. The model

The utility function of a government is $u^G(g_t, x_t)$, where $\frac{\partial u^G}{\partial g_t} > 0, \frac{\partial^2 u^G}{\partial g_t^2} < 0$, $\frac{\partial u^G}{\partial x_t} < 0$, and $\frac{\partial^2 u^G}{\partial x_t^2} > 0$. All variables are expressed in per capita terms. It is assumed that u^G is a constant relative risk aversion utility function. The government's rate of time preference is θ^G. The tax is assumed to be lump-sum. The budget constraint of the government is

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

where B_t is the accumulated nominal government bonds, R_t is the nominal interest rate for government bonds, and S_t is the nominal amount of seigniorage in period *t*. R_t is composed of the real interest rate r_t and the expected change of bonds' price by inflation $\pi^e_{b,t}$ such that $R_t = r_t + \pi^e_{b,t}$. Let $b_t = \frac{B_t}{p_t}$ and $s_t = \frac{S_t}{p_t}$, and $\pi_t = \frac{\dot{p}_t}{p_t}$ is the inflation rate in period *t*. By divided by p_t, the budget constraint is transformed to

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

and it is equivalent to

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

Hence, the optimality problem of the government is

$$\text{Max} \quad E_0 \int_0^\infty u^G(g_t, x_t) \exp(-\theta^G t) dt$$

subject to

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

On the other hand, a representative household maximizes the following expected utility:

$$\text{Max} \quad E_0 \int_0^\infty u^P(c_t) \exp(-\theta^P t) dt$$

where u^P and θ^P are the utility function and the rate of time preference of the representative household, subject to the following constraint:

$\dot{k}_t = f(k_t) - c_t - g_t$,

where $f(\bullet)$ is the production function, k_t is the real capital per capita, and c_t is the real consumption per capita.[21] The constraint means that the output $f(k_t)$ in each period is demanded for the private consumption c_t, the private investment $\dot{k}_t$ and the government expenditure g_t. The government expenditure g_t is an exogenous variable for the representative household because the government is a Leviathan. It is assumed that $u^{P'} > 0$ and $u^{P''} < 0$ and the number of population is constant.

Initially, this model does not include money and the seigniorage S_t is assumed to be an exogenous variable. The model is extended to one that includes money in sub-section III.5.

3. The law of motion for price

3.1 The consequence of heterogeneity between a government and households

The optimality conditions of both the government and the representative household yield the following important and clear-cut results, which are inevitable consequences of heterogeneity between a government and households.

Theorem 1: $\pi_{b,t}^e = \pi_t + \theta^G - \theta^P$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$.

Proof: Let Hamiltonian H be

$H = u^G(g_t, x_t)\exp(-\theta^G t) + \lambda_t[b_t(R_t - \pi_t) + g_t - x_t - s_t]$ where λ_t is a costate variable.

[21] The constraint is equivalent to $\dot{k}_t = f(k_t) - c_t - \dot{b}_t - x_t - s_t + b_t(R_t - \pi_t)$.

The optimality conditions of the government's above problem are

(1) $$\frac{\partial u^G(g_t,x_t)}{\partial g_t}\exp\left(-\theta^G t\right) = -\lambda_t$$

(2) $$\frac{\partial u^G(g_t,x_t)}{\partial x_t}\exp\left(-\theta^G t\right) = \lambda_t,$$

(3) $$\dot{\lambda}_t = -\lambda_t\left(R_t - \pi_t\right),$$

(4) $$\dot{b}_t = b_t\left(R_t - \pi_t\right) + g_t - x_t - s_t,$$

(5) $$\lim_{t\to\infty}\lambda_t b_t = 0.$$

Combining conditions (1), (2) and (3) yields the following equations:

$$\frac{g_t\dfrac{\partial^2 u^G(g_t,x_t)}{\partial g_t^2}}{\dfrac{\partial u^G(g_t,x_t)}{\partial g_t}}\frac{\dot{g}_t}{g_t}+\theta^G = R_t-\pi_t = r_t+\pi_{b,t}^e-\pi_t, \text{ and}$$

$$-\frac{x_t\dfrac{\partial^2 u^G(g_t,x_t)}{\partial x_t{}^2}}{\dfrac{\partial u^G(g_t,x_t)}{\partial x_t}}\frac{\dot{x}_t}{x_t}+\theta^G = R_t-\pi_t = r_t+\pi_{b,t}^e-\pi_t.$$

Here, $\dfrac{g_t\dfrac{\partial^2 u^G(g_t,x_t)}{\partial g_t^2}}{\dfrac{\partial u^G(g_t,x_t)}{\partial g_t}}\dfrac{\dot{g}_t}{g_t} = 0$ and $\dfrac{x_t\dfrac{\partial^2 u^G(g_t,x_t)}{\partial x_t{}^2}}{\dfrac{\partial u^G(g_t,x_t)}{\partial x_t}}\dfrac{\dot{x}_t}{x_t} = 0$ at the steady state such that $\dot{g}_t = 0$ and $\dot{x}_t = 0$, and thus $\theta^G = r_t+\pi_{b,t}^e-\pi_t$.

Here, by the optimality conditions of the representative household, $r_t = \theta^P$ at the steady state such that $\dot{c}_t = 0$, $\dot{k}_t = 0$ and $\dot{g}_t = 0$.

Hence $\theta^G = \theta^P+\pi_{b,t}^e-\pi_t$ and thus $\pi_{b,t}^e = \pi_t+\theta^G-\theta^P$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$.

Q.E.D.

Under the following assumption that the expected rate of inflation will perfectly realize, theorem 1, i.e. the equation $\pi_{b,t}^{e} = \pi_t + \theta^G - \theta^P$ determines the path of rates of inflation, disinflation or deflation and thus depicts the basic law of motion for price.

Assumption:

(A1) The expected change of bonds' price by inflation $\pi_{b,t}^{e}$ in period *t* is formed by expected inflation rates in period *t* such that $\pi_{b,t}^{e} = E_t \int_t^{t+1} \frac{\dot{p}_v}{p_v} dv = E_t \int_t^{t+1} \pi_v dv$ where E_t is the expectation operator.

(A2) Expected inflation rates are perfectly realized and thus $\int_t^{t+1} \pi_v dv = \pi_{b,t}^{e} = E_t \int_t^{t+1} \pi_v dv$.

Assumption (A1) means that the expected change of bonds' price by inflation $\pi_{b,t}^{e}$ equals the expected general price change during period *t*, and because R_t is based on the budget constraint of the government $\dot{B}_t = B_t R_t + G_t - X_t - S_t$, assumption (A1) is quite natural one. Assumption (A2) simply assumes rational expectations.

Corollary 1: $R_t - \pi_t = \theta^G$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$.

Proof: See Appendix 1.

That is, the real interest rate for government bonds estimated using the current inflation rate is the time preference rate of the government.

Lemma 1: If and only if $\theta^G = -\dfrac{g_t - x_t - s_t}{b_t}$ at the steady state, then the transversality condition (5) $\lim_{t\to\infty} \lambda_t b_t = 0$ holds.

Proof: Substituting the results of theorem 1 and corollary 1 into conditions (3) and (4) and solving both differential equations yield the equation: $\lambda_t b_t = -\exp\left[(g_t - x_t - s_t)\int \frac{1}{b_t} dt + C^{\#}\right]$ at the steady state where $C^{\#}$ is a certain constant. Thereby it is necessary to satisfy $g_t - x_t - s_t < 0$ and $\lim_{t\to\infty} \int \frac{1}{b_t} dt = \infty$ for the transversality condition (5) to be held.

Here, by condition (4), $\dfrac{\dot{b}_t}{b_t} = \theta^G + \dfrac{g_t - x_t - s_t}{b_t}$ at the steady state. Hence if $\dfrac{\dot{b}_t}{b_t} = \theta^G + \dfrac{g_t - x_t - s_t}{b_t} = 0$ at the steady state then b_t is constant and thus $\lim_{t\to\infty} \int \frac{1}{b_t} dt = \infty$. Thereby the transversality condition holds. However, if $\dfrac{\dot{b}_t}{b_t} = \theta^G + \dfrac{g_t - x_t - s_t}{b_t} < 0$ at the steady state then b_t diminishes to zero, then the transversality condition (5) can not hold because $g_t - x_t - s_t < 0$. If $\dfrac{\dot{b}_t}{b_t} = \theta^G + \dfrac{g_t - x_t - s_t}{b_t} > 0$ at the steady state then $\lim_{t\to\infty} \dfrac{\dot{b}_t}{b_t} = \theta^G$ and thus b_t increases as time passes and $\lim_{t\to\infty} \int \frac{1}{b_t} dt = \dfrac{C^{\#\#}}{\theta^G}$ where $C^{\#\#}$ is a certain constant. Thereby the transversality condition (5) also can not hold.

Q.E.D.

If the transversality condition is satisfied, then, at the steady state, the increase of government's debts $\theta^G b_t$, i.e. the real interest rate of government bonds estimated using the current inflation rate θ^G times accumulated debts b_t, is equal to the amount of reduction of debts $-(g_t - x_t - s_t)$ in any period.

Inflation rates will not have seasonal cycles, and therefore the following assumption will be seen as quite natural.

Assumption: (A3) π_t does not have any cycle of length 1.

Lemma 2: If and only if $\pi_{t+\zeta} = \pi_t + 2\zeta(\theta^G - \theta^P)$, π_t does not have any cycle of length 1.

Proof: See Appendix 2.

Hence, under assumptions (A1) and (A2), inflation rates develop according to the following theorem.

Theorem 2: $\dot{\pi}_t = 2(\theta^G - \theta^P)$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$ if $\theta^G = -\frac{g_t - x_t - s_t}{b_t}$ at the steady state.

Proof: By theorem 1 and assumption (A1) and (A2), $\int_t^{t+1} \pi_v dv - \pi_t = \theta^G - \theta^P$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$. Thereby $\frac{d\pi_t}{dt} = \pi_{t+1} - \pi_t$.

Here, by lemma 2, $\pi_{t+1} = \pi_t + 2(\theta^G - \theta^P)$. Hence, $\frac{d\pi_t}{dt} = \pi_{t+1} - \pi_t = 2(\theta^G - \theta^P)$.

Q.E.D.

Theorem 2 shows the consequence of heterogeneity in preferences between a government and households, i.e., inflation plays a crucial role to reconcile the contradiction in the difference of time preference rates between a government and households. People are forced to reconcile the contradiction in time preference rates by expecting inflation because they know that the Leviathan government has no intention to be forced to default in any situation even if its budget constraint may not be satisfied.[22] Theorem 2 indicates that if there is heterogeneity in time preference rates between a government and households, it will be impossible to construct a model of a stable economy without inflation, simply because there will be no other way to reconcile the contradiction in the time preference rates than inflation.

3.2 Persistence

It is a stylized fact that inflation has a nature of persistence. It is well-known that US inflation showed high persistence particularly in 1960s and 1970s.[23] In the New Keynesian theory, this nature of persistence is a puzzle that is difficult to be solved.[24] However, the model in the paper has a feature of persistence intrinsically because inflation rates have a unit root at the steady state.

Proposition 1: Inflation rates have a unit root at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$ if $\theta^G = -\frac{g_t - x_t - s_t}{b_t}$ at the steady state.

Proof: By lemma 2, $\pi_{t+1} = \pi_t + 2\left(\theta^G - \theta^P\right)$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$. Hence, $\pi_{t+1} - \pi_t = 2\left(\theta^G - \theta^P\right)$ at the steady state.

[22] This is the very point Buiter (2002, 2004) criticizes. He has denounced the FTPL as a fallacy for the reason that if default is rule out, budget constraints must be satisfied always by any economic agent.

[23] See e.g. Cogley and Sargent (2001) and Stock (2001).

[24] See e.g. Holden and Driscoll (2003).

Q.E.D.

Persistence may be also observed in transition periods. Even though an economy is not at steady state, if $\frac{g_t u^{G''}(g_t)}{u^{G'}(g_t)} \frac{\dot{g}_t}{g_t}$, $-\frac{x_t u^{G''}(x_t)}{u^{G'}(x_t)} \frac{\dot{x}_t}{x_t}$, and $-\frac{c_t u^{P''}(c_t)}{u^{P'}(c_t)} \frac{\dot{c}_t}{c_t}$ are relatively small compared to θ^G and θ^P, price movements (inflation/deflation) will be observed to have a nature of persistence.

3.3 Debts and inflation

Government's debts b_t are constant at the steady state although inflation rates follow theorem 2.

Remark 1: $\dot{b}_t = 0$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$, and $\dot{k}_t = 0$ if $\theta^G = -\frac{g_t - x_t - s_t}{b_t}$ at the steady state, and the amount of government's debts at the steady state is that $b_t = -\frac{g_t - x_t - s_t}{\theta^G}$.

Proof: By condition (4) and corollary 1, $\dot{b}_t = b_t(R_t - \pi_t) + g_t - x_t - s_t = b_t\theta^G + g_t - x_t - s_t$ at the steady state. Since $b_t = -\frac{g_t - x_t - s_t}{\theta^G}$ at the steady state, then $\dot{b}_t = b_t\theta^G - b_t\theta^G = 0$ at the steady state.

Q.E.D.

The amount of government's debts b_t at the steady state depends on θ^G, g_t, x_t and s_t, and thus it depends on the functional form and the values of parameters in government's utility function

u^G. These results, i.e. firstly $\dot{b}_t = 0$ while $\dot{\pi}_t \neq 0$ and secondly b_t depends on θ^G and u^G, imply that the relationship between inflation and government's debts will be unclear and inconclusive in empirical studies if liner relations between them are assumed.[25]

Remark 1 will also contribute to the argument over fiscal sustainability, because the nominal interest rate R_t and inflation rate π_t are endogenous in the model although they are fixed *ad hoc* in most existing studies regarding fiscal sustainability. More importantly, the key that distinguishes the model from the existing models is the inclusion of the time preference rate of government θ^G that plays a crucial role in remark 1.

Unless the transversality condition is violated, i.e. unless the equation $b_t = -\frac{g_t - x_t - s_t}{\theta^G}$ does not hold at the steady state, government's debts b_t are sustainable by lemma 1and there is no possibility of default.[26]

3.4 Hyperinflation

Theorem 1 and 2 predict a hyperinflation in case of extremely high θ^G.[27]

Remark 2: If θ^G becomes extremely high while θ^P stays at the usual value, inflation rates extremely increase.

What will make θ^G extremely high? Higher rates of time preference mean very myopic

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[25] See e.g. Karras (1994), Darrat (2000), or Fischer, Sahay and Végh (2002).

[26] Of course there is a possibility of default if a government borrows money from foreigners over whom the government has only limited authority.

[27] Hence, a hyperinflation is not caused by the growth of money. This view is consistent with the conclusion of Fischer, Sahay and Végh (2002). They conclude that causation (in the Granger sense) runs from inflation to money growth, and that once inflation has been triggered, monetary policy has typically been accommodative.

government's behavior. It is likely that if a government is formed by a party that is expected to collapse soon and is never considered to come back to power, the government may behave very myopically. This situation will occur e.g. just after the defeat in a war. Hyperinflations were often observed just after the end of a regime, e.g. Germany after the WWI, Japan after the WWII, and Russia after the collapse of the Soviet Union. In those transitional periods, governments were very fragile and may have acted very myopically and thus it is highly likely that those transitional governments had very high θ^G.

This result that the extremely myopic behavior of fragile governments is the source of hyperinflations appears quite natural and intuitively acceptable. It is not necessary to assume adaptive expectations or sunspots like the well-known hyperinflation model of Cagan (1956). Conversely, as Sargent (1982) emphasizes, a hyperinflation can be ended if θ^G becomes lower e.g. by replacing the incumbent government with a political party that has much lower rate of time preference.[28]

3.5 Chronic inflation

Theorem 1 and 2 also predict the existence of chronic inflations that were observed e.g. in 1960s and 1970s in many industrialized countries.

Remark 3: If inflation rates are not so high and $\theta^G - \theta^P$ is positive but not so small, the inflation rates increase steadily but stays low compared to hyperinflations in a relatively long period.

Broadly speaking there are two views regarding chronic inflations. In the first view, chronic

[28] Sargent (1982) emphasizes that a credible change in policies, preferably embedded in legal and institutional changes, could bring a hyperinflation to an end at very small cost.

inflations are the result of the lack of policy-maker's motive to stabilize inflation, and in the second view, the bad lucks or honest mistakes of policy-makers yield chronic inflations.[29] The view derived from the remark 3 will be categorized into the first view. Although governments know that $\theta^G - \theta^P > 0$ and thus inflation rates will accelerate, the Leviathan governments still purse their ideological policy objectives that are given higher priority. A chronic inflation will end if the incumbent government is replaced by a political party whose rate of time preference is lower than that of households. On the other hand, if a party with higher rate of time preference rises to power, chronic inflation will be observed even if monetary authorities have correct information and there is no large negative shock.[30]

3.6 Disinflation, deflation and great depression

If in reverse $\theta^G - \theta^P$ is negative, disinflation and in some cases deflation will be observed. Furthermore, a deeper deflation has the possibility to fall into a great depression.

Proposition 2: If $\theta^G - \theta^P < 0$, then in a finite period an economy becomes unstable.

Proof: If $\theta^G - \theta^P < 0$, then by theorem 2, $\dot{\pi}_t = \theta^G - \theta^P < 0$ at the steady state and by assumption (A1), the decrease of inflation rate π_t accelerates as time passes. Hence, in a finite period $\left|\pi_{b,t}^e\right|$ exceeds $r_t = \theta^P$, i.e. $r_t + \pi_{b,t}^e = \theta^P + \pi_{b,t}^e < 0$. However, the nominal interest rate $R_t = r_t + \pi_{b,t}^e$ cannot be negative due to the zero bound, i.e. $0 \le R_t = r_t + \pi_{b,t}^e$. Thereby in the case that $\theta^P + \pi_{b,t}^e < 0$, then $\theta^P + \pi_{b,t}^e < 0 \le R_t = r_t + \pi_{b,t}^e$ and thus $\theta^P < r_t$, i.e. the real interest rate is higher than the rate of time preference of households in any period. Hence, an

[29] See e.g. Collard and Dellas (2004).

[30] Collard and Dellas (2004) shows that explanations that take the second view that the bad lucks or honest mistakes of policy-makers yield chronic inflations require an implausibly severe recession to generate a chronic inflation.

economy can not reach the steady state such that $\dot{c}_t = \dot{k}_t = 0$.

Q.E.D.

Imagine that there is a shock to θ^P that makes θ^P increases drastically.[31] In this case, an economy will fall into a severe recession because the higher θ^P makes the output and consumption lower. In addition, if the increase of θ^P is so large that $\left|\pi_{b,t}^e\right|$ exceeds $r_t = \theta^P$ immediately, by proposition 2 the economy becomes unstable instantly. This devastating situation may explain part of the development of the Great Depression.[32] In this situation, if the government is replaced by a political party with the higher rate of time preference θ^G that matches the increased rate of time preference of households, instability of the economy will be prevented although the higher θ^P still makes the output and consumption lower.[33]

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[31] The concept of time-varying time preference has a long history, dating back to the era of Böhm-Bawerk (1889) and Fisher (1930), and the possibility of hike of time preference rate is not deniable. A mechanism of time-varying time preference is examined in detail in Harashima (2004a, c).

[32] A moderate deflation such that $\left|\pi_{b,t}^e\right| < r_t = \theta^P$ dose not destabilize an economy. Atkeson and Kehoe (2004) concludes that there is no empirical relationship between deflation and depression except for the Great Depression.

[33] The Japanese economy experienced a protracted slump that has been often pointed out to be analogous to the Great Depression. They are similar in the sense that the nominal interest rates were zero and the economies appear to have been in a "liquidity trap." However, there is a very different aspect, i.e., the loss of output was much larger in the Great Depression than in the slump of Japan in 1990s. This difference may be explained by both governments' different responses to these situations. The Hover administration did not change economic policies in the early stage of the Great Depression, but in Japan the government drastically changed economic policies in early 1990s and increased the expenditure of public works hugely and issued huge government's bonds. These different responses may have led to the different consequences that in the U.S. θ^G stayed low and thus the economy became instable but in Japan θ^G increased sharply and thus the economy escaped from instability.

III. THE RELATION TO EXISTING MODELS

1. The fiscal theory of the price level

In the FTPL and also in the quantity theory of money, the utility function of government is not explicitly assumed. Nevertheless, it can be shown that it is implicitly assumed in those theories that the utility function of government is such that $E_0\int_0^\infty u^G(g_t, x_t)\exp(-\theta^G t)dt = \text{constant}$ for any g_t and x_t and thus $u^G = \text{constant}$.

Proposition 3: If the utility function of a government is a special one such that $u^G = \text{constant}$, then the optimality conditions for the government are (i) the budget constraint $\dot{b}_t = b_t(R_t - \pi_t) + g_t - x_t - s_t$ and (ii) the transversality condition.

Proof: Let Hamiltonian H be

$H = u^G(g_t, x_t)\exp(-\theta^G t) + \lambda_t[b_t(R_t - \pi_t) + g_t - x_t - s_t]$ where λ_t is a costate variable. The optimality conditions are

(6) $\dfrac{\partial H}{\partial g_t} = 0$,

(7) $\dfrac{\partial H}{\partial x_t} = 0$,

(8) $\dfrac{d\lambda_t}{dt} = -\dfrac{\partial H}{\partial b_t}$,

(9) $\dfrac{db_t}{dt} = -\dfrac{\partial H}{\partial \lambda_t}$,

(10) $\lim_{t\to\infty} \lambda_t b_t = 0$.

If the utility function of the government is that $u^G = \text{constant}$, then conditions (6) and

(7) are $\frac{\partial H}{\partial g_t} = -\lambda_t = 0$ and $\frac{\partial H}{\partial x_t} = \lambda_t = 0$ thus $\lambda_t = 0$, and thereby conditions (6) and (7) hold for any $\pi^e_{b,t}, \pi_t, g_t, x_t,$ and s_t in any period. In addition in case $\lambda_t = 0$, condition (8) $\frac{d\lambda_t}{dt} = -\lambda_t(R_t - \pi_t) = 0$ holds for any $\pi^e_{b,t}, \pi_t, g_t, x_t,$ and s_t in any period.

Hence, the optimality conditions are condition (9) and the transversality condition (10). Here, condition (9) is equivalent to the budget constraint $\dot{b}_t = b_t(R_t - \pi_t) + g_t - x_t - s_t$. As a result, if the utility function of the government is a special one such that $u_G = \text{constant}$, then the optimality conditions are (i) the budget constraint $\dot{b}_t = b_t(R_t - \pi_t) + g_t - x_t - s_t$ and (ii) the transversality condition.

Q.E.D.

Proposition 3 indicates that both the FTPL and the quantity theory commonly base upon a special utility function of the government such that $u^G = \text{constant}$ and thus both theories are arguing about the interpretation of the budget constraint and the transversality condition. In this case $\pi^e_{b,t}, \pi_t, g_t,$ and x_t are indeterminate since conditions (6) and (7) hold for any $\pi^e_{b,t}, \pi_t, g_t,$ and x_t in any period. To fix these variables, it is necessary to make either prices $\pi^e_{b,t}$ and π_t or government's behavior g_t and x_t be exogenously given. In the FTPL, the former option, i.e. prices $\pi^e_{b,t}$ and π_t are assumed to be exogenous and the government adjusts g_t and x_t for b_t not to explode, is called Ricardian and the latter option, i.e. government's behavior g_t and x_t are exogenous and prices $\pi^e_{b,t}$ and π_t are adjusted for b_t not to explode is called non-Ricardian.[34] Both options are theoretically possible and it appears difficult to judge *a*

[34] As Kocherlakota and Phelan (1999) argues, in the Ricardian regime, the control of money supply on the assumption of the quantity theory of money is not sufficient to pin down the time path of inflation rate. Traditionally

priori which option describes the world more correctly.[35] Nonetheless, taking proposition 3 into consideration, the argument which of the Ricardian and the non-Ricardian is correct seems to be infinitely inconclusive because both options commonly base upon a very special utility function of government such that $u^G = \text{constant}$ for any g_t and x_t.

While the FTPL has argued vaguely about government's behavior regarding fiscal policies, the paper investigated it in detail and found that, in government's behavior, the rate of time preference is crucial for inflation. Inflation is caused not by deficits or accumulated government's debts but by the time preference rate of government. The budget constraint is still a constraint of a government that is used when the government solves its optimization problem. In these senses, the model in the paper is different from the FTPL. However, it should be noted that the conclusion in the paper is same as that of the FTPL in the sense that the price level is determined not by monetary factors but by fiscal factors. Hence, the model in the paper should be regarded not as denying the FTPL but as presenting a microfoundation of the FTPL, i.e. specifying a non-Ricardian fiscal policy rule that is reasonable and more importantly derived from optimization of government.

2. The monetary policy rule

In the conventional models of monetary policy, three kinds of equations, i.e. the equation that describes monetary transmission channels, a Phillips curve and a monetary policy rule,

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a monetarist type rule, e.g. purely speculative time trends in velocity, has been often assumed implicitly.

[35] "Ricardian" and "non-Ricardian" are interpreted as depicting fiscal policy rules. Having only the budget constraint, it is necessary to introduce a fiscal policy rule that determine how a government behaves for expenditure to fix the price level. If we assume governments are rational, fiscal policy rules should be results of the optimization of government. However, in most researches the Ricardian and non-Ricardian fiscal policy rules are merely introduced *a priori* without considering the optimization of government, while theorem 2 in the paper is a result of the optimization of government.

determine the movement of inflation.[36] As is well-known, monetary transmission mechanisms and the Phillips curve are even now controversial. However, the law of motion for price in the model in the paper is irrelevant to any of the above three kinds of equations. Hence, in the model, there is no influence of monetary authorities on inflation since the time preference rates of government and households determine the rate of inflation. Governments, not monetary authorities, determine the rate of inflation through their policy stances that are reflected in the rates of time preference. Monetary authorities may be seen effective for managing inflation only in the case that changes of monetary authority's policies are backed by governments and thus people think that the time preference rates of governments change coincidentally with the changes of monetary policies. Without support of a government, a policy change independently determined by a monetary authority may fail because people do not think that the time preference rate of the government coincidently changed. This conclusion is similar to that of the FTPL in the sense that a tough and independent monetary authority is not sufficient to guarantee price stability but needs also an appropriate fiscal policy.[37]

However, the above result will not deny the existence of the conventional monetary transmission mechanisms in any time. Probably the conventional mechanisms are valid for short-term disturbances of inflation, while theorem 2 in the paper will prevail in the long-run. If so, how can the Taylor rule be interpreted in the framework of the paper? The Taylor rule is regarded as describing the Fed's behavior well. The Taylor rule for the stochastic inflation rate $\pi_t^{\#}$ and the stochastic output gap $y_t^{\#}$ with mean zero is

$$i_t = r^* + \pi_t^{\#} + \mu\left(\pi_t^{\#} - \pi^*\right) + \eta y_t^{\#},$$

where i_t is the central bank's policy rate, r^* is the equilibrium real interest rate, π^* is the inflation

[36] See e.g. Svensson (1999) or Mankiw (2001).

[37] For example, Cochrane (2000) contends that monetary policy may be intrinsically irrelevant to price determination.

target of the central bank, and $\pi_t^{\#}$ is the stochastic inflation rate. The Taylor rule may be useful to stabilize short-term fluctuations of inflation caused by various shocks under the following assumptions, particularly if the central bank can control the nominal interest rate, although the long-run inflation is dominated by theorem 2.

Assumptions:

(A4) The central bank can control its policy rate i_t at will.

(A5) At the steady state such that $\dot{c}_t = \dot{k}_t = 0$, $E_t i_{t+v} = r^* + \pi^*$ for any v (> 0).

(A6) The stochastic inflation rate $\pi_t^{\#}$ is composed of a short term i.i.d. shock ε_t with mean zero and the non stochastic part of inflation rate π_t that is analyzed in the previous sections and thus $\pi_t^{\#} = \pi_t + \varepsilon_t$.

Assumption (A4) is, needless to say, necessary for monetary policies to be workable. Assumption (A5) is necessary for monetary policies to be useful because, if the nominal interest rate deviates from $r^* + \pi^*$ in the long run, the economy can not be stable.

Proposition 4: If $\theta^G - \theta^P = 0$, then for an economy to be stable, the inflation target π^* of the central bank in the Taylor rule should be the current rate of inflation π_t that is constant.

Proof: By theorem 2, if $\theta^G - \theta^P = 0$, then π_t is constant. Here if π^* is different from π_t and thus $\pi^* = \pi_t + \varphi$ where φ is a constant, the Taylor rule is $i_t = r^* + \pi_t^{\#} + \mu(\varepsilon_t - \varphi) + \eta y_t^{\#}$. Because $E_t i_{t+v} = r^* + \pi_t - \mu\varphi$ for any v (> 0) and thus $E_t i_{t+v} - \pi_t = r^* - \mu\varphi = \theta^P - \mu\varphi$ for any v (> 0), then the expected real interest rate $E_t i_{t+v} - \pi_t$ (π_t is constant) is different from the rate of time preference of households θ^P in any time and thus it is impossible to be that

$E_t i_{t+v} = r^* + \pi^*$ for any v (> 0). Hence, an economy can not reach the steady state such that $\dot{c}_t = \dot{k}_t = 0$.

Q.E.D.

Since the long-run inflation rate is determined by theorem 2, the central bank must accommodate its long run policy to theorem 2 in a situation that the central bank can control the nominal interest rate. If the central bank does not accommodate its policy in the long-run, the economy will destabilize.

Remark 4: By proposition 4, if $\theta^G - \theta^P = 0$, then the inflation target π^* of the central bank in the Taylor rule should be the current inflation rate π_t even though the current inflation rate π_t is high, say over 10 % annually. To reduce this high inflation rate, the government must be replaced by a political party that has the lower rate of time preference θ^G compared with the rates of time preference of the incumbent government and households, i.e. the difference between the rates of time preference should be changed to be that $\theta^G - \theta^P < 0$.

A question about the Great Inflation in 1960s and 1970s has been put forward: why didn't the governments and monetary authorities in those days take policies to reduce the rate of inflation. Some contend that the governments and monetary authorities in those days cared inflation less compared with the governments and monetary authorities after 1980s, and some conclude that the governments and monetary authorities in those days took policies based on the biased estimation of output gaps.[38] Proposition 4 and remark 4 will present another kind of explanation that may be seen as a variant of the first explanation. That is, the governments in those days were neither strange nor different from the ordinary people in the sense that

[38] See e.g. Collard and Dellas (2004).

$\theta^G = \theta^P$, but being ordinary itself made the high rate of inflation persist because the current inflation rate π_t in those days was already high. To reduce this high inflation rate, the government needed to be replaced by a reform minded political party that had the far lower rate of time preference. The Reagan administration may have been such a government.

3. The Phillips Curve

In the model in the paper, the Phillips curve is irrelevant. However, empirically the short-run positive relation between inflation and output gaps has been observed. Behind this phenomenon, there may be a short-term mechanism that is independent of the mechanism described in the model in the paper. However, there is a theoretical possibility that theorem 2 can generate the Phillips curve.

Suppose that initially $\theta^G = \theta^P$. If θ^P shifts upwards for some reasons, the production and consumption at steady state in an economy must decrease.[39] In reverse, if θ^P shifts downward, the production and consumption at steady state in an economy must increases. Hence, after a shock to θ^P, the production will deviate from its previous trend downward in case of an upward shift of θ^P and upward in case of a downward shift of θ^P.[40] On the other hand, if θ^P shifts upward, the inflation rate will decrease due to theorem 2 and in reverse if θ^P shifts downward, the inflation rate will increase. As a result, when θ^P changes while θ^G does not, a positive correlation between π_t and $\hat{y}_t$ will be estimated in transition periods where $\hat{y}_t = y_t - \bar{y}_t$ and $\bar{y}_t$ is a trend. This positive correlation between π_t and $\hat{y}_t$ may be

[39] Fluctuations of time preference rate have been regarded as natural phenomena since the era of Böhm-Bawerk (1889) and Fisher (1930). See e.g. Harashima (2004a, c).

[40] The transition path from the old steady state to the new steady state in case of shifts of θ^P may be complex. It is examined in detail in Harashima (2004b).

observed as a Phillips curve.[41]

This explanation of the Phillips curve does not require any friction. In case of other shocks, e.g. technology shocks or leisure preference shocks, some kinds of frictions are basically necessary to explain the mechanism of the Phillips curve.

4. The optimal fiscal policy

If the utility function and time preference rate of a government is a special one such that $u^G = u^P(c_t)$ and $\theta^G = \theta^P$, then the optimization problem of the government is identical with that for the optimal fiscal policy. The government maximizes the expected utility of a representative household that is same as the expected utility of the government. In this case, if g_t and x_t are both irrelevant with c_t, then $\frac{\partial u^P(c_t)}{\partial g_t} = 0$ and $\frac{\partial u^P(c_t)}{\partial x_t} = 0$, and thus the optimality conditions in the case of $u^G = u^P(c_t)$ are identical to those in the case of $u^G = \text{constant}$. Hence, the theory of the optimal fiscal policy generally assumes the tax systems that have the nature of $\frac{\partial u^P(c_t)}{\partial x_t} < 0$.

Point is to whom it is optimal. In the theory of the optimal fiscal policy, the optimal situation is the situation where the expected utility of a representative household is maximized. This reflects the benevolent view of government.[42] Hence the optimal fiscal theory requires an unusual incentive that a government maximizes not its own expected utility but the expected utility of a representative household, although households maximize their own expected utilities and firms maximize their own profits. For this incentive to be rational for the government, the utility function and time preference rate of the government must be identical to those of the

[41] It should be noted that Philips curves generated by the above mechanism have a possibility of shifts of curves according to changes of the rates of time preference of government and households.

[42] See e.g. Downs (1957).

representative household in any time. As a result, the optimal fiscal policy implicitly assumes that only the political parties that have the same utility function and time preference rate as those of a representative household can win elections.[43] The theory of the optimal fiscal policy will be useful if this assumption is valid. However, as was argued in section II, in reality it will not be rare that the utility function and time preference rate of a government is different from those of a representative household and thus the assumption may often be violated.

5. The theory of money

In this subsection, money is introduced into the model. The well-known money in utility model of Sidrauski (1967) is used as the model for households. A representative household maximizes the expected utility

Max $E_0 \int_0^{\infty} u^P(c_t, m_t) \exp(-\theta^P t) dt$

subject to

$$\dot{a}_t = (ra_t + w_t + z_t) - [c_t + (\pi_t + r_t) m_t] - g_t .$$

where $a_t = k_t + m_t$, and m_t is the real money, w_t is the real wage, and z_t is the real government transfers. It is assumed that $r_t = f'(k_t)$, $w_t = f(k_t) - k_t f'(k_t)$ and the lump-sum government transfers z_t is equal to the seigniorage s_t and thus $s_t = \dot{m}_t + \pi_t m_t$. It is also assumed that $\frac{\partial u^P(c_t, m_t)}{\partial m_t} > 0$ and $\frac{\partial^2 u^P(c_t, m_t)}{\partial m_t^2} < 0$. As usual, it is assumed that although all households receive transfers from a government in equilibrium, when making decisions, each of households takes the amount it receives as given and independent of its money holdings.

At the same time, the government maximizes the expected utility,

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[43] This assumption is drawn from the theory of policy convergence. See the literature of the policy convergence, most of which base upon Downs (1957).

Max $E_0 \int_0^\infty u^G(g_t, x_t) \exp(-\theta^G t) dt$

subject to

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

Proposition 5: At the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$, the real quantity of money m_t follows the law of motion that satisfies $\frac{\partial u^P(c^*, m_t)}{\partial m_t} = [\pi_0 + \theta^P + 2(\theta^G - \theta^P)t] \frac{\partial u^P(c^*, m_t)}{\partial c^*}$ where c^* is c_t at the steady state, if $\theta^G = -\frac{g_t - x_t - s_t}{b_t}$ at the steady state.

Proof:

(Step1) Let Hamiltonian H be

$H = u^P(c_t, m_t) \exp(-\theta^P t) + \lambda_t [r_t a_t + w_t + z_t - c_t - (\pi_t + r_t) m_t - g_t]$ where λ_t is a costate variable, and c_t and m_t are control variables and a_t is a state variable. The optimality conditions for the representative household are

(11) $\frac{\partial u^P(c_t, m_t)}{\partial c_t} \exp(-\theta^P t) = \lambda_t$,

(12) $\frac{\partial u^P(c_t, m_t)}{\partial m_t} \exp(-\theta^P t) = \lambda_t(\pi_t + r_t)$,

(13) $\frac{d\lambda_t}{dt} = -\lambda_t r_t$,

(14) $\dot{a}_t = (ra_t + w_t + z_t) - [c_t + (\pi_t + r_t) m_t - g_t]$,

(15) $\lim_{t \to \infty} \lambda_t a_t = 0$.

By conditions (11) and (12), $\dfrac{\dfrac{\partial u^P(c_t,m_t)}{\partial m_t}}{\dfrac{\partial u^P(c_t,m_t)}{\partial c_t}} = \pi_t + r_t$, and by conditions (11) and (13),

$$-\frac{c_t \dfrac{\partial^2 u^P(c_t,m_t)}{\partial c_t^2}}{\dfrac{\partial u^P(c_t,m_t)}{\partial c_t}} \frac{\dot{c}_t}{c_t} + \theta^P = r_t \cdot$$

Hence, $\theta^P = r_t$ at the steady state such that $\dot{c}_t = 0$ and $\dot{k}_t = 0$, and thus

$$\frac{\dfrac{\partial u^P(c_t,m_t)}{\partial m_t}}{\dfrac{\partial u^P(c_t,m_t)}{\partial c_t}} = \pi_t + \theta^P \text{ at the steady state.}$$

(Step2) As for the government, by the result of (Step1) such that $\theta^P = r_t$ at the steady state such that $\dot{c}_t = 0$ and $\dot{k}_t = 0$, and by theorem 2, $\dot{\pi}_t = 2(\theta^G - \theta^P)$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$, then $\pi_t = 2(\theta^G - \theta^P)t + \pi_0$. This relation is independent of the real quantity of seigniorage and thus from the real quantity of money.

(Step3) Combining the results of (Step1) and (Step2) yields the equation:

$$\frac{\dfrac{\partial u^P(c_t,m_t)}{\partial m_t}}{\dfrac{\partial u^P(c_t,m_t)}{\partial c_t}} = \pi_0 + 2(\theta^G - \theta^P)t + \theta^P$$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$. Hence the real quantity of money m_t satisfies $\dfrac{\partial u^P(c^*,m_t)}{\partial m_t} = \left[\pi_0 + \theta^P + 2(\theta^G - \theta^P)t\right]\dfrac{\partial u^P(c^*,m_t)}{\partial c^*}$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$.

Q.E.D.

Because inflation rates are determined by theorem 2 and is independent of the quantity of money, the quantity of money is demanded based on the independently determined inflation rate and the utility obtained from actual transactions that are the exact role played by money. This result that central banks act passively shares the same view with Sargent and Wallace (1981) and the literature of the FTPL.

Proposition 5 has the following important implication.

Corollary 2: The rate of return on money $-\pi_t$ is not necessarily equal to that on capital r_t.

Proof: By proposition 5, at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$, $\frac{\partial u^P(c^*, m_t)}{\partial m_t} = \left[\pi_0 + \theta^P + 2\left(\theta^G - \theta^P\right)t\right]\frac{\partial u^P(c^*, m_t)}{\partial c^*}$ is not necessarily zero. Hence, by condition (12) $\frac{\partial u^P(c_t, m_t)}{\partial m_t}\exp\left(-\theta^P t\right) = \lambda_t\left(\pi_t + r_t\right)$, $\pi_t + r_t$ is also not necessarily zero, and thus the rate of return on money $-\pi_t$ is not necessarily equal to that on capital r_t.

Q.E.D.

Corollary 3: If $\theta^G - \theta^P \geq 0$ and $\pi_0 > -\theta^P$, then $\pi_t + r_t > 0$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$ if $\theta^G = -\frac{g_t - x_t - s_t}{b_t}$ at the steady state.

Proof: $\frac{\partial u^P(c_t, m_t)}{\partial c_t} > 0$ and thus by condition (11), $\lambda_t > 0$. By proposition 5, if $\theta^G - \theta^P \geq 0$ and $\pi_0 > -\theta^P$, then $\frac{\partial u^P(c_t, m_t)}{\partial m_t} > 0$ at the steady state. Hence, by condition (12) $\frac{\partial u^P(c_t, m_t)}{\partial m_t}\exp\left(-\theta^P t\right) = \lambda_t\left(\pi_t + r_t\right)$, $\pi_t + r_t > 0$.

Q.E.D.

Corollary 3 predicts positive nominal interest rates. For both government and households, the nominal interest rate need not be zero to achieve optimality. This result gives a very different picture from that the well-known Friedman rule gives, but may be considered quite natural because in reality nominal interest rates are positive which is seen as normal.

In addition, proposition 5 predicts the negative marginal quantity of money.

Corollary 4: $\frac{\partial m_t}{\partial \pi_{b,t}^e} < 0$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$

if $\theta^G = -\frac{g_t - x_t - s_t}{b_t}$ at the steady state.

Proof: By (Step1) in the proof of proposition 5, $\frac{\frac{\partial u^P(c_t,m_t)}{\partial m_t}}{\frac{\partial u^P(c_t,m_t)}{\partial c_t}} = \pi_t + \theta^P$ at the steady state.

Because $\pi_{b,t}^e = \pi_t + \theta^G - \theta^P$ by theorem 1, $\frac{\partial u^P(c_t,m_t)}{\partial m_t} = \left[\pi_{b,t}^e + \left(2\theta^P - \theta^G\right)\right]\frac{\partial u^P(c_t,m_t)}{\partial c_t}$ and

thus $\frac{\partial^2 u^P(c_t,m_t)}{\partial m_t^2} = \frac{\partial \pi_t^e}{\partial m_t}\frac{\partial u^P(c_t,m_t)}{\partial c_t}$ at the steady state. Hence, $\frac{\partial m_t}{\partial \pi_{b,t}^e} = \frac{\frac{\partial u^P(c_t,m_t)}{\partial c_t}}{\frac{\partial^2 u^P(c_t,m_t)}{\partial m_t^2}} < 0$ at

the steady state because $\frac{\partial^2 u^P(c_t,m_t)}{\partial c_t^2} < 0$ and $\frac{\partial u^P(c_t,m_t)}{\partial c_t} > 0$.

Q.E.D.

Corollary 4 is consistent with the feature of the well-known money demand function of Cagan (1956), i.e. the higher the expected inflation, the lower will be the demand for real money. However, it should be noted that because inflation rates follow theorem 2, given the initial inflation rate there is only one path for inflation and thus the mechanism of hyperinflation Cagan (1956) shows does not exist in this model.[44]

IV. CONCLUDING REMARKS

What is the ultimate source of inflation still remains as a central question for economists. It is reflected in the recent heated debate over the Fiscal Theory of the Price Level. Kocherlakota and Phelan (1999) stresses that the key force behind the FTPL is that a government is fundamentally different from households. To find the true mechanism of inflation, therefore, we should make an investigation into the behavior of government more extensively. One of the reasons why many economists are skeptical about the FTPL may be that the concept of non-Ricardian policy is too general and non-Ricardian policies include too many fiscal policy rules, many of which may be unrealistic and absurd and lead to unfavorable and unacceptable consequences. Hence, it will be necessary to pin down such a non-Ricardian fiscal policy rule that may prevail in reality and, more importantly, is not an *ad hoc* exogenous fiscal policy rule but derived from optimization of government. We need, so to speak, a microfoundation of the Fiscal Theory of the Price Level.

The paper examined a model that explicitly included a government's maximization problem in the conventional general equilibrium framework. According to the literature of political economy, e.g. Downs (1957) and Alesina and Cukierman (1990), it will not be rare that government's preferences are not identical to those of a representative household. More importantly, the paper adopted the Leviathan view of government, the most prominent reference of which is Brennan and Buchanan (1980).

The explicit inclusion of a government's maximization problem produced a simple and

[44] As was shown in remark 2, the model in the paper predicts a hyperinflation when the time preference rate of a government is extremely high.

clear-cut result: inflation is ultimately caused by the difference of the rates of time preference between a government and households. This is an inevitable consequence of heterogeneity in time preference rates between a government and households. Without inflation, an economy can not be stable, and thus inflation plays a crucial role to stabilize an economy, i.e. to reconcile the contradiction in the time preference rates that will make rational agents confuse and unable to plan future economic activities rationally. This result appears quite natural because if we model an economy with heterogeneity in time preference rates between a government and households, it will be impossible to model a stable economy without inflation, simply because there will be no other way to reconcile the contradiction in the time preference rates than inflation.

This clear-cut result sheds new light on various phenomena of inflation, e.g. persistence, hyperinflation, chronic inflation, disinflation, deflation and so on. For example, the model in the paper has the intrinsic nature of persistence, i.e. inflation rates in the model have a unit root. For another example, the model in the paper can be seen as a unified model that explains various types of inflation, e.g. hyperinflation, chronic inflation, disinflation and deflation, by a single mechanism such that different combinations of the time preference rates of government and households generate various types of inflation.

This result also gives us new interpretations of the existing various inflation related models. For example, if money is included in the model, positive nominal interest rates are predicted, which is in sharp contrast to the Friedman rule. For another example, the paper predicts that the argument between the FTPL and the quantity theory will be infinitely inconclusive, because both theories equally correspond to a special case of the model in the paper, i.e. the utility of a government is constant in any time, and thus the optimality conditions of the government are reduced to only two equations, i.e. the budget constraint and the transversality condition. Nevertheless, in the sense that the price level is determined not by monetary factors but by fiscal factors, the conclusion in the paper is same as that of the FTPL and the model in the paper can be regarded as presenting a microfoundation of the FTPL. As

Christiano and Fitzgerald (2000) argues, so far the non-Ricardian assumption has not been regarded as a good characterization of policy in all times and places, rather it has been seen as a concept that can be applied to only limited episodes. However, the result in the paper implies that a type of non-Ricardian policy rule, e.g. the rule found in the paper, prevails in most times and places.

The novelty of the paper is that it specifies a clear-cut, simple, easily tractable and reasonable non-Ricardian fiscal policy rule that is derived from optimization of government and is the basis of the law of motion for price, i.e. it establishes a realistic and reasonable microfoundation of the FTPL. The fundamental mechanism found in the paper is amazingly simple and beautiful: $\dot{\pi}_t = 2\left(\theta^G - \theta^P\right)$. The key is the contradiction in the rates of time preference between a government and households that must be reconciled by inflation. This simple equation bridges the gap between the real world and the nominal world. What should be stressed repeatedly is that this equation is an inevitable consequence of heterogeneity in preferences between a government and households, and if there is heterogeneity in time preference rates between a government and households, we will not be able to construct a model of a stable economy without inflation. The clear-cut, simple and beautiful mechanism of inflation found in the paper may narrow down significantly the scope for investigation into the ultimate source of inflation.

APPENDIX

1. Proof of corollary 1

By theorem 1 and assumptions (A1) and (A2),

$\int_t^{t+1} \pi_v dv - \pi_t = \pi_{b,t}^e - \pi_t = R_t - r_t - \pi_t = \theta^G - \theta^P$ at the steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$ and $\dot{k}_t = 0$. Hence, $R_t - \pi_t = \theta^G$ due to $r_t = \theta^P$ at the steady state.

Q.E.D.

2. Proof of lemma 2

It is self-evident that the law of motion $\pi_{t+\zeta} = \pi_t + 2\zeta\left(\theta^G - \theta^P\right)$ follows theorem 1 under assumptions (A1) and (A2) and does not have any cycle of length 1.

Here, assume that π_t does not follow the law of motion $\pi_{t+\zeta} = \pi_t + 2\zeta\left(\theta^G - \theta^P\right)$ at a period $t+\mu$ and thus $\pi_{t+\mu} = \pi_t + 2\zeta\left(\theta^G - \theta^P\right) + \kappa$ where $\kappa \neq 0$. Since $\int_t^{t+1} \pi_v dv - \pi_t = \theta^G - \theta^P$ must be satisfied for any t by theorem 1 and assumptions (A1) and (A2), then it is necessary that $\pi_{t+\gamma} = \pi_t + 2\zeta\left(\theta^G - \theta^P\right) - \kappa_\gamma$ for any γ $(\mu < \gamma < \mu + 1)$ where $\int_\mu^{\mu+1} \kappa_\gamma d\gamma = -\kappa$.

Here, to maintain the relation $\int_t^{t+1} \pi_v dv - \pi_t = \theta^G - \theta^P$, the inflation rate $\lim_{\varphi\to 0} \pi_{t+\mu+1+\varphi}$ must follow $\lim_{\varphi\to 0} \pi_{t+\mu+1+\varphi} = \pi_t + 2\zeta\left(\theta^G - \theta^P\right) + \kappa$ because without it $\lim_{\varphi\to 0} \int_{t+\mu+\varphi}^{t+\mu+1+\varphi} \pi_v dv - \pi_t = \theta^G - \theta^P - \kappa \neq \theta^G - \theta^P$. Hence, there is a cycle of length 1 such that in every 1 term π_t deviates by κ. This contradicts assumption (A3), thereby π_t must follow the law of motion $\pi_{t+\zeta} = \pi_t + 2\zeta\left(\theta^G - \theta^P\right)$.

Q.E.D.

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