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A SIMPLE TEST FOR THE DEGREE OF CENTRAL BANK INDEPENDENCE

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The optimal choice of the tax rate and the inflation rate framework is extended to develop a simple econometric test for the degree of central bank independence. Two models of fiscal dominance associated with the optimal collection of seigniorage and the inflationary bias in the presence of fiscal side distortions are developed. Empirical tests for the theoretical results are conducted with data from 17 OECD countries classifying these countries into three groups of optimal fiscal and monetary policy regimes. The test results are consistent with the Bade-Parkin classification of the degree of central bank independence.

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I. INTRODUCTION

The study of the relationship between the fiscal authority and the monetary authority in a fiscal-monetary policy mix regime has been one of the oldest research areas in the macroeconomic literature. With projections of unusually large deficits in most OECD countries, a major concern in the literature is to analyze the effects of budget deficits on the economy, especially the consequences of government deficits for money growth and inflation. If the monetary authority responds to larger deficits by purchasing more government debt --by monetizing the debt-- then the growth rate of the monetary base and the inflation rate would increase, inducing another kind of distortions.

As an alternative to explicit taxation, the government can finance part of its spending through creation of high-powered money. The ability of the government

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to finance spending by issuing money is the seigniorage associated with its sovereign monetary monopoly. The government finance viewpoint or the optimal tax viewpoint in explaining money growth and inflation can be important in this respect. The consideration of the 'institutional' schemes in the consolidated government sector is crucial in this study of the systematic link between monetary policy and the government budget. The 'degree of central bank independence' describes the characteristics of the institutional schemes related to the various forms of accommodation and revenue raising in the fiscal-monetary policy mix.

Although it is generally accepted that the Federal Reserve in the United States, for instance, enjoys some independence from the Treasury[1], it is well known that there could be an indirect link between them through nominal interest targeting. Given the Fed's target interest rates, Treasury borrowing, which can lead to interest rate increases, triggers Fed open market purchases to keep the interest rate from rising above its target level. In some other countries that have a more dependent form of central banking, the Treasury may simply order the central bank to monetize some of the debt, implying that the government finance viewpoint may be more important in explaining inflation.

From a government finance viewpoint, the work of Mankiw (1987) provides an optimal inflation-tax rate choice framework. In the model, the government minimizes the expected present value of the social losses from distortionary taxation and inflation subject to the budget constraint, which includes the real revenue from seigniorage as an explicit part of the government revenue. In its purest form, the theory of the optimal collection of seigniorage implies that the revenue requirement is the sole determinant of inflation. A crucial implication of the theory in Mankiw is the positive correlation between the (average) tax rate (θ=tax revenue / GNP) and the inflation rate (π) arising from the optimal financing behavior of the government.

When we regard the tax rate and the inflation rate as the representative policy instrument of the fiscal authority and the monetary authority respectively, the finding of some relation between the two variables implies the existence of a relationship between the two authorities. This aspect of the model sheds light on the study of the degree of central bank independence in optimal fiscal and monetary policy regimes. In fact, Mankiw's work is not based on considerations about institutional or behavioral aspects of the policy regimes. There exists only the consolidated government in which the Fed plays the same role as the Treasury in collecting a tax called the inflation tax.

Though the revenue from seigniorage is included in the government budget as an identity in every country and every period, from the analytical viewpoint, the theory of the optimal collection of seigniorage implies that the revenue from

[1] There are some discussions on how much the Fed is really independent from the President and the Congress in the U.S.. Wooley(1986) provides a detailed discussion of this issue.

seigniorage is a main factor in explaining money growth and inflation (the only factor in its purest form). In this sense, the idea of the model is consistent with the concept of 'fiscal dominance' in Sargent and Wallace (1981). By investigating varing relations between the fiscal and monetary policy variables in a rational choice-theoretic framework of the government optimization, which incorporates different aspects of institutional or behavioral arrangements, we may be able to figure out some factors useful in explaining differing optimal fiscal-monetary policy regimes and the degree of central bank independence.

For the issue of the degree of central bank independence, there exists an 'institutional' study by Bade and Parkin (1985, 1987), Mascianaro and Tabellini (1988), and Fair (1980) reported in Alesina (1988) as the Bade-Parkin table that classifies the central banks of 16 OECD countries in four groups from the least independent (group 1) to the most independent (group 4).[2] According to Alesina (1988), the classification is affected by at least four factors: 1) the institutional and formal relationships between the Banks and the executive and legislative bodies; 2) informal relationships and contracts between Central Bankers and members of the executive body; 3) budgetary and financial relationships between the Central Bank and the executive body; and 4) macroeconomic relationships, namely the existence of rules forcing the Central Bank to accommodate fiscal policy.

However, it is not easy --in fact almost impossible-- to quantify all these elements precisely, and the results should depend on some subjective criteria. The nice feature of the optimal tax-inflation framework which will be developed in this paper is that it can provide a neat and quantitative way to test for the degree of central bank independence empirically. By modelling different coordination environments of the fiscal authority and the monetary authority, we find different relations between the two policy instruments. By testing the existence of the relations empirically, we wish to find the optimal policy-mix regime and the degree of central bank independence.

The purpose of this paper is to develop a simple econometric test for the degree of central bank independence based on optimal behaviors of the government. Developing a version of Mankiw's model in a discrete-time and period-by-period optimization framework, we derive a more general condition for the theory of the optimal collection of seigniorage. Once we obtain the condition, we develop a model that explains the positive correlation between the tax rate and the inflation rate observed in the U.S., for instance, without referring to the collection of seigniorage. This model studies an implication of the inflationary bias of the policymaker in the presence of fiscal side distortions from an optimal government finance viewpoint. So it is closely related to the work of

[2] Recently, Berument(1998) showed that countries with higher levels of central bank independence generate less seigniorage revenue using a testing scheme of an optimal government finance model. He used Bade-Pakin type classifications to incorporate the degree of central bank independence in the testing scheme.

Barro & Gordon (1983). The two models are supposed to have different degrees of fiscal dominance. Then some empirical tests are done for the two theoretical results to identify the appropriate fiscal and monetary policy regimes. The tests are done for 16 OECD countries shown in the Bade-Parkin table using annual data from the 1960's to the present to compare the test results to the Bade-Parkin classifications. The theoretical results turn out to be useful and to be supported empirically.

Section II presents a model of the optimal collection of seigniorage and the alternative model. Following the differences in the policy mix schemes, the first model is called that of the strong form of fiscal dominance and the second model that of the weak form of fiscal dominance. Section III has some empirical test results to determine the optimal fiscal and monetary policy regimes in the 16 OECD countries and Korea. Section IV has conclusions.

II. THE MODEL: STRONG VS. WEAK FORM OF FISCAL DOMINANCE

1. The Model of the Strong Form of Fiscal Dominance

In this model, money growth and inflation are explained by the optimal collection of seigniorage. The real revenue from seigniorage is the main factor explaining inflation. The model implicitly assumes a consolidated government sector and, therefore, a direct link between the two authorities through the collection of seigniorage. Hence, a very dependent form of central banking is expected. In this context, it is the model of the strong form of fiscal dominance.

In each period, the government minimizes the following social cost function with respect to the distortionary tax rate and the inflation rate subject to its budget constraint:

$$[f(\theta_t)+h(\pi_t)]y_t \tag{1}$$

where θ_t=tax rate (tax revenue/GNP)

π_t=inflation rate $((p_t-p_{t-1})/p_{t-1})$

y_t=exogenous level of real output

and $f'>0$, $f''>0$, $h'>0$, $h''>0$.

The deadweight social cost induced by the distortionary tax is denoted by $f(\theta_t)y_t$, and the social cost of inflation is denoted by $h(\pi_t)y_t$. Both of them are assumed to be homogeneous in output. As discussed in Mankiw (1987), the social cost of inflation includes the losses associated with the disruption of the efficient functioning of markets as well as direct costs such as increased menu costs.

The intertemporal government budget constrain in period t is as follows:

$$(1+r)\,D_{t-1}+(G_t-T_t)=D_t+(M_t-M_{t-1})/P_t \tag{2}$$

where r = real interest rate,

D_t = real debt held by the public at period t,

G_t = real government expenditure at period t,

T_t = real tax revenue at period t,

M_t = money stock at the end of period t,

P_t = price level at period t.

It should be stressed that the real revenue from seigniorage $((M_t-M_{t-1})/P_t)$ is included in the budget constraint explicitly for the analytical purposes of the model.

Suppose that money demand is described by a quantity equation type:[3]

$$M_t=k_tP_ty_t \tag{3}$$

where $k_t=k(i_t, y_t)$, $k_1<0, k_2<0$ and i_t = nominal interest rate.
With the Fisher equation, k_t(the inverse of the income velocity) is:

$$k_t=k(r+\pi_t^e, y_t),\ \pi_t^e=\text{expected inflation rate.} \tag{4}$$

Using equation (3), the real revenue from seigniorage is expressed as follows:

$$\begin{aligned}(M_t-M_{t-1})/P_t &= k_t\,y_t-(1+\pi_t)^{-1}\,k_{t-1}\,y_{t-1}\\ &\cong k_t\,y_t-(1-\pi_t)k_{t-1}\,y_{t-1}\end{aligned} \tag{5}$$

From an optimal government finance viewpoint, we assume that G_t and D_t are determined first by the fiscal authority and the demand for bonds, respectively. Then the fiscal authority chooses θ_t(taxes) and the monetary authority chooses π_t (seigniorage) to finance the spending minus the borrowing from the public. In the consolidated government sector set-up, the two authorities

[3] There is one complication in this analysis. In the government budget constraint (2), the amount that is received by the government is the increase in the stock of high-powered money. But the object of inflation taxation is the real money balance held by the public : inflation acts just like a tax because people are forced to spend less than their income and pay the difference to the government in exchange for extra money. Hence some analysis on the demand for money should be incorporated into the model and the basic measure of the money stock demanded is M1. In the later part, it will be seen that the income velocity of M1 plays an important role in explaining the inflation tax rate since it reflects the change of real money holding of the public as the object of taxation. This complication does not change the essence of the following analyses as long as it is assumed that there is a stable relation between the change in M1 and the change in high-powered money.

choose θ_t and π_t optimally regarding them as two instruments they have. The choice is made by solving the following optimization problem:[4]

$$\underset{\theta_t,\ \pi_t}{Min.}\{f(\theta_t + h(\pi_t))\}y_t \tag{6}$$
$$s.t.\ (1+r)D_{t-1} + G_t - D_t = \theta_t y_t + k(r + \pi_t^e, y_t)y_t - (1-\pi_t)k_{t-1}y_{t-1}$$

To solve the above optimization problem, one assumption is adopted from the expectation mechanism in Barro and Gordon (1983): the government solves the optimization problem with given initial conditions in each period, including the expectation mechanism. The policymaker is not required to select an inflation rate that equals the given expected inflation rate. However, if the public understands the mechanism of policy choice, a full equilibrium must involve $\pi_t = \pi_t^e$.[5] As long as there is no direct constraint of π_t on π_t^e, the government cannot affect $k(r+\pi_t^e, y_t)$ systematically. Hence, π_t^e and k_t is a given condition in the optimization.[6]

In the optimization problem in (6), $D_t, G_t, D_{t-1}, k_{t-1}, y_{t-1}$ are predetermined variables and $y_t, \pi_t^e, r, k_t = k(r+\pi_t^e, y_t)$ are exogenous variables assumed to be known to the government. Hence, we have the following first-order condition equation describing the optimal solution of the model:

$$h'(\pi_t)/f'(\theta_t) = k_{t-1}y_{t-1}/y_t = k_{t-1}/(1+g_t) \tag{7}$$

where $g_t = (y_t - y_{t-1})/y_{t-1}$ (real growth rate).

The intuitive explanation for the f.o.c. equation (7) is as follows. The one unit increase of θ_t increases the revenue by y_t and that of π_t increases the revenue by $k_{t-1}y_{t-1}$(π_t is a tax on pre-existing real balance holding $M_{t-1}/P_{t-1} = k_{t-1}y_{t-1}$). On the other hand, the one unit increase of θ_t increases the social cost by $f'(\theta_t)y_t$ and the one unit increase of π_t by $h'(\pi_t)y_t$. The optimal behavior implies the equality of the ratios in the marginal cost and the marginal revenue side.

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[4] Since G_t's and D_t's are determined first and exogenously, and expectations are held fixed, the present choice of θ_t and π_t does not affect the future choices. So the cost function of one period is used. The present analysis, which focuses on the determination of tax composition at a point in time, abstracts from the timing of taxes : the intertemporal aspect of the tax smoothing literature (e.g. Barro(1979)) is not considered. A period-by-period optimization framework is adopted to study the intratemporal optimality condition in a discretionary policy regime.

[5] Another kind of expectation mechanism is the once-and-for-all choice of reaction function formulated, for instance, in Sargent and Wallace (1975).

[6] As a result of the assumption, only the left-hand side of the Laffer curve (for the collection of seigniorage) is studied. Hence, this model can not be used for the case of hyperinflation.

Using this model of the optimal collection of seigniorage in a discrete time, period-by-period optimization framework, with standard assumptions on the income velocity of money, we obtain a more general testable result. By approximating the ratio of marginal costs --the marginal rate of substitution-- using a quadratic cost function,

$$\{ c_1 \pi_t^2 + c_2 \theta_t^2 \} y_t, \quad c_1, c_2 > 0 \tag{8}$$

equation (7) becomes:

$$\pi_t / \theta_t = c \cdot k_{t-1}/(1+g_t) \text{ where } c = c_2 / c_1 . \tag{9}$$

The left-hand side variable is the ratio between the two choice variables at period t and the right-hand side variable is exogenous and assumed to be known. The theory implies π_t / θ_t, that is proportional to the marginal rate of substitution, and the marginal revenue ratio $k_{t-1}/(1+g_t)$ have an exact positive correlation over time. This result will be tested empirically below. By testing the relation (9), we want to detect the optimal policy regime of the strong form of fiscal dominance that indicates a very dependent form of central banking. The practical usefulness of the model will be verified in later experiments.

2. The Model of the Weak Form of Fiscal Dominance

A model that has a different nature is developed here to explain a second kind of relationship between the fiscal authority and the monetary authority. The model economy in the weak form of fiscal dominance has the following features. First, money growth and inflation can be explained in part as a reaction to the overall level of economic activity as represented by either unemployment or real output. Second, the collection of seigniorage is not a factor that determines money growth and inflation. Quantitatively, the revenue from seigniorage constitutes an insignificant part of the government budget. Third, there still exists a channel that makes the government finance problem matter in explaining inflation. The first two features imply a less dependent form of central banking. However, since the government finance problem is still adopted in explaining inflation and a relationship between the tax rate and the inflation rate is found in the following analysis, the model is called that of the weak form of fiscal dominance. The two authorities are connected in a certain way without a significant role of the collection of seigniorage.

The crucial assumption that generates the channel is the existence of a government which tries to exploit the short-run trade-off between the inflation rate and the unemployment rate in each period in an optimal government finance problem. The optimization problem of the government is as follows:

$$\underset{\theta_t,\,\pi_t}{Min.}\ \{f(\theta_t)+h(\pi_t)\}y_t^n \tag{10}$$

$$s.t.\ (1+r)D_{t-1}+G_t-D_t=\theta_t y_t$$

where $y_t=\tau_t(\pi_t-\pi_t^e)+y_t^n$, $\tau_t=\alpha\cdot yf_t>0$ (See (11) below for α.)

y_t^n=natural rate of output level

yf_t=output when the total labor force employed.

Several points concerning the optimization problem (10) should be clarified. First, for the social cost function, the same function is used as the previous one in (1) except that it is now homogeneous in the natural rate of output level. The idea that the social cost is weighted by the output level is to capture the idea that the social losses increase as the scale of the economy increases with a strong assumption of homogeneity of degree 1. In this model where the government tries to exploit the short-run trade-off between inflation and unemployment, the right measure of the overall level might be the natural rate of output level. In fact, it turns out that the implication of the theory is not affected by the scale factor in the objective function.

Second, in the government budget constraint, the term for the revenue from seigniorage is omitted. This reflects that the collection of seigniorage is not a factor in determining money growth and inflation. The direct revenue aspect of the money growth plays an insignificant role in the government choice problem (10). Using the theoretical result derived from the choice problem (10), we want to detect an optimal policy regime in which the collection of seigniorage is not a factor in explaining money growth.

Third, the relation $y_t=\tau_t(\pi_t-\pi_t^e)+y_t^n$ is derived as follows. Starting from the following expectation augmented Phillips curve,

$$u_t=u_t^n-\alpha(\pi_t-\pi_t^e),\ \ \alpha>0 \tag{11}$$

where u_t=unemployment rate

u_t^n=natural rate of unemployment

and using a linear production function to assume a tight link between output level and employment in a simplified way,[7]

$$y_t=a_t N_t \tag{12}$$

where a_t=input coefficient (labor productivity)

[7] The simplification is justifiable as long as output and employment in practice move in the same direction, even if not exactly in lock step.

N_t = labor force employed

we can express relation (11) in terms of output level:

$$y_t = \tau_t(\pi_t - \pi_t^e) + y_t^n, \quad \tau_t = \alpha \cdot yf_t. \tag{13}$$

Now, we solve the optimization problem (10) given the people's expectation π_t^e as in Barro and Gordon. The f.o.c. equation in a full rational expectation equilibrium is as follows:

$$h'(\pi_t)/\theta_t f'(\theta_t) = \tau_t / y_t^n. \tag{14}$$

Since the public understands the policymaker's choice problem, a full rational expectation equilibrium implies $\pi_t^e = \pi_t^*$ (the optimal choice of the government) and this fact was used to derive (14).

In (14), it can easily be shown that τ_t / y_t^n is approximately a constant:[8]

$$\tau_t / y_t^n = \alpha \cdot yf_t / y_t^n = \alpha / (1 - u_t^n) = \alpha'. \tag{15}$$

Then condition (14) implies a positive correlation between the tax rate and the inflation rate without any shifting factor. The intuitive explanation is as follows. The government tries to use the unexpected inflation to reduce unemployment --i.e., to increase the output-- in a discretionary policy regime. When this aspect is combined with a government finance problem, we can regard both θ_t and π_t as instruments to raise the tax revenue $T_t = \theta_t y_t$. With the two instruments that are distortionary, the optimal behavior implies the use of them in the same direction. The inflationary bias of the discretionary monetary policy explained in Barro and Gordon (1983) in the presence of distortions in the fiscal side (k in their objective function is less than 1) is also shown in this model: π_t^* is positive though the normal level of the cost function is 0. Hence, it is shown that we can obtain a positive correlation between the tax rate and the inflation rate in the model of the weak form of fiscal dominance where the collection of seigniorage does not matter in explaining π_t. Barro and Gordon type behavior combined with a government finance problem can produce the result. For empirical tests in the next section, we investigate the positive correlation between θ_t and π_t to detect the weak form of fiscal dominance policy regime. In a sense, this test would be the first attempt to test the result of Barro and Gordon.[9]

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[8] It is believed that the natural rate of unemployment in the U.S., for instance, is 4%~6%. The 1% change in its level changes α' by only 1%. In a relatively short-run analysis, the natural rate of unemployment can be supposed to be a constant.

[9] It is recognized that the structure of the two models are different. We test the existence of

Ⅲ. EMPIRICAL TESTS

1. The Joint Hypotheses and the Set-up for Tests

The above optimal policy regimes can be tested by testing the f.o.c. equations. For the weak form, without any other time-variant variables in condition (14), it is tested whether there is a positive correlation between θ_t and π_t as the theory implies.[10] At this stage, we do not need any specific functional form for the cost structure to test condition (14). For the strong form, as shown in (7) and in (9), it should be tested whether the ratio between the optimal π_t and θ_t that is proportional to the MRS increases as the marginal revenue ratio $k_{t-1}/(1+g_t)$ increases. In this testing problem, the marginal cost should be approximated using a specific cost function; a quadratic cost function is adopted for the test in the CES family. Hence, the quadratic cost approximation is tested as a part of the joint hypothesis of the strong form. As a consequence, it should be recognized that the test results for the strong form can be sensitive to the functional forms adopted. This problem will be discussed in more detail below. There are 4 possible results of the tests. Rejection of both forms of the joint hypotheses implies either that the policy choices are non-optimal or that the policy regime is not characterized by a model of fiscal dominance implying a certain degree of independence in the central banking.

For the test, we run regressions for each joint hypothesis for the level terms. As indicated in Granger and Newbold (1974), if the variables in the regression follow a random walk or if they have a time-trend,[11] a typical result would be a high R^2 and very low Durbin-Watson statistic ('spurious regression'). As is well known, when the error terms are autocorrelated, the usual significance tests are invalid. Since the main purpose of the test is to see whether there exists a statistically significant positive correlation, we certainly need better estimates when the Durbin-Watson statistic is too low. As the first correction for this problem, we use the conventional AR(1) maximum likelihood estimates. In addition to the AR(1) maximum likelihood estimates, however, we report the differenced-form regressions when a joint hypothesis is accepted, as suggested by Granger and Newbold (1974).

For statistical inference for the joint hypotheses, the following routine tests are done: 1) the Durbin-Watson test is done using d_u in the 1% significance points

inflationary bias studied in Barro and Gordon(1983) in an optimal government finance problem.

[10] The theoretical result of the weak form of fiscal dominance happens to coincide with the theory of the optimal collection of seigniorage in Mankiw. This is not to contradict the result of Mankiw. A more general condition for the optimal collection of seigniorage was obtained in a different model.

[11] It is generally supposed that the tax rate and the inflation rate are approximately random walks in theory and practice.

in the Savin-White table as the critical value: 2) the one-tail t-tests are done for each regression to see the correct sign at the 5% and 10% significance level. The set-up for the empirical test is as follows:

strong form of fiscal dominance

$MRS = \alpha_1 + \beta_1 MRR + \delta_1 TIME + \mu_1 D$ and AR(1) specification

$MRS1 = \alpha_2 + \beta_2 MRR1 + \mu_2 D1$

weak form of fiscal dominance

$INF = \alpha_3 + \beta_3 TAX + \delta_3 TIME + \mu_3 D$ and AR(1) specification

$INF1 = \alpha_4 + \beta_4 TAX1 + \mu_4 D1$

where $MRS = \pi_t / \theta_t, MRR = k_{t-1}/(1+g_t), INF = \pi_t, TAX = \theta_t$

$VAR1 = VAR - VAR(-1)$

$TIME$ = linear time trend

D = Dummy variable for oil-shock period.

The tests are done using annual data from the 1960's to the present for the 16 OECD countries that are shown in the Bade-Parkin table (1985, 1987) and Korea.[12] The regression results are reported in the following subsections.

2. The United States

For the period of 1961～1996, only the weak form of fiscal dominance is accepted. The regression results are reported in Table 1. In the sense that π_t / θ_t (that is proportional to MRS) and MRR do not co-vary in the period, the optimal collection of seigniorage interpretation of Mankiw(1987) is not obtained.

[12] We use the Government Finance Statistics(GFS) and International Financial Statistics(IFS) data. To calculate the tax rate, the total government revenue in IFS is divided by the nominal GDP. The inflation rate is the rate of change in CPI. To get k_t, M1 is divided by the nominal GDP. The real GDP growth rate is calculated. The Dummy variable D has 1's for the oil-shock period(1974-76, 1979-81) and 0's in other period.

[Table 1] Test Results for U.S.

	Strong Form : Dependent Var = MRS					
61 - 96	CON	MRR	TIME	D	$\bar{R}^2$	D.W.
Level	1.09	-2.73	-0.01	0.29	0.71	1.43
	(3.58)	(-3.18)	(-2.46)	(7.12)		
AR(1)	-0.01	1.89	-0.00	0.16	0.74	2.02
	(-0.1)	(0.92)	(-0.19)	(3.36)	Rho = 0.82(7.32)	
	Weak Form : Dependent Var = INF					
61 - 96	CON	TAX	TIME	D	$\bar{R}^2$	D.W.
Level	-15.52	1.16	-0.05	5.91	0.70	1.12
	(-2.68)	(3.13)**	(-1.30)	(7.56)		
AR(1)	-11.71	1.23	-0.15	3.08	0.81	1.98
	(-1.64)	(3.70)**	(-1.47)	(3.72)	Rho = 0.73(5.40)	
Diff	-0.04	1.20		2.83	0.48	2.04
	(-0.15)	(3.80)**		(3.98)		

Notes : t-values are in the parentheses.
** :significant at 5% level
Diff : differenced-form regression

3. Group 1: Australia, Italy, New Zealand, Spain

The test results (Table 2,3) show that the fiscal-monetary policy mix in Italy, Spain, Australia --classified as having the most dependent form of central banking in the Bade-Parkin table-- is characterized by the strong form of fiscal dominance. In Italy and Spain, no significant positive correlation between π_t and θ_t is found. But it is seen that π_t / θ_t and MRR have a significant positive correlation. For Australia, both forms are accepted and we can not distinguish one policy regime from the other. In New Zealand only the week form is accepted though this country is classified as a Group1 country.

4. Group 2: Belgium, Canada, Denmark, France, Netherlands, Norway, Sweden, United Kingdom

In Sweden, only the strong form is accepted. In Norway, Canada, Denmark, Belgium, and U.K., only the weak form is accepted.[13] Hence, we detect the weak form in 5 out of 8 Group 2 countries. In France and Netherlands, neither of the joint hypotheses are accepted(Table 4, 5). For these two countries, we can infer that the testing scheme can not be applied or that in the aspect of budgetary relations and fiscal accommodation these countries have a certain degree of independence in central banking even though these countries are classified as Group 2 countries in the Bade-Parkin table.

[13] In Canada, time-trend is omitted in the test since it is insignificant.

[Table 2] Test Results for Group 1 Countries(Strong Form)

	Strong Form : Dependent Var = MRS					
	CON	MRR	TIME	D	$\overline{R}^2$	D.W.
Italy 63 - 96						
Level	-0.37	2.75	-0.01	0.35	0.78	1.14
	(1.66)	(5.07)**	(-2.73)	(4.21)		
AR(1)	-0.61	3.19	-0.01	0.23	0.83	1.80
	(-1.37)	(3.73)**	(-1.01)	(2.75)	Rho = 0.53(3.13)	
Diff	-0.01	2.65		0.18	0.29	2.10
	(-0.41)	(2.23)**		(2.47)		
Spain 62 - 95						
Level	-0.04	3.82	-0.01	0.54	0.37	0.85
	(-0.04)	(1.53)*	(-1.50)	(3.29)		
AR(1)	1.42	5.45	-0.04	-0.12	0.79	2.09
	(0.65)	(1.85)**	(-1.14)	(-1.04)	Rho = 0.87(9.51)	
Diff	-0.00	5.39		-0.12	0.08	2.10
	(-0.12)	(1.92)**		(-1.13)		
Australia 61 - 96						
Level	0.87	-2.92	-0.01	0.27	0.59	1.15
	(4.15)	(-3.72)	(-1.98)	(4.87)		
AR(1)	5.46	4.72	-0.09	0.07	0.75	1.97
	(0.38)	(2.29)**	(-0.51)	(1.54)	Rho = 0.96(14.42)	
Diff	0.00	2.40		0.09	0.10	1.80
	(0.26)	(1.44)*		(1.77)		
New Zealand 61 - 96						
Level	0.37	-1.18	0.00	0.19	0.74	1.99
	(6.26)	(-6.97)	(1.12)	(5.31)		

Notes : t-values are in the parentheses.
** : significant at 5% level
* : significant at 10% level
Diff : differenced-form regression

[Table 3] Test Results for Group 1 Countries(Weak Form)

Weak Form : Dependent Var = INF						
	CON	TAX	TIME	D	$\overline{R}^2$	D.W.
Italy 63 - 96						
Level	4.37	0.07	0.01	11.40	0.52	1.05
	(1.56)	(0.24)	(0.08)	(5.79)		
AR(1)	21.38	0.26	-0.40	3.49	0.78	2.01
	(1.10)	(0.59)	(-1.0)	(2.20)	Rho = 0.85(8.50)	
Spain 62 - 95						
Level	9.91	-2.63	0.90	2.28	0.62	1.21
	(3.79)	(-5.39)	(4.88)	(1.29)		
AR(1)	32.37	-0.43	-0.29	-1.62	0.74	2.06
	(1.18)	(-0.64)	(-0.48)	(-1.14)	Rho = 0.87(9.50)	
Australia 61 - 96						
Level	-13.36	1.01	-0.13	7.75	0.47	0.98
	(-2.0)	(2.51)**	(-1.41)	(5.59)		
AR(1)	2.00	0.60	-0.22	2.38	0.72	1.89
	(0.15)	(1.62)*	(-0.98)	(1.89)	Rho = 0.81(6.95)	
Diff	-0.06	0.55		2.12	0.08	1.99
	(-0.16)	(1.66)*		(1.81)		
New Zealand 61 - 96						
Level	-6.19	0.74	-0.27	8.12	0.46	0.93
	(-1.39)	(3.14)**	(-2.29)	(4.60)		
AR(1)	0.86	0.89	-0.50	2.54	0.71	2.22
	(0.08)	(3.15)**	(-2.42)	(1.59)	Rho = 0.72(5.90)	
Diff	-0.15	0.80		1.97	0.19	2.37
	(-0.28)	(3.01)**		(1.27)		

Notes : t-values are in the parentheses.
** : significant at 5% level
* : significant at 10% level
Diff : differenced-form regression

[Table 4] Test Results for Group 2 Countries(Strong Form)

Strong Form : Dependent Var = MRS						
	CON	MRR	TIME	D	$\overline{R}^2$	D.W.
Sweden 61 - 95						
Level	-56.64	115.02	0.26	10.67	0.41	1.51
	(-1.39)	(1.95)**	(1.12)	(3.02)		
Norway 61 - 95						
Level	0.42	0.54	-0.00	0.06	0.42	2.00
	(7.43)	(-2.60)	(-1.94)	(1.78)		
Canada 61 - 94						
Level	0.46	-1.57		0.27	0.51	1.05
	(3.69)	(-1.93)		(4.94)		
AR(1)	0.28	-0.15		0.05	0.74	1.64
	(1.50)	(-0.14)		(1.04)	Rho = 0.10(0.55)	
Denmark 61 - 96						
Level	0.65	-1.13	-0.00	0.10	0.68	1.78
	(7.93)	(-2.81)	(-3.51)	(3.35)		
Belgium 61 - 94						
Level	1.13	-3.73	-0.01	0.26	0.60	1.20
	(3.98)	(-3.78)	(-2.37)	(4.71)		
AR(1)	21.74	4.73	-0.23	0.07	0.75	1.96
	(0.15)	(2.26)**	(-0.23)	(1.53)	Rho = 0.98(12.96)	
Diff	0.00	2.20		0.09	0.10	1.74
	(0.24)	(1.29)		(1.77)		
U.K. 61 - 95						
Level	0.18	-0.09	0.00	0.30	0.61	1.65
	(2.42)	(-0.81)	(0.28)	(6.80)		
France 61 - 95						
Level	80.79	-114.33	-0.78	16.57	0.59	1.00
	(2.93)	(-1.72)	(-3.47)	(5.64)		
AR(1)	104.22	-138.07	-1.11	9.50	0.78	1.58
	(3.26)	(-1.86)	(-3.66)	(3.27)	Rho = 0.57(4.46)	
Netherlands 61 - 96						
Level	0.48	-0.63	-0.01	0.03	0.47	0.81
	(3.80)	(-1.28)	(-5.43)	(0.87)		
AR(1)	0.46	-0.25	-0.01	0.03	0.68	2.22
	(3.02)	(-0.38)	(-4.04)	(0.94)	Rho = 0.50(3.62)	

Notes : t-values are in the parentheses.
** : significant at 5% level
Diff : differenced-form regression

[Table 5] Test Results for Group 2 Countries(Weak Form)

Weak Form : Dependent Var = INF						
	CON	TAX	TIME	D	$\bar{R}^2$	D.W.
Sweden 61 - 95						
Level	3.64	-3.22	0.08	4.69	0.30	1.35
	(1.84)	(-0.93)	(1.42)	(3.85)		
AR(1)	7.13	-1.00	-0.01	1.88	0.38	1.97
	(1.50)	(-0.33)	(-0.07)	(1.33)	Rho = 0.55(3.33)	
Norway 61 - 95						
Level	6.76	0.41	-0.34	2.51	0.47	1.50
	(3.89)	(3.80)**	(-3.58)	(2.16)		
Canada 61 - 94						
Level	-1.33	0.30		5.72	0.51	1.07
	(-0.37)	(1.54)*		(5.43)		
AR(1)	-4.36	0.47		0.94	0.74	1.64
	(-0.62)	(1.43)*		(1.03)	Rho = 0.88(8.16)	
Diff	-0.11	0.57		0.76	0.09	1.73
	(-0.38)	(1.80)**		(0.88)		
Denmark 61 - 95						
Level	8.30	0.30	-0.30	5.34	0.54	1.32
	(4.26)	(2.11)**	(-3.04)	(5.06)		
AR(1)	11.73	0.35	-0.40	1.70	0.65	1.70
	(2.11)	(1.69)*	(-2.49)	(1.44)	Rho = 0.66(4.69)	
Diff	-0.34	0.44		0.98	0.12	1.82
	(-0.86)	(2.27)**		(0.90)		
Belgium 61 - 94						
Level	-12.82	0.96	-0.10	7.64	0.47	0.94
	(-1.88)	(2.22)**	(-1.02)	(5.33)		
AR(1)	2.89	0.62	-0.24	2.35	0.73	1.87
	(0.18)	(1.68)*	(-0.88)	(1.88)	Rho = 0.82(6.90)	
Diff	-0.07	0.58		2.14	0.09	1.96
	(-0.17)	(1.73)**		(1.84)		
U.K. 61 - 95						
Level	-7.36	0.50	-0.10	10.72	0.63	1.74
	(-0.90)	(1.67)*	(-1.24)	(7.27)		

[Table 5] Continued

Weak Form : Dependent Var = INF						
	CON	TAX	TIME	D	$\bar{R}^2$	D.W.
France 61 - 95						
Level	5.68	45.35	-0.37	4.88	0.68	0.99
	(3.70)	(4.14)**	(-4.28)	(4.36)		
AR(1)	15.74	14.25	-0.32	2.21	0.83	1.73
	(1.74)	(1.11)	(-1.81)	(2.61)	Rho = 0.82(8.17)	
Diff	-0.05	9.14		2.13	0.15	1.75
	(-0.18)	(0.76)		(2.61)		
Netherlands 61 - 96						
Level	8.04	0.01	-0.11	3.88	0.42	0.84
	(5.35)	(0.09)	(-1.53)	(3.38)		
AR(1)	11.62	0.04	-0.21	1.62	0.69	2.21
	(3.14)	(0.51)	(-2.20)	(1.87)	Rho = 0.64(4.92)	

Notes : t-values are in the parentheses.
** : significant at 5% level
* : significant at 10% level
Diff : differenced-form regression

5. Group 3: Japan

In Japan, only the strong form is accepted (Table 6). The theory of the optimal collection of seigniorage can explain about 70% of the variation of π_t/θ_t. A certain degree of dependence of central banking on budgetary relations is indicated. This result is consistent with a conventional view on the financial system of Japan.

6. Group 4: Germany and Switzerland

These two countries are supposed to have the most independent form of central banking in the Bade-Parkin classification. For Switzerland, the test results (Table 6) show that both of the joint hypotheses are rejected. Hence, the test results are consistent with the Bade-Parkin classification. For Germany, however, we find a weak form relationship in the pre-unification period(1961~89).

[Table 6] Test Results for Group 3 & 4 Countries

	Strong Form : Dependent Var = MRS					
	CON	MRR	TIME	D	$\overline{R}^2$	D.W.
Japan 61 - 93						
Level	-1.65	10.68	-0.02	0.25	0.66	1.36
	(-2.64)	(4.98)**	(-4.27)	(1.66)		
AR(1)	-1.83	11.14	-0.02	0.27	0.68	1.79
	(-2.07)	(4.04)**	(-2.73)	(1.64)	Rho = 0.32(1.74)	
Diff	-0.03	11.73		0.31	0.31	2.24
	(-0.47)	(3.33)**		(1.85)		
Germany 61 - 89						
Level	0.50	-0.75	-0.01	0.08	0.50	1.24
	(2.56)	(-0.47)	(-2.94)	(3.06)		
AR(1)	0.26	1.66	-0.01	0.03	0.60	1.72
	(1.08)	(0.84)	(-2.36)	(1.15)	Rho = 0.56(2.93)	
Swizerland 61 - 95						
Level	1.09	-0.71	-0.01	0.22	0.08	0.83
	(0.99)	(-0.40)	(-0.90)	(1.83)		
AR(1)	0.44	0.80	-0.01	0.15	0.42	1.52
	(0.54)	(0.70)	(-0.57)	(1.26)	Rho = 0.62(4.19)	
	Weak Form : Dependent Var = INF					
	CON	TAX	TIME	D	$\overline{R}^2$	D.W.
Japan 61 - 93						
Level	14.01	-0.15	-0.18	5.62	0.43	1.21
	(4.73)	(-0.68)	(-2.50)	(3.52)		
AR(1)	14.65	-0.11	-0.20	4.61	0.51	1.92
	(3.05)	(-0.37)	(-1.50)	(2.44)	Rho = 0.42(2.22)	
Germany 61 - 89						
Level	8.16	0.37	-0.30	1.64	0.16	1.19
	(5.78)	(4.68)**	(-4.88)	(2.75)		
AR(1)	7.98	0.28	-0.25	1.15	0.68	1.69
	(3.08)	(2.80)**	(-2.84)	(1.82)	Rho = 0.51(2.67)	
Diff	-0.09	0.18		0.81	0.08	1.77
	(-0.38)	(1.68)*		(1.37)		
Swizerland 61 - 95						
Level	19.88	-2.07	0.04	1.88	0.29	1.07
	(4.11)	(-3.19)	(1.02)	(2.28)		
AR(1)	14.53	-1.02	-0.04	1.17	0.52	1.40
	(3.22)	(-2.43)	(-0.56)	(1.31)	Rho = 0.63(4.21)	

Notes : t-values are in the parentheses.
** : significant at 5% level
* : significant at 10% level
Diff : differenced-form regression

7. Korea

Although Korea does not appear in the Bade-Parkin table, we apply the testing scheme to Korea. It is a generally accepted view that Korea has a very dependent form of central banking. The test results show that only the strong form is accepted for the 1972~96 period(Table 7).

8. Functional Forms and the Robustness of the Results

To test the theory of the strong form of fiscal dominance, marginal costs had to be estimated by a specific cost function and in the test, a quadratic cost function was used. Hence, the joint hypothesis in the testable form includes, among others, the quadratic cost structure. It is generally expected that the test results can be sensitive to the functional forms adopted.

To see the implication of functional forms adopted, suppose the following CES cost function is adopted as a more general cost function:

$$\{c_1\pi_t^\alpha + c_2\theta_t^\alpha\}^{1/\alpha}y_t,\ \ \alpha>1,\ \ c_1, c_2>0. \tag{16}$$

[Table 7] Test Results for Korea

Strong Form : Dependent Var = MRS						
72 - 96	CON	MRR	TIME	D	$\overline{R}^2$	D.W.
Level	0.29	8.54	-0.01	0.77	0.79	2.27
	(0.38)	(1.66)*	(-1.63)	(5.50)		
Diff	-0.03	13.41		0.61	0.44	2.92
	(-0.42)	(1.67)*		(3.42)		
Weak Form : Dependent Var = INF						
72 - 96	CON	TAX	TIME	D	$\overline{R}^2$	D.W.
Level	13.06	0.33	-0.23	14.36	0.77	2.15
	(1.84)	(0.45)	(-1.01)	(6.36)		
Diff	-0.67	1.17		10.60	0.41	2.89
	(-0.60)	(0.86)		(4.00)		

Notes : t-values are in the parentheses.
* : significant at 10% level
Diff : differenced-form regression

It is clear that minimizing (16) is equivalent to minimizing the following:

$$\{c_1\pi_t^{\alpha}+c_2\theta_t^{\alpha}\}y_t. \tag{17}$$

With this CES function, the f.o.c. equation (7) becomes

$$(\pi_t/\theta_t)^{\alpha-1}=c\cdot k_{t-1}/(1+g_t),\ \ c=c_1/c_2. \tag{18}$$

The next step to test (18) would be taking logs:

$$\log(\pi_t/\theta_t)=\tau_0+\tau_1\log\{k_{t-1}/(1+g_t)\},\ \ \tau_1=1/(\alpha-1)>0. \tag{19}$$

Now, the testing scheme is changed to log forms: log(MRS) is regressed on log(MRR).

If the testing scheme (19) is applied to the 6 countries where the strong form was accepted in the quadratic cost specification, some minor changes are found; except for Australia and Korea, the strong form is accepted in other 4 countries. If the testing scheme (19) is applied to the two countries in Group 4, the result is not changed. Hence, though we get results more similar to the Bade-Parkin classification when the quadratic cost function is adopted, the statistical outcomes are not greatly changed by adopting a CES function in the test. The main feature of using a CES function is that the marginal rate of substitution is a simple function of the ratio between the two choice variables. So the ratio between the two distortionary policy instruments is a meaningful variable in the theory and in the test.

If a cost function that does not belong to the CES family is used to test the theory such as (20), the testing scheme takes a totally different form as in(21).

$$\{c_1\pi_t^{\alpha}+c_2\theta_t^{\beta}\}y_t,\ \ \alpha\neq\beta,\ \alpha,\ \beta>1 \tag{20}$$

$$\log\pi_t=\delta_0+\delta_1\log\theta_t+\delta_2\log\{k_{t-1}/(1+g_t)\},\ \ \delta_1,\delta_2>0,\ \ \delta_1\neq 1 \tag{21}$$

This testing scheme was used in different context by Porterba and Rotemberg (1990)[14] for 5 country samples (U.S., Japan, Germany, France, U.K.). Applying the testing scheme (21) in the countries where the strong form was accepted leads to a different conclusion. It is recognized that the testing scheme (21) can produce different test results.

Several comments are in order here. First, it is not surprising that we obtain different results since we have different testing scheme using cost functions with

[14] In a model of the optimal collection of seigniorage, Porterba and Rotemberg(1990) obtained a similar result to that of our strong form in that an exogenous variable m_{t-1}/y_t appears in the f.o.c equation(m_t is real money stock, so it is equal to $k_{t-1}/(1+g_t)$.).

different characteristics. All the test results reported in the text show that the theory approximated by a quadratic cost function in the CES family can explain the data in some countries. A crucial argument here is that the cost structure can be tested only as the form of a joint hypothesis --the theory estimated by a cost function.[15] Rather than doing a seemingly impossible test for the cost structure as the pre-step of the test, we include a specific cost structure as a part of the joint hypothesis tested.

Second, we observe the differences in the dependent variables in the two testing schemes and the better performance of the scheme (19) in explaining the data in Spain and Italy. So it can be thought that the theory of the optimal collection of seigniorage derived from the model of the strong form of fiscal dominance is helpful in explaining the ratio of the two distortionary policy instruments. To explain the level of inflation itself, we may need some other components not explained by the theory of the optimal collection of seigniorage. Adding these components in (21), we may be able to get correct signs for δ_1 and δ_2.[16]

Third, it should be noted that the specification (21) has an inadmissible feature.[17] In the theory, π_t and θ_t are two choice variables and $k_{t-1}/(1+g_t)$ is an exogenous variable in the optimization problem. In the estimation using the specification (21), we see that one endogenous variable is in the right-hand side of the regression equation. For the determination of the two choice variables, we generally need two equations: the f.o.c. equation in (7) and the budget constrain in (6). So in the specification (21), we are using only one structural equation in a two equation system and with the correlation between one explanatory variable and the error term, we obtain biased and inconsistent OLS estimates for the structural coefficients. One nice feature of adopting a CES cost function is that we do not have any endogenous variable in the right-hand side of the regression equation. This problem of simultaneity in the estimation also reflects a difficulty of estimating the cost structure as a pre-step of the test.[18] Recognizing those complicating problems arising from the adoption of a specific functional form in the test as discussed above, we summarize our test results in the final subsection, comparing them directly to the Bade-Parkin classification.

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15 We think that the cost structure can be tested 'only when' the theory is true and it is the only rule generating the data. But using (21), we want to test the theory itself. Hence the hypothesis should have a form of a joint hypothesis.

16 Mankiw (1987) shows that his empirical results suggest that the revenue requirement can explain about one third of the variation in the inflation rate in the U.S..

17 Andrew Abel pointed out this problem.

18 At the last part of Poterba and Rotemberg's work, they provided an instrumental variable estimation result. However, their main conclusions are still drawn from the testing scheme (21).

9. The Test Results and Central Bank Independence

The test results classify the 17 OECD countries into three groups of policy regimes: strong form of fiscal dominance, weak form of fiscal dominance and non-fiscal dominance. If the framework turns out to fail in explaining the data, a possible interpretation is that the policy-mix scheme can not be characterized by the policy environment of fiscal dominance implying a certain degree of central bank independence. The consideration of institutional differences is a critical component that leads to a different interpretation from that of existing work in addition to differences in modelling and testing.[19]

In Table 8, the Bade-Parkin table and the test results are reproduced as the final output of this paper. Similar classifications are obtained, in that 3 out of 4 Group 1 countries are characterized by the strong form of fiscal dominance, and 5 out of 8 Group 2 countries are characterized by the weak form of fiscal dominance. 1 out of 2 Group 4 countries is characterized by non-fiscal dominance. For the other middle Group countries, there are no distinctive features in the classification and somewhat different results are obtained in the optimal tax rate-inflation rate framework.

Ⅳ. CONCLUSIONS

The optimal choice of the tax rate and the inflation rate framework in Mankiw (1987) was extended to study the relationship between the fiscal authority and the monetary authority. From a government finance viewpoint explaining money growth and inflation in a discretionary policy regime, two models assuming different degrees of fiscal dominance were developed. The optimal collection of seigniorage and inflationary bias associated with distortions in the fiscal side respectively yielded certain relations between the two policy variables through which the systematic link between the federal budget and money growth is revealed.

The theories had testable forms. Consideration of the degree of independence of central bank was valuable in the context of modelling and empirical testing. The usefulness of the models to identify different optimal fiscal-monetary policy regimes was shown using data from the 16 OECD countries in the Bade-Parkin table and for the case of Korea. In the case of Group 1 countries, although we cannot explain the policy-mix scheme in terms of the optimal collection of seigniorage using Mankiw's model in spite of the very dependent form of central banking in the Bade-Parkin classification, the strong form of fiscal dominance was detected in our testing scheme. In the U.S., the weak form of

[19] In Roubini and Sachs(1988), applying Mankiw's regression to some other countries, they showed that the Mankiw's framework works for only 3 out of 15 countries. Our results show that the weak form is accepted in 9 out of 17 countries. In our framework, there are some more tests and interpretations with different data set.

[Table 8] Test Results and the Degree of Central Bank Independence

Countries	Test Results	Bade-Parkin Results
Italy	SFFD	Group 1
Spain	SFFD	Group 1
Australia	SFFD/WFFD	Group 1
New Zealand	WFFD	Group 1
Sweden	SFFD	Group 2
Norway	WFFD	Group 2
Canada	WFFD	Group 2
Denmark	WFFD	Group 2
Belgium	WFFD	Group 2
U.K.	WFFD	Group 2
France	NFD	Group 2
Netherlands	NFD	Group 2
Japan	SFFD	Group 3
U.S.	WFFD	Group 3
Germany	WFFD	Group 4
Swizerland	NFD	Group 4
Korea	SFFD	-

Notes : SFFD = strong form of fiscal dominance
WFFD = weak form of fiscal dominance
NFD = non-fiscal dominance

fiscal dominance was accepted. For 9 countries including 5 Group 2 countries, the policy-mix scheme was characterized by the weak form of fiscal dominance. Based on a government optimization framework, we developed the first econometric test for the degree of central bank independence.

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