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OPTIMAL SEIGNIORAGE IN DEVELOPING COUNTRIES : AN EMPIRICAL INVESTIGATION

SAADI-SEDIK Tahsin*

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*CERDI-CNRS-University of Auvergne, 65 Boulevard F. Mitterrand, B.P. 320, 63009 Clermont-Ferrand, France. Phone : +33 (0) 4-73-17-74-23, Fax : +33(0) 4-73-17-74-28, Email: T.saadi-sedik@u-clermont1.fr.

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Abstract

This paper investigates the predictions of the theory of optimal seigniorage in developing countries over the period 1970-1999. The tax smoothing hypothesis, tested on forty selected developing countries, is rejected. However, the hypothesis that economies with high levels of expenditure and taxation also have high levels of inflation tax, tested on the forty selected developing countries and on a larger sample (up to 112 developing countries) can not be rejected.

Keywords: Optimal seigniorage, tax smoothing, developing countries, panel unit root tests, GMM.

Résumé

Cet article analyse, empiriquement, les prédictions de la théorie du seigneuriage optimal dans le contexte des pays en développement sur la période 1970-1999. L'hypothèse du lissage fiscal, testée sur un échantillon sélectif de quarante pays en développement, est rejetée. Cependant, l'hypothèse testée sur ces quarante pays et sur un échantillon plus large (jusqu'à 112 pays en développement), selon laquelle les pays qui ont des taux de dépenses et de prélèvements publics élevés ont également des taux de taxe d'inflation élevés ne peut pas être rejetée.

Mots-clef: Seigneuriage optimal, lissage fiscal, pays en développement, tests de racine unitaire en panel, GMM

Introduction

The government can have an important role in the economy by investing in human capital and infrastructure. Spending is necessary to improve the environment for private sector development and sustained economic growth. The government can finance its spending, mainly, by three methods: conventional taxes, borrowing and issuing money[1]. The methods of financing public spending are not neutral. The same amount of public spending can, fundamentally, have different effects on private sector and economic efficiency depending on the nature of spending and the method of financing. One method of financing considered particularly distortionary is seigniorage.

Seigniorage is government revenue from issuing money base. This increase of money supply is a source of inflation. That is why the term inflation tax is used. The growth of base money decreases the real value of money already issued. Inflation is then considered as a tax, which hits money base holders. By analogy, the rate of inflation is considered to be a tax rate, and the real base money is considered to be a tax base. There are, however, differences between seigniorage and inflation tax. In a growing economy, a part of seigniorage depends on an increase in real money demand.

Seigniorage is an important source of government revenue for many developing countries. However, the level of inflation tax and, of seigniorage vary among developing countries. How can the variability of inflation and of seigniorage between countries be explained? There are two main theoretical explanations. According to the first theory, based on the Phillips curve, government's objective function depends positively on the employment rate and negatively on the inflation rate. Unanticipated inflation with nominal wage contracts reduces real wages and thereby lowers real labor cost for employers. This lower cost

1 Government could have non-tax revenues, these revenues are important in oil producing countries (for example Kuwait).

encourages an increase in employment and consequently output. However, this creates positive inflation expectations, which result in an inflation bias. Private agents know that government has incentives to increase inflation rates, thus they do not have confidence in low inflation rates. In order to prevent a large increase in unemployment the government must validate the anticipations of private agents (see Kydland and Prescot [1977] and Barro and Gordon [1983]). For small open economies in developing countries, this argument could be expressed slightly differently. Salaries are not the main method of labor remuneration. A large part of the latter is constituted of benefits which determine the relative price of non tradable goods (or the real exchange rate). In the presence of flexible exchange rates, the monetary authority has an incentive to inflate. The resulting nominal depreciation of the exchange rate could lead to the depreciation of the real exchange rate if the inflation is not fully anticipated. In export-orientated industry, the latter developments can lead to increase exports that will enhance the economy and reduce the balance of trade deficit. However, if the inflation rate is anticipated by private agents, the government has to validate these anticipations leading to an inflation bias and to an appreciation of the real exchange rate. Thus, in a flexible exchange regime, there is permanent inflation due to the credibility constraint (S.&P. Guillaumont, 1995).

The second theory is the monetary financing of public spending. Recent research in this field has developed along two main lines. The first of these focuses on the temptation to effect resource transfers from the private sector to the government through an unanticipated inflation. This theory deals only with the rate of inflation that maximizes the government revenue *à la* Cagan (1956). The rate of inflation that maximizes the government revenue is different between countries, this explains the difference in inflation rates between countries. However, the rate of inflation that maximizes government's revenue could be very high and for some countries there is no Laffer relationship (Easterly, Mauro and Schmidt-Hebbel,

1995). The second stresses a dynamic aspect of the public-finance problem, and focuses on the optimal distribution of inflation over time and across all other available taxes to finance an exogenous amount of public spending. If one admits that in the real world "sum-lump" taxes are not available, that is to says all taxes imply distortions and if one considers inflation tax like any other conventional tax, then the theory of optimal seigniorage may be the most appropriate.

The theory of optimal taxation, implies that marginal deadweight losses should be equated across all available taxes (Ramsey, 1927) and time periods (Barro, 1979). Recently, these theories have been extended to models of optimum seigniorage and conventional taxation. Originally Phelps (1973) developed a model in which monetary and fiscal policies were coordinated to minimize the total excess burden of financing an exogenous amount of government spending. This theory has enjoyed renewed interest since Mankiw (1987), Grilli (1989), Poterba and Rotemberg (1990) and Trehan and Walsh (1990) developed models in which seigniorage and conventional taxes were set to minimize deadweight losses across all available taxes and time periods. When other taxes imply high deadweight losses and/or when the administrations costs to collect conventional taxes are high, government should use both conventional taxes and seigniorage to minimize the distortions of all available taxes. In many developing countries one observes two common characteristics: (i) government revenue from issuing money base is an important source of financing public spending and (ii) *social costs* of conventional taxes are very high. In this study, we will analyze the variability of inflation tax across developing countries within the framework of the theory of optimal inflation tax.

The remainder of the paper is organized as follows. In the next section, we will present the basic idea of the theory of the optimal seigniorage and its testable implications together with the presentation of some limits of this theory. In section 3, we will test the implications of the theory of optimal seigniorage. First, we will test Barro's hypothesis, namely the

hypothesis of revenue smoothing (tax and seigniorage smoothing). Then, we test the implications of Phelps hypothesis, namely the positive correlation between seigniorage and public spending and seigniorage and government tax rate. The last section contains the conclusion.

I. The theory of optimal seigniorage

Background

Research, on monetary policy, has focused on the optimal rate of inflation since Friedman work in 1969. According to Friedman, optimal monetary policy, defined as one that maximizes the consumer surplus, is characterized by a nominal interest rate equal to zero, corresponding to a negative inflation rate. This rate of inflation is called the "Friedman rule". This rule was justified with the first best argument that the price charged for the use of real balances should be set equal to the production cost, which is approximately zero. The conditions under which the Friedman rule holds, have been the subject of intense academic debate over the past 30 years. Historically, Phelps (1973) following an approach *à la* Ramsey (1927) was the first to challenge the relevance of Friedman's (1969) result by arguing that, in a second best world where government expenditures must be financed with distortionary taxes, liquidity should be taxed as any other good. With this approach, one searches for the rate of inflation that minimizes the deadweight losses of all taxes, and not the rate of inflation that maximize the government revenue *à la Cagan (1956)*. According to Phelps, in the public finance context and when sum-lump taxes are not available, a positive rate of inflation could be optimal. According to this theory, the higher the deadweight losses of conventional taxes, the higher the rate of inflation.

Barro (1979) further developed the theory of optimal taxation with the tax smoothing argument. If the marginal social cost of raising revenue is increasing in the tax rates, as one

would typically expect, the optimal fiscal policy entails smoothing tax rates over time. In Barro's model, government uses public debt (deficits) to smooth tax rates over time. Thereby, public debt finances transitory spending and taxes finance permanent spending.

Direct extensions of the tax smoothing argument *à la Barro* (1979) and the theory of optimal public finance *à la Phelps* (1973) are the models developed by Mankiw (1987), Grilli (1989), Poterba and Rotemberg (1990) and Trehan and Walsh (1990). In these models, government raises revenue from two sources to finance an exogenous amount of public spending. The first source is a tax on output, such as an income tax or sale tax. The second source of revenue is seigniorage, the printing of new money. Both ways of raising revenue cause social losses. The government can use a combination of these two instruments to minimize the present value of these social losses subject to the intertemporal budget constraint (see for example, Mankiw, 1987 and Grilli, 1989). The optimal fiscal and monetary policy, resulting from this optimization exercise, satisfies three equations. The first equation equates the marginal social cost of taxation today and in the future. The second equates the marginal social cost of inflation today and in the future. These two equations express the tax smoothing argument *à la* Barro (1979). The third equates contemporaneously the marginal social cost of raising revenue through direct taxation and the marginal social cost of raising revenue through seigniorage. The latter equation expresses the argument *à la* Phelps (1973).

Empirical implications

The latter equation, which relates the tax rate to the rate of inflation, expresses a crucial implication of the theory of optimal seigniorage. In response to a permanent changes in government spending (a permanent exogenous shock on public spending), government uses both instruments. An increase in public spending implies higher levels of conventional taxes. To equate the marginal costs of conventional tax and seigniorage, an increase in seigniorage is required. Thus, seigniorage and conventional tax revenue move in the same direction. Hence

the level of inflation and the level of seigniorage moves together with the tax rate (tax revenue). This implies a positive relationship between seigniorage and tax revenue and seigniorage and public spending. Further, Grilli (1989) and Trehan and Walsh (1990), have pointed out that models *à la* Mankiw imply that both the inflation rate (seigniorage) and tax rate (tax revenue) should have a unit root and should be cointegrated. This is, of course, a result analogous to the random walk property of consumption derived by Hall (1978). This latter relationship is called revenue smoothing (tax and seigniorage smoothing).

Thus, the theory of optimal inflation tax can be tested in two different manners. (i) The revenue smoothing hypothesis (tax and seigniorage smoothing). Seigniorage, tax revenue and government spending have a unit root and have cointegration relationships. (ii) The existence of a positive correlation between seigniorage and tax revenue and seigniorage and public spending. The former represents the Barro's tax smoothing argument and the latter represents the Phelps argument.

The theory of optimal seigniorage is based on a simple idea, namely that government set public finance policy in order to minimize the social cost of different methods of financing public spending. However, this theory implies many implicit hypotheses some of them are unrealistic particularly in developing countries. In the next section, we will examine the greater shortcomings of the theory of optimal seigniorage which will allow us to better evaluate our empirical results.

The limits of the theory of optimal seigniorage

From the theoretical point of view, Kimbrough (1986) showed that if we consider money as an intermediate good, that is to say money reduces transaction costs, the argument *à la* Phelps (1973) will not necessary imply that a positive inflation rate is optimal. Thus depending on the hypothesis of money, (intermediate or final good) predictions can change.

Végh (1989), however, showed that if marginal costs of conventional taxes are increasing, it is still optimal to have a positive inflation rate.

The theory of optimal seigniorage supposes that there is perfect coordination between the fiscal and monetary authorities, monetary creation is only for fiscal purposes[2] and the stock of monetary base is a free instrument of the fiscal policy. In some countries there are institutional constraints limiting monetary creation. For example, countries of CFA franc zones[3]. In countries with currency board, monetary creation is beyond governmental control, because it depends on international transactions (the global balance).

In a fixed exchange rate regime, the monetary authority has to defend the parity of money. If the stability of the exchange rate is also an objective of the monetary policy, monetary authority will probably choose an inflation rate which is different from that predicted by the theory of optimal seigniorage. Fischer (1982), shows that a fixed exchange regime is more disciplinary than a flexible one. If the exchange regime is part of the optimal policy of the government, its cost should be included in the government's objective function (Grilli, 1989).

Furthermore, the revenue smoothing hypothesis (tax and seigniorage smoothing) is based on very strong implicit hypotheses which are unrealistic for developing countries. In developing countries, a number of inherent institutional characteristic must be taken into account. Edwards et Tabellini (1991) outlined that one ought to take into account the fact that often the domestic capital market is not well developed. Hence most public borrowing must be sought from abroad, using external debt. This introduces two complications that may change the nature of optimal policy. Firstly, developing countries generally face credit constraints in international capital markets. Secondly, to the extend that they can borrow

[2] According to Cukierman (1993), an expansionary monetary policy could be used for four main reasons: Employment, revenue, balance of payment and financial stability (interest rate smoothing).
[3] The credits of Central banks to governments are limited to 20% of the government tax revenues.

abroad, they can only borrow in foreign currency; this means that external debt may increase exposure to exchange rate risk or terms of trade risk. Both these complications presumably weaken the revenue smoothing principle, since they raise the cost of issuing public debt. However, they do not alter the prescription that the inflation tax should covary positively with other tax rates and with the levels of public spending.

Finally, inflation tax could react as a "residual source of government revenue" (Click, 1998). It increases as the other sources of revenue decrease, thus inflation tax will not finance permanent government spending, it only finances the transitory part of public spending. In this case, there is no relationship between permanent government spending and the correlation between the tax rate and inflation tax is negative. This effect is increased by the exogenous volatility of tax revenue of developing countries exporting raw materials (Honahan, 1996). Poterba and Rotemberg (1990) argue that there is a difference between the two sources of revenue: the conventional taxes cannot be adjusted quickly (as usually they must be voted by the legislators) while inflation tax can be adjusted quickly in response to a temporary increase in government spending. However, the correlation (negative or positive) between inflation tax and conventional tax should be interpreted with caution. A reverse causality could appear due to Olivera (1967) and Tanzi (1977) effect. Empirical tests of the theory of optimal seigniorage must take into account the problem of reverse causality.

II. Empirical evidences

Review of previous empirical literature

Mankiw (1987) argues that the theory of optimal seigniorage performs relatively well in explaining the behavior of nominal interest rates and inflation in the postwar USA data. His conclusion is based on the finding that the inflation rate (and the nominal interest rate) and the average tax rate are indeed positively and significantly correlated. Amano (1998) provides

empirical evidence on the validity of the optimal seigniorage hypothesis for Canada and the USA over the 1953 to 1993 period. Poterba and Rotemberg (1990), on the other hand, raise some doubts about the generality of this theory. They extended Mankiw's analysis to Japanese, German, French and UK data, and found that a significant positive correlation is present only in the Japanese data.

Trehan and Walsh (1990), tested the cointegration relationship between inflation and tax rate in the U.S. data over the period 1914-1986. They found that these two variables are nonstationary. However, they found very weak evidence of a cointegration relationship between these two variables. This suggests that revenue-smoothing considerations have not been significant elements in determining the behavior of seigniorage. Grilli (1989) and Dupuy (1993) tested the cointegration relationship between seigniorage and the tax; and seigniorage and public spending in an European context. Both studies showed mitigated results. Edwards and Tabillini (1991) tested the cointegration relationship of 21 developing countries. They rejected the implications of this theory.

De Haan, Zelhorst and Roukens (1993) analyzed seigniorage in a sample of 42 developing countries. They found a positive correlation between public spending and seigniorage. In addition, Campillo and Miron (1996) examined data from 62 countries and concluded that their results are consistent with the view that optimal tax considerations are important in determining inflation rates. Click (1998) analyzed the seigniorage in a cross-section of developing and developed countries and found that average government spending is not a determinant of seigniorage.

This review of the empirical literature shows that even if the theory of optimal seigniorage has sound foundations , there are many doubts concerning the behavior of governments in the real world. Two studies test the theory of optimal seigniorage in the context of developing countries: the results are contradictory. Thus, an empirical investigation

of the theory of optimal seigniorage in developing countries, in which the different predications are tested, is merited. In this study, revenue smoothing hypothesis is tested using the new econometric tools for panel data, namely the panel unit root tests. The possible reverse causality between tax and seigniorage is corrected using the Generalized Method of Moment estimators (GMM system).

Data and measurement of seigniorage

Seigniorage versus inflation tax

The total revenue from seigniorage as fraction of GDP is:

$$\frac{\dot{M}}{Y} = \frac{\dot{M}}{M}\frac{M}{Y} = m.m \qquad (1)$$

Where M is the monetary base, Y is the GDP, μ is the growth rate of the money base and m is the money base over GDP[4].

If we suppose that the demand of money is described by the quantity equation:

$$M/P=k.\ Y \qquad (2)$$

Where P is the general level of price, k is the velocity of money (taken to be constant). Expressing this equation in growth rate terms we have:

$$\frac{\dot{M}}{M} = \frac{\dot{P}}{P} + \frac{\dot{Y}}{Y} \Leftrightarrow m = \frac{\dot{M}}{M} = \frac{\dot{P}}{P} + \frac{\dot{Y}}{Y} = (p + g) \qquad (2')$$

Then, from (1) and (2') we have:

$$\frac{\dot{M}}{Y} = (p + g)m = pm + gm$$

Where p is the rate of inflation and g is the growth rate of the economy.

[4]Monetary base and GDP are in nominal term. If the real monetary base and GDP were used the results would be the same, as long as both variables are deflated with the GDP price index.

Thus the seigniorage ($\frac{\dot{M}}{Y}$) has two components. The term pm is the inflation tax, by analogy p is the tax rate and m represents the tax base. The term gm reflects the increase in money demand due to the economic growth. The former is called "active seigniorage" and the latter is called "passive seigniorage" (Fisher, 1982). Thus the seigniorage is measured as the variation of the stock of the money base, during a given time period (year), as ratio of GDP ($\frac{\dot{M}}{Y}$ or $\frac{\Delta M}{Y}$). This measure is the most widely used in the literature: it is used, among others, by Cagan (1956), Marty (1968), Friedman (1971), Fischer (1982), Barro (1982), Cukierman, Edwards and Tabellini (1992) and Click (1998).

However, one can argue that seigniorage and inflation tax have not the same distortions and the appropriate measure is the inflation tax. The inflation tax is then measured by inflation rate times money base stock over GDP ($p.m$)[5].

Data

We will test the prediction of the theory of optimal seigniorage in developing countries using a large cross-section times series data. The data come from Government Financial Statistics (GFS), International Financial Statistics (IFS) and World Development Indicators (WDI). To test the revenue smoothing implications of the theory of optimal seigniorage, long terms series data are required. In this study we imposed to the three variables (seigniorage, tax revenue and public spending) to have at least 20 observations by country. Only forty developing countries satisfied this restriction. Thus we tested the revenue smoothing hypothesis on these forty countries over the period 1970-1999. Then, the Phelps implications were tested on the forty selected developing countries and the analysis is extended to the whole sample (up to) 112 developing countries. For the implications of Phelps hypothesis, the investigation was based on the average levels of seigniorage over the whole period 1970-1999 (or as much of the period that was available) and over the three sub-periods

[5]For a discussion on the measure of seigniorage see Drazen [1985], Dupuy [1992] and Honahan [1996].

(1970-1979, 1980-1989 and 1990-1999), this subdivision will allow us to use panel data properties.

Testing the revenue smoothing hypothesis

As shown in Grilli (1989) and Trehan and Walsh (1990), the revenue smoothing hypothesis imply that (i) the variables are unit-root nonstationary and (ii) there are cointegration relationships between seigniorage and tax rates and seigniorage and public spending. The existence of nonstationarity by itself does not prove that the hypothesis under consideration is correct; nonstationarity as a result of revenue smoothing must also be shown[6]. These considerations would imply a cointegration relationship between these variables.

In this study we will use a panel unit root test based on individual unit root tests. The panel data unit root test suggested by Levin and Lin (1992, 1993) is based on a very restrictive hypothesis which is rarely ever of interest in practice. Namely, the homogeneity of roots across units. Im, Pesaran and Shin (1997) relax the restrictive hypothesis of the Levin and Lin test, however several difficulties still remain. For example, the time dimension is the same for all the cross-section units. This test is not suitable for an unbalanced panel as is the case in this study. To overcome these difficulties, Maddala and Wu (1999) and Choi (2001) propose a test developed by Fisher (1932) which is based on combining the p-values of the test-statistic for a unit root in each cross-sectional unit. The Fisher test is non-parametric, and may be combined for any arbitrary choice unit root test. It is an exact test and the statistic given by

$$-2\sum_{i=1}^{N}\ln(pi)$$

[6] Indeed, the unit root is a necessary but not sufficient condition of the tax smo othng hypothesis.

is distributed as a Chi-squared variable with 2N degrees of freedom under the assumption of cross-sectional independence. p_i is the p-value of the test statistic on unit i. This test can be used either for the units root or cointegration hypothesis[7].

Results

In order to conduct the panel unit root test, as described above, unit root tests for each country must firstly be conducted. Then take the p-value of each individual test (each country) to compute the statistic of panel unit root test. Thus, individual unit root test, for each country and for each variable, were performed (see Table I). Then, we computed the statistic of Maddala and Wu (MW) for each variable (Table II).

For seigniorage, we rejected the null of unit root for most of the countries (column 3, Table I)). The MW statistic is explosive rejecting the necessary condition of the cointegration relationship[8]. Thus, the "seigniorage smoothing" hypothesis is rejected. However, one can argue that inflation tax reflects better the distortions of monetary financing of public spending. We performed the individual unit root for inflation tax (column 4). For most countries, the variable is stationary. The MW test reject the null of unit root nonstationary (Table II). Thus the necessary condition of the cointegration relationship is rejected. There are non cointegration relationships between inflation tax and public spending and inflation tax and tax revenue[9]. This result is probably due to the implicit hypotheses which are unrealistic in the context of developing countries, for example many developing countries have credit constraints.

The other way to test the theory of optimal seigniorage is based on the equation that equates the marginal social cost of raising revenue through direct taxation and the marginal social cost of raising revenue through seigniorage for each period. In this case, the test

[7] Therefore the null hypothesis to be tested is: *H_0 : all time series are unit root nonstationary;* H_A : At least one time series is stationary.

[8] For many countries the p-value is close to zero, the logarithm is vary high in absolute values.

consists of searching for a positive correlation between seigniorage and the tax rate and seigniorage and public spending. These are the implications of the Phelps hypothesis.

Testing the Phelps hypothesis

Mankiw found a positive relationship between inflation (and nominal interest rate) and the taxation rate for US data. However, one can extend the predications of this model to the cross section analysis as mentioned by Mankiw (1987, p. 340):

"*ceteris paribus, economies with high levels of expenditure and taxation also have high inflation and nominal interest rates. Implementing of such a test, however, would likely require taking into account the cross national variation in the efficiency of the system of taxation"*.

The problem is that the efficiency of a fiscal system is difficult to measure. Thus we have to use some proxies. The variables of control have to take into account the efficiency of the tax system. The following methodology was used.

$$S_{i,t} = a\, X_{i,t} + ?_i + e_{i,t}$$

Where S is the seigniorage, X is a set of control variables including the variable that reflects the theory of optimal seigniorage, ? represents a set of unobserved time-invariant country-specific effects, e is the error term, and the subscript *i* and *t* represent country and time periods, respectively[10].

The variables

As explained in section 2, we have two variables of interest: public spending as a percentage of GDP and government tax revenue as a percentage of GDP. The two variables are expected to be positively correlated to seigniorage (to the inflation tax).

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[9] However, as shown in table I, for many countries public spending and the tax rate are unit-root nonstationary (column 1 and 2). For both variables, we can not reject the unit root null at any usual significance level.
[10] Time dummies can also be included in the equation to account for time-specific effects.

We have, however, to control for the other variables reflecting partially the efficiency of tax system and tax administration. The following control variables are used. (i) Urban population as a percentage of total population. On the one hand, the urban sector is easier to tax, thus we can expect a negative relationship between urbanization and seigniorage (Cukierman, Edwards and Tabellini, 1992). On the other hand, urbanization enhances underground and informal activities which are hard to tax. This last argument is the main hypothesis in the models of Canzoneri and Roger (1990) and Nicolini (1998). This variable, generally speaking, could be a proxy for political instability (Cukierman, Edwards and Tabellini, 1992). The probability of political conflicts is higher in urban areas than in rural areas. (ii) The size of a country is an important determinant of the level of tax revenue (Tanzi, 1989). The size of the country is measured by the size of its population. The bigger countries tend to have more complex fiscal systems, thus have relatively more inefficient fiscal system. Thus the size of a country could have a positive effect on seigniorage. If we suppose, however, that there is economy of scale in public administrations, the average costs of collecting tax is decreasing. In this case the relationship between the size of a country and seigniorage is negative. (iii) The GDP per capita. More advanced countries usually tend to have more ability to design more sophisticated and efficient fiscal systems. Thus GDP per capita is expected to be correlated negatively with seigniorage. (iv) The trade openness is measured as the sum of imports plus exports as a percentage of GDP. The expected effect of trade openness on seigniorage is negative. In many developing countries, imports and exports represent important tax bases which are easy to tax and incur low administration costs. In addition, in more open countries the elasticity of demand of money in inflation rate is higher. More openness makes foreign currencies available. This increases the substitution between moneys. In this case the optimal inflation rate is lower in more open economies (Romer, 1993). (v) Institutional constraints limit monetary creation. The aim is to control for the

exchange regime. One way to do this is to introduce dummies for the exchange regimes. The problem, however, is that the exchange regime could be determined endogenously thus one has to take the exchange regime at the beginning of the period. In this study, we have to take the exchange regime of the early 70s. This is not pertinent because it does not take into account the evolution, over time, of the exchange regime. Having said that, we constructed a dummy which takes the value of one if the country belongs to the CFA zone and zero otherwise. This exchange regime is exogenously determined. The expected coefficient of this dummy is negative. In the following regressions, all variables are expressed in logarithm except the CFA dummy. Thus the coefficient of each variable can be interpreted as the elasticity (except CFA dummy).

The relationship between public spending and inflation tax

First, we tested the implications of Phelps hypothesis for the forty selected developing countries then for the whole sample. The results are shown in the table III. The variables were averaged for the whole period (1970-1999) and for the three sub-periods each of ten years (1970-1979, 1980-1989 and 1990-1999). The sample was divided into sub-periods (seventies, eighties and nineties), this allows to introduce in the equations time dummies for each sub-period and allow to use panel data properties.

As predicted by the theory, there is a highly significant positive relationship between public spending and inflation tax. The results are robust for the sub-group of forty countries (column 1 to 4) and for the whole sample (1' to 4') and with different estimators (OLS, OLS pooling, Random-Effect and Fixed-Effect estimators). The coefficient on public spending are close to 1. This implies that an increase in public spending of 1 percent of GDP is associated approximately with 1 percentage point increase in inflation tax revenue.

The relationship between tax revenue and inflation tax

The other variable of the theory of optimal seigniorage is government tax revenue. This variable, however, is endogenously determined in the theory of optimal seigniorage and there is a problem of reverse causality between conventional tax and inflation tax due to Olivera-Tanzi effect. The Generalized-Method-of-Moments estimators allow us to control for unobserved country-specific effects and potential endogeneity of the explanatory variables. The usual method of dealing with the country-specific effects, in the context of panel data, has been to first-difference the regression equation (Anderson and Hsiao, 1982). We adopt the assumption of *weak exogeneity* of the explanatory variables, in the sense that they are assumed to be uncorrelated with future realizations of the error terms. However some variables could be strictly exogenous (urbanization ratio and population). In addition to the internal instruments we can use external exogenous instruments (agriculture and manufacturing value added as percentage of GDP).

There are, however, conceptual and statistical shortcoming with this estimator. We use an alternative *system estimator* that reduces the potential biases and imprecision associated with the usual difference estimators (Arelllano and Bover 1995 and Blundell and Bond 1998). The alternative estimator combines, in a system, the regression in differences and regression in levels. The lagged levels of the variables could be used as instruments in the regression in differences and the lagged differences of the variables could be used the regression in levels. Then in the following the effect of a given variable on the inflation tax is referred to the association between the exogenous component of that variable and the inflation tax.

The results are shown in table IV, as expected the tax revenue is significantly and positively correlated to inflation tax revenue. An increase of 1 percent of GDP in tax revenue is associated approximately with 1 percentage point increase in inflation tax revenue.

We estimate the same equations (as in table III and IV) but the depended variable is seigniorage as percentage of GDP (table V and VI). Generally speaking, the results are the same.

III. Conclusion

The full econometric implications of this theory, namely the revenue smoothing hypothesis, is rejected for the forty selected developing countries. However, the Phelps hypothesis implications could not be rejected both for the forty selected developing countries and for the whole sample. An exogenous increase in public spending implies an increase in both conventional taxes and seigniorage. Countries with high rates of conventional taxes and with high levels of public spending have high levels of seigniorage. This suggests that in order to reduce the level of seigniorage and inflation in developing countries the government can use two instruments. The first instrument is to reduce the level of public spending. However many developing countries have reduced their public spending to the levels of "minimum acceptability" particularly in health, education and infrastructure (Ghura, 1998). The second instrument is to reform the tax system. For example, improving the efficiency of tax system, implementing taxes with lower distortions (shifting from trade taxes to VAT), fighting the corruption, etc.

Table I. Individual Unit Root Tests

The following table presents Phillips-Perron tests for unit roots for the three variables. A single asterisk (*) indicates that the null hypothesis of a unit root is rejected at the 10 percent significance level; two asterisks (**) indicate a rejection at the 5 percent significance level; and three asterisks (***) a rejection at the 1 percent significance level.

Countries	Public spending	Tax revenue	Seigniorage	Inflation tax
Argentina	--	--	**	***
Botswana	--	--	***	--
Brazil	**	--	--	--
Burkina Faso	--	--	***	**
Cameroon	--	--	***	***
Chile	*	--	**	**
Colombia	--	*	***	*
Congo, Dem. Rep.	**	--	***	*
Costa Rica	--	--	***	*
Dominican Republic	--	--	***	*
Ecuador	--	--	***	--
Egypt, Arab Rep.	--	--	*	--
Fiji	--	--	***	*
Ghana	--	--	***	*
India	--	--	**	***
Indonesia	--	*	***	***
Iran, Islamic Rep.	--	--	--	--
Jordan	--	--	***	*
Kenya	--	--	***	*
Korea, Rep	***	--	***	--
Malawi	--	--	***	--
Malaysia	--	*	***	*
Mauritius	--	*	***	**
Mexico	--	--	**	--
Morocco	--	--	***	*
Nepal	--	--	***	***
Nicaragua	--	--	***	***
Oman	--	***	**	***
Pakistan	--	*	***	*
Papua New Guinea	--	--	***	--
Paraguay	--	--	***	--
Peru	***	*	*	***
Philippines	--	--	***	***
Romania	--	--	--	***
Sri Lanka	--	**	**	***
St. Kitts and Nevis	*	**	***	***
Syrian Arab Republic	--	--	***	--
Togo	--	--	***	***
Turkey	**	--	***	--
Uruguay	--	--	**	--

Table II: Maddala-Wu statistics for panel unit rout tests

	Public spending % of GDP	Inflation tax % of GDP	Tax revenue % of GDP	Seigniorage % of GDP
MW statistic	93,624	112,878	90,171	(--)*
Observations	40	40	40	40

Maddala and Wu (MW) panel unit root test of public spending, inflation tax, tax revenue and seigniorage.
Chi-2 critical value at (1%), (5%) and (10%) are respectively (112,329), (101,879) and (96,578). *The MW statistic for Seigniorage could not be computed since some individual p-values take the value of zero.

Table III: Inflation tax and public spending

	Selected countries				**Whole sample**			
	(1) OLS	(2) OLS pooling	(3) RE	(4) FE	(1') OLS	(2') OLS pooling	(3') RE	(4') FE
Dummy CFA	-.7271802	-.8421322	-.9044154	-.641605	-.834579	-.8681778	-.8758612	
	(-1.18)	(-1.73)	**(-1.15)**	(-1.37)	(-3.72)	(-3.90)	(-2.59)	(dropped)
GDP per capita	-.8508932	-.591171	-.4640977	-.3948175	-.4790062	-.433089	-.4243892	-.8836487
	(-3.08)	(-2.44)	**(-1.69)**	(-1.37)	(-3.11)	(-3.30)	(-3.03)	(-2.43)
Openness	-1.562573	-1.229415	-.8265644	-.3948175	-.3995381	-.778319	-.5476844	-.0893012
	(-4.64)	(-4.51)	**(-2.59)**	(-0.83)	(-1.36)	(-3.88)	(-2.45)	(-0.22)
Urbanization	1.62097	1.160238	.6513619	-1.215184	1.012893	.9018927	.7189019	-.8897894
	(3.49)	(3.35)	**(1.46)**	(-1.44)	(4.01)	(4.97)	(3.27)	(-1.42)
Population	-.2323126	-.1573813	-.0044168	1.101107	.1142516	-.0324006	.0267763	.7264028
	(3.03)	(-2.65)	**(-0.03)**	(1.54)	(1.57)	(-0.67)	(0.39)	(1.26)
Public spending	**1.06458**	**1.107236**	**1.055659**	**1.361736**	**.7110151**	**.7423906**	**.7270481**	**.7449141**
	(1.31)	**(2.48)**	**(2.40)**	**(2.27)**	**(2.35)**	**(3.01)**	**(3.17)**	**(1.62)**
Intercept	3.900221	2.139494	1.285651	3.925189	-.7106817	1.008176	.6314002	6.282212
	(1.67)	(1.40)	**(0.65)**	(1.29)	(-0.54)	(1.09)	(0.56)	(2.36)
Adjusted R^2	0.4172	0.2814	**.2477**	0.1538	0.3367	0.2539	0.2451	0.1213
Number of observations	40	112 Groups (40)	112 Groups (40)	112 Groups (40)	109	216 Groups (104)	216 Groups (104)	216 Groups (104)

The dependent variable is inflation tax as % of GDP . t-statistics are in parentheses. All variables are in logarithm, except CFA dummy. Time dummies, if significant, are introduced (not shown).

Table IV: Inflation tax and tax revenue : GMM system estimators

	Selected countries	**Whole sample**
GDP per capita	-0.969844	-1.064017
	(-4.661423)	(-9.347744)
Openness	-1.434760	-0.729897
	(-5.611824)	(-3.578885)
Urbanization	1.842061	1.538640
	(5.370801)	(7.858452)
Population	-0.326647	-0.170698
	(-2.345375)	(-3.116818)
Tax revenue	**0.838519**	**1.140133**
	(1.889964)	**(4.448746)**
Intercept	4.620002	2.307888
	(4.352329)	(2.739216)
J-statistic	0.305558	0.311365
Number of observations	40	104

The dependent variable is inflation tax as % of GDP . t-statistics are in parentheses. All variables are in logarithm

Table V: Seigniorage and public spending

	Selected countries				**Whole sample**			
	(1) OLS	(2) OLS pooling	(3) RE	(4) FE	(1') OLS	(2') OLS pooling	(3') RE	(4') FE
Dummy CFA	-.0946739 (-0.17)	-.1823373 (-0.59)	-.3776971 (-0.60)		-.484835 (-2.96)	-.5124326 (-3.91)	-.5536999 (-2.34)	
GDP per capita	-.3558858 (-2.17)	-.2715026 (-1.96)	-.1685748 (-0.79)	-.4897967 (-1.28)	-.1801614 (-1.89)	-.2154914 (-2.74)	-.2040352 (-1.97)	-.6722538 (-2.40)
Openness	-.6452151 (-2.16)	-.6350141 (-2.73)	-.5659239 (-0.79)	-.1758442 (-0.45)	-.1775174 (-1.23)	-.2898163 (-2.03)	-.256817 (-1.54)	-.0627342 (-0.20)
Urbanization	.7961392 (2.25)	.5360772 (2.09)	.1132069 (0.35)	-.4404063 (-0.73)	.4257992 (2.13)	.4518594 (3.11)	.3398673 (2.13)	-.2873875 (-0.65)
Population	-.0934544 (-1.40)	-.0828242 (-1.48)	-.0722155 (0.67)	-.0078575 (-0.01)	.0172491 (0.40)	-.0440413 (-1.15)	-.0452682 (-0.88)	-.0472192 (-0.11)
Public spending	**.9807496 (1.45)**	**.9361678 (2.67)**	**.8367846 (2.41)**	**.7966058 (1.65)**	**.5192295 (2.44)**	**.5262477 (2.83)**	**.4911574 (2.96)**	**.5403285 (2.38)**
Intercept	-.1125341 (-0.07)	.3148045 (0.29)	1.147584 (0.72)	3.829342 (1.52)	-.6674495 (-0.80)	.0152975 (0.03)	.3266319 (0.39)	4.766233 (2.38)
R^2	0.2034	0.1359	0.1098	0.1083	0.1721	0.1303	0.1259	0.1095
Number of observations	40	118 Groups (40)	118 Groups (40)	118 Groups (40)	112	236 Groups (112)	236 Groups (112)	236 Groups (112)

The dependent variable is seigniorage as % of GDP . t-statistics are in parentheses. All variables are in logarithm, except CFA dummy . Time dummies, if significant, are introduced (tot shown).

Table VI: Seigniorage and Tax revenue : GMM system estimators

	Selected countries	**Whole sample**
GDP per capita	-0.176828 (-1.792272)	-0.530231 (-3.795965)
Openness	-0.810503 (-4.636951)	-0.349479 (-1.594660)
Urbanization	0.584399 (4.370970)	0.679190 (4.288593)
Population	-0.127205 (-1.008524)	-0.119334 (-2.354533)
Tax revenue	**1.081691 (2.223108)**	**0.931865 (4.288593)**
Intercept	0.421218 (0.223314)	0.818357 (0.995941)
J-statistic	0.343356	0.160509
Number of observations	40	111

The dependent variable is seigniorage as % of GDP . t-statistics are in parentheses. All variables are in logarithm

REFERENCES

Amano, R. (1998) On the optimal seigniorage hypothesis *Journal of Macroeconomics,* **20** (2), 295–308

Anderson, M. and Hsiao, C. (1982) Estimating of dynamic models with error components, *Journal of the American Statistic Association*, **76**, 598-606.

Arellano, M. and Bond, S.R. (1991) Some tests of specification for panel data: Monte Carlo evidence and an implication to employment equation, *Review of Economic Studies*, **58**, 277-297.

Arellano, M. and Bover, O. (1995) Another look at the instrumental-variable estimation of error-components models, *Journal of Econometrics*, **68**, 29-52.

Barro, R. (1979) On the determination of the public debt, *Journal of Political Economy*, **87**(5), 940-971.

Barro , R. (1982) Measuring the FED's revenue from money creation, *Economics Letter*s **10**, 327-332.

Barro, R., and Gordon, D. (1983) Rules, discretion and reputation in a model of monetary policy, *Journal of Monetary Economics*, **12**, 101-121.

Blundell, R. and Bond, S. (1998) Initial conditions and moment restrictions in dynamic panel data models, *Journal of Econometrics*, **87** (1), 115-144.

Cagan, P. (1956) *The monetary dynamics of hyperinflation, In Studies in the quantity theory of money*, edited by Milton Friedman, PP. 25-117. Chicago: University of Chicago press.

Campillo, M., and Miron J. (1996) Why does inflation differ across countries?, *NBER Working paper* n° 5540.

Canzoneri, M. and Rogers C. (1991) Is the European community an optimal currency area ? Optimal taxation versus the cost of multiple currencies, *American Economic Review,* **80**, 419-449.

Choi, I. (2001, a) Unit root tests for panel data, *Journal of International Money and Finance*, **20**, 249-272.

Click, R. W. (1998) Seigniorage in a cross-section of countries, *Journal of Money, Credit, and Banking*, **30**(2), 154-171.

Cukierman, A., Edwards, S. and Tabellini, G. (1992) Seigniorage and political instability, *American Economic Review*, **82**, 537-555.

De Haan, J., Zelhorst D., and Roukens, O. (1993) Seigniorage in developing countries, *Applied Financial Economics*, **3**, 307-314.

Drazen, A. (1985) A general measure of inflation tax revenues, *Economics Letters*, **17**, 327-330.

Dupuy, M. (1992) La question du seigniorage dans les pays de la CEE, *Revue d'Intégration Européennes*, **15**(23).

Dupuy, M. (1993) Essai de vérification de la théorie du seigneuriage optimal pour les pays de la CEE, *Revue Economie Politique*, **103** (1).

Edwards, S. and Tabellini, G. (1991) Explaining fiscal policies and inflation in developing countries, *Journal of International Money and Finance*, **10**, S16-S48.

Easterly, W.R., Mauro P.R. and Schmidt-Hebbel K. (1995) Money demand and seigniorage-maximizing inflation, *Journal of Money, Credit, and Banking*, **27**, 583-603.

Fischer, S. (1982) Seigniorage and the case for national money, *Journal of Political Economy*, **90** (21), 295-313.

Friedman, M. (1969) The optimum quantity of money and other essays *Aldine, Chicago, IL.*

Friedman, M. (1971) Government revenue from inflation", *Journal of Political Economy,* **79**, 846-56.

Ghura, D. (1998) Tax revenue in Sub-Saharan Africa: effects of economic policies and corruption, *IMF Working Paper*, WP/135.

Grilli, V. (1989a) Seigniorage in Europe, in A European Central Bank? Perspective on monetary unification after ten fears of the EMS, de Cecco and Giovannini, Cambridge university press.

Guillaumont S. and P. (1995) Ebranlement et consolidation des fondements des francs CFA, *Revue d'Economie du Développement* (3), 87-111.

Honahan, P., (1996) Does it matter how seigniorage is measured?, Applied Financial Economics, **6**(3), 293-300.

Im, K. S., Pesaran, M. H. and Shin, Y. (1997) Testing for unit roots in heterogeneous panels, *Discussion paper, Department of Applied Economics*, University of Cambridge.

Kimbrough, K. (1986) The optimal quantity of money rule in the theory of public finance, *Journal of Monetary Economics*, **20**, 327-341.

Levin, A., and Lin C. (1992) Unit root tests in panel data: asymptotic and finite sample properties, *Discussion Paper 92-93, Department of Economics*, University of California at San Diego.

Levin, A., and Lin C. F. (1993) Unit root tests in panel data: new results, *Discussion Paper Discussion Paper 56,* University of California at San Diego.

Maddala, G., and Wu, S. (1999, Special Issue) A comparative study of unit root tests and a new simple test, *Oxford Bulletin of Economic and Statistics*, **61**, 631–652.

Mankiw, G. (1987) The optimal collection of seigniorage : theory and evidence, *Journal of Monetary Economics*, **20**, (2), 327-341.

Marty, A.L., (1968) The optimal rate of growth of money, *Journal of Political Economy*, **76**, 860-873.

Nicolini, J.P. (1998) Tax evasion and the optimal inflation tax, *Journal of Development Economics*, **55**, 215-232.

Phelps, E.S. (1973) Inflation in the theory of public finance, *Swedish Journal of Economics*, **75**, 77-82.

Poterba, J.M. et Rotemberg, J.J. (1990) Inflation and taxation with optimizing governments, *Journal of Money, Credit, and Banking*, **22** (1).

Ramsey , F. (1927) A contribution to the theory of taxation, *Economic Journal* **37** 47-61.

Romer, D. (1993) Openness and inflation: theory and evidence, *Quarterly Journal of Economics*, **108** (4), 869-903.

Tanzi (1989) The impact of macroeconomic policies on the level of taxation and the fiscal balance in developing countries, IMF Staff Papers, **36** (3).

Trehan B. and Walsh C. (1990) Seigniorage and tax smoothing in the United States, *Journal of Monetary Economics* **25,** 97-112.

Végh , C.A. (1989) Government spending and inflationary finance: a public finance approach, *IMF Staff Paper*, **3** (3).