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# Modelling and Testing Ricardian Equivalence: A Survey

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## Abstract

Ricardian Equivalence states that, under certain circumstances and for a given path of expenditures, the substitution of debt for taxes does not affect private sector wealth and consumption. Ricardian Equivalence is based on the premise that debt financing is only a change in the timing of taxation that has no impact on private sector consumption if the present value of the stream of taxation remains unchanged. This paper provides a model that illustrates the implications of Ricardian Equivalence, surveys the relevant literature, and considers the effects of relaxing the basic assumptions. It also critically reviews recent empirical work on Ricardian Equivalence.

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## Summary

The consequences of alternative fiscal policies have been largely tied to the various methods of financing fiscal deficits. It is possible, however, to focus on the differential impact of the alternative mechanisms of financing public expenditures. As the government absorbs resources from the private sector in order to finance its spending, a question arises about the impact of such absorption on private sector consumption and, therefore, on aggregate demand. In particular, it is possible to inquire about the differential effects on private sector wealth and consumption of financing government spending with taxes as opposed to debt.

A central proposition in this context is that, under certain circumstances, it makes no difference to the level of aggregate demand if the government finances its outlays by debt or by taxation. This is the so-called Ricardian Equivalence theorem, which states that, for a given path of expenditures, maintaining a balanced budget is equivalent to running a debt-financed deficit since the substitution of debt for taxes does not affect private sector wealth and consumption. Ricardian Equivalence is based on the premise that an issue of public debt is always accompanied by a planned increase in future taxes needed to service this higher level of public indebtedness. Thus, since debt financing is perceived only as a change in the timing of taxation, the Ricardian proposition asserts that such a change has no impact on private sector wealth and consumption as long as the present value of the stream of taxation remains unchanged.

This paper provides a unified model that illustrates the implications of Ricardian Equivalence and, with its help, reviews the literature on the subject, considers the effects of relaxing the basic assumptions, and provides a framework to study the implications of various extensions, including the discussion of open, monetary, and growing economies. In addition, it surveys the empirical work on Ricardian Equivalence that focuses on those tests that look at the response of private consumption to government budget variables.

Changes in the ratio of taxes to debt may, in practice, result in nonnegligible effects on private consumption and the macro economy. While these effects may reflect a violation of some basic Ricardian assumptions (e.g., perfect capital markets), another possibility is that changes in this ratio signal to agents changes in future fiscal policies, and this has an impact on current consumption. In fact, the equivalence proposition emerges only under a very specific set of fiscal signals conveyed by observed policy actions, that is, that current tax cuts that are accompanied by increases in the stock of public debt imply higher taxation in the future. The paper characterizes the impact of government policies on current consumption under a variety of fiscal signals, and reviews some of the evidence on the type of signals that could have been extracted in practice.

## I. Introduction

A common macroeconomic feature characterizing many industrial and developing countries in recent years is the growth and persistence of fiscal deficits. Although this is certainly not a new phenomenon, it is apparent that attempts to reverse these developments are drawing increasing attention in the design and implementation of adjustment policies. The analysis of the impact of fiscal deficits on aggregate demand and, through it, on the rate of inflation, the balance of payments, the level of employment, and the real interest rate has become a centerpiece of macroeconomic policy studies.

Although the study of the consequences of alternative fiscal policies has been directly tied to the various methods of financing fiscal deficits, it is possible to focus, as many of recent controversies on the subject have done, on the differential impact of the alternative financing mechanisms of public expenditures. As the government proceeds to absorb resources from the private sector in order to finance its spending, a question arises about the impact of such absorption on private sector consumption and, therefore, on aggregate demand. In particular, it is possible to inquire about the differential effects on private sector wealth and consumption of financing government sector spending with taxes as opposed to debt.

The central proposition in this context is that, under a specific set of circumstances, it actually makes no difference to the level of aggregate demand throughout the economy if the government finances its outlays by debt or by taxation (see Ricardo (1951), and Buchanan (1958)). This is the so-called Ricardian-Equivalence theorem which states that, for a given path of expenditures, it is economically equivalent to maintain a balanced budget or to run a debt-financed deficit since the substitution of debt for taxes does not affect private sector wealth and consumption. The underpinnings of Ricardian Equivalence are based on the premise that the issue of public debt in the current period is always accompanied by a planned increase in future tax collections which would be needed to serve this higher level of public indebtedness. Thus, since debt financing is perceived only as a change in the timing of taxation, the Ricardian proposition asserts that such a change has no impact on private sector wealth and consumption as long as the present value of the stream of taxation remains unchanged (see Barro (1974, 1978a)).

The policy implications of this proposition and the trade-offs that it may offer to the policymakers are, indeed, important and, therefore, a careful assessment of its analytical as well as its empirical validity is of much relevance. It is evident that in order for this equivalence to hold, a number of assumptions and conditions are required. Although many models have been developed which could produce Ricardian results, and in the context of those models the restrictions and limitations of the conditions required for its holding could be evaluated, with only a few exceptions there is no unified analytical framework that allows a

comprehensive consideration of the relative importance of the specific assumptions, and that permits, without undue complications, an analysis of the consequences of extending the basic model to cover more realistic circumstances. Furthermore, while a large body of empirical work on the equivalence proposition has accumulated over recent years, there is a variety of conflicting and inconclusive evidence which raises doubts about the methodology used in some of these studies.

The purpose of this paper is to provide a simple unified model that allows to illustrate the implications of Ricardian Equivalence and, with its help, review the literature on the subject, consider the effects of relaxing the basic assumptions, and provide a framework to study the implications of various extensions. Key among such extensions are the explicit discussion of open, monetary, and growing economies. In addition, we present an updated survey of empirical work on Ricardian Equivalence that focuses on those tests that looked at the response of private sector consumption to government budget variables. 1/

Changes in the ratio of taxes to debt may, in practice, result in nonnegligible effects on private consumption and the macro economy. While these effects may reflect a violation of one or several of the assumptions required for equivalence (as, for example, the assumption of perfect capital markets), another possibility is that changes in this ratio signal to agents changes in future fiscal policies, which in turn have an impact on current consumption. In fact, the equivalence proposition emerges only under a very specific set of fiscal signals conveyed by observed policy actions, i.e., that current tax cuts that are accompanied by increases in the stock of public debt imply higher taxation in the future. In the paper, we also characterize the impact of government policies on the current level of consumption under a variety of fiscal signals, and review some of the evidence on the type of signals that could have been extracted in practice.

The paper is organized as follows. The basic assumptions and derivation of Ricardian Equivalence are presented in Section II in the context of a simple intertemporal model. Section III discusses the conditions under which equivalence arises in three extended frameworks: a monetary economy, an open economy, and a growing economy. The main channels giving rise to deviations from equivalence are analyzed in Section IV. Specifically, we focus there on the role of borrowing constraints, distortionary taxes, uncertainty, and finite lives. Empirical evidence on the response of consumption to government budget variables is evaluated in Section V. Section VI discusses the implications of the fiscal regime and fiscal signals for the behavior of private consumption, and Section VII concludes the paper.

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1/ Other tests of Ricardian Equivalence have related interest rates to government budget variables. Overall, the evidence from these tests is not conclusive. For most recent work along these lines, see Evans (1985) and Tanzi (1985a, 1986). For previous surveys of the analytical aspects of Ricardian Equivalence, see Barro (1978a), Buiter and Tobin (1979), Dotsey (1985), and Tobin (1980).

## II. Ricardian Equivalence: Statement, Assumptions, and Derivation

The Ricardian-Equivalence theorem of government finance states that substitution of debt for taxes does not affect private sector wealth and consumption. 1/ The conditions and assumptions required for Ricardian Equivalence to emerge can be described by specifying a two-period model of the economy which consolidates the intertemporal budget constraints of the public and private sectors. 2/ As explained in the next section, most of the results from the two-period model carry over to a multi-period set-up with growth.

Consider a two-period model where period o is the 'present' and period 1 is the 'future'. Period -1 is used to take into account historically given conditions. We use throughout the following notation: G: government nominal spending on goods and services; T: government nominal lump-sum tax collection; B': government debt; i: nominal interest rate; C: nominal private sector consumption; B: private sector debt; Y: non-assets income; P: price level. The lowercase letters g, $\tau$, b', c, b, and y are used to denote the real values of the corresponding variables whose nominal values were denoted by uppercase letters. The government budgets for periods o and 1 are given in nominal terms by:

$$G_o - T_o + i_{-1}B'_{-1} = B'_o - B'_{-1} \tag{1}$$

$$G_1 - T_1 + i_o B'_o = - B'_o, \tag{2}$$

where the left-hand side is the government budget deficit (inclusive of interest payments). 3/ Dividing the first equation by the price level $P_o$ and the second by $P_1$, and consolidating them into a single equation yields:

$$g_o + g_1(1+r_o)^{-1} + (1+r_{-1})b'_{-1} = \tau_o + \tau_1(1+r_o)^{-1}, \tag{3}$$

where:

$$1 + r_o \equiv (1+i_o)(P_o/P_1) \quad \text{and} \quad 1 + r_{-1} \equiv (1+i_{-1})(P_{-1}/P_o),$$

with r denoting the real interest rate. Equation (3) is the intertemporal government budget constraint. It states that the present value of government spending plus initial government liabilities must equal the present value of government tax collections. The equation is a solvency requirement on the government, in that in order for private agents to

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1/ See Barro (1974, 1978).

2/ This is the simplest framework that can be used to analyze intertemporal aspects of Ricardian Equivalence. The model used is similar in many respects to the open economy specification in Frenkel and Razin (forthcoming), Chapter 7.

3/ Notice that since this is a two-period model, we have assumed that $B_1 = 0$, i.e., that all the debt is retired in period 1.

lend to government they would want to assure that the latter will raise enough revenue to cover both its spending and the repayment of its debt, i.e., that government plans to satisfy equation (3). 1/

With respect to the private sector, its budget constraints for periods o and 1 in nominal terms are:

$$C_o = Y_o + B_o - (1+i_{-1})B_{-1} - T_o \tag{4}$$

$$C_1 = Y_1 - (1+i_o)B_o - T_1 \, . \tag{5}$$

Expressing these equations in real terms and consolidating yields:

$$c_o + c_1(1+r_o)^{-1} = y_o + y_1(1+r_o)^{-1} - \tau_o - \tau_1(1+r_o) - (1 + r_{-1})b_{-1}. \tag{6}$$

Equation (6) is the intertemporal budget constraint faced by the private sector. The present value of consumption spending must equal the present value of net income minus the initial debt commitment. Optimal consumption decisions can be described by the solutions to the problem: choose $(c_o, c_1)$ so as to maximize $U(c_o, c_1)$ subject to equation (6), where U denotes consumer's utility function. 2/

Ricardian Equivalence can be shown to emerge in this set-up by substituting the expression for taxes in equation (3), the intertemporal government budget constraint, into the private sector intertemporal constraint of equation (6), to yield:

$$c_o + c_1(1+r_o)^{-1} = y_o - g_o + (y_1-g_1)(1+r_o)^{-1} \, . \tag{7}$$

Since in a closed economy a debtor position of the public sector must be matched by a creditor position of the private sector, $b = -b'$, and, hence, these debt terms drop out from the analysis. Equation (7) is the intertemporal budget constraint of the private sector, that holds under the assumption that this sector fully internalizes the budget constraints of the public sector. It can be seen that for a given pattern of government spending $(g_o, g_1)$ any two debt-tax patterns $(b'_o, \tau_o)$ and $(\hat{b}'_o, \hat{\tau}_o)$ that satisfy the government budget constraint will imply the same equilibrium quantities and prices. In this case, these two

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1/ Further discussion of this issue is presented in Section IV.5.

2/ Throughout the analysis we assume that government spending does not affect private sector utility. Since the Ricardian hypothesis concerns with how a given path of government spending is financed by taxation versus by bonds' sales, this assumption does not affect the analysis. Where the assumption is critical, however, is in empirical tests of the equivalence proposition, which have to control for the effects of changes in government spending (see Section V).

debt-tax patterns are equivalent economically; the timing of taxes and the size of government debt do not influence private sector behavior.

According to equation (7), the government variable that matters for private sector consumption decisions is the present value of government spending, $g_o + g_1(1+r_o)^{-1}$, and not the specifics of its financing. Put in Milton Friedman's words, "the whole of what government spends is extracted from the community resources, not solely that part financed by what are called taxes." 1/ Given this, changes in the ratio of taxes to government debt that are accompanied by changes in current or future government spending generally will not lead to Ricardian-Equivalence results. For example, a current tax cut that is accompanied by a decrease in future government spending, such that the government intertemporal budget constraint is satisfied, has a positive impact effect on the private sector's perceived wealth and consumption. In order for Ricardian Equivalence to hold, a current tax cut must be assumed to signal an increase in future taxes and no change in government spending.

The Ricardian-Equivalence proposition requires a number of key assumptions about the economic environment and the behavior of economic agents. These assumptions have been reflected in the previous derivation and include: (a) perfect capital markets with no borrowing constraints on consumers; (b) nondistortionary taxes; (c) full certainty about the path of future taxes and government budget policies; and (d) equal planning horizon for private and public sectors. In what follows, we consider the implications of relaxing some of these assumptions for the Ricardian-Equivalence results. Before that, however, it is pertinent to maintain the above assumptions but extend the basic framework in order to consider three additional environments. First, we examine the case of a monetary economy in which the government can also finance the budget deficit through money creation. Second, we consider an open economy whose capital market is integrated with the rest-of-the-world's. Third, a multi-period growing economy is discussed.

## III. Extensions

### 1. A monetary economy

This section considers Ricardian Equivalence in a monetary economy. It is shown that changes in the public debt/taxes ratio have no influence on private sector behavior to the extent that these changes are not accompanied by changes in the money supply path. This condition will be met only in the extreme case that the government meets its debt obligations by taxation--that is, bonds are fully backed by direct taxation and, therefore, there is no monetization of public debt. 2/

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1/ Wall Street Journal, April 26, 1984.

2/ Sargent (1982a) refers to this scenario as the polar Ricardian regime.

The two-period model developed previously can now be extended to analyze a monetary economy. To simplify matters we define money as the monetary base, whose nominal and real values are denoted by M and m, respectively. It is further assumed that money balances yield utility to individuals (e.g., by providing liquidity services), an assumption that generally implies positive demands for money in periods o and 1. The government budget equations (1) and (2) become now:

$$G_o - T_o + i_{-1}B'_{-1} = (B'_o - B'_{-1}) + (M_o - M_{-1}) \tag{8}$$

$$G_1 - T_1 + i_o B'_o = - B'_o + (M_1 - M_o). \tag{9}$$

Government budget deficits can now be financed by issuing debt or money. Expressing these equations in real terms and consolidating yields:

$$g_o + g_1(1+r_o)^{-1} + (1+r_{-1})b'_{-1} + (1+\pi_o)^{-1}m_{-1} =$$

$$\tau_o + \tau_1(1+r_o)^{-1} + \left(\frac{i_o}{1+i_o}\right) m_o + m_1(1+r_o)^{-1} \tag{10}$$

where $1 + \pi_o = P_o/P_{-1}$ . Equation (10) is the intertemporal government budget constraint, stating that the present value of government spending plus initial government debt and money liabilities must equal the present value of tax collections plus revenue from money creation.

Similarly, the intertemporal budget constraint of the private sector can be expressed as:

$$c_o + c_1(1+r_o)^{-1} + \left(\frac{i_o}{1+i_o}\right) m_o + m_1(1+r_o)^{-1} = y_o + y_1(1+r_o)^{-1}$$

$$\tau_o + \tau_1(1+r_o)^{-1} + m_{-1}(1+\pi_o)^{-1} - (1+r_{-1})b_{-1} \; . \tag{11}$$

When the private sector fully internalizes government budget policies, i.e., substituting the present value of taxes from equation (10) into the right-hand side of equation (11), its wealth is still equal to the right-hand side of equation (7). Under these conditions, Ricardian Equivalence can be formally stated as follows: any two government policy patterns $(g_o, g_1, M_o, M_1, \tau_o, \tau_1)$ and $(g_o, g_1, M_o, M_1, \hat{\tau}_o, \hat{\tau}_1)$ that satisfy the intertemporal government budget constraint induce the same behavior by the private sector, because the policy change in question does not alter individuals' budget sets. 1/

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1/ See Lucas (1984).

As stressed by Wallace (1981) and Lucas (1984), one way to interpret Ricardian Equivalence in a monetary economy is as an irrelevance proposition about open market operations. That is, while the path of money ($M_o$, $M_1$) influences private sector behavior, the specific channel through which money is injected into the economy, changes in taxes or open market operations with government bonds, is of no independent importance for real economic variables such as consumption.

All these results hold, as indicated previously, for the polar case in which increases in private sector holdings of government securities signal increased future explicit tax collections. Another polar case arises when increased government securities will be paid off not by collecting higher explicit taxes but by issuing base money and thus imposing on the public an inflation tax. In this case, changes in the public debt/taxes ratio can have nonneutral effects on private sector behavior because changes in a distortionary tax are being used. These nonneutralities depend on how money is modelled in the system and on the specific distortions that arise due to the inflation tax. For example, Aiyagari and Gertler (1985) consider an overlapping-generations economy with heterogeneous agents whose utility depends, among other variables, on real money balances. They produced examples in which changes in the ratio of public debt to explicit taxes, that are accompanied by changes in the inflation tax, redistribute the burden of government finance between the young and the old and thus may have an impact on aggregate consumption. On the other hand, these effects do not arise in models with homogeneous agents and separable utility among consumption and real money balances (see, for example, Liviatan (1982)), where the only effect of increases in inflation on private sector behavior is to reduce this sector's utility, due to its reduced money holdings, with no effect on its aggregate level of consumption.

## 2. An open economy

Consider now an open economy facing a given real interest rate in world capital markets. 1/ Agents in the economy can freely borrow or lend at this interest rate, denoted by $r^*$. To the extent that the international interest rate faced by the public and private sectors is the same, then the same set of assumptions that gave rise to equivalence in a closed economy will also give rise to it in the open economy under consideration. Specifically, a tax cut that is accompanied by an increase in the government's foreign debt will have no impact effects on private sector consumption and wealth. This increase in the government's external debt is fully internalized by the private sector which takes into account the taxes to be imposed in the future in order to finance the flow of payments to foreign lenders. Thus, internal and external public sector debt are treated in the same way by the private sector.

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1/ On Ricardian Equivalence in the world economy, see Frenkel and Razin (1985, 1986).

In order to illustrate these results, we turn to an open economy version of the real model developed in Section II. Assume, for simplicity, that all borrowing by government and consumers in the domestic economy is made from foreign lenders. Under these assumptions, internalizing the intertemporal government budget constraint into that of the private sector yields:

$$c_o + c_1(1+r_o^*)^{-1} = y_o - g_o + (y_1-g_1)(1+r_o^*)^{-1} - (1+r_o^*)(b_{-1}+b'_{-1}) \ . \qquad (12)$$

According to equation (12), the net present value of consumption expenditures must equal the net present value of real resources available to the private sector minus the initial value of the economy's external debt commitment. The higher the value of this commitment, the lower will be the level of wealth and, hence, of consumption. For a given value of this predetermined variable, however, neither taxes nor the government's subsequent foreign borrowing have an effect on wealth, which is affected by the government spending variables $g_o$ and $g_1$ and not by the form of finance.

An interesting application of the importance of the existence (or lack thereof) of Ricardian Equivalence in open economies is provided by Helpman and Razin (1985). They study the effects of exchange rate management, aimed at reducing inflation, on real economic variables. Inspired by the experience of Israel in the early 1980s and Argentina and Chile in the late 1970s, Helpman and Razin consider a policy-induced slowdown in the rate of devaluation that is not accompanied by government budget adjustment in the form of fiscal contraction. They show that this policy leads to an increase in government's foreign borrowing and, hence, to an eventual loss of international reserves. To the extent that Ricardian Equivalence holds, this form of exchange rate management has no wealth effects on the private sector, which fully internalizes the future implications of government policies. After showing that in the countries mentioned above slowdowns of devaluation were accompanied by increases in private consumption, by real exchange rate appreciation, and by a worsening in the trade balance, Helpman and Razin modeled one specific form of deviation from Ricardian Equivalence that yields results that generally conform with the evidence. Their model is based on the idea that due to finite lives individuals face higher effective interest rates than government; see also Blanchard (1985) and Section IV.4 below. A welfare implication of their analysis is that the devaluation slowdown benefits the current generation and imposes a burden on future generations.

### 3. Growth

When extending the model to a multi-period growing economy, it can be shown that the same type of assumptions that imply Ricardian Equivalence in the simple model considered in Section II yield the same implication for this extended framework, Barro's (1974) framework, with operative bequests, can be considered as one such framework. While in the two-period model of Section II the government paid all its

outstanding debt by the second period, an important question that arises in a multi-period framework is whether the government can continuously finance a permanent budget deficit by selling bonds to the public. This question has been analyzed by McCallum (1984) in the context of an optimizing money-and-growth model, extended to include government bonds. McCallum showed that the answer depends on the definition of the deficit. If the latter is defined inclusive of interest payments, then it turns out that a permanent deficit can be financed with bonds. However, this is not the case if the deficit is defined exclusive of interest payments. Moreover, an implication of McCallum's analysis of the former case is that the stock of willingly held government bonds can increase permanently at a higher rate than output growth, provided that the difference is smaller than the rate of time preference. He suggests, though, that government default incentives would grow together with the size of its debt, so that his results do not necessarily imply that unbounded debt growth is likely to be observed in reality. For some empirical evidence on this issue, see the last part of Section V.

## IV. Deviations from Ricardian Equivalence

It is likely that, in practice, changes in the stock of government debt and in the timing of taxes will have an impact on private sector behavior as well as the economy's equilibrium allocations. What are the main economic explanations for possible deviations from Ricardian Equivalence? One possibility is that these changes are accompanied by shifts in government spending and/or in the extent of monetization of government debt. As mentioned earlier, we assume away this possibility in the meantime, and will return to it in the next section. Another possibility is that some of the other basic assumptions required for Ricardian Equivalence are not actually met. Four main deviations from these basic assumptions have been emphasized in previous work: the existence of borrowing constraints, of distortionary taxes, of uncertainty about future taxes, and of different planning horizons for private and public sectors. In this section we discuss each of these cases. 1/

### 1. Borrowing constraints

To illustrate how borrowing constraints affect the Ricardian-Equivalence result, 2/ we consider here, for simplicity, an open economy in which it is assumed that the private sector faces higher borrowing rates than those faced by the government. The higher private borrowing

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1/ See also Barro (1978a) and Carmichael (1982) for an analysis of these and other deviations.

2/ For recent work linking consumption to fiscal policy and liquidity constraints, see Hubbard and Judd (1986). They assume that low-productivity individuals cannot borrow against their future income (see Section V), and thus have a marginal propensity to consume equal to one with respect to a current period cut in taxes. In this subsection, we use a different type of constraint.

rate could reflect risk of default, costs of verifying solvency, or administrative and transaction costs of operating the loan that are higher, from the foreign lender's perspective, for the private sector than for the public sector. 1/ One interpretation of these conditions is that government has an advantage over the private sector in carrying out credit market operations, a situation that seems especially relevant for LDCs. 2/

Specifically, assume that the private sector faces an effective interest rate of $(1 + r^*)(1 + \lambda)$, where $\lambda$ is a borrowing premium that reflects the above considerations, and $r^*$ is the international interest rate (which applies to government borrowing from abroad). Under these assumptions, government's and consumers' intertemporal budget constraints are respectively given by:

$$g_o + g_1(1+r^*_o)^{-1} + (1+r^*_{-1})b'_{-1} = \tau_o + \tau_1(1+r^*_o)^{-1} , \tag{13}$$

$$c_o + c_1[1 + r^*_o(1+\lambda_o)]^{-1} = y_o - \tau_o + (y_1-\tau_1)[1 + r^*_o(1+\lambda_o)]^{-1}$$

$$- [1 + r_{-1}(1+\lambda_{-1})]b_{-1} . \tag{14}$$

Incorporating the government's constraint into that of the private sector's yields:

$$c_o + c_1[1 + r^*_o(1+\lambda_o)]^{-1} = y_o + y_1[1 + r^*_o(1+\lambda_o)]^{-1} - g_o - g_1(1+r^*_o)^{-1}$$

$$- (1+r^*_{-1})^{b'}_{-1} - [1 + r^*_{-1}(1+\lambda_{-1})]b_{-1} + \lambda_o r^*_o \tau_1 A , \tag{15}$$

where:

$$A \equiv (1+r^*_o)^{-1}[1 + r^*_o(1+\lambda_o)]^{-1} .$$

It can be seen that only when there are no borrowing constraints on the private sector (i.e., $\lambda_{-1} = \lambda_o = 0$), equation (15) reduces to equation (12), which gives the intertemporal constraint that applies to an open economy that satisfies Ricardian Equivalence. A cut in present taxes that signals an increase in future taxes increases private sector wealth as long as $\lambda_o > 0$. The reason for this is that when the govern-

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1/ Notice, however, that a similar type of results would arise if private transactions in foreign exchange are subject to taxation such that the effective cost of foreign borrowing is higher for the private sector compared with the government. A specific example of this sort of taxes is discussed in the next subsection.

2/ In fact, most of the foreign borrowing by LDCs is done by the public sector or through its guarantees.

ment cuts present taxes, it finances its deficit by foreign borrowing which carries an interest rate of $r_o^*$. 1/ Effectively, then, it is as if the private sector has borrowed from abroad at a lower interest rate than the one it faces otherwise. Thus, in contrast with the equivalence proposition, this change in the timing of taxes will affect private sector behavior. Moreover, changes in the ratio of government to private foreign borrowing have, in this case, nonneutral effects on the economy's equilibrium.

An important assumption implicitly made in the analysis is that when collecting taxes in the future period in order to repay debt, the government has lower transaction (and other) costs compared with those of foreign lenders (see Barro (1978a)). In fact, the relatively high borrowing costs for consumers may, for example, reflect substantial monitoring required to assure repayment. Then, it is only if the government is more efficient than foreign agents at performing this monitoring that the above arguments would hold. Alternatively, if government monitoring costs were the same as the private sector's and if it charged consumers a premium to cover these costs, then Ricardian Equivalence would arise again. It is only to the extent that transaction costs for collecting repayment of private loans are higher than for collecting taxes that the results given in the previous paragraph hold. 2/

While the analysis so far indicates that borrowing constraints may be important in explaining deviations from Ricardian Equivalence, the constraints do not necessarily lead to such deviations. In particular, Hayashi (1985) provides examples from the literature on imperfect capital markets in which Ricardian Equivalence holds despite the existence of borrowing constraints. His examples suggest that unless the exact nature of imperfections in loan markets is identified and the types of arrangements that are available for agents to pool risk are specified, the implications of borrowing constraints for the effects of government budget policies cannot be determined.

## 2. Distortionary taxes

Another key assumption underlying the derivation of Ricardian Equivalence is that taxes are lump-sum and nondistortionary. In practice, however, most existing taxes are likely to be distortionary. These taxes may apply to personal income, consumption, corporate income,

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1/ An implicit assumption here is that the interest rate $r_o^*$ charged by foreigners does not depend on the application of the funds by the borrowing government. In fact, some of the effects discussed here could be offset if private sector projects have a higher rate of return than those of the public sector. This could reduce the risk of lending to the private sector which could reduce or eliminate the spread.

2/ For a somewhat related analysis of the effects of open market operations that stresses the role of differences in the technology of public versus private sector intermediation, see Wallace (1983).

foreign borrowing, etc. Changes in the timing of these distortionary taxes can affect private sector and economy-wide allocations through their induced wealth, redistribution, and intertemporal substitution effects, and thus lead to deviations from Ricardian Equivalence. 1/

Consider, for example, an open economy where its government imposes a tax on interest payments against foreign borrowing by the private sector. For simplicity, lump-sum and other taxes are assumed to be non-existent. The intertemporal government budget constraint is given by:

$$g_o + g_1(1+r^*_o)^{-1} + (1+r^*_{-1})b'_{-1} = r^*_{-1}\theta_{-1}b_{-1} + r^*_o\theta_o b_o(1+r^*_o)^{-1} \qquad (16)$$

where $\theta$'s denote the tax rates that apply to private sector interest payments on foreign borrowing. The right-hand side of this equation gives the present value of tax collections by the government, and the left-hand side gives the present value of government spending and initial debt liabilities. The private sector constraint is:

$$c_o + c_1[1 + r^*_o(1+\theta_o)]^{-1} = y_o + y_1[1 + r^*_o(1+\theta_o)]^{-1} - [1 + r^*_{-1}(1+\theta_{-1})]b_{-1} \; . \qquad (17)$$

Consolidating these constraints yields:

$$c_o + c_1[1 + r^*_o(1+\theta_o)]^{-1} = y_o + y_1[(1+r^*_o)]^{-1} - g_o - g_1(1+r^*_o)^{-1} - (1+r^*_{-1})(b_{-1} + b'_{-1}) + r^*_o\theta_o b_o(1+r^*_o)^{-1} \; . \qquad (18)$$

When there is no tax on interest payments against foreign borrowing, $\theta_o = 0$, and equation (18) reduces to equation (12), one that embodies Ricardian Equivalence. However, in the presence of taxes, Ricardian Equivalence need not prevail. In particular, consider a tax cut, implemented through a reduction $\theta_{-1}$, that is accompanied by a pertinent change in $\theta_o$, such that the intertemporal government budget constraint is satisfied. The change in $\theta_o$ will generally have both substitution and wealth effects. For example, an increase in $\theta_o$, which is the tax rate on interest payments to be paid in the future period, alters the relative price of present versus future consumption in a way that will lead consumers to substitute away from future toward current consumption. This increase also has wealth effects. While the analysis has focused on a specific tax, similar considerations apply to other distortionary taxes. Changes in labor income taxes and corporate income taxes, for example, will typically affect labor supply, production, and consumption incentives through substitution, wealth, and distribution

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1/ Lucas (1986) argues for considering distortionary taxes as the main way to generate deviations from equivalence. On the macroeconomic effects of distortionary taxes in an intertemporal framework, see Aschauer and Greenwood (1985). The effects of budget deficits under distortionary taxes in open economies are analyzed by Frenkel and Razin (forthcoming), Chapter 8.

effects. Similar considerations apply to the case of money finance, discussed in Section III.1 above, which results in the distortionary inflationary tax. 1/

In addition to the aggregate real effects of distortionary taxes, changes in the level or in the type of taxation are likely to have distribution effects that reflect differential incidence across individuals in the economy. These distribution effects further contribute to possible deviations from neutrality that arise in the presence of distortions. In recent work, Cukierman and Meltzer (1986) emphasize the redistribution effects of changes in public debt, both over time and across generations. They do that in a framework that represents an extension of Barro's (1974) to allow for heterogeneity in agents' abilities, wage earnings, and initial nonhuman wealth. Cukierman and Meltzer show that some agents may be bequest-constrained in that, while their optimal behavior would be to leave negative bequests to their successors, 2/ they cannot reach such position in practice because, under the prevailing institutions, they cannot directly obligate the future labor income of their descendants. Such individuals are likely to favor any tax cuts that increase their lifetime income at the expense of their descendants', and any such tax cuts thus have nonneutral effects on the aggregate demand for consumption. The authors also characterize the conditions under which the political process will result in a fiscal policy scenario that features lower current taxes, high debt, and higher social security deficits.

3. Uncertainty about future taxes

In deriving the Ricardian-Equivalence proposition, it is assumed that a current cut in taxes signals a future increase in government tax collections. The nature, amount, and timing of these future increases in taxes are assumed to be known with certainty by consumers. Obviously, this is a strong assumption. In practice, while the current period's tax cuts may indeed be associated with future increases in taxes, the exact timing, the type of tax to be increased (e.g., property, wage, inflation, and other taxes), and its incidence across individuals are all uncertain. This uncertainty may lead to deviations from equivalence.

One source of uncertainty is the incidence of future taxes. Consider, for example, a two-period consumer whose disposable income in the future (period 1) is given by $(1 - \alpha_1)y_1$, where $y_1$ is the non-assets' gross income and $\alpha_1$ is the tax rate that applies to such income.

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1/ A similar argument could be made for the case of default by the government on its liabilities, which could be considered a type of distortionary tax. This point is discussed in more detail in Section IV.3.

2/ As recognized by Barro (1974), his analysis of Ricardian neutrality holds as long as individuals' desired bequests to their descendants are nonnegative.

Assume, for simplicity, that future gross income is known in advance, but the tax rate, $\alpha_1$, is uncertain. Clearly, a cut in taxes in the present period may signal an increase in future taxes and, thus, an increase in the expected value of $\alpha_1$. To the extent that this change enhances the uncertainty about incidence of future taxes, agents would perceive an increase in the uncertainty attached to future disposable income, which in the present case is equal to $y_1^2$ Var $\alpha_1$. 1/ For risk-averse consumers, increased uncertainty about future net income will typically lead to higher saving (and lower current consumption) aimed at smoothing out the path of consumption over time. Thus, this provides an example of how a tax cut may lead to a decrease in current consumption, in contrast with the equivalence proposition.

While in this example future gross income was assumed to be known, uncertainty about this variable is, in practice, another source of uncertainty about future taxes. To highlight this case, consider a situation where there is full certainty about the future tax rate, $\alpha_1$, and its incidence, yet future gross (and hence net) income is uncertain. 2/ Then, the variance of future disposable income equals $(1-\alpha_1)^2$ Var $y_1$. A tax cut in the current period that signals an increase in the tax rate $\alpha_1$ in the next period reduces the uncertainty attached to future disposable income. Hence, this effect works in an opposite direction for the current level of private sector consumption than the one considered in the previous paragraph. What happens here is that the income tax is acting as an insurance mechanism. To see this, we can express tax payments as $\alpha_1 y_1 = \alpha_1 \bar{y}_1 + \alpha_1(y_1 - \bar{y}_1)$, where $\bar{y}_1$ is average future income in the economy. For an individual whose future income happens to be higher than the average, he pays an insurance payment. However, those with income lower than average receive an insurance payment. Thus, an increase in $\alpha_1$ increases income-risk sharing and this reduces individual uncertainty about after-tax income, which in turn may lead to an increase in consumption. Obviously, this effect would arise only to the extent that government taxation provides insurance that is not available in the private market; or, if it is available, then, for this effect to arise, it must be assumed that government has comparative advantage in insurance provision.

The analysis has illustrated how uncertainty about future taxes may give rise to deviations from Ricardian Equivalence. Clearly, more complexity (and realism) can be added by jointly considering uncertainty about different types of taxes (e.g., income versus excise taxes) and

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1/ Var $\alpha_1$ is the ex ante variance of $\alpha_1$ across individuals.

2/ See Chan (1983) and Barsky, Mankiw, and Zeldes (1986). The discussion here draws on Dotsey (1985).

about the future level of taxes per se. While one could pursue this avenue in detail, the overall results in terms of Ricardian Equivalence are likely to resemble those of the present analysis. Another useful extension would be to explicitly incorporate in the analysis the probability of the government defaulting or running into arrears on its liabilities to the private sector. Although expected defaults will probably lead to the emergence of a risk premium in interest rates, to the extent that compensation is not full, one can treat default as a form of taxation. If there is uncertainty about future defaults, this probably has similar effects as those considered in this subsection.

4. Different planning horizons for private and public sectors

A necessary condition for Ricardian Equivalence to obtain is that households and government have the same planning horizons and use the same discount factor in their present value calculations. Here we analyze a departure from this condition that arises due to individuals' uncertainty about their lifetime. The main result from analyzing this departure is that, in the presence of such uncertainty, and assuming no bequest motive, a tax cut will lead to a rise in perceived wealth and consumption of currently alive individuals. That is, the tax cut enables a shifting of future tax liabilities to later generations, whose welfare is assumed not to affect that of the current generation. 1/

Consider the two-period open economy analyzed in Section III above. Assume now that due to mortality consumers are uncertain about their lives in the future period, and denote by p the probability of death before the start of the next period. Drawing on Blanchard's (1985) model, we incorporate this uncertainty into the analysis as follows. 2/ It is assumed that loans require the purchase of life insurance. Such life insurance assures that outstanding debt commitments are met regardless of whether the debtor is alive or not. Assuming a large number of identical agents, free entry, and a zero profit condition in the insurance business, the effective interest rate faced by consumers becomes now $R_o = [(1+r^*_o)/(1-p)] - 1$, where $r^*_o$ is the riskless world real interest rate. This is the effective cost of borrowing for consumers. It differs from government's cost of borrowing, $r^*_o$, as long as there is a nonzero probability of death. When the intertemporal government budget constraint is fully taken into account by consumers, their budget constraint is:

$$c_o+c_1(1+R_o)^{-1} = y_o+y_1(1+R_o)^{-1} -g_o-g_1(1+r^*_o)^{-1} - (1+R_{-1})b_{-1} - (1+r^*_{-1})b'_{-1} + p\tau_1 [(1-p)(1+R_o)]^{-1}. \quad (19)$$

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1/ See Barro (1978a) and Chan (1983).

2/ For an open economy formulation, see Frenkel and Razin (forthcoming).

It can be seen that when $p = 0$, equation (19) becomes identical to equation (12), which is the relevant budget constraint under Ricardian Equivalence. However, when $p > 0$ a current period tax cut that is accompanied by an increase in future taxes through an increase in $\tau_1$ raises the consumers' perceived wealth and consumption. Due to mortality, the current tax cut signals a less than one-to-one increase in the present value of future taxes to be paid by currently living consumers. Put differently, the tax cut effectively shifts part of the burden of taxation from current to future generations. 1/

A crucial assumption in deriving these non-Ricardian results is that the added tax liabilities on descendants are not fully counted in the wealth calculations by current taxpayers. Otherwise, and to the extent that voluntary intergenerational transfers are operative within the private sector, the shift from tax to debt finance would not represent a new opportunity for the current generation to extract funds from future generations (see Barro (1974)). 2/ In such a case, current consumers will react to a cut in their present taxes by increasing their voluntary transfers to the next generation so as to restore the balance of wealth across generations to its previously optimal level, and, consequently, current consumption would remain unchanged, as in the equivalence case. These considerations highlight the importance of determining the impact of government debt and taxation policies on intergenerational transfers.

## V. Empirical Evidence

This section presents a survey of empirical evidence on the impact of government budget variables on private consumption and on the Ricardian-Equivalence hypothesis. While the survey is selective, it covers the main methods that have been used in empirically testing this hypothesis.

A traditional approach in testing the Ricardian proposition with time-series data has been to regress private consumption on government budget as well as other relevant variables. A prototype of such regression is given by the following equation:

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1/ What happens if, in contrast to the assumptions here, the government's planning horizon is shorter than that of individuals? Obviously, this would affect the policy actions taken by a specific administration. However, in making its consumption decisions the private sector will probably take into account how future administrations will deal with the commitments left by the present one. Thus, there is still an intertemporal government budget constraint even though administrations do change.

2/ Cukierman (1986) analyzes nonneutralities that arise when, due to uncertainty about the length of lifetime, individuals attach a positive probability to their being bequest-constrained at some future date.

$$c_t = a_o + a_1 y_t + a_2 y_{t-1} + a_3 g_t + a_4 w_t + a_5 \tau_t + a_6 b'_t + a_6 b'_t + a_7 tr_t + a_8 z_t + \mu_t \,, \qquad (20)$$

where c is a measure of private consumption expenditures, y is personal or national income, g is government spending on goods and services, $\tau$ is tax revenue, w is household's net worth, b' is net government debt, tr is government transfers, z measures other variables which are not related to the government budget, and $\mu$ is a stochastic error term. All variables are generally expressed in real per capita units, and t is a time index. The variables $y_t$ and $y_{t-1}$ are included as proxies of permanent income which, together with beginning of period's net worth ($w_t$), are assumed to affect consumption. In some formulations, personal income and government spending are decomposed into permanent and transitory components. The coefficient on government spending is interpreted as reflecting two effects: the impact of this variable on private sector consumption through its direct impact on wealth (as, e.g., in equation (7) above), and its impact through the substitutability of private sector consumption and government spending, which in turn depends on how government spending affects private sector utility. 1/

To test for Ricardian Equivalence, most studies along this approach test the restriction $a_5 = a_6 = a_7 = 0$. If this restriction is met by the data, the equivalence proposition is not rejected; otherwise, it is rejected. The empirical evidence on this issue is inconclusive. On the one hand, studies by Barro (1978b), Kochin (1974), Kormendi (1983), Seater and Mariano (1985), and Tanner (1979) report evidence that supports the null hypothesis. However, conflicting evidence has been reported by Blinder and Deaton (1985), Feldstein (1982), Modigliani (1984), Modigliani and Sterling (1985), and Reid (1985). To a large extent, these discrepancies reflect differences in sample periods, econometric techniques, and methods of empirically measuring the different variables. 2/ For example, Modigliani and Sterling (1985) dispute Kormendi's (1983) results on these grounds. They claim that by changing the methods of deflating government private sector expenditures, of measuring real government interest payments, and of estimation (including more lags than Kormendi and focusing on a formulation in levels and not in rates of change), Kormendi's basic results on equivalence are reversed. Along similar lines, Reid (1985) shows that the results are sensitive to averaging of variables over business cycles, and to whether the economy is undergoing a period of business contraction or expansion. And Hernandez-Cata (1982) shows that some of the coefficients estimated by Feldstein (1982) are sensitive to correction for multi-collinearity.

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1/ Some studies have also explicitly considered the effects of social security on consumption.

2/ That this is the case is also stressed in Hernandez-Cata's (1982) previous review of empirical evidence.

Even if problems of measurement and estimation were nonexistent, one can object to using estimates of equation (20) to test for Ricardian Equivalence. To elaborate on this point, it is useful to compare the equation actually estimated (equation (20)) with the general specification suggested by a multi-period version of the intertemporal model developed in the previous sections:

$$c_t = f(y_t, y_{t+1}, g_t, g_{t+1}, w_t, r_t, r_{t+1}, \tau_t, \tau_{t+1}, tr_t, tr_{t+i}, k_t, k_{t+i}, \ldots), \qquad (21)$$

for i = 1, 2, ..., T. The variable k measures here money creation to finance the government deficit. Consumption in each period is related to current and (expected) future values of its fundamental determinants: income, government spending, interest rates, etc. Within this formulation, Ricardian Equivalence amounts to zero restrictions on the block of variables measuring current and future taxes, transfers, and debt; yet the exact specification to be tested depends on the specific postulated mechanism that is supposed to give rise to nonequivalence. Typically, none of the future variables suggested by the theoretical models are explicitly included in the estimated equation (20), 1/ a surprising feature given that Ricardian Equivalence embodies a strong intertemporal element. Consequently, the fact that a researcher finds, for example, that $a_5$, $a_6$, and $a_7$ are significantly different from zero may just be an indication that current taxes, transfers, and government debt are 'good' predictors of future government spending, quite in line with equivalence. Unless an equation like (20) is jointly and explicitly considered with the signalling role of the explanatory variables for their own future values, this equation is not likely to be informative in a decisive way on the empirical validity of Ricardian Equivalence. Moreover, equation (20) abstracts from interest rates, government money creation, and government's foreign debt, variables that are likely to affect consumption; these omissions may create additional bias in the parameter estimates. Another difficulty with the traditional approach is that it typically does not make explicit the optimality problem that gives rise to the estimated consumption function, thus generating ambiguity in the interpretation of a given set of results.

A more recent approach in empirical tests of equivalence is based on directly deriving the estimated relations from an explicit intertemporal optimization framework. To illustrate how such a test can be constructed, consider the model analyzed by Leiderman and Razin (1987). Their modelling of deviations from Ricardian neutrality draws heavily on the work of Blanchard (1985). Specifically, assume that there are overlapping generations of rational agents that have finite horizons. There is a probability $\gamma < 1$ that an individual will survive to the next period. The consumer is assumed to face a given safe interest factor R (= 1 + interest rate) that is determined in world

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1/ Studies that distinguish between permanent and transitory components of the explanatory variables are a partial exception.

capital markets; however, due to lifetime uncertainty, the effective (risk-adjusted) interest factor is $R/\gamma$. Disposable income is assumed to be stochastic and is denoted by yd. Consumer's utility in period t+j is valued at time t according to $\delta^j U(c_{t+j})$, where $\delta$ is the subjective discount factor, c is consumption, and U is the utility function. The probability of survival from t to t+j is $\gamma^j$ and, therefore, expected lifetime utility as of period t is given by:

$$E_t \sum_{j=0}^{\infty} (\gamma\delta)^j U(c_{t+j}) \tag{22}$$

where $E_t$ is the conditional expectations operator.

Assuming that individuals maximize equation (22) subject to the budget constraint:

$$c_t = b_t + yd_t - (R/\gamma)b_{t-1} , \tag{23}$$

where b denotes consumer's debt, and to the solvency condition $\lim_{t\to\infty} (\gamma/R)^t b_t = 0$ and postulating a quadratic utility function of the form $U(c_t) = \alpha c_t - 0.5c_t^2$ , where $\alpha > 0$ and $c_t < \alpha$ , Leiderman and Razin (1987) show that the optimal consumption function has the form:

$$c_t = \beta_0 + \beta_1 E_t w_t \tag{24}$$

where:

$$\beta_0 = \gamma\alpha(1 - \delta R)[\delta R(R-\gamma)]^{-1} \quad \text{and} \quad \beta_1 = (1 - \frac{\gamma}{\delta R^2}) .$$

$E_t w_t$ is expected wealth defined as:

$$E_t w_t = E_t \sum_{j=0}^{\infty} (\gamma/R)^j yd_{t+j} - (R/\gamma)b_{t-1} . \tag{25}$$

Aggregating over all cohorts, dividing by the size of population, and using algebraic manipulations, Leiderman and Razin (1987) derive the following equation for aggregate consumption per capita ($C_t$):

$$C_t = -\beta_0(R - 1) + (1 - \gamma)\beta_1 E_{t-1} \sum_{j=0}^{\infty} (\gamma/R)^{t+j}(Y_{t+j} - T_{t+j}) + \psi C_{t-1} + \varepsilon_t \tag{26}$$

where Y and T are aggregate per capita gross income and taxes, respectively, and $\psi = \gamma/\delta R$ .

Equation (26) can be used to test the Ricardian-Equivalence proposition in the present model. The key parameter in this context is $\gamma$. When $\gamma = 1$, consumers' behavior satisfies Ricardian neutrality, and equation (26) indicates that only lagged consumption $C_{t-1}$ can be used to predict current consumption (over and above the constant term)--as in Hall (1978). However, when $\gamma < 1$, expected wealth affects consumption over and above the effect of lagged consumption. In such case, a cut in current period taxes raises expected wealth and, thus, results in an increase in current consumption. The reason for this effect is that under these circumstances the future tax increases that are needed in order to intertemporally balance the government budget are given a smaller weight by finite-horizon consumers than the weight they give the current cut in taxes.

In order to implement equation (26) with time-series data, it is required to specify, under rational expectations, the stochastic processes that govern the evolution of gross income and taxes. A simplifying assumption in this context is that these processes are first-order autoregressive:

$$Y_t - Y_{t-1} = \rho_Y(Y_{t-1} - Y_{t-2}) + \eta_{Yt} \qquad (27)$$

$$T_t - T_{t-1} = \rho_T(T_{t-1} - T_{t-2}) + \eta_{Tt} \qquad (28)$$

where the $\rho$'s are time independent and the $\eta$'s are serially uncorrelated zero-mean stochastic terms that are orthogonal to variables dated t-1 and previously. Using equations (27) and (28) to calculate expectations of future incomes and taxes, the following expression is obtained for consumption at time t:

$$C_t = d_0 + d_1 Y_{t-1} + d_2 Y_{t-2} + d_3 T_{t-1} + d_4 T_{t-2} + d_5 C_{t-1} + \mu_t \ , \qquad (29)$$

where the d-coefficients satisfy a set of nonlinear restrictions that arise by virtue of the assumption of rational expectations and that are specified in Appendix I.

Equations (27)-(29) form a system that can be jointly estimated by maximum likelihood subject to these cross-equation nonlinear restrictions. Leiderman and Razin (1987) implemented a version of this system using monthly time series for Israel covering the high-budget-deficits period of 1980-85. They actually estimated an extended version of the model above, one that allows for liquidity constraints as an additional source of nonneutrality and for some degree of durability of consumer

goods. 1/ Their findings provide support to the hypothesis of Ricardian neutrality, in that neither the $\gamma = 1$ hypothesis, 2/ nor the hypothesis of absence of liquidity constraints are rejected at standard significance levels. The estimated $\delta$ is very close to unity, and $\alpha$ turns out to satisfy the theoretical restrictions of being positive and greater than $c_t$ for all values of the latter in the sample.

While these results are supportive of the neutrality hypothesis, it would be desirable to investigate their robustness in more complex frameworks that allow for (i) other channels of nonneutralities, such as the existence of distortionary taxes or income redistribution effects of government policies; (ii) more general specifications of preferences and stochastic processes; and (iii) monetary and exchange rate effects on consumption. In any case, this discussion suggests that empirically testing Ricardian Equivalence using an intertemporal stochastic framework is not only a feasible task but also the most appropriate approach to test the theory underlying this hypothesis.

Aschauer's (1985) work is another application of this approach. Assuming that households maximize the present value of utility from consumption in current and future periods, and that the utility function is quadratic, he focuses on the Euler equation (or first-order condition):

$$E_{t-1}c_t^* = \alpha_0 + \alpha_1 \beta c_{t-1}^* \ . \tag{30}$$

The variable $c_t^*$ measures effective private consumption which is assumed to be given by $c_t^* = c_t + \bar{\delta} g_t$, where c measures actual private sector spending on consumption, and g measures government expenditures. $E_{t-1}$ is the expectation of a given variable conditional on information up to time, t-1. Thus, this specification allows for government spending effects on private sector utility: each unit of g is assumed to yield the same utility as $\bar{\delta}$ units of private spending. The parameters $\alpha_0$ and $\alpha_1$ are explicitly derived in the analysis. They are nonlinear functions of the real interest rate, the rate of time preference, and the bliss level of effective consumption. Equation (30) can be rewritten as:

$$c_t = \alpha_0 + \alpha_1 c_{t-1} + \alpha_1 \bar{\delta} g_{t-1} - \bar{\delta} E_{t-1} g_t + \nu_t \ . \tag{31}$$

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1/ Another extension they consider is to allow for substitutability between public and private consumption in private sector's utility. For other tests of Ricardian neutrality that used Blanchard's (1985) model in their specifications, see van Wijnbergen (1985) and Haque (1986).

2/ Hubbard and Judd (1986) and Poterba and Summers (1986) argue that since measured survival probabilities are very close to unity, the Blanchard (1985) channel for generating nonneutrality is not likely to be significantly important in reality.

To estimate this equation assuming rational expectations, a time-series process must be assumed for $g_t$ so as to generate the expected values $E_{t-1}g_t$. Considering such a process jointly with the consumption equation yields the system actually estimated by Aschauer:

$$c_t = d_o + d_1 c_{t-1} + d_2(L)g_{t-1} + d_3(L)D_{t-1} + \mu_{1t} , \quad (32)$$

$$g_t = e_o + e_1(L)g_{t-1} + e_2(L)D_{t-1} + \mu_{2t} , \quad (33)$$

where d(L) and e(L) denote polynomials in the lag operator. According to equation (33), lagged values of government spending and deficits (D) are used to forecast current values of government spending. The null hypothesis is a set of cross-equation nonlinear restrictions on the parameters. Aschauer's findings, based on quarterly U.S. data for 1948:I to 1981:IV, yield an estimated value of $\bar{\delta} = 0.23$. That is, a one dollar increase in government spending leads to a 0.23 cents offset through a decrease in private sector consumption spending. 1/ Moreover, the data do not reject the cross-equation restrictions, indicating that the impact of government deficits and spending on private sector consumption can be attributed to the channel specified here, i.e., through substitutability of public spending for private consumption in consumers' utility. Although these findings support the notion of Ricardian Equivalence, it is not clear how statistically powerful they are because the alternative, non-Ricardian, hypothesis is not tightly specified in the model.

The notion that liquidity constraints are important in generating deviations from equivalence has been stressed by Hubbard and Judd (1986). They performed simulations attempting to determine the magnitude of the aggregate marginal propensity to consume out of a temporary tax cut. To do so, they extend Blanchard's (1985) model by specifying the existence of two types of individuals: those with low productivity and wage who have no access to borrowing against their future wages, and high productivity and wage individuals who can borrow. In a Ricardian set-up and with perfect capital markets, the marginal propensity to consume out of a temporary tax cut is equal to zero. When capital markets are perfect but there is a positive probability of death, Hubbard and Judd (1986) obtain Blanchard's (1985) consumption function, for which they show the simulated marginal propensity to consume is positive but of a negligible order of magnitude. However, when that model is extended so that 20 percent of the labor force is assumed to be liquidity constrained, there is a more than quadrupling in the value of the marginal propensity to consume. This result is due to the fact that consumption equals the wage for low productivity workers, so that for them a tax cut is met with a marginal propensity to consume equal to unity. In these calculations liquidity constraints take the form of full credit rationing. In practice, there could be other forms of capturing the relevant constraints as, e.g., through differential

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1/ See Kormendi (1983) for a similar estimate.

interest rates. Existing tests for liquidity constraints have been recently surveyed by Hayashi (1985). According to him, the time-series evidence is not conclusive and key parameters have not been precisely estimated. One possible reason for this is that time-series studies have looked at economy-wide aggregate data, and probably useful information on liquidity constraints of different sectors is lost in the process of aggregation. The most useful evidence on liquidity constraints is likely to emerge from micro data. While the pertinent micro evidence surveyed by Hayashi (1985) suggests a nonnegligible role for liquidity constraints, the fact that the behavioral parameters are contaminated with measurement errors in the variables and with tastes' shocks creates econometric problems of identification that have not been fully overcome yet.

A simulation-based assessment of another source of nonequivalence is presented by Barsky, Mankiw, and Zeldes (1986). They consider deviations from Ricardian Equivalence that arise due to uncertainty about future taxes; see Section IV.3 above. In particular, they focus on conditions under which a tax cut and debt issue increase risk-sharing and thus lead to a reduction in individual uncertainty about after-tax income. Thus, there is a positive marginal propensity to consume out of a tax cut, because the latter reduces precautionary saving. Obviously, a key assumption in the analysis is that by increasing future taxes (matching the current tax cut) government provides insurance to individuals that is not available in the private market. Under plausible assumptions regarding preferences and the extent of income uncertainty, the authors' simulations deliver nonnegligible marginal propensities to consume out of a tax cut like, e.g., 0.3 or 0.5. Thus, they claim that even though consumers are Ricardian in that they fully discount future tax liabilities, their consumption does react to the current tax cut due to its effect on uncertainty. Again, a key assumption used in generating this effect is that there are no markets through which agents can insure against future income risk.

Other empirical studies have directly focused on the intergenerational implications of Ricardian Equivalence; for recent surveys of the methods and findings, see Kotlikoff (1984) and Boskin and Kotlikoff (1985). Models in which equivalence holds are generally models of intergenerational altruism: consumption of particular extended family members depends on the resources of other extended family members. Controlling for demographic changes, this implies that consumption should be invariant to changes in the age distribution of resources. Boskin and Kotlikoff (1985) take the latter to be the null hypothesis (i.e., the altruism hypothesis) for their econometric work on postwar U.S. data. Their results indicate rejection of the altruism model, in that the age distribution of personal income (and some of its components) has significant explanatory power for aggregate consumption beyond that of other more standard determinants of consumption. While these are unambiguous results, the authors suggest that more work is required in checking for model misspecifications before one can reach final judgment on the validity of the altruism model. Other work,

mostly with cross-section data, that has concentrated on the effects of social security and of intergenerational transfers has generally produced results that contradict the altruism or equivalence hypothesis; for details, see Kotlikoff (1984).

Finally, there is the issue of whether a government can run a permanent bond-financed deficit, and thus have government-debt growth indefinitely (see McCallum (1984)). Hamilton and Flavin (1986) look at this issue with an empirical perspective. They show that the hypothesis that government can accumulate a continuously growing stock of debt, as a result of budget deficits, is mathematically equivalent to the hypothesis that prices can rise continuously in a self-fulfilling speculative bubble. They suggested using empirical tests that were developed for the latter hypothesis to provide evidence on the government borrowing hypothesis. After conducting several econometric tests based on postwar time-series for the United States, they concluded that the evidence supports the idea that government is not perceived by private markets to implement a policy of continuous borrowing over time.

## VI. The Signalling Role of the Fiscal Regime

The fiscal regime prevailing in the economy constitutes an additional important factor in determining whether the response of private consumption to changes in the tax to debt ratio will be as predicted by Ricardian Equivalence. While this issue has not received, in our opinion, the attention it merits in previous work, we discuss below how assessments of the effects of government budget policies on the economy's equilibrium depend on what is being assumed about such a regime. 1/

When other basic assumptions are met, the specific fiscal regime under which the Ricardian Equivalence arises is one in which government debt is fully backed by taxation. Following Sargent (1982a), we refer to this as the polar Ricardian fiscal regime. In this case, an increase in government bonds in the hands of the public signals increased future explicit tax collections with a present value that exactly matches the value of existing government's bond obligations. The regime represents a case of fiscal accommodation, in that an open market sale by the central bank leads to an increase in future taxes so as to finance the new debt.

A second polar policy scenario can be referred to as the polar non-Ricardian fiscal regime, in which bonds are backed by implicit taxation in the form of money creation. 2/ An increase in the stock of government bonds signals, in this case, a change in future base money growth so that government debt is eventually monetized and, therefore, is likely to affect private consumption. Here, monetary policy is fully

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1/ See Feldstein (1982) and Sargent (1982a).

2/ This is the scenario assumed in Sargent and Wallace's (1981) framework.

accommodating fiscal deficits, in that the central bank issues money so as to finance these deficits. 1/

The cases just discussed are extreme examples of fiscal regimes. In reality, observed regimes generally lie between these extremes, according to the extent of fiscal and monetary accommodation used by the authorities. Furthermore, while the discussion above implicitly assumed that the time path of government spending is given, in many circumstances changes in taxes and debt may signal future changes in government spending which will induce a completely different set of changes in private sector behavior.

These considerations suggest that a prerequisite for analyzing the effects on the economy of, for example, a tax cut coupled with a bond issue is to specify the fiscal signals conveyed by the policy change. In a polar Ricardian regime, and provided that the assumptions required for equivalence are met, the tax cut will have no effects on private sector wealth, consumption, and interest rates. However, to the extent that the tax cut signals a decrease in future government spending, it will generally lead to an increase in private sector's perceived wealth and will thus have a positive impact effect on the demand for consumption. Similarly, policy changes that signal future changes in monetization and in the distortionary inflation tax will, generally, have nonnegligible effects. In an open economy, analysis of the fiscal regime has to take into account the possibility of resource transfers from abroad. In a regime in which bond financing of deficits is likely to be serviced with future foreign transfers and aid, an increase in government spending is likely to have a larger impact on consumption than in a regime where bond issues signal the need for future tax liabilities. Clearly, therefore, the results of the analysis are sensitive with respect to the characteristics of the fiscal regime in operation. 2/

Fiscal regimes differ in practice across countries and time periods. Furthermore, at each point in time there is, typically, uncertainty about the regime that will prevail from then on. For example, a high and unsustainable government budget deficit financed by debt can be taken to signal future contractions in the deficit. However, whether these contractions will be effected through cuts in spending, increases in explicit tax collections, or enhanced monetization, and when these actions will be taken, is typically unknown. Economic agents have subjective probability distributions for future behavior of government variables and these distributions are adjusted to the fiscal signals provided by the actions of the authorities (see Feldstein (1982)). This uncertainty about the policy regime may affect the behavior of the

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1/ On the validity of some basic monetarist principles under different fiscal regimes, see Aiyagari and Gertler (1985).

2/ As discussed by Sargent (1982a), the degree of substitution between demands for assets (like base money and government bonds) also depends on the prevailing regime.

economy. Specifically, Drazen and Helpman (1986) and Masson (1986) have explicitly shown how the dynamics of inflation during a transition from a period of unsustainable deficits to one of sustainable policies strongly depend on this uncertainty. The latter may give rise to a positive risk premium on bonds' interest rates, reflecting inflation uncertainty, and to changes in private sector saving and consumption. Moreover, as stressed by Drazen and Helpman (1986), policy regime uncertainty may imply that looking at contemporaneous correlations between budget deficits and inflation is not a meaningful way of determining the inflationary impact of a given government budget. 1/

In conclusion, what theory requires for meaningful policy analysis is an intertemporal signalling approach, whereby the implications of a given policy change for the intertemporal relationship between monetary and fiscal policy are explicitly taken into account before assessing the effects of this policy change on the private sector and the economy.

What is the evidence on fiscal regimes? Given the recent key role of budget deficits in industrialized countries, it is appropriate to begin by summarizing the pertinent actual figures for these countries. 2/ These figures provide some information on the regime in operation. The main recent evidence for industrialized countries as a group is as follows: (i) the ratio of central government budget deficit to GDP increased from 1.5 percent of GDP in 1972 to 5.75 percent of GDP in 1983; this is almost a quadrupling of this ratio; and (ii) this increase in the deficit is the result of an increase in total outlays twice as fast as in revenues. Total outlays increased from 26.5 percent of GDP in 1972 to 35.25 percent of GDP in 1983, with interest payments being the most important factor accounting for this increase. On the other hand, total central government revenues of industrial countries rose by more than 4 percentage points from 1972 to 1983, from 25 percent of GDP to 29.25 percent of GDP, primarily through increases in nontax revenue and social security contributions; 3/ and (iii) the increased deficit was mostly financed by domestic borrowing. Domestic financing rose from 4.5 percent of total outlays in 1972 to 5.75 percent in 1983. Financing from the monetary authorities accounted for a small percentage of total outlays, reaching a maximum of 2.5 percent of outlays in 1975 and declining since then. Similarly, foreign financing played a relatively minor role for industrialized countries; it reached an average value of 1.5 percent of total outlays during 1972-83, and exhibited a downward trend throughout this period.

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1/ This discussion also suggests that since the probability of change in regime is not constant, the coefficients in consumption equation regressions, like equation (20), are not likely to be invariant through time.

2/ The figures reported are taken from the IFS Supplement Survey, Introduction, 1986.

3/ On the deficit experience in industrial countries, as well as conceptual and definitional issues when measuring budget deficits, see Tanzi (1985b).

Assuming that a continuation of these debt-financed deficits is not sustainable, these facts ought to signal either future decreases in the size of deficits or increased monetization. Judging from recent history, increases in money seignorage are not likely to be heavily used. 1/ If that is the case, there is still an issue as to the specifics of future cuts in deficits: will these take place primarily through decreased spending or through increased taxation? Obviously, the answer to this question is typically uncertain. Yet, in predicting the future behavior of private consumption, different answers to this question will yield different predictive implications. For the United States, one possibility at this juncture is to use evidence on how large deficits were actually reduced in the past. As is known, the largest budget deficits that occurred in the United States in the past can be attributed to war periods like the Civil War, and World Wars I and II. Tax rates and revenue increased in each war episode, but government spending rose by more, thus creating these large budgetary deficits. After the wars, sooner or later, the deficits reversed into surpluses, with decreases in postwar government spending absorbing most of the action in this direction. 2/ Thus, to some extent, wartime deficits have signalled postwar surpluses with government spending falling more than taxes after the war. While the current scenario is one of nonwar increases in deficits, the resolution of these deficits may well take the form suggested by these wartime episodes. Alternatively, the deficits may primarily signal future increases in taxation, an option that has opposite implications for the behavior of current private consumption than those of the possibility previously discussed. Since government policies generally differ across countries, our discussion suggests that it would be important to use past and current information on a country-specific basis in order to detect the signals that are most likely to be conveyed by the current deficit policies in each case.

Key aspects of observed fiscal regimes have been addressed by several studies using econometric techniques. Most such studies focused on the extent to which current and past deficits have been accompanied by monetary accommodation. In some of the studies, e.g., Blinder (1983) and Joines (1985), specific central bank reaction functions are postulated and estimated, with budget deficits appearing as one of the explanatory variables for money creation. Other authors, as King and Plosser (1985), have investigated this issue in a relatively model-free form by using vector autoregressions. Most of the pertinent evidence has been surveyed by Dwyer (1985), and the main conclusion arising from these

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1/ For evidence on the United Kingdom, see Buiter (1985). Obviously, this scenario differs from that of hyperinflationary episodes. Sargent (1982b) develops the argument that changes in the fiscal signals toward less monetization of public debt were an important factor in determining the success at stopping inflation in the European hyperinflations of the 1920s.

2/ See Peacock and Wiseman (1961), and Tanzi (1985b).

studies, 1/ based on data for the United States and other industrialized countries, is that there is no clear and statistically significant link between budget deficits and government money creation. This conclusion is consistent with the actual figures on monetization discussed earlier for the United States.

Quite surprisingly, there are only few studies that provide evidence on the predictive role of budget deficits and other government variables for future values of government spending and revenue. Some evidence is presented by von Furstenberg, Green, and Jeong (1986), who concentrated on the sequencing of taxes and spending. Using quarterly postwar data for the United States and vector autoregression analysis, the authors concluded that there is no evidence in support of the hypothesis that changes in taxes precede (and/or effectively limit) changes in spending in the same direction. The reverse sequence, spend first and tax later on, received some support from the data. This was particularly so for two categories out of disaggregated spending: cyclically adjusted transfers and defense spending. In their study of postwar annual data for the United States, King and Plosser (1985) found that government purchases and tax rates do not appear to be predictable from the other fiscal and monetary variables considered except for some role of the previous year's real deficit. While these findings are useful, they are only indicative. Further work using data for different countries and time periods is required before one can characterize the signalling role of currently observed variables for future levels of government spending and revenue.

## VII. Concluding Remarks

In this paper, we have surveyed some aspects related to the effects of government budget policies on private sector consumption. We have centered our discussion around the Ricardian-Equivalence theorem of government finance, which states that substitution of debt for taxes has no impact on private sector wealth and consumption. While this is a valid and useful proposition, there are likely to be deviations from it in practice. These deviations need not be attributed to irrationality or lack of full discounting of future tax liabilities by the public. Agents may be fully rational, yet due to the presence of factors such as borrowing constraints or distortionary taxes which represent departures from Ricardian assumptions, their optimal behavior will result in the nonequivalence of taxes and debt insofar as aggregate demand is concerned. Also, to the extent that substitution of debt for taxes conveys signals of future changes in government spending and/or in money creation, private consumption will not remain invariant. Other sources for nonequivalence were discussed in detail in the paper.

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1/ See also the cross-country comparison presented by Demopoulos, Katsimbris, and Miller (1983).

The fact that there exist deviations from Ricardian Equivalence implies that deficit finance policies can have impacts on private consumption and aggregate demand that would be nonexistent otherwise. However, by exploiting these deviations, policymakers may affect the fundamental sources for nonequivalence. 1/ Thus, nonequivalence opens up policy trade-offs whose positive and normative implications remain to be explored.

Finally, it should be stressed that we have considered the implications of only a specific set of fiscal and monetary policies within a given institutional framework. In practice, changes in government budget actions may be accompanied by substantial policy-induced changes like financial liberalization or opening up of the economy which can result in important effects on the private sector's real and portfolio decisions.

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1/ Using as an example the set-up with borrowing constraints (see Section IV.1 above), foreign lenders to the domestic government may change their method of determining interest rates depending upon the use that the domestic government makes of the borrowed funds.

## APPENDIX

### The Nonlinear Restrictions Embodied in Equation (29)

Using equations (27) and (28) in the text to calculate expectations of future incomes and taxes, an expression for consumption at time t was obtained:

$$C_t = d_0 + d_1 Y_{t-1} + d_2 Y_{t-2} + d_3 T_{t-1} + d_4 T_{t-2} + d_5 C_{t-1} + \mu_t \ .$$

The d-coefficients in the above equation satisfy the following restrictions:

$$d_0 = \frac{\gamma\alpha(R-1)(\delta R-1)}{\delta R(R-\gamma)} \ ,$$

$$d_1 = (1-\gamma)(1 - \frac{\gamma}{\delta R^2})[(\frac{R}{R-\gamma})(1+\rho_y) + \frac{\rho^2 Y\gamma}{R} + \frac{\gamma^2\rho_Y^2}{R(1-\rho_Y)(R-\gamma)}$$

$$- \frac{\rho_Y^4\gamma^2}{(1-\rho_Y)R(R-\rho_Y\gamma)} \ ,$$

$$d_2 = (1-\gamma)(1 - \frac{\gamma}{\delta R^2})(\frac{R}{R-\gamma}) - d_1 \ ,$$

$$d_3 = -(1-\gamma)(1 - \frac{\gamma}{\delta R^2})[(\frac{R}{R-\gamma})(1+\rho_T) + \frac{\rho_T^2\gamma}{R} + \frac{\gamma^2\rho_T^2}{R(1-\rho_T)(R-\gamma)}$$

$$- \frac{\rho_T^4\gamma^2}{(1-\rho_T)R(R-\rho_T\gamma)}] \ ,$$

$$d_4 = (1-\gamma)(1 - \frac{\gamma}{\delta R^2})(\frac{R}{R-\gamma}) - d_3 \ ,$$

$$d_5 = \gamma/\delta R \ .$$

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