Government saving and private saving in Brazil*

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This paper discusses the effectiveness of government's attempts to raise national and private savings by increasing the saving of the public sector. Using the Brazilian economy as a case study, the paper shows that the successfulness of such policies depend on the degree of foresight of private agents. Theory suggests that different outcomes are possible. Two types of econometric exercises are performed to offer evidence on the responsiveness of national saving to reductions in the government's current account deficit. The first one uses a standard nested consumption function approach that attempts to discriminate among different theories on the basis of the estimated coefficients. The second test uses cointegration techniques to test for Ricardian Equivalence. The empirical results obtained in both sets of tests reject Ricardian Equivalence, implying that an increase in government savings is a powerful way to increase national savings. Moreover, the results obtained in the consumption function approach indicate that reductions in government spending translate in larger increases in national savings than increases in net tax revenues.

1. Introduction; 2. Theoretical considerations; 3. Econometric modelling; 4. Conclusion.

1. Introduction

Previous analyses of the evolution of savings in Brazil[1] call attention to the important role played by government savings until the mid-seventies and

[1] See, for example, Werneck (1983), Afonso and Dain (1987).

the major deterioration in the government's current account in the eighties. In such works it is usually pointed out that a recovery of government savings is a fundamental requirement if the country is to increase its national savings and investment rates in order to achieve the target rate of growth of about 7% a year. In fact, changes in the level of public saving constitute the most direct tool at the government's disposal for altering the national savings rate. The level of public saving is subject to direct government control through changes in taxation and public sector expenditures and, except for the possibility that increases in public saving induce a countervailing decrease in private saving, growth in government saving will translate into an equal increase in national saving. The possibility of a countervailing movement of private savings, however, is regarded by some economists as the expected outcome and not merely a curious proviso. In fact, such effect, a consequence of the so-called Ricardian Equivalence Hypothesis, constitutes a major result of the New Classical approach to fiscal policy and, therefore, whether changes in public saving have a significant and easily predictable effect on national saving is an empirical question of fundamental importance.

In this essay I intend to undertake an empirical investigation of the possible links between private and government savings, especially their degree of substitution, assessing the appropriateness of the Ricardian Equivalence Hypothesis in the Brazilian economy.

The article is organized as follows. Section 2 summarizes the different theoretical perspectives on the relationships between public and private savings. In section 3 two different approaches are used in order to provide econometric evidence on the importance of the countervailing reduction of private saving in response to an increase in government saving. First, in section 3.1 I estimate a general specification of a consumption function that can give support to any of the theories discussed in section 2. Section 3.2 uses test for cointegration between consumption and disposable income as an alternative way to test for Ricardian equivalence. Finally, section 4 concludes the essay. A description of the data series used, their construction and sources is included in the data appendix at the end of the article.

2. Theoretical considerations

In the standard Keynesian model there is a clear link between national saving and government saving. An increase in personal taxes, given government spending, will increase government saving by the extent of the increase in tax revenues, but will reduce private saving only by the reduction in disposable income times the marginal propensity to save. Since in the Keynesian model individuals have high propensities to consume out of

current income, the marginal propensity to save is, therefore, low and the offsetting effect on national saving is likely to be minor. In the is-lm version of the Keynesian model, the increase in taxes will reduce aggregate demand as well as the demand for money. For a given money supply, the interest rate will have to fall, inducing an increase in investment spending. Therefore, the reduction in disposable income will be smaller than in the simplest version of the model described above, and the decrease in private saving is also smaller.

The most widely accepted theory of aggregate saving behavior, particularly when the issue under scrutiny is the effect of fiscal policy on capital formation, is the life-cycle theory of savings. In essence this theory states that the only constraint on a household's choice for its lifetime consumption path is the fact that the present value of consumption (and bequests) has to be equal to the present value of lifetime income and inheritances. In this framework the consumption undertaken by a household in any given period is a certain proportion of the household's total wealth, where total wealth is defined to include both the present value of future labor earnings and accumulated asset wealth. Given that young people save relatively little as they forecast increases in their future incomes, that middle-aged consumers, at the peak of their life-time earning potential, save a lot, in anticipation of a fall in income after retirement, and that the elderly tend to dissave or to save very little, the model takes the propensity to consume out of wealth to rise with age, and to vary with the rate of interest, although in an unpredictable fashion. This theory is useful in analyzing the consequences of changes in government savings. Most changes in government saving will affect a given cohort in one of two ways, or both. First, they may alter a household's wealth by changing the stream of future earnings, as in the case of a change in taxes. Second, they may affect the rate at which households discount future consumption and income. An increase in the discount rate has two effects: it changes the propensity consume out of wealth, although in an ambiguous direction; and it reduces the present value of future earnings, reducing consumption and increase savings. Of foremost importance, however, in the neoclassical model is the assumption that the economy is composed of overlapping generations, with finite life spans. This implies that individuals and governments generally have different time horizons when assessing their budget constraints. The fundamental prediction that an increase in government dissaving in the form of a debt financed tax reduction affects the lifetime disposable income of the private sector and, therefore, has an impact on consumption and saving decisions. This occurs because the agents that gain from the tax reduction will not be obliged to pay higher future taxes. Therefore, government debt works as a mecha-

nism that shifts the burden of lower current taxes to the future generations that will have to face higher taxes.

This view of the effects of government budget deficits on national savings has been challenged recently by Barro (1974) and by a number of other authors. These authors, in accordance to the fundamental tenets of new classicism, argue that sound economic conclusions can only be derived in well specified models of individual optimization. They, therefore, developed microbased models where optimizing agents make consumption and production decisions on the basis of all available information in a competitive equilibrium setting. Their argument, often referred to as the Ricardian Equivalence Hypothesis (REH), holds that in the long run the present value of the government's tax revenues must equal the present value of its expenditures. A substitution of debt for tax finance today, with expenditures held constant, entails tax increases in the future. A rational consumer should be indifferent between paying $1 taxes today, and paying $1 plus interest in taxes tomorrow. Since the present value of the individual's lifetime budget constraint is invariant with respect to the timing of taxes, his saving decisions remain unaltered. Up to this point the model looks very similar to the neoclassical model described above, but for the possible expansion of the information set used by agents when forming their forecasts about the future, as implied by the assumption of rational expectations. The fundamental difference, however, lies in the suggestion that the utility of any generation is linked to the utility its descendents and that, as a result, bequests are optimally determined.

The utility function of the current generation can be written as $U_c = U_c(C_c, U_d)$ where C_c is the consumption level of the current generation and U_d is utility level of its direct descendents, which, in turn, depends on the descendents' consumption level and its descendents utility. This formulation implies that, although the current generation cares directly only about the utility level of its direct descendents and not of any future generation, they indirectly care about every future generation.

If a generation's welfare is affected by the fact that its heirs will have to pay the taxes that the former are shifting to the future, then the currently living agents will optimally adjust its bequests in order to ensure that the future generation is not affected by fiscal policy. This implies that even agents with finite lives will feel the effects of future taxation, *i.e.*, the chain linked nature of the utility function implies that the planning horizon becomes infinite, so that agents behave as if they were infinitely lived. As a result, tax changes should have no effect on national savings. Fiscal actions by the government are fully offset by countervailing actions by individuals in order to restore the pre-change optimal situation.

This argument, if correct, rejects fiscal stabilization theory, severely limits the efficacy of deficit policy as a tool of savings policy, dispenses with worries that social security contributions depress aggregate savings and breaks the traditional link between government deficits and current account deficits.[2] Therefore, whether or not the REH is valid has extremely important theoretical, as well as policy, implications.

In order to establish this proposition a number of key assumptions is required, each of which has been criticized by subsequent authors.[3] The main theoretical objections refer to the fact that the interest rate used to discount future changes to the individual's and government's budget constraint are the same (assumption of perfect capital markets), that all government revenues are collected by lump-sum taxes, that future taxes and incomes are not subject to uncertainty (or, equivalently, that there are complete markets), that debt is eventually repaid and that agents are effectively infinite-lived.

Although casual empiricism suggests that such assumptions are far from descriptive, Barro (1988) takes issue with each of the criticisms addressed to his theory and shows that the points that invalidate a strict version of Ricardian Equivalence do not lend clear support to any specific alternative. Furthermore, he argues that the criticisms imply that budget deficits have only second-order effects on the economy, with no first order effects. He concludes that while departures from Ricardian Equivalence might be important, these should be modelled explicitly and that the Ricardian approach should become the benchmark model for assessing the effects of fiscal policy.

To conclude, the Ricardian result is the logical outcome of rational forward looking private agents recognizing the fact that the government is subject to an intertemporal budget constraint and the implications that follow from it. However, given the restrictive nature of the assumptions required to derive it, the relevance of the Ricardian conclusions for the real world is dubious[4] and, therefore, the theory should be tested empirically.

A balanced reading of the available empirical evidence[5] seems to indicate that changes in government savings are likely to have important impacts on national savings.

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[2] Corden (1986) discusses the relevance of the REH, as well as other recent developments in macro-theory, for developing countries.

[3] See, for example, Modigliani et alii (1985), Tobin (1980), among others.

[4] Bernheim (1989, p. 56) argues that "while the Ricardian exercise is an interesting thought experiment, it is predicated upon extreme and unrealistic assumptions. Those who recommend this framework as a guide to actual policy formulation offer a prescription for disaster."

[5] See Bernheim (1987) for a theoretical and empirical review.

3. Econometric modelling

3.1 Conventional tests

A standard approach to assess the relationship between private and government sector saving decisions is to specify consumption (or saving) functions for the private sector intended to capture the salient features of the REH, the conventional view relating consumption to current income and wealth and the life-cycle hypothesis (LCH). The idea is to nest the three hypotheses in a single specification that, when tested, will lend support to one of the views. In what follows we adhere to this type of procedure, following Modigliani et alii (1985), and in the next section we propose an alternative testing technique.

The consumption function used in the tests performed bellow makes use of the following accounting identities and definitions, some of which are slightly different from their traditional definitions in the national accounts:

$$NNP = C + G + S_p + S_g = C_t + S_t \tag{1}$$
$$Y_d = NNP + rD - T^* = NNP - T \tag{2}$$
$$rD = iD - \Pi D \tag{3}$$
$$S_p - Y_d - C_p \tag{4}$$
$$DEF = -S_g = G - T = \text{Inflation adjusted current account deficit} \tag{5}$$

Where NNP = net national product; Y_d = disposable income; C_t = total consumption expenditure; C = private consumption; G = goverment consumption; S_p = (inflation adjusted) saving of the private sector; S_g = (inflation adjusted) saving of the government; $S_t = S_p + S_g$; T = direct taxes minus net (adjusted) transfers plus indirect taxes net of subsidies plus the revenues from the inflation tax; W = end of period wealth of the private sector, including government debt; T^* = taxes gross of transfers other than real interest payments; D = end of period government debt, net of holdings of the central bank and of the foreign sector; iD = nominal net interest payments on national debt; rD = real net interest payments on national debt and ΠD = inflation induced capital losses on national debt.

Notice that here disposable income (Y_d) includes ex-post real interest payments (rD) on public debt, rather that the nominal interest and deducts the inflation tax. Correspondingly, the government deficit (DEF) includes only real interest payments as interest expenses and treats the inflation tax as a source of revenue. These adjustments, based on the assumption of absence of money illusion, will be subject to empirical tests at a later stage.

Note, also, that for the Ricardian Equivalence Hypothesis what matters is not total government spending, but government consumption. The presumption is that total government spending includes investment spending and since the latter produces a stream of future benefits, it will not be perceived by the private sector as a source of future taxes. Similarly, according to the Ricardian Equivalence Hypothesis, the portion of public debt that should not be perceived as private wealth is the one that is issued to finance government consumption, not the portion that finances the acquisition of productive capital.

Following Modigliani et alii (1985) we can write the consumption function as:

$$Cp = a.Y_d + b.W + c.D + d.DEF \tag{6}$$

The REH can be formulated as follows:

$$C = a.(Y_d - DEF) + b.(W - D) \tag{7}$$

where the income variable is the total physical output of the economy net of the resources used up by the government and, in the same spirit, we assume that government debt is not part of private wealth and, therefore, deduct it from the wealth variable, W.

The savings function that corresponds to (7) is given by:

$$St = (1 - a)(Y_d - DEF) - b(W-D) \tag{8}$$

In contrast to this the conventional model is expressed in the form:

$$Cp = a.Y_d + b.W \tag{9}$$

and the corresponding savings function is:

$$S_t = (1 - a)Y_d - DEF - b.W \tag{10}$$

We can see that in the REH formulation (7), a substitution of debt for tax finance for a given level of government expenditure leaves $(Yd - DEF)$ and $(W - D)$ unaffected, thus causing no change in consumption. Equation (9), on the other hand, shows a rise in consumption. Modigliani et alii suggest that the LCH is somewhere between the other two and can be expressed as in (6), above, which we reproduce here for convenience:

$$Cp = a.Y_d + b.W + c.D + d.DEF \tag{6}$$

with $a > -d > 0$, d being close to zero and $c < b$ and close to zero. These restrictions imply that consumption depends on the anticipated present value of net income and wealth over a finite life-cycle. In the limit, if Barro's intergenerational links hold, $c = -b$ and $d = -a$, and equation (6) collapses into the REH formulation (7).

Using (2), (4) and (5) we can write the national savings function that corresponds to (6):

$$St = (1 - a). Y_d - (1+d).DEF - bW - cD \qquad (11)$$

Thus, equation (6) provides the basis for simultaneous tests of the three hypotheses. All three imply that a and b should be positive. Both c and d should be non-positive with c smaller than $-b$ and d smaller than $-a$. We will undertake the tests using the consumption function formulation to avoid problems of savings measurement.

Therefore, we have:

Traditional "Keynesian" case: $a > 0$; $b > 0$; $c = 0$; $d = 0$.

Ricardian case: $a > 0$; $b > 0$; $c = -b$; $d = -a$.

Lyfe-cycle case: $a > 0$; $b > 0$; $-b < c < 0$; $-a, < d < 0$.

In the life-cycle case, c and d would in principle be consistent with any value between zero and $-b$ and zero and $-a$, respectively, though it suggests that they should fall not too far from zero.

Table 1 reports the results obtained in a number of tests based on equation (6). All the variable definitions can be found in the appendix. The estimations are based on annual observations over the period 1965-1985. In order to account for endogeneity problems instrumental variables are used. In all the regressions disposable income is instrumentalized by lagged real GDP *per capita* and lagged real gross investment *per capita*.

The first row reports a standard income driven consumption function, showing a high marginal propensity to consume of about 0.84. Regression (2) presents an estimate of the conventional Ando-Modigliani aggregate consumption function. The coefficient that obtains for the wealth variable is about 0.13 and it is statistically significant. We, therefore, are unable to reject the null hypothesis that the coefficient of the wealth variable is equal to zero. Note that this result also obtains when ordinary least squares are used.

Specification (3) provides the first nested test using the hybrid consumption function given by equation (6). As mentioned above, if the Ricardian

Table 1

	C	Y_d	W	D	DEF	AR^2	DW
(1)	1047.9	0.843				.996	1.849
	(0.62)	(70.4)					
(2)	8706.4	0.629	0.131			.996	2.174
	(2.23)	(6.30)	(2.16)				
(3)	8483.4	0.591	0.169	-1.259	-0.139	.996	2.336
	(2.28)	(5.08)	(2.74)	(-1.09)	(-0.41)		
(4)	8213.9	0.616	0.161	-0.157		.997	2.418
	(2.07)	(6.10)	(2.59)	(-1.96)			
(5)	8942.1	0.564	0.163		-0.346	.996	2.125
	(2.31)	(4.82)	(2.38)		(-1.28)		
(6)	900.4	0.841			-0.027	.995	1.827
	(0.42)	(55.1)			(-0.10)		

Notes: 1965-85; (.)= t statistic; method=TSLQ (I.V.).

Equivalence Hypothesis is valid, the coefficient on the deficit should equal the negative of the coefficient on disposable income. The results obtained do not lend support to the Ricardian hypothesis. The coefficient on the deficit is only about 23% of that on disposable income and it is not statistically significant. Had this coefficient been significant, this result would be more closely associated with the Life-cycle Hypothesis; however, the insignificance of the deficit coefficient tends to argue in favor of a simple wealth augmented formulation.

The additional restriction implied by the Ricardian Hypothesis is that the coefficient of public debt should be the negative of the coefficient on the debt-inclusive wealth variable, so that debt "should not matter". The results obtained seem to indicate that a lot of discounting in fact does take place, an outcome that is close to the predictions of the Ricardian Hypothesis.

The fourth row drops the insignificant deficit variable, with virtually no change in the other coefficients. Finally, rows (5) and (6) show specifications where the debt and wealth variables are not included.

Since the nested test developed above implies restriction on the coefficient values taken as a set, an F test was built in order to test the joint null-hipothesis that the coefficient of income and that of the deficit are equal in absolute value, but of opposite signs, the same being true for the coefficients on wealth (inclusive of debt) and debt. The obtained F statistic of 4.524 allows us to reject the null-hypothesis implied by the Ricardian Proposition.

Consider now the following equation:

$$C_p = a.Y_d + b.W + c.D + d.DEF + h.rD \qquad (12)$$

Equation (12) can be used to address the question of how the marginal propensity to consume out of real interest income compares to the marginal propensity to consume out of other forms of income, taxes and transfers. This comparison provides us with a weak test of Ricardian Equivalence. This is so because according to the Ricardian Equivalence Hypothesis, transfers to or from the government should not affect households intertemporal decisions, irrespective of whether they are real or purely nominal transfers. It thus follows that if individuals consume their transfers, Ricardian Equivalence does not hold. Therefore, the following testing strategy can be used: if the REH is correct, the marginal propensity to consume out of interest income should be zero. In the other extreme, the standard view implies that the marginal propensity to consume out of interest income is equal to that out of other sources of income. Finally, the Life-cycle Hypothesis implies that it be a little smaller than that of other forms of income, given the greater volatility of interest rates and the resulting confusion between permanent and temporary changes, on the part of the public.

Table 2

	C	Yd	W	D	DEF	rD	AR^2	DW
(7)	5587.65	0.661	0.110	-0.310	-0.431	2.138	.997	2.32
	(1.54)	(6.11)	(1.76)	(-2.76)	(-1.216)	(1.630)		
(8)	7701.9	0.641	0.145	-0.252		0.809	.997	2.45
	(1.57)	(4.56)	(1.68)	(-1.44)		(0.61)		
(9)	9582.8	0.584	0.168			0.257	.997	2.51
	(2.22)	(5.13)	(2.38)			(1.75)		

Notes: 1965-85; (.)=*t* statistic; method=TSLQ (I.V.).

Given that our definitions of disposable income and deficits already incorporate real interest income, the standard view implies that the coefficient on *rD* should be zero. The REH implies that it should be the negative of the sum of the coefficients on *Yd* and *DEF*. The Life-cycle Hypothesis lies in between. Table 2 shows the results obtained in such tests.

In regression (7) the estimated coefficient of *rD* is 2.138, a result that does not lend support to any of the theories discussed. Specifically, this figure is substantially different from the value implied by the Ricardian Equivalence Hypothesis [-(0.661-0.431) = -0.230]. However, when we look at the associated *t* statistic (1.63) we see that we cannot reject the hypothesis that the coefficient is equal to zero, a result that conforms to the standard

view. In specification (8) we drop the insignificant deficit variable, reconfirming the results just discussed. In summary, these tests indicate that consumption responds to real interest income, contradicting the REH.[6]

3.1.1 Public saving and the saving rate

We can use the results obtained in the previous sections to derive an expression for the national saving rate and use it to analyze overall saving impact of changes in the government saving behavior.

This can be done by plugging regression (4), our best specification of private consumption behavior, in the definition of national saving:

$$S_n = GNP - G - C \tag{13}$$

We, therefore, obtain the following expression for the level of national savings:

$$S_n = -8213.97 + 0.385.GNP - 0.615.rD + .615.T - 0.161.W + 0.157.D - G \tag{14}$$

Dividing equation (14) by GNP, we obtain the following expression for the predicted national saving rate:

$$S_n/GNP = 0.385 - 8213.97/GNP - G/GNP - 0.615rD/GNP + 0.615T/GNP - 0.6115W/GNP + 0.157D/GNP \tag{15}$$

Equation (15) can be used to analyze the impact of different government policies on the national saving rate. It shows, for example, that an increase in government saving, brought about by an increase in tax collection equal to 1% of GNP, with expenditures constant, will increase the saving rate by 0.615% of a percentage point. Alternatively, a reduction in government consumption expenditures by 1% of GNP increase the saving rate by the same amount, whereas a reduction in spending obtained by cutting interest payments by 1% of GNP has a positive effect on the national saving rate of 0.615 of a percentage point. The improvement obtained when government savings are increased by cutting government consumption is bigger than that produced by an increase in taxes and/or a reduction in transfers, because

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[6] A regression where the real interest on domestic debt is taken out of the disposable income and deficit measures and added as an additional explanatory variable results in:
$C = 4015.8 + 0.703\,Y_d + 0.089\,W - 0.525\,D - 0.506\,DEF + 3.761\,rD$
    (0.83)   (5.06)   (1.16)   (-1.19)   (-1.27)   (1.27)
These values reconfirm the results discussed above.

part of these changes are translated into reductions in private disposable income and private savings.

These results imply that changes in public saving have a strong and positive effect on national saving. Moreover, we have found that the effect is stronger if improvements on the government accounts are obtained through a reduction in consumption expenditures rather than by reducing net transfers.

3.2 Alternative formulation

Despite the popularity of this approach, it should be noted that this specification of the consumption (or savings) function is criticized by some authors as being inconsistent with a theoretical framework in which Ricardian Equivalence can hold, given that it is not explicitly derived from intertemporal utility maximization in a rational expectations setting. This, it is argued, generates ambiguities in the interpretation of the results obtained, casting doubt on their validity.

More recently, alternative empirical formulations have been developed, allowing for explicit intertemporal optimization in the derivation of the relations to be tested. Examples of this approach are Haque (1986, 1987) and Leiderman and Razin (1988). Such work, however, is also subject to criticism mainly due to its dependence on the explicit form of the Euler equations utilized in the intertemporal optimization procedure and due to the assumed behavior of the time series process used in order to generate the expected values of the relevant variables.

In what follows I present an alternative procedure, first suggested by Jaeger (1988), that tests for Ricardian Equivalence by exploring long-run information in times series data for private consumption, income and budget deficits. The idea is that if consumer's behavior is consistent with the Ricardian proposition they will base their decisions on an income concept that incorporates the intertemporal government budget constraint. Therefore, under Ricardian Equivalence, the consumption and the modified income series should move together in time, in the sense that they do not drift too much apart. That is, Ricardian Equivalence imposes restrictions on the long run behavior of the consumption and income series. This section uses the concept of cointegration to test for the presence of such restrictions in the Brazilian case.

3.2.1 Theoretical considerations

Let us assume the standard life cycle-permanent income hypothesis of consumption behavior, with an infinite horizon and in a rational expecta-

tions setting. In this framework, consumption is a function of permanent income as follows:

$$C_t = \Omega \ (r), Yp_t \tag{16}$$

Where C_t is real private consumption, Yp_t is permanent income, which is defined to be constant over time and to represent the maximum amount that the consumer can spend for in each period for the indefinite period, given the value of his future real, after net-taxes, gross labor income, $Y_t - T_t$, and the influence of his real non-human assets, A_t, which include real public debt. Ω is a proportionality factor that depends on the exact form of the utility function and on r, the after-tax real interest rate, which is taken to be a constant. E_t denotes the mathematical expectations operator conditional on full public information at time t.

Therefore, we can write:

$$\sum (1/1 + r)^i \ Yp_t = (1 + r) \ A_{t-1} + \sum (1/1 + r)^i \ E_t \ (Y_{t+i} - T_{t+i})i \tag{17}$$

Given the constancy of Yp_t, noting that $A_{t-1} = A_t /(1+r)$ and that $\sum(1/1+r)^i$ is the sum of an infinite geometric sum and is equal to $(1+r)/r$, we can re-write (17) as:

$$Yp_t = r/(1+r) \ [A_t + \sum (1/(1+r)) \ E_t \ (\ Y_{t+i} - T_{t+i})] \tag{18}$$

and the consumption function as:

$$Ct = \Omega\{(r/(1+r)) \ [A_t + \sum (1/(1+r))^i \ E_t(Y_{t+i} - T_{t+i})]\} \tag{19}$$

As Campbell (1987) recognizes, the conditions for (19) to hold exactly are very restrictive. The difficulties involve aggregation problems, the assumption of infinite lives, and the assumptions of a constant interest rate and certainty equivalence. Moreover, as forcefully argued by Jaeger (1988), under the assumption that decisions are based on all relevant information about the future course on income and taxes, private agents take into account the government budget constraint when deciding on consumption and saving.

Let the government budget constraint in real terms be written as:

$$G_{t+1} + r.B_t = T_{t+1} + (B_{t+1} - B_t) \tag{20}$$

or

$$B_{t+1} = (1+r).[Bt + Gt - T_t] \tag{20'}$$

Where B_t denotes real public debt and G_t real government consumption. Iterating (20') over time and imposing a no-Ponzi-Game condition, *i.e.*, a solvency constraint that prevents the government from choosing a path of explosive debt, we derive the following expression for the intertemporal budget constraint:

$$B_t = \Sigma \, (1/(1+r))^i \, [E_t T_{t+i}] - \Sigma \, (1/(1+r)^i \, [\, E_t G_{t+i} \,] \tag{21}$$

Note that T_t includes the inflation tax since the revenue obtained from money financing is regarded as a particular type of distorting tax revenue.

Inserting (21) into (19) results in:

$$Ct = \Sigma \, (r/(1+r)) \, [A_t - B_t] + \Sigma \, (1/(1+r))^i \, E_t \, (Y_{t+i} - G_{t+i}) \,] \tag{22}$$

Equation (22) summarizes the consumption behavior of private agents. As we can see, consumers internalize the government intertemporal budget constraint and, accordingly, do not consider the public debt as part of their net wealth. Additionally, the relevant income variable is the total physical output of the economy net of the resources used up by the government. This "Ricardian" measure of income implies that the optimal consumption path depends on the present value of government expenditures but not on the path of tax revenues and government debt. *i.e.*, it is invariant to the form of finance used by the government and should be distinguished from the standard definition of disposable income where taxes are deducted from total output.

The subsequent analysis follows Jaeger (1988) closely and identifies disposable income of the private sector (*YD*) as conventionally measured with the following expression:

$$YD_t = (r/(1+r) \, A_t + Y_t - T_t \tag{23}$$

Similarly, a measure of "Ricardian disposable income" (YD^*) can be defined as:

$$YD^*_t = r/(1+r) \, (A_t - B_t) + Y_t - G_t \tag{24}$$

We now multiply (23) and (24) by Ω and subtract the resulting expression from (19) and (22) respectively to obtain, after some algebra:

$$C_t - \Omega . YD_t = \Omega \Sigma \, (1/(1+r))^i E_t \, [Y_{t+i} - T_{t+i}] \tag{25}$$

and

$$C_t - \Omega.YD_t^* - \Omega.\Sigma \, (1/(1+r))^i \, E_t \, [Y_{t+i} - G_{t+i}] \qquad (26)$$

Following Campbell's (1987) discussion of "saving for a rainy day" we note that the left hand side of both equations corresponds to a measure of savings (exactly so if $\Omega = 1$) and is an optimal predictor of expected future changes in the income measures on the right hand side.

3.2.2 Econometric model

In this section I use the concept of cointegration recently developed by Engle and Granger (1987), to test for the presence of the long-run restrictions on the behavior of income and consumption that stem from the expressions (25) and (26) derived above.

The standard theory of statistical inference in econometrics is based on the hypothesis that the series under consideration are stationary and ergodic. A vector of N random variables x_t for which time series observations are available is called covariance stationary if its mean vector, as well as its covariance and autocovariance matrices, are time invariant, that is, the properties of the stochastic process are unaffected by a change of time origin. It follows that the mean and the variance of the process are constant and that the autocovariances and autocorrelations depend only on the lag (time difference). The main forms of nonstationarity are trend and seasonal variations in the mean vector and covariance matrices of the stochastic process. Loosely speaking ergodicity means that the sample moments approach the population moments as its size approaches infinity.

As Stock and Watson (1988, p. 149) put it: "For macroeconometric analysis to be of any value, then, it must be that the historical experiences comprising an econometric time series are on the one hand sufficiently different from each other that more experiences provide additional information, but on the other hand sufficiently similar that combining individual experiences can elucidate the underlying economic structure. These two requirements are the essence of the technical assumption that a time series is ergodig and stationary."

A time series is called integrated of order d is a series that requires differencing d times, before it becomes stationary. It is written $I(d), d \geq 0$. If a time series xt is $I(0)$, then it is stationary, whereas if it is $I(1)$ its first difference ($\Delta x_t = x_t - x_{t-1}$) will be stationary. An integrated series is said to have a unit-root in its autoregressive representation. Nelson and Plosser (1982) have shown that many economic time series exhibit a unit-root process, *i.e.*, are non-stationary. Use of non-stationary series in regression analysis can lead to "spurious" correlations.

If two series x_t and y_t are $I(1)$, then it is generally true that the linear combination $z_t = y_t - ax_t$ will also be $I(1)$. However, it is possible that z_t be $I(0)$. Although two or more variables may be individually non-stationary, a linear combination of these variables may be stationary. If this is the case x_t and y_t are said to be cointegrated, with a being called the cointegrating parameter and $(1, -a)$ the cointegrating vector. Thus, even though x_t and y_t are dominated by long-run components (say, a trend) such components cancel out when we consider the relationship $z_t = y_t - ax_t$, it is as if the variables are moving together in time.

Cointegration can be thought of as the statistical counterpart of the concept of long-run equilibrium in economic theory. The equilibrium interpretation is that fundamental economic forces do not let the variables drift too far apart in time, that is, deviations from a long run equilibrium are bounded. Only if integrated time series are cointegrated is there a meaningful equilibrium relationship between them.

In terms of our discussion, if Ricardian Equivalence holds, consumption should be cointegrated with the modified concept of disposable income, *i.e.*, the concept that takes into account the intertemporal government budget constraint. It is possible, however, that the time series data do not contain enough information for discriminating between Ricardian and non-Ricardian restrictions on the long-run behavior of consumption.[7]

The testing strategy using cointegration theory is as follows: we first run diagnosis tests on the relevant variables to determine whether they are stationary or non-stationary. This is necessary since for Consumption and income (in either of its definitions) to be $CI(1,1)$, each of the individual series ought to be stationary in first differences. Next, we run cointegration regressions to test for the existence of long run equilibrium relationships among the variables.

If income, net taxes, and government expenditures turn out to be integrated of order one, as in previous research, the theoretical considerations above imply that the sums of the right hand sides of (25) and (26) will also be stationary. Now, if the consumption and the disposable income measures are found to be non-stationary variables in levels, (25) implies that Ct is (should be) cointegrated with YDt, whereas (26) implies that Ct should cointegrate with YD^*t.

As stressed by Jaeder (1988, p.7) the cointegration tests could give rise to four possibilities:

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[7] This possibility arises because the government budget deficit might be stationary in the period under observation. If this is the case, C_t and YD_t can be cointegrated even if C_t and YD^*_t cointegrate according to (9'). This is because the Ricardian measure of disposable income, YD_t' is simply the sum of conventionally measured disposable income, YD_t, and the government budget deficit.

a) C_t is cointegrated with YD_t as well as YD^*_t. The data generated by this economy should be judged uninformative with respect to the validity of the REP.

b) C_t cointegrates with YD_t but not with YD^*_t. The standard version of the PIH which implies Ricardian Equivalence has to be rejected.

c) C_t cointegrates with YD^*_t but not with YD_t. PIH as well as REP cannot be rejected.

d) C_t neither cointegrates with YD_t nor with YD^*_t. The assumed behavioral hypothesis for long run consumption behavior is rejected and we can infer nothing concerning the validity of REP within this testing framework.

3.2.2.1 Empirical results

As a first step, in table 3, I report results of Dickey-Fuller tests for unit roots in the time series used for testing cointegration. Data is annual from 1947 to 1986. These tests are based on the following equation:

$$\Delta X_t = \alpha + \beta. X_{t-1} + \varepsilon \qquad (27)$$

Critical values from Fuller (1976) are approximately -2.95 for a 0.05 significance level and -2.60 for a 0.10 significance level. (Sample size = 50.)

The null-hypothesis of non-stationarity in levels of the variables cannot be rejected. The table shows test statistics for unit root in the various

Table 3

$\Delta C_t = -0.114 + 0.013\ C_{t-1}$ (0.263) (0.023) -0.432 0.572	$Q_{LB} = 11.23$
$\Delta YD_t = -0.181 + 0.019\ YD_{t-1}$ (0.236) (0.020) -0.766 0.954	$Q_{LB} = 11.22$
$\Delta YD^*_t = 0.011 + 0.002\ YD_{t-1}$ (0.243) (0.021) 0.045 0.107	$Q_{LB} = 9.90$
$\Delta G_t = -83.46 + 0.051\ G_{t-1}$ (587.9) (0.042) -0.141 1.196	$Q_{LB} = 14.03$
$\Delta T_t = -10111.3 + 0.493\ T_{t-1}$ (5358.7) (0.322) -1.886 1.531	$Q_{LB} = 6.56$

variables. The numbers in parentheses bellow the coefficients are standard errors and the numbers bellow them are *tm* statistics. A comparison of these statistics with the critical values listed at the bottom of the table shows that we cannot reject the hypothesis of a unit root for each of the series under consideration. In addition, the table shows the Ljung-box Q statistic, used for testing the null hypothesis that all autocorrelations are zero. The tests were run with up to 10 lags and the results indicate that we cannot reject the null hypothesis.

I then test whether a second unit root is present. Table 4 shows the results obtained in testing for a second unit root. The appropriate regression is:

$$\Delta_2 X_t = \alpha + \beta_1.\Delta X_{t-1} + \beta_2.\Delta_2 X_{t-1} \tag{28}$$

and the table is built like table 3.

The results clearly reject the hypothesis of a second unit root. Therefore, we conclude that all the series in question require first differencing to induce stationarity, *i.e.*, they are all integrated of order one.

<div align="center">

Table 4

$\Delta_2 C_t = 0.025 - 0.722\ \Delta C_{t-1} - 0.161\ \Delta_2 C_{t-1}$
$\quad\quad\quad (0.013)\quad (0.215)\quad\quad (0.165)$
$\quad\quad\quad\ 1.899\quad -3.359\quad\quad -0.976$

$\Delta_2 YD_t = 0.035 - 0.808\ \Delta YD_{t-1} + 0.067\ \Delta_2 YD_{t-1}$
$\quad\quad\quad\ (0.014)\quad (0.207)\quad\quad\ (0.171)$
$\quad\quad\quad\ 2.483\quad -3.892\quad\quad\ 0.395$

$\Delta_2 YD^{*}_t = 0.026 - 0.741\ \Delta YD^{*}_{t-1} - 0.118\ \Delta_2 YD^{*}_{t-1}$
$\quad\quad\quad\ (0.013)\quad (0.213)\quad\quad\ (0.167)$
$\quad\quad\quad\ 1.985\quad -3.478\quad\quad -0.708$

$\Delta_2 G_t = 719.08 - 1.426\ \Delta G_{t-1} + 0.488\ \Delta_2 G_{t-1}$
$\quad\quad\quad (252.88)\quad (0.299)\quad\quad\ (0.219)$
$\quad\quad\quad\ 2.843\quad\ -4.761\quad\quad 2.222$

$\Delta_2 T_t = -1718.11 + 2.658\ \Delta T_{t-1} - 1.527\ \Delta_2 T_{t-1}$
$\quad\quad\quad (1176.43)\quad\ (0.443)\quad\quad (0.443)$
$\quad\quad\quad -1.460\quad\quad 5.995\quad\quad -3.035$

</div>

Tests for cointegration between consumption and the two alternative income concepts are based on the following regression:

$$C_t = \alpha + \beta\ Y_t + \varepsilon_t \tag{29}$$

In all tests the null hypothesis is no-cointegration. The first test uses the Durbin-Watson (CRDW) statistic from the cointegrating regression. If the

residuals are non-stationary, the CRDW approaches zero. Therefore, if the CRDW statistic exceeds the relevant critical value we reject the null hypothesis of no-cointegration. The additional tests aim at investigating the existence of a unit root in the residuals of the cointegrating regression. Rejection of the unit root hypothesis establishes that the residuals of the cointegrating regression follow a stationary process, which implies the existence of cointegration between the variables. In order to undertake this analysis we apply the Dickey-Fuller (DF) and the augmented Dickey-Fuller tests on the residuals of the cointegrating regression. In addition, we apply the same tests to the "reverse regressions" (regressions of both definitions of income on consumption).

The results of the tests for cointegration are summarized in tables 5 and 6. Table 5 shows that consumption is cointegrated with conventionally defined disposable income. The Durbin-Watson statistic of 0.815 is big enough to reject the null-hypothesis of no-cointegration at the 1% level. For both definitions of disposable income, the Dickey-Fuller test implies that we cannot reject he null hypothesis of no-cointegration. Following Engle and Granger's (1987, p. 269) recommendation, however, we use the augmented version of the test, since additional lags are significant[8] and this test has more power than DF in a higher power system. The ADF value of -3.428 allows us to reject the null hypothesis of no-cointegration at the 2.5% level. Note, also, that these conclusions are unchanged when we apply the tests to the statistics shown in table 6, for the reversed regressions.

The results for cointegration between consumption and the Ricardian definition of income are less conclusive. The Durbin-Watson statistics of 0.470 in table 5, and of 0.467 in table 6, show a marked fall but we still

Table 5
Cointegration tests

(1) $C_t = 1.321 + 0.873\, YD_t$	2) $C_t = 0.665 + 0.927\, YD*_t$
(7.377) (55.488)	(3.199) (50.897)
$R^2 = 0.987$	$R^2 = 0.985$
CRDW = 0.815	CRDW = 0.470
DF = -3.065	DF = -1.942
ADF = -3.428	ADF = -2.032

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[8]   Only significant lags were retained.

Table 6
Cointegration tests (reverse regressions)

(1)$YD_t = -1.355 + 1.130\ C_t$	2) $YD*_t = -0.542 + 1.062\ C_t$
(-5.908) (55.488)	(-5.908) (50.897)
$R^2 = 0.987$	$R^2 = 0.985$
CRDW = 0.812	CRDW = 0.467
DF = 3.028	DF = 2.0300
ADF = -3.369	ADF = -2.105

reject the null hypothesis of no-cointegration at the 5% level. Nevertheless, the ADF values of -2.032 and -2.105 in tables 5 and 6, respectively, imply that we cannot reject the null-hypothesis of no-cointegration.

It is possible that the rejection of cointegration in the "Ricardian" regressions, when using the ADF test, is due to the presence of heteroskedasticity, which reduces the power of the test. In order to test for such an effect, an ARCH model was estimated, regressing the residuals of the cointegrating regression on the squared values of their lags. When using a small number of lags, we found support for the presence of an ARCH effect, suggesting that the ADF test might be erroneously leading us not to reject the hypothesis of no-cointegration.[9]

4. Conclusion

This article addressed the question of how public sector saving decisions affect the behavior of the private sector regarding the later decision as to how much to consume and how much to save. The first approach was to specify a hybrid consumption function that was then used in a nested test of the different theories of saving behavior, in Brazil, over the period 1965-85. Our test results indicate that government saving do affect national saving, i.e., we do not find evidence of an offsetting behavior of private savings that could validate the predictions of the Ricardian Equivalence Hypothesis. We, furthermore, found out that increases in government saving

[9] The nR^2 statistics obtained in the test for Arch effects in the residuals of equations (1),(2), (3) and (4) in tables 5 and 6, using one lag are 11.52; 15.10; 13.56; and 14.12, respectively. Such values allow us to reject the null hypothesis that the coefficient of the lagged squared residuals is zero. Maddala (1988, p. 409), however, suggests care when interpreting the results on the lagged residuals since they might be proxying for omitted lagged of the explanatory variables.

brought about by reductions in government consumption expenditures are more powerful than tax increases in raising the national saving rate.

In the second section cointegration techniques were used in order to test for Ricardian Equivalence, bypassing the shortcomings of the standard consumption function approach. We found out that the standard definition of disposable income is clearly cointegrated with consumption spending. The outcomes of the test using the Ricardian definition of disposable income are less clear cut. While according to the Durbin Watson statistic we cannot reject the null-hypothesis on no-cointegration, the Augmented Dickey-Fuller test implies that we should reject that null-hypothesis. Engle and Granger (1987, p. 270) compare the alternative test statistics and suggest that while there is no optimality theory for such tests, the ADF should be used in applied studies at this point. If we follow this advice, we conclude that the Ricardian version of disposable income is not cointegrated with consumption expenditure in Brazil, from 1947 to 1986. Nevertheless, as stressed by the results obtained in the ARCH tests, this outcome should be taken with caution, since the conflicting test statistics might be suggesting that the data does not contain enough information to discriminate between Ricardian and non-Ricardian behavior.

Data appendix

Following are brief definitions of the data series used in the text, with the corresponding sources:

C — In the consumption function tests we use total consumption spending from the Brazilian National Accounts, FIBGE, deflated by CPI and normalized by population. In the cointegration tests we use the natural logarithm of real consumption percapita (LC).

Yd — In the consumption function tests, the variable is defined as Gross National Disposable income (FIBGE), plus the difference between nominal and real interest payments (FIBGE, Banco Central do Brasil), minus inflation Tax, taken from Cysne (1988), deflated by CPI and normalized by population.

YD — In the cointegration tests the variable is measured as the natural logarithm of the disposable income of the private sector (FIBGE).

YD^* — The Ricardian measure of disposable income is measured as the natural logarithm of the disposable income of the private sector (FIBGE) plus the government's saving in the current account (FIBGE) plus the revenues from the inflation tax (Cysne, 1988), minus government payments of monetary correction on the domestic debt (FIBGE).

W — Real Wealth is defined as the sum of private sector net financial holdings and the stock of capital. Net financial holdings are defined as the

sum of currency, demand deposits, time deposits, bills of exchange, ORTN's in the hands of the public, LTN's in the hands of the public, State and municipal bonds in the hands of the public, housing bonds, saving bonds, forced savings (PIS + PASEP + FGTS). All measured as end of year stocks (source is *Boletim do Banco Central do Brasil*, various issues). The stock of capital up to 1975 is taken from Bonelli and Malan (1976), who, in turn, follow the methodology of Bonelli (1975). From 1975 on I updated the series by adding the yearly flow of net investment in the transformation industry to the stock of capital in the previous year. Net values are calculated by deducting a constant 5% depreciation estimate from gross figures. Data is from *Pesquisa industrial*, FIBGE, various issues.

D — Private sector holdings of government debt. Includes LTN's, ORTN's and other government bonds held by the public (*i.e.*, deducts Central Bank holdings from bonds outstanding), end of year values. Source is Banco Central do Brasil, various issues.

DEF — Government deficit in the current account minus payments of monetary correction. *i.e.*, incorporates only real interest payments.

G — Government expenditures in the current account. National Accounts, FIBGE.

T — Net tax burden. National Accounts, FIBGE.

MC — Government payments of monetary correction. From 1970 to 1985, the source is FIBGE. For the years 1965 to 1969 I estimated the difference between nominal and real interest payments as the average yearly stock of real debt per capita multiplied by $ln(1 + \Pi)$, where Π is the rate of inflation in the general price index (IGP, FIBGE).

Resumo

Este artigo discute a eficácia das políticas governamentais que visam aumentar a poupança nacional através de aumentos na poupança do setor público. Utilizando o caso brasileiro como exemplo, o artigo mostra que o sucesso de tais políticas depende da capacidade de previsão do setor privado. Em fase das diversas possibilidades teóricas existentes, propõe-se o teste empírico da questão. Dois tipos de exercícios econométricos são efetuados para estimar a sensibilidade da poupança nacional a reduções no déficit em conta corrente do governo. O primeiro grupo utiliza uma função consumo para discriminar entre as diversas possibilidades teóricas, a partir do valor dos coeficientes estimados. O segundo grupo utiliza o conceito de co-integração entre séries temporais para testar a validade da "Equivalência Ricardiana" no caso brasileiro. Os resultados empíricos obtidos nos dois grupos de testes rejeitam a "Equivalência Ricardiana", sugerindo que aumentos na poupança do setor público induzem a aumentos na poupança

nacional. Ademais, os resultados obtidos nos testes da função consumo sugerem que reduções nos gastos de consumo do Governo revertem em aumentos na poupança nacional superiores àqueles obtidos através de uma elevação em suas receitas líquidas.

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