A CROSS-COUNTRY ANALYSIS OF PRIVATE CONSUMPTION, INFLATION AND THE "DEBT NEUTRALITY HYPOTHESIS"

Giuseppe Nicoletti

CONTENTS

This paper was written while the author was a consultant in the Monetary and Fiscal Policy Division of the Department of Economics and Statistics at OECD. Thanks are due to Bruce Montador for his support and advice throughout this work and to Luca Barbone for his helpful suggestions. Partial funding from the Consiglio Nazionale delle Ricerche (Progetto Finalizzato CNR, "Struttura e evoluzione dell'economia italiana", Contr. 8601349.53) is also acknowledged. The author is particularly indebted to Nicola Rossi for his most useful comments.

INTRODUCTION

Over the last fifteen years, the fiscal position of many OECD countries has been dominated by the growing financing needs of the government sector. Notwithstanding recent improvements in the budget balances of some Member countries, in most cases the outlook for the long-run sustainability of current fiscal policies remains worrisome. High debt levels and sustained government deficits have increased awareness among economists and the general public of the necessity of budgetary adjustments designed to bring these variables under control in the medium term.

In an economic environment where the concern about the sustainability of fiscal policies is deepening, the consumption behaviour of the private sector can be influenced by anticipations about future fiscal events. The most influential attempt to introduce "fiscal expectations" into a forward-looking model of private sector behaviour was made in a paper by Barro (1974) who showed that, under rather stringent assumptions, the correct private sector anticipations of the future fiscal policies of the government imply that the choice between tax and debt finance is irrelevant. If valid, this proposition would have important policy consequences, since it implies that only government direct absorption of goods and services can "crowd out" private resources. This line of reasoning has been dismissed by many economists as requiring excessively prescient consumers and unrealistic assumptions about markets and the structure of taxation. Nonetheless, a complete divorce between probable future developments and current behaviour seems inconsistent with fundamental economic reasoning, at least in the context of the forward-looking theory of consumption that has become generally accepted within the economics profession. Aside from the restrictive hypotheses required by the irrelevance proposition, fiscal expectations could affect current market outcomes if private agents take account of the possible reactions of the authorities to persistent public finance imbalances. In this case, the effects of current and planned budgetary policies may differ substantially from those traditionally predicted by macroeconomic theory.

The purpose of this paper is to present a new empirical analysis of the fiscal expectations issue in the context of a cross-country sample of eight OECD countries. To date, cross-country analyses of the tax-discounting hypothesis have been very few. Moreover, past analyses generally pooled international data sets without taking

a comparative approach, although comparing the impact of different experiences of debt and deficits on private consumption seems a most promising avenue for research'. This literature is also frequently marred by the use of *ad hoc* consumption models and by the omission of important variables, making the results difficult to interpret.

The analysis undertaken in this paper attempts at overcoming some of these limitations. The impact of fiscal expectations in different countries is studied using a flexible specification of the consumption model which allows for various effects usually ignored in the literature. A life-cycle demand system for durables and non-durables is derived from individual optimizing behaviour using Theil's differential approach to demand analysis (also known as the "Rotterdam model"). The main advantage of this approach is that the implied consumption equations are general enough to nest many alternative hypotheses about consumers' behaviour. For instance, under appropriate parameter restrictions, the model is consistent with both "random walk" and "error correction" models of consumption. In contrast with many of the previous analyses the model specification includes real interest rate effects, the possibility of direct substitution between private and public consumption and inflation adjustment of disposable income. Previous studies made it clear that model specification as well as the choice of the consumption aggregate and of the independent variables affect in important ways the results of tests of the debt neutrality proposition. The estimation of separate equations for durables and non-durables makes it possible to check the model specification by imposing parameter restrictions within and across equations.

The model nests, through an appropriate definition of the current and future components of intertemporal wealth, the traditional life-cycle model within an augmented specification embodying fiscal expectations. Expectations relate both to future taxes designed to finance the service of the debt (the so-called "tax-discounting" hypothesis) and to the financial wealth losses implied by the future rate of inflation (the so-called "Hicksian correction" hypothesis). By appropriately varying the two parameters expressing the degree of tax-discounting and the degree of *ex ante* inflation adjustment of disposable income, three limiting cases can be obtained: the "basic" model, with no inflation-correction and no tax-discounting; the "Hicks" model, with full inflation-correction and no tax-discounting; and the "Barro" model, with full tax-discounting.

Inferences are based on cross-section and time-series data relative to eight major OECD countries – the United States, Japan, Germany, France, Italy and Belgium – over the 1961-1985 period. In a first stage of the analysis, data are pooled using the dummy-variable approach, and a set of standard covariance analysis tests is performed, suggesting a significant heterogeneity of the slope parameters in different countries. In a second stage, single-country estimates are obtained allowing a comparative examination of the coefficients of inflation correction and tax discounting across countries.

The main results of the analysis can be summarised as follows. First, the hypothesis that agents fully perceive the inflation tax levied by the government on the outstanding value of its debt can never be rejected and is in many cases strongly supported by the data. Second, with some remarkable exceptions, the hypothesis that government debt policies are neutral is decisively rejected. In many instances, however, fiscal expectations have a significant impact on consumption. The importance of their effects appears to be related to the different historical developments in inflation, deficits and debts experienced by the individual countries. The results of the analysis show that countries in which inflation losses were historically higher and where the dynamics of public debt and deficits seem to be explosive provide higher estimates of the inflation-correction and tax-discounting parameters. This may be interpreted as an indication that the private sector "learns with time" and that, in some cases, the public concern over the necessity of fiscal restraint has important repercussions on agents' saving behaviour.

The plan of the paper is as follows. The next section briefly outlines the conflicting models and the theoretical rationale for the introduction of fiscal variables in life-cycle consumption functions. Section II reviews some of the methodological issues involved in testing the fiscal expectations hypothesis. Section III describes the consumption model that is the basis for the analysis. Section IV discusses the behaviour of private and public saving over the sample period and examines the results of the estimations and of a set of nested and non-nested tests that oppose the basic model, the Hicks model and the Barro model. A summary of the findings concludes the paper.

I. AN OVERVIEW OF THE THEORETICAL ISSUES

The conventional consumption function, derived from the Life Cycle or Permanent Income Hypotheses and embodied in most existing econometric models, relates consumption to various proxies for the private sector's intertemporal wealth. These usually include current (and/or lagged) disposable income and the stock of the private sector's financial and, possibly, fixed assets. This widely accepted model of consumption behaviour, which henceforth will be called the "basic model", deals in an asymmetric way with the influence of fiscal variables on consumption. Current taxes, government transfers (including interest payments) and government debt-creation are accounted for by relating consumption to disposable income and by including the stock of monetary and interest-bearing debt in the private sector's stock of wealth. However, the effects on current consumption of future taxes and transfers, as well as the effects of current and future government consumption, are usually ignored, which is strange for a theory that embodies a strong intertemporal

element. In addition, while the theory imposes heavy informational requirements on agents, who are sometimes supposed to be able to "pierce the corporate veil", no allowance is usually made for the ability of agents to foresee the current and future constraints faced by the government and the implications of inflation for the real value of their stock of financial assets.

The policy implications of the basic model are well known. An increase in government debt financing causes, at least in the long run, a crowding-out of private saving and, hence, of capital accumulation that shifts the burden of the debt on future generations (Modigliani, 1961, 1986). These conclusions rest on the proposition that private saving, being controlled by life cycle considerations of "selfish" generations, is largely independent of the government's current and future budget stance.

The asymmetries of the basic model, first noticed by Bailey (1962), were addressed in what has come to be known as the "ultrarational" approach[2]. In this approach agents are assumed to incorporate, to some extent, the intertemporal constraint of the government into their own budget constraints and to take account of the consequences of government activities for their own welfare levels. An important implication of this hypothesis is the possibility of a direct substitution between private and government-related activities. This can occur either through a substitution of public for private consumption or through a substitution of public for private savings. The first effect derives in a straightforward way from the assumption that government consumption yields utility to individuals in a non-separableway. The second depends on the tax-discounting hypothesis, namely the idea that individual agents foresee the future tax liabilities associated with current and future deficit financing of government expenditures and take account of them in their present behaviour.

The implications of the hypothesis of ultrarationality have been pursued on different levels. The extreme view, mostly stemming from the work of Barro (1974), is based on the so-called "dynastic model". The dynastic model subsumes the aggregate behaviour of different (overlapping) generations of finitely-lived consumers in the behaviour of a single infinitely-lived representative consumer. The combination of ultrarationality and of dynastic behaviour can be shown to have drastic implications. First, the consumption behaviour of agents depends on total resources available to the economy – i.e. national income net of government absorption – rather than on disposable income; given the level of public spending, agents respond to every government bond issue with a dollar-for-dollar increase of private saving. Second, government debt ceases to be considered net wealth by the private sector since its current value is exactly offset by the discounted value of the future taxes necessary to finance the stream of interest payments that it implies; in other words, the stock of government debt does not affect consumption levels since it leaves agents' lifetime wealth unaffected. Third, there is no replacement of

government debt for private assets in agents' portfolios (entailing a debt burden for future generations in terms of reduced capital accumulation) because agents can maintain the pre-debt optimal allocation of resources across generations by altering the level of private bequests[3].

From a policy point of view, the implications of this hypothesis are far-reaching. Since all channels of influence of public debt are neutralised, whether a given stream of government expenditures is financed through taxes or debt has an equivalent effect on the economy. In this model (henceforth called the "Barro" model), debt-financed tax cuts have no effect at all on the economy and no crowding-out effects should be expected from the accumulation of government debt. These results, often referred to as the Ricardian Equivalence Proposition, are clearly at odds with the implications of the basic model[4].

While Barro's formal results are interesting from a theoretical point of view, their empirical relevance can be questioned, given the extremely restrictive assumptions necessary for the Ricardian Equivalence Proposition to hold. These assumptions concern the nature of individual preferences and of government policies as well as the configuration of markets. In particular, the validity of the equivalence proposition requires:

a) The existence of operative intergenerational transfers (bequests or gifts) motivated by the altruistic nature of individual preferences (Becker, 1974);
b) Certainty about agents' lifetimes;
c) The absence of capital market imperfections; and
d) That the long-run financing regime of the government consists only of non-distortionary taxation[5].

In addition, the consolidation between public and private accounts which leads to the equivalence proposition implicitly requires that the intertemporal budget constraint of the government be binding, i.e. that the government be solvent in the long-run[6].

Income taxation, monetisation of deficits, liquidity constraints and imperfections in intergenerational transfers, among many other features of real world economies, suggest that the Barro model has limited empirical content. But the probable failure of many of the above assumptions does not prevent the ultrational approach from providing a less restrictive depiction of reality than the one put forth by the basic model. While it seems clear that the fiscal expectations hypothesis does not hold in its strongest presentation, direct crowding-out of private expenditure and expectations about future tax increases (or spending cuts) could be important factors in determining the impact of current fiscal policies and the effects of planned budgetary adjustments. For instance, if concern about future taxes is strong and substitutability between private and public consumption is high, current deficits would depress private spending while the announcement of future budget

restrictions would stimulate it. If, on the contrary, tax discounting is negligible and public consumption does not substitute for private consumption, current deficits would stimulate consumption while spending cuts or tax increases would depress it.

These considerations suggest it is important to design and test models of consumption embedding elements of ultrarationality. Ideally, models of this kind should explicitly account for the reaction function of the fiscal authorities and the features of the economy (such as the myopia of agents or market imperfections) that violate the assumptions of the Barro model. This modelling strategy, coupled with the assumption of rational expectations, would stress the signalling role of current and past fiscal behaviour, leading to an analysis of the effects of fiscal policy richer in implications than the traditional one. This line of research, termed the Extended Life Cycle Hypothesis by Modigliani and Sterling (1986) and the Fiscal Expectations Hypothesis by Feldstein (1982), is still in its infancy stage. It is important, however, to keep in mind when interpreting the estimates of the tax-discounting parameter reported below that it should be related to a complex set of interactions between the characteristics of agents' preferences, the constraints that they face and their perception of the fiscal authorities' reaction function.

II. AN OVERVIEW OF METHODOLOGICAL ISSUES

Empirical analyses of tax-discounting behaviour are usually based on models that "nest" the basic and the Barro specifications by including the stock of government debt and the government surplus among the regressors of the consumption equation. The basic model is obtained when government debt is fully included in private wealth and government consumption does not affect disposable income; the Barro model is obtained when private wealth excludes government debt and the coefficients of disposable income and the government surplus are equal, implying that disposable income is redefined as the difference between national income and government absorption[7].

When life-cycle consumption functions are tested under the null hypothesis of the Barro model, the evidence is ambiguous*. On the one hand there is strong evidence that the implications of the pure Barro model are violated: the relevant restrictions, when tested jointly, are usually rejected. On the other hand, a number of statistical results suggest that conventional consumption functions are mis-specified: it appears to be very difficult to obtain significant coefficients for government debt (and/or for social security wealth) and government revenues, while the coefficient of the government surplus is almost always significant and positive. In addition, there is some evidence of a negative effect of government consumption on private consumption.

As many authors have stressed, the estimates of consumption functions embodying fiscal variables suffer from three econometric problems that are difficult to solve. First, variables such as debt and debt service or income and government revenues, which are essential to the analysis, are strongly correlated over time, implying that some degree of collinearity is inevitable at least when the data consists of aggregate time series. Second, consumer spending, disposable (or national) income and the government surplus (or its components) are jointly determined over the business cycle, suggesting that it might be difficult to obtain satisfactory estimates of the separate effects of these variables on consumption using standard OLS methods. Third, public debt, the government surplus and government consumption are hardly measured correctly: the "deadweight debt" resulting from government net saving is generally not observable and government consumption is often underestimated since many items that are included in government capital accumulation account do not generate revenue flows equal to their initial cost[9].

Generally the coefficient estimates of the fiscal variables are also extremely sensitive to model specification. With few exceptions, however, studies of the tax-discounting hypothesis have been quite vague about the microfoundations of the models tested. The relationships between the functional specification, the hypotheses tested and the underlying model of individual behaviour – in terms of preferences, time horizon, constraints faced by consumers and attitude towards uncertainty – are usually ignored. Consequently, a variety of ad *hoc* specifications have been employed. This is a source of specification errors which could be eliminated by a more consistent derivation of the model, possibly leading to additional structural restrictions. As it stands, these models frequently suffer from the omission of important explanatory variables.

A serious omission concerns the question of inflation-adjustment. Generally, disposable income and the deficit are defined gross of the inflation-premium component of interest payments, and expected inflation is not allowed to influence the agents' perception of their wealth (exceptions are the studies by Koskela and Virèn, 1983; Modigliani *et* al., 1985; and Modigliani and Jappelli, 1986). To maintain that agents suffer from this kind of "money illusion" is clearly at odds with the considerable degree of rationality and foresight required by the tax-discounting hypothesis. In addition, while tax discounting behaviour is far from having been validated empirically, there is a significant body of empirical evidence pointing out that, in many countries, partial or complete Hicksian correction of disposable income accurately describes the behaviour of private agents (see, for Italy, Rossi and Schiantarelli, 1982; Marotta, 1983, 1984; Lecaldano *et* al., 1984 and Rossi, 1986; for Germany and the United Kingdom, von Ungern-Sternberg, 1981, 1987; Hendry and von Ungern-Sternberg, 1981; and Pesaran and Evans, 1984; for the United States, Poole, 1972).

Another problem is that most of the models in the literature either do not account or account very poorly for the future components of human wealth. The

difficulty of finding closed-form solutions in forward-looking models of consumption is well known; but in relating consumption only to current wealth and expressing their null hypothesis in terms of the Barro model (which requires that agents have long-run perfect foresight), many authors are either mis-specifying their models or misinterpreting their results. The disregard for future expected components of wealth can obscure the interpretation of the coefficient estimates of the (included) current fiscal variables. For instance, a significant negative coefficient on the deficit could be explained by the strong correlation between this variable and the (omitted) future transfers and taxes. In such cases the estimates cannot yield reliable information on the validity of the tax-discounting hypothesis.

Other omissions concern the real interest rate and government consumption. Estimates of consumption sensitivity to these variables are interesting in their own right, but controlling for them is particularly important in measuring the impact of government deficits on private consumption. Given the correlation of deficits and real rates in the last decade, a negative effect of deficits on private consumption could proxy for the effect of the real rate. Similarly, substitutability (or complementarity) of private and public consumption could be a direct "crowding-out" (or crowding-in) channel that operates independently of the tax-discounting effect; consumption specifications that ignore this effect are correct only if government consumption does not yield valuable services to the private sector (or does it in an additive way).

While this study broadly follows the approach taken in the literature by nesting the traditional consumption function into an augmented specification allowing for tax-discounting behaviour, the model developed in the next section enhances previous attempts to estimate the extent of fiscal illusion by avoiding some of the specification errors just described. Thus, the analysis derives from the optimising behaviour of a representative agent a flexible functional form that *i)* embeds some overidentifying restrictions that allow to test its specification; *ii)* allows for a specification (intermediate between the Basic and the Barro specifications) that assumes inflation adjusting of disposable income; *iii)* uses appropriate proxies for the expected stream of net labour incomes; and *iv)* accounts for possible real interest rate and government consumption effects.

III. A MODEL OF CONSUMPTION BEHAVIOUR

A. A demand system for durables and non-durables

The model presented below is an extension of the work by Rossi (1986) based on Theil's "differential approach" to modelling demand systems[10]. Rossi's

consumption model is extended by deriving a life-cycle demand system for durables and non-durables and by nesting the fiscal expectations hypothesis into the life-cycle framework. The resulting flexible functional form combines many alternative hypotheses of consumption behaviour, encompassing under certain conditions, both the "random walk" and "error-correction" models of consumption[11]. The model also allows for a varying real interest rate and, consistently with the ultrarational approach, accounts for the direct substitutability between public and private consumption.

It is supposed that consumer preferences are defined in a non-separable way over three broad aggregates of goods, services from durables, non-durables and services and government consumption. Preferences are weakly separable over present and future consumption and consumers maximise intertemporal utility subject to a lifetime budget constraint free to lend and borrow at the same interest rate. The application of the "differential approach" (Theil, 1980) leads to a demand system that can be expressed, in order to facilitate comparisons with earlier studies, in terms of "economic" consumption (defined as the sum of services from durables and non-durables and services) and consumption of non-durables and services. In this system, the typical consumption equation (augmented by a relative price term in the case of non-durables) takes the following form[12]:

$$\hat{c}_t = b_o + \sum_{s=o}^{T-t} b_{1,t+s}\, r_{t+s} + b_2 \ln (Q_{t-1}/c^E_{t-1}) + \quad [1]$$
$$+ b_3\, \epsilon_t + \sum_{s=o}^{T-t} b_{4,t+s}\, \hat{g}_{t+s} + u_t$$

where c_t = generic real consumption aggregate;
c^E = real "economic" consumption;
g_t = real public consumption of goods and services;
r_t = real rate of return on assets held from period $t-1$ to t;
Q_t = real intertemporal wealth;
u_t = random component;

and, for any variable x, $\hat{x} = \Delta (\ln x)$.

Equation [1] relates the rates of growth of consumption to a weighted average of current and future real interest rates, to the beginning-of-period wealth-to-consumption ratio, to innovations in real human wealth and to current and future rates of growth of government consumption. Variables indexed $t+i$ $(i=0,1,2,\ldots,T)$ represent point expectations formulated at the beginning of period t on the basis of information available at the end of period $t-1$ (T being the economic horizon of the decision-maker).

This equation describes the equilibrium response of consumption to changes in relative prices and incomes affecting the individual's intertemporal budget set. The presence of the lagged wealth-consumption ratio reflects the fact that, contrary to standard life-cycle models, homotheticity of preferences is not assumed. With no homotheticity, consumption shares in each period depend both on relative prices

and on the stock of intertemporal wealth. If preferences were homothetic, the lagged wealth-to-consumption ratio would be a function of lagged real interest rates and relative prices. By adding to homotheticity the assumption of rational expectations, the income innovation ϵ_t becomes a white noise disturbance and [1] can be interpreted as a generalization of Hall's random walk model[13]. It is worth noting, however, that equation [1], as well as most of the analysis that follows, may be interpreted also in terms of the error-correction model proposed by Davidson *et al.* (1978), the lagged wealth-consumption ratio playing the role of an integral control mechanism.

The coefficients in [1] are ratios between the structural parameters – which depend on preferences and initial conditions – and expenditure shares on the two kinds of goods. Barnett (1979) shows that, under mild conditions, models like [1] can be interpreted as aggregate demand systems with coefficients constant over time. In particular, the constancy of the macro coefficients does not imply nor require the same constancy at the micro level.

The empirical analysis is carried out using estimable versions of [1] for "economic" consumption and consumption of non-durables. An identical equation is also estimated for aggregate consumption expenditure as defined in national accounts[14]. The use of [1] in assessing the empirical scope of the hypothesis of ultrarationality requires two more steps. First, an expression for intertemporal wealth (Q_t) which nests the basic model and the Barro model must be derived. Second, this wealth specification, as well as other variables in the model, must be expressed in terms of observables.

B. Nesting the basic model and the Barro model

In the ultrarational approach individuals embed the intertemporal constraint of the government into their own budget constraints. Consider the following standard expression for the representative consumer's intertemporal budget constraint:

$$Q_t = w_{t-1}(1 + r_t) + b_{t-1}(1 + r_t) + y_t^T - \tau_t^T$$

where w is real end-of-period non-human wealth net of the real end-of-period stock of government debt 6; and y^T and τ^T are the discounted values of the stream of future labour incomes y and of the real resources τ absorbed by the public sector over the economic lifetime of the decision unit, which is assumed to end at T $(0 \leqslant T \leqslant \infty)$. Assuming that the planning horizon of the government is TG $(0 \leqslant TG \leqslant \infty)$ and ignoring money financing, the public sector's intertemporal budget can be expressed in an analogous way:

$$b_{t-1}(1 + r_t) + g_t^{TG} = \tau_t^{TG}$$

where g^{TG} is the discounted value of current and future government expenditures

and τ^{TG} is the discounted value of current and future taxes net of transfers (excluding interest payments on government debt)[15]. Note that, if the planning horizon of the government is infinite, this equation only states that the stream of current and future interest payments on government debt must be financed through a corresponding stream of primary surpluses. It puts no constraints on the repayment of the principal[16].

Assuming that agents perceive correctly the public sector constraint, so that deviations from ultrarationality are only due to the lack of coincidence between the timing of taxation and the economic horizon of agents, the consolidation of the private and public sector budget constraints leads to the following definition of the lifetime wealth of the representative consumer:

$$\begin{aligned} Q_t = {} & w_{t-1} + (1 - a_8) b_{t-1} + \\ & + Y_t^d + a_8 s_t - a_7 (1 - a_8) q_t b_{t-1} + \\ & + (y_{t+1}^T - \tau_{t+1}^T) + a_8 \sigma_{t+1}^{TG} \end{aligned} \qquad [2]$$

where Y^d is national accounts disposable income; s and σ are respectively the government deficits gross and net of interest payments; q is the expected rate of inflation from $t-1$ to t; and for any variable x and time horizon k, x_{t+1}^k denotes the sum $x_t^k - x_t$.

Equation [2] is a general expression that accounts for the influence of fiscal expectations on the agents' perception of lifetime wealth. The parameter a_8 represents the share of government intertemporal revenues expected to be levied during the average lifetime of consumers. It is defined as the ratio of the discounted net taxes expected by private agents to the discounted value of the net taxes implied by the government intertemporal budget constraint:

$$a_8 = (\tau_t^T - \tau_t)/(\tau_t^{TG} - \tau_t)$$

As a_8 varies from zero to unity, it describes the wealth implications of various degrees of coincidence between the private and public intertemporal constraints. When agents are myopic or when the bulk of taxation is concentrated beyond their lifetimes ($a_8 \rightarrow 0$), only current disposable income, possibly adjusted for inflation losses, enters the definition of human wealth, while non-human wealth includes the full amount of government debt. When agents behave as dynasties or when the bulk of taxation is distributed within their lifetimes ($a_8 \rightarrow 1$), human wealth includes current national income and the future stream of labour incomes net of current and future government consumption, while non-human wealth excludes government debt. In the general case ($0 < a_8 < 1$), both government expenditures *and* their mode of financing affect perceived intertemporal wealth.

The parameter a_7 expresses the degree to which agents recognise the holding losses on their nominally denominated assets implied by the current expected rate of

inflation. Ignoring inflation losses on foreign assets and capital losses other than those implied by changes of the general level of prices, only the outstanding value of government debt is subject to depreciation. Adjustment of disposable income for the holding losses due to inflation is consistent with Haig-Simons' wealth accounting and with Hicks' "central concept of income" as "the maximum value (the agent) could have spent on consumption while maintaining the real amount of his capital stock intact" (for a theoretical discussion of Hicks' concept of income see Jump, 1980). The parameter a_7 ($0 \leqslant a_7 \leqslant 1$) allows for deviations from such a Hicksian perspective.

If $a_7 = 7$, inflation does not affect agents' perceived income. If $a_7 = 0$ agents suffer from a kind of money illusion and inflation increases their perceived incomes through nominal interest transfers. Finally, if $0 < a_7 < 1$, inflation affects agents' perceived incomes only partially. It is important to notice that the effect of inflation (and hence the Hicksian correction of disposable income) is relevant only as long as a_8 is not unity, since in this case government debt ceases to be private wealth.

C. The estimable model and its properties

Substituting Q_t by [2] and expressing the variables appearing as expectations in terms of observable magnitudes, the following estimable version of model [1] is obtained:

$$\begin{aligned}\hat{c}_t = {} & a_0 + a_1\, {}_{t-1}r_t + a_2 \log (w^*_{t-2}/c^E_{t-1}) + \\ & + a_3 \log (Y^{*d}_{t-1}/w^*_{t-2}) + a_4\, {}_{t-1}\hat{Y}^*_t + \\ & + a_5 (\hat{Y}^*_t - {}_{t-1}\hat{Y}^*_t) + a_6\, {}_{t-1}\hat{g}_t\end{aligned} \qquad [3]$$

In equation [3] ${}_{t-1}x_t$ denotes the expectation of any variable based on information available at time $t-1$, and the variables superscripted by a star define the three components of "nested" lifetime wealth – i.e. initial non-human wealth (w^*), current disposable income (Y^{*d}) and future net labour incomes (Y^*):

$$w^*_{t-2} = w_{t-2} + (1 - a_8)\, b_{t-2}$$

$$Y^{*d}_{t-1} = Y^d_{t-1} + a_8 s_{t-1} - a_7 (1 - a_8)_{t-2} q_{t-1} b_{t-2}$$

$${}_{t-1}Y^*_t = {}_{t-1}y_t - {}_{t-1}\tau_t + a_8\, {}_{t-1}\sigma_t$$

The model relates the rate of change of consumption to the expected real interest rate, to the previous period wealth-consumption and income-wealth ratios, to the anticipated and unanticipated growth in net labour incomes and to the rate of growth of government consumption.

The derivation of model [3], which is the basis for the subsequent analysis, involves several approximations. First a linear approximation is used in order to

decompose the logarithm of Q_t into its three components'[7]. Second, myopic expectations are assumed, i.e. for any x,

$$_{t-1}x_{t+i} = {}_{t-1}x_t \quad \text{for any } i > 0.$$

Third, the ratio of the logarithm of discounted future incomes to current disposable income is approximated by the one-period-ahead expected growth of income, and innovations in expected human wealth are approximated by the error in the income forecast:

$$log({}_{t-1}Y_t^{*T}/Y_{t-1}^{*d}) = {}_{t-1}\hat{Y}_t^*$$
$$\epsilon_t = \hat{Y}_t^* - {}_{t-1}\hat{Y}_t^*$$

It is important to note that, given the "nested" definition of net incomes, the expected and unexpected income growth variables can be expressed as follows:

$$_{t-1}\hat{Y}_t^* = {}_{t-1}\hat{Y}_t + a_8\ \gamma_{t-1}({}_{t-1}\hat{y}_t - {}_{t-1}\hat{g}_t) + (1-a_8)\ \theta_{t-1}({}_{t-1}\hat{y}_t - {}_{t-1}\ \hat{\tau}_t)$$
$$(\hat{Y}_t^* - {}_{t-1}\hat{Y}_t) = (1+a_8\ \gamma_{t-1} + (1-a_8)\ \theta_{t-1})(\hat{y}_t - {}_{t-1}\hat{y}_t) +$$
$$-a_8\ \gamma_{t-1}(\hat{g}_t - {}_{t-1}\hat{g}_t) - (1 - a_8)\ \theta_{t-1})(\tau_t - {}_{t-1}\ \tau_t)$$

where γ_t and θ_t are the "nested" tax-to-income and expenditure-to-income ratios:

$$\gamma_t = (g_t / Y_t^*)$$
$$\theta_t = (\tau_t / Y_t^*)$$

The expressions for the anticipated and unanticipated income variables point out how, in model [3], market expectations concerning the rates of growth of government consumption and net taxes can affect private consumption.

Given the "nested" definitions of wealth, disposable income and future net labour incomes, the specification of the model depends non-linearly on the inflation-correction and tax-discounting parameters, a_7 and a_8. Fiscal expectations affect the model in three ways: through the definition of non-human wealth, w^*, through the definition of current disposable income, Y^{*d}, and through the definition of anticipated and unanticipated income growth. The last effect is usually ignored in the literature. By varying a_7 and a_8 in the unit-interval, three limiting specifications can be obtained: the basic model ($a_7=0, a_8=0$), the Hicks model ($a_7=1, a_8=0$) and the Barro model ($a_8=1$).

The restrictions on the coefficients are of two kinds: within-equation and cross-equations. Within-equation restrictions require that:

R1 $\quad a_2, a_3, a_4, a_5, > 0$
R2 $\quad a_2 \geqslant a3$
R3 $\quad 0 \leqslant a_7, a_8 \leqslant 1$

In the equilibrium interpretation of [3], which relates the dynamic structure of the

model to the assumption that preferences are not homothetic, coefficients a_2 to a_5 are directly related to the Slutzky income effects. The first restriction reflects the assumption that income effects are positive. The second restriction is implied by the fact that the short-run wealth elasticity is equal to (a_2-a_3). The third derives from the definitions of a_7 and a_8 provided in the previous paragraph.

No sign restrictions can be put on coefficients a_0, a_1 and a_6. The interest rate coefficient (a_1) combines a (negative) intertemporal substitution effect and a (positive) income effect. Similarly, the effect of government consumption (a_6) is *a priori* ambiguous, since there are no reasons to believe that this kind of government activity is a substitute (or a complement) for private consumption. Finally, note that, although in the context of the above derivation the constant has no specific role to play (while the other coefficients are related to preferences, a_0 is just a function of initial conditions), it is easy to think of extensions of the model in which this coefficient would capture changes in the structure of preferences over time (Theil, **1975**).

Two obvious cross-equations restrictions concern the tax-discounting and the Hicksian-correction factors. The rationality of agents requires that the tax-discounting and Hicksian-correction factors be the same in the two equations (the coefficients of the non-durable consumption and economic consumption equations being indexed respectively by a superscript N and a superscript E):

R4 $\quad a_7^N = a_7^E \quad$ **and** $\quad a_8^N = a_8^E$

A less obvious restriction involves the income and wealth coefficients. Symmetry in the derivation of the two equations implies that:

R5 $\quad (a_2^E / a_2^N) = (a_3^E / a_3^N) = (a_4^E / a_4^N) = (a_5^E / a_5^N)$

These restrictions state that the ratios of the income effects on the two consumption aggregates must be equal, regardless of the component of intertemporal wealth they refer to. Note also that, in accordance with the life-cycle theory of consumption, **[3]** restricts the steady state elasticity of consumption to income and wealth to be unity (Modigliani and Ando, **1963**)[18].

Finally, it is important to emphasize again that, under suitable restrictions on the parameters a_2 and a_3, the model is undistinguishable from an error-correction model with an integral control mechanism. However, in such a disequilibrium interpretation, the meaning of the coefficients a_2 to a_5 changes. These must be related to the parameters of the underlying adjustment-cost function, a_2 representing the "proportional control", (a_2-a_3) the "integral control" and a_4, a_5 the "derivative controls". If the adjustment-cost function is quadratic, the higher are a_2 and/or (a_2-a_3) the slower is the error-correction mechanism.

IV. EMPIRICAL ANALYSIS

A. The data

Model [3] was estimated using three different measures of consumption in ***per capita*** terms: "economic" consumption (CE) – defined as the sum of non-durables, services and services from durable goods; consumption of non-durables and services (CND); and aggregate consumption expenditure (C). Estimations were carried out on annual data over the period **1961-85** for eight OECD countries – United States, Japan, Germany, France, United Kingdom, Italy, Canada and Belgium. The real service flow of durables was equated to the depreciation of their beginning-of-period stock, assuming, for simplicity, that their rate of return is on average close to zero[19]. Non-human wealth was defined as the sum of the private sector's stocks of capital and housing (net of discards), the stock of durables and the stock of net foreign assets. With the exception of Italy – for which data refer to the public sector – government debt, the government surplus, government net revenues and government consumption are defined on a general government basis. Government surpluses are the current net savings of the general government sector and net government debt is defined as outstanding liabilities less financial assets[20]. Expectations about income, government consumption and inflation are approximated by the simple average of the annual forecasts published in successive issues of OECD ***Economic Outlook;*** expectations about net taxes are proxied by actual rates of growth[21].

In general, flow data (private and government consumption, income and net taxes), deflators, interest rates and population have been drawn from OECD sources ***(National Accounts,*** Analytical Data Base interest files, ***Labour Force Statistics)*** while stock data (the components of non-human wealth) were collected, when possible, from sectoral balance-sheet accounts or other national sources. In a few cases stock series were partially generated from flows using perpetual inventory methods. A more detailed description of the data and of their sources is contained in Nicoletti (1988).

The countries analysed provide a large spectrum of historical experiences of debt and deficits. Charts A to C provide some evidence on the behaviour of public debts, deficits and private saving over the sample period. Three major tendencies of debts and deficits are apparent:

- First, in all countries, the trend level of government surpluses has been, during the last decade, persistently lower than in the earlier period.
- Second, except for Japan and Germany, where an upward trend of the basic surplus started as early as **1975,** the change in the levels of government net saving and its decreasing trends were due both to smaller basic surpluses and to the effect of debt accumulation on the debt service

component of current transfers. In many countries, by the early 1980s the upward tendency of the debt ratios has become very pronounced and, in some cases (Italy, Belgium, United States and Canada), even explosive (for a more detailed analysis of actual and projected debt dynamics in OECD countries see Chouraqui ***et al.,*** 1986).

- Third, except for Italy and Canada, the net-of-interest government balances have improved in the most recent period, although in most cases not sufficiently to stabilize debt ratios.

These trends suggest that the history of recent years represents an ideal experiment for testing the implications of the fiscal expectations hypothesis and of the Barro model. Government saving has decreased in a persistent way and, in most countries, if governments actually intend to be solvent in the long run, the apparently unsustainable paths of debt accumulation call for budgetary adjustments in the near future (see Chouraqui ***et al.,*** 1986). In this context, the hypothesis of ultrarationality predicts that public dissaving should, at least to some extent, have been offset by increased private saving. On the contrary, traditional life-cycle models predict that private saving should have declined together with government saving, causing the national saving rate to decline even more.

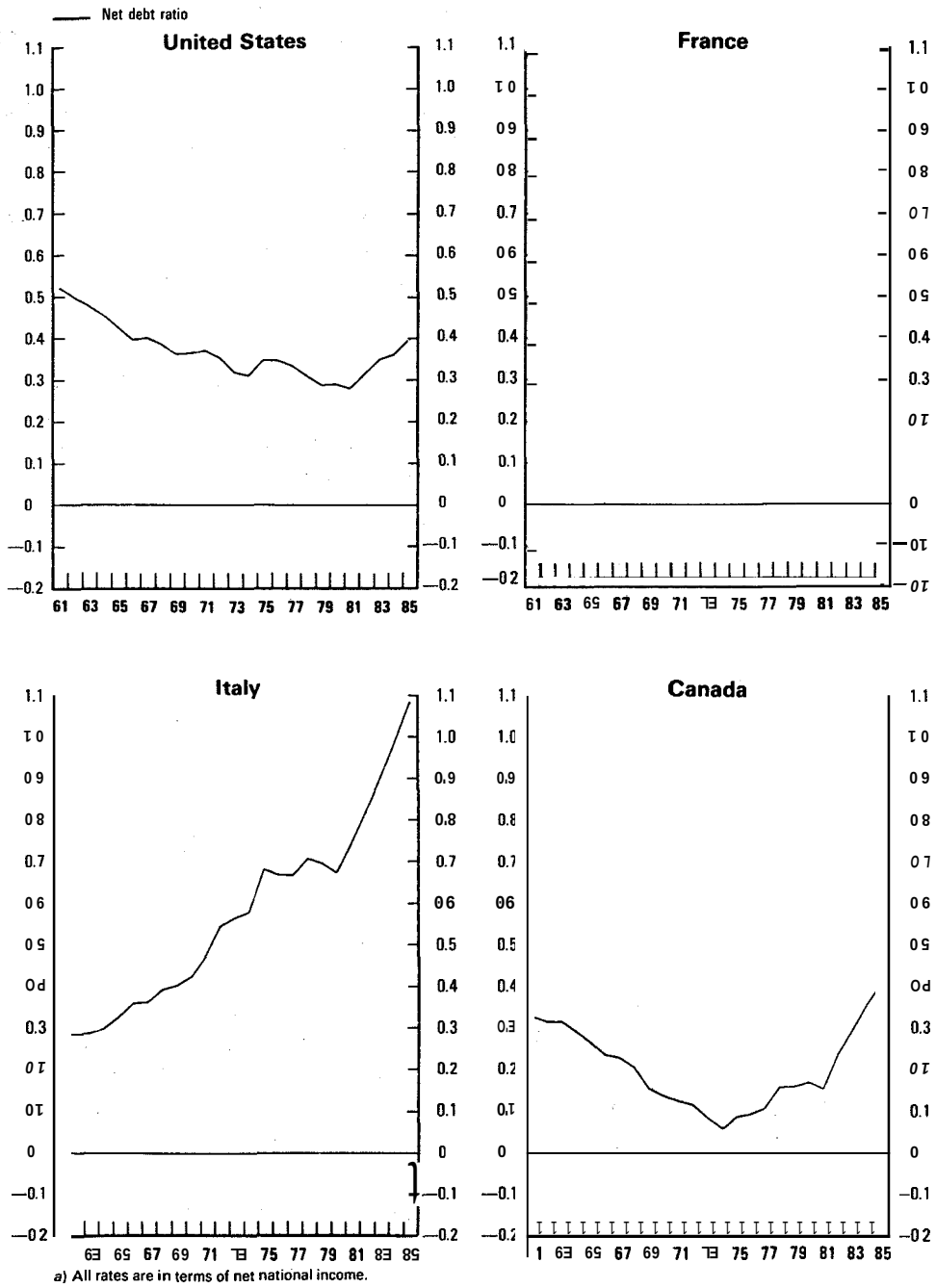
What is the evidence on the comparative behaviour of the saving rates of the government sector, of the private sector and of the nation? Chart C superimposes the time profile of the private and national saving rates (net of the consumption of fixed capital) to that of general government net saving. For illustrative purposes, broken linear trends were fitted to the time series behaviour of sectoral savings.

The evidence provided by these graphs does not lend much support to the ultrarational view. Although in the 1961-73 period, the private saving rate generally behaved consistently with the tax-discounting hypothesis (in all countries, except Canada, its trend was inversely related to the trend of the government surplus), its behaviour in the more recent period is largely inconsistent with the Barro model (save for a larger variability, the personal saving rate displayed the same characteristics as the private saving rate over the sample period). Of course, in the light of the earlier discussion, the 1974-85 period provides a more significant check of the validity of the model, since it is precisely over this period that the budget balance of many governments took on an unsustainable stance. This notwithstanding, except in the United Kingdom and Canada, the private saving rate coupled the downward trend of the government saving with a generally mild trend decline which, ***prima facie,*** contradicts the predictions of the Barro model. In no country was the private saving rate sufficiently sustained to offset the decrease in government saving. As a result, the national saving rate was generally lower in 1985 than in 1970.

Of course this casual evidence on the contemporaneous behaviour of private and public savings need not falsify the fiscal expectations hypothesis or even the Ricardian equivalence proposition. It is logically possible that increased deficits

CHART A

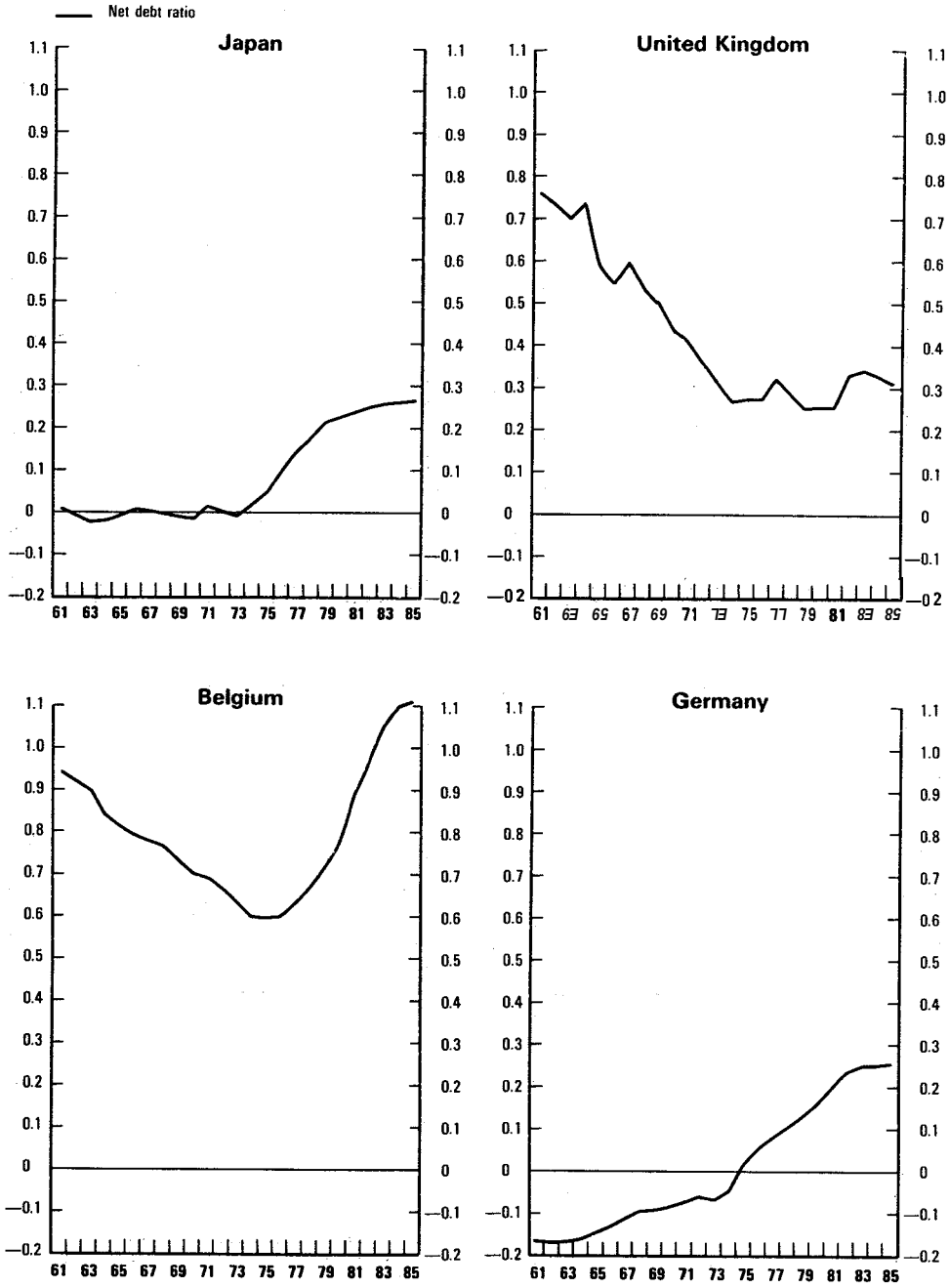
GENERAL GOVERNMENT NET DEBT RATIOS (a)



a) All rates are in terms of net national income.

CHART A (continued)

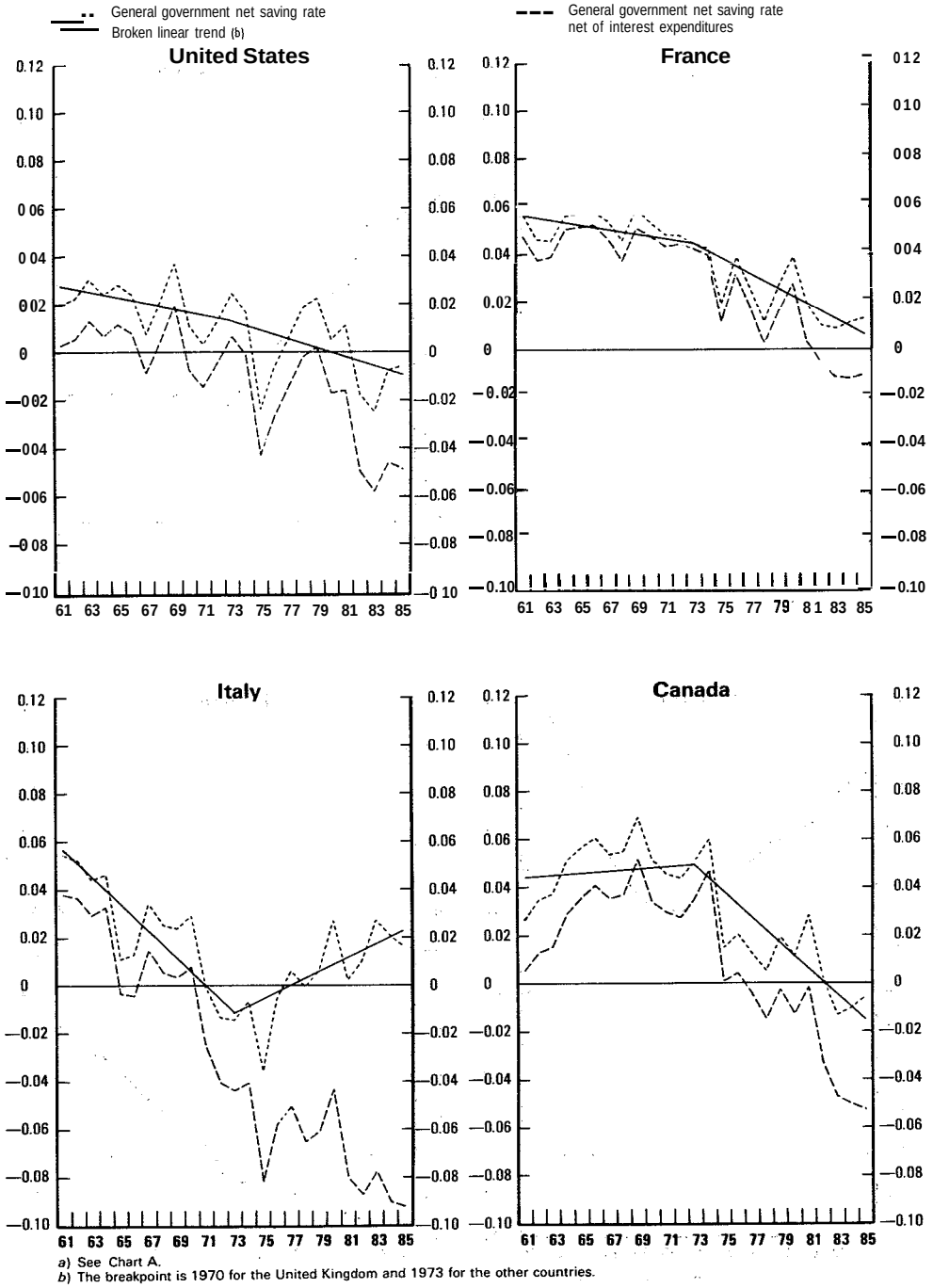
GENERAL GOVERNMENT NET DEBT RATIOS (a)



a) All rates are in terms of net national income.

CHART B

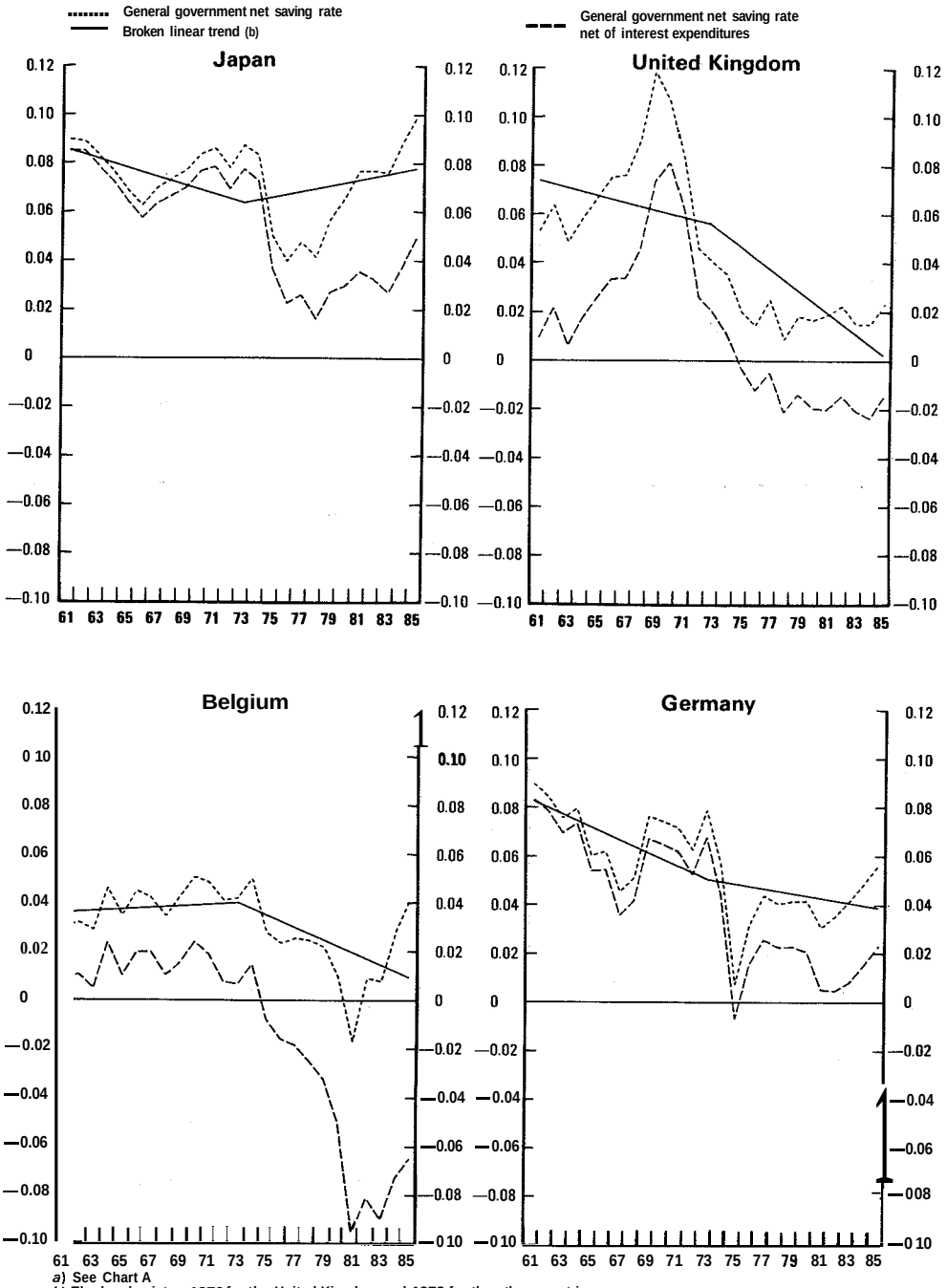
GENERAL GOVERNMENT NET SAVING RATES (a)



a) See Chart A.
b) The breakpoint is 1970 for the United Kingdom and 1973 for the other countries.

CHART B (continued)

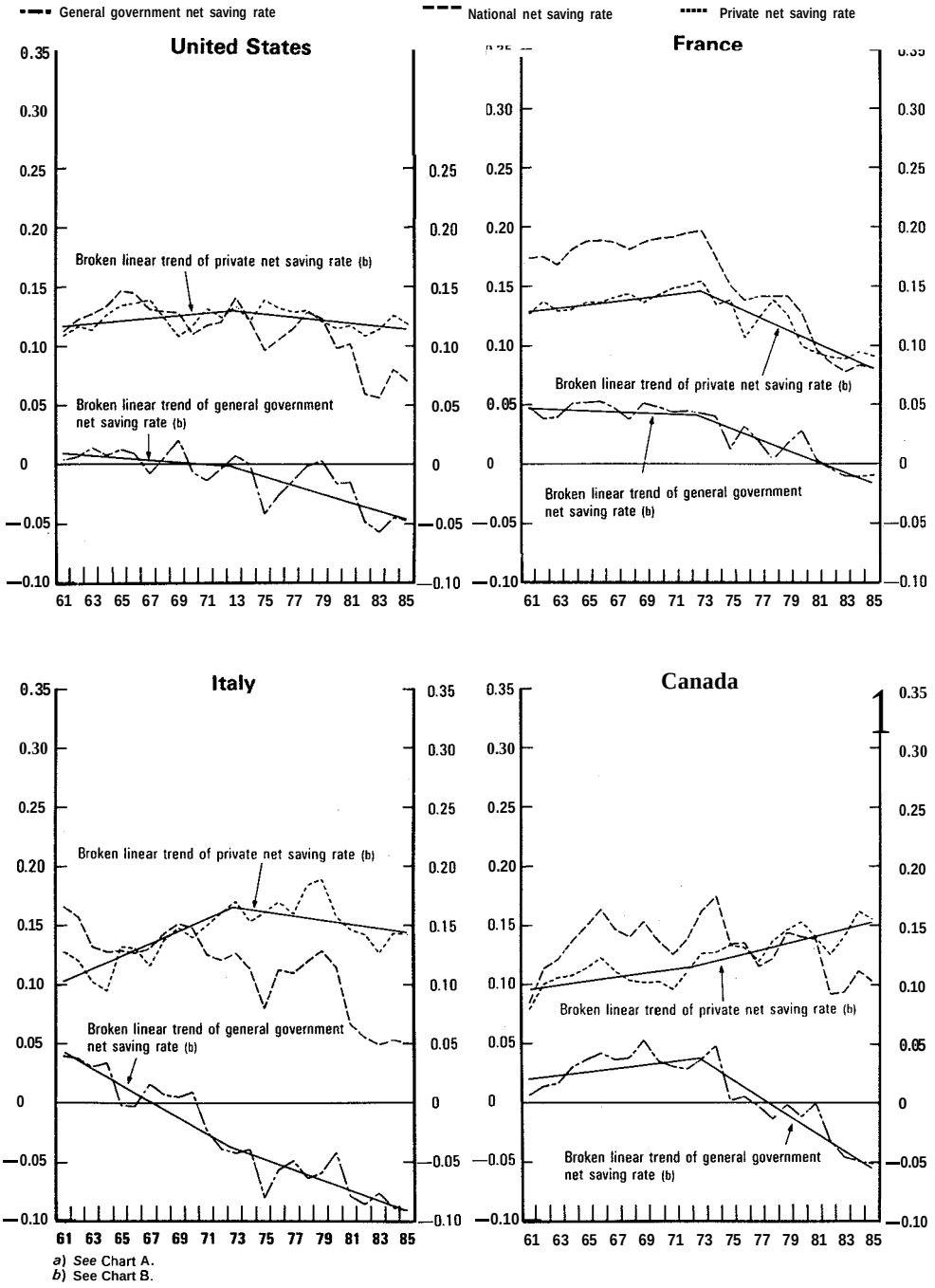
GENERAL GOVERNMENT NET SAVING RATES (a)



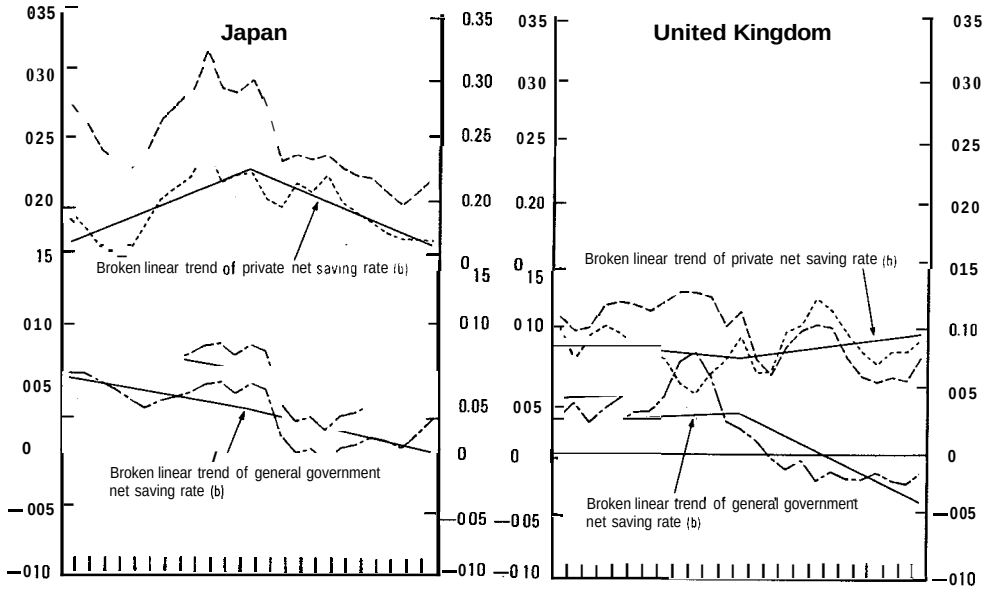
a) See Chart A
b) The breakpoint is 1970 for the United Kingdom and 1973 for the other countries

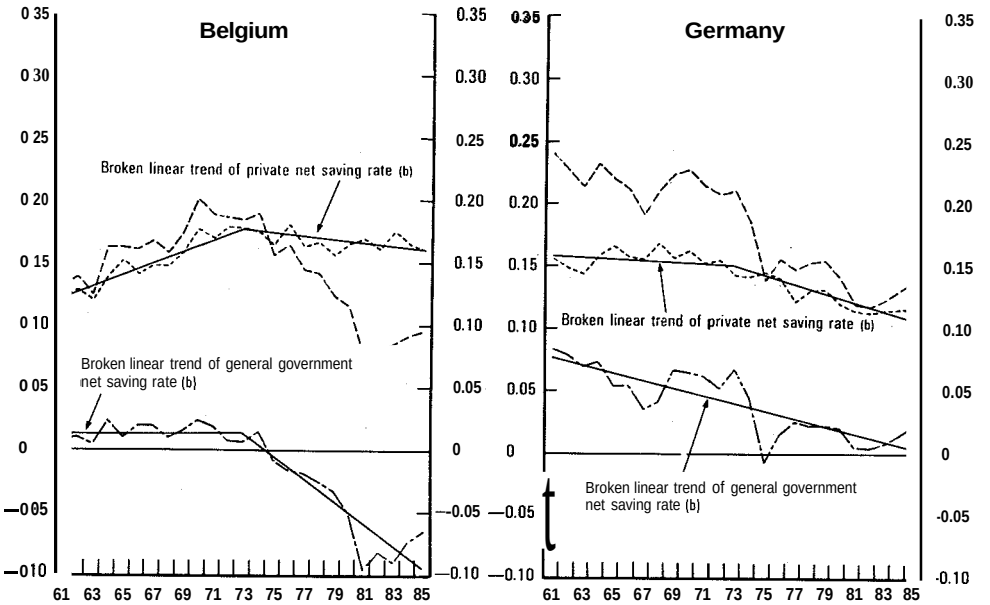
CHART C

SECTORAL AND NATIONAL SAVING RATES (a)



a) See Chart A.
b) See Chart B.





a) See Chart A.
b) See Chart B.

actually raised private savings but that other factors caused private savings to decline, offsetting the Ricardian effect (Poterba and Summers, 1987). Only an econometric analysis which controls for the contemporaneous effect on saving of other variables (as income, wealth, real rates, etc.) can yield additional information on this point.

B. Estimation and tests

Based on model [3], equations for CE, CND and C were estimated on the pooled data set and on single country data. Joint estimates of the parameters a_7 and a_8 were obtained by a "grid search" over twenty-five values in the square [(0,1),(0,1)].

Given the use of scanning procedures, the quantitative magnitudes of the estimates of a_7 and a_8 have a limited meaning perse. Their individual statistical significance cannot be assessed and at times the likelihood surface associated with the regressions is too flat for the results of the scanning to have any statistical reliability. Attemps were made, nonetheless, to extract useful information from the data in two ways. First, *F*-tests of various joint restrictions on a_7 and a_8 were performed under the maintained hypothesis that their "true" values are those resulting from the scanning. These tests are interpreted as checks of the robustness of the scanning results. Second, further discrimination between the model specifications resulting from the restrictions was attempted under the assumption that these specifications are non-nested, i.e. that neither one can be obtained from the other by imposing suitable restrictions on the parameters.

A very simple procedure for comparing non-nested models has been developed by Davidson and MacKinnon (1981). The test designates one specification as the null hypothesis and regresses the dependent variable on this model augmented by the prediction of the alternative model. For linear models (such as the present one, when a_7 and a_8 are restricted to preassigned values), the appropriate test-statistic is Davidson and MacKinnon's J. This is simply the regression t-value associated with the coefficient of the prediction of the alternative model. If this value is larger than the corresponding critical threshold, the null hypothesis is rejected. The intuition behind the test is obvious: a model specification is rejected if the information brought in by the competing specification improves its fit in a significant way. The test can be reversed (reversing the roles of the null and alternative hypotheses) allowing, in principle, to choose a model specification that is never rejected by the data. Of course, it is possible that both hypotheses are rejected in turn or that neither one is rejected. In these cases nothing substantial can be inferred from the test about the "correct" model specification. J-tests are performed in the three limiting cases of the basic model, the Hicks model and the Barro model.

The discussion of the estimates and of the tests ignores the relative price effects, which were never significant, and the direct crowding-out effects of

government consumption, which were insignificant in most regressions. These latter effects are briefly discussed in the next section (the reader interested in more detail is referred to Nicoletti, 1988).

a) Estimates from pooling

Table 1 shows the results of the pooled regressions for CE, CND and C. For each consumption aggregate, Table 1.A shows the estimates of the "preferred" equation (i.e. the equation resulting from the scanning) and Table 1.B the F and J-test statistics. The fit of the model appears quite good. The standard errors and the adjusted R^2s are better than average for a consumption model expressed in *log*

Table 1. **Pooled regressions (1961-85)**[a]

A. Unrestricted estimates[b]

	Number of observations	a_0	a_1	a_2	a_3	a4	a_5	a_7	a_8	SEE	R^2	F
Dependent variable												
CE	120	-0.001 (0.005)	-0.03 (0.038)	0.1067 (0.015)	0.1066 (0.016)	0.399 (0.043)	0.307 (0.031)	1	0.75	0.009	0.67	48.8
CND	168	-0.002 (0.003)	-0.051 (0.03)	0.11 (0.013)	0.11 (0.015)	0.391 (0.035)	0.345 (0.028)	1	0.5	0.009	0.7	78.0
C	192	-0.002 (0.003)	-0.093 (0.032)	0.083 (0.014)	0.08 (0.015)	0.569 (0.038)	0.49 (0.031)	1	0.5	0.011	0.73	102.9

B. Tests of hypotheses

Test	F[c]			J[d]					
Hypothesis H_0	Unrestricted estimate			Basic		Hicks		Barro	
Hypothesis H_1	Basic	Hicks	Barro	Hicks	Barro	Basic	Barro	Basic	Hicks
Dependent variable									
CE	11.6	7.3	1.7	3.0	6.4	-0.08	5.5	2.1	2
CND	18.1	8.7	5.5	3.7	6.2	-0.4	5	3.4	3.4
C	15.7	10.2	13.7	2.8	6	0.3	5.2	5.6	5.5

Key: CE = log change of *per capita* real consumption of non-durables, services and services from durable goods.
CND = log change of *per capita* real consumption of non-durables and services.
C = log change of *per capita* real consumption expenditure.

a) Equations estimated by GLS using the first order autocorrelation correction of Kmenta (1971, pp. 508-12).
b) Obtained by scanning of 25 values of (a_7, a_8) over the square $[(0, 1), (0,1)]$.
c) The 1 per cent, 5 per cent and 10 per cent critical values for the *F*-statistic are 48, 3.1 and 24.
d) The *J*-statistic is asymptotically t-distributed (Davidson and MacKinnon, 19811.

changes and, as expected, economic consumption statistically dominates aggregate consumption expenditure. Coefficients are correctly signed, of acceptable magnitudes and sufficiently stable across equations. A negative and significant real interest rate coefficient is found for CND and C, implying long-run elasticities of −0.01 and −0.05. In the CE equation this coefficient is negative but not significant. The lagged wealth and income variables are both very significant and suggest long-run marginal propensities close to zero for wealth and close to the corresponding average propensities for income. Restriction R2 is satisfied and restrictions R4 and R5 do not seem rejected by the data. Finally, the "nested" definitions of anticipated and unanticipated income growth are always very significant, explaining alone a large part of the time series behaviour of the dependent variable. On the whole, the results suggest that the specification of the model cannot be rejected.

The "grid search" yielded estimates of unity for the inflation-correction parameter (a_7) and estimates ranging from 0.5 to 0.75 for the tax-discounting parameter (a_8). These estimates point out that consumption is only affected by real interest payments on public debt and that the impact of these real transfers is considerably lowered by a strong degree of tax-discounting. The absence of money illusion is consistent with consumer rationality and with the findings of other studies of the Hicksian correction hypothesis. Vice versa, the high estimates obtained for a_8 are in sharp contrast with the generally low degree of tax-discounting detected in previous studies of the ultrarationality hypothesis. The results, however, are quite robust. Except for the preferred CE equation which cannot be distinguished from the Barro model, the *F*-tests reject at high levels of significance the three limiting model specifications. Similarly, the J-tests reject in turn the basic model, the Barro model and the Hicks model (although the latter is preferred over the basic model), suggesting that the "correct" model specification may be at an intermediate level of tax-discounting such as that resulting from the scanning.

This conclusion, however, must be qualified in several respects. In general, the pooling of the data increases the degrees of freedom and, by reducing the multicollinearity between the explanatory variables, improves the efficiency of the estimates, but pooling methods present two dangers: selectivity and heterogeneity bias. The first type of bias, implied by a distorted sample selection, is unlikely to be important in this case, since the international cross-section provides a wide spectrum of national debt and deficits experiences. On the contrary, the heterogeneity of the intercept and slope parameters across countries could affect in important ways the results of the scanning.

The scope for heterogeneity bias was explored by performing a set of standard analysis-of-covariance tests. First, using the results of the preferred equations, the pooled model (i.e. the null hypothesis of homogeneous intercept and slope coefficients) was tested against single-country estimates (i.e. the alternative

hypothesis of heterogeneous intercept and slope coefficients). Then the model with country-specific intercepts was estimated and tested against the single-country equations. Finally, a test of the joint significance of the country-specific intercepts was performed conditional on the homogeneity of the slope coefficients (i.e. the model with the country intercepts was opposed to the pooled model). These tests confirmed the presumption that the hypothesis of parameter homogeneity across countries is inappropriate. The first test rejected the hypothesis of complete homogeneity at very high levels of significance in all equations. The second test strongly rejected the hypothesis that heterogeneity is due to the intercepts alone, suggesting that the intercept dummies are not able to catch in a satisfactory way the differences between countries. Finally, the conditional test was barely able to reject the hypothesis that the country intercepts are jointly equal to zero. In addition, individual estimates of the country-specific intercepts in the dummy-variable model were insignificant in all countries except the United States and Canada, and the coefficients associated with the constant term in the pooled equations were also found to be insignificant. The results of the last two tests and the insignificance of the constant terms indicate that the source of the heterogeneity is mainly among the slope coefficients of the different countries. Therefore in order to obtain more reliable information on the inflation-correction and tax-discounting parameters, it is necessary to analyse the results of the single country equations.

b) Single equation estimates

Tables 2 to 5 report the results of the regressions on a country-by-country basis. As for the pooling estimates, the fit of the model appears quite good. Except in the equation for Japan, which probably suffers from data problems, the model explains a large part of the time-series behaviour of consumption in the different countries, with standard errors ranging from 0.5 per cent (for the United States and France) to 1.2 per cent (for Italy) and adjusted R^2s ranging from 63 per cent (for Belgium) to 86 per cent (for France)[22]. In three out of the five countries for which data on durable services are available (United States, United Kingdom and France), the CE equation dominates the other two (in terms of *SEE* and R^2), the opposite ranking obtained for Italy and, especially, Canada probably pointing out that the proxy for the service flow from durables is inadequate for these countries.

The examination of the coefficients' magnitudes points out that for most countries restrictions R 1 and R 2 are satisfied. Using sample means of consumption, wealth and income, the estimates of a_2 and a_3 imply long-run propensities to consume out of wealth and income ranging respectively from nil to 0.08 and from 0.61 to 0.81. On average, these estimates are respectively lower and higher than, but broadly consistent with, the propensities predicted by Modigliani and Ando (1963) in the case of a stationary economy with a zero real interest rate. An inspection of the ratios between the wealth and income coefficients of the CE

Table 2. **Single country regressions (1961-85)[a]: Japan and France**

A. Unrestricted estimates[b]

	Dependent variable	a_0	a_1	a_2	a_3	a_4	a_5	a_7	a_8	SEE	R^2	DW	F
Japan	C	−0.026 (0.057)	0.139 (0.167)	0.1 (0.134)	0.098 (0.114)	0.746 (0.191)	0.601 (0.123)	0.5	0.25	0.015	0.76	1.9	15.9
	CE	−0.008 (0.044)	−0.208 (0.065)	0.076 (0.058)	0.062 (0.041)	0.386 (0.08)	0.381 (0.077)	0.5	0.5	0.005	0.86	2.4	30.7
France	CND	−0.011 (0.05)	−0.186 (0.068)	0.072 (0.06)	0.058 (0.043)	0.391 (0.083)	0.39 (0.081)	0.5	0.5	0.005	0.84	2.3	26.9
	C	0.02 (0.068)	−0.28 (0.085)	0.012 (0.088)	0.01 (0.061)	0.567 (0.133)	0.371 0.1	0.75	0.75	0.007	0.81	2.5	20.8

B. Tests of hypotheses

Test	F^c				J^d					
Hypothesis	H_0	Unrestricted estimate			Basic		Hicks		Barro	
	H_1	Basic	Hicks	Barro	Hicks	Barro	Basic	Barro	Basic	Hicks
	Dependent variable									
Japan	C	0.4	0.4	1.1	−0.07	1.0	0.1	1.0	1.5	1.5
	CE	1.2	1.2	1.1	−0.05	1.6	0.3	1.6	1.6	1.6
France	CND	1.1	1.2	1.1	0.2	1.5	0.04	1.5	1.6	1.6
	C	1.8	1.9	0.4	−0.03	1.9	0.5	1.9	1.1	1.0

equations and the corresponding coefficients of the CND equations shows also that restriction R5 is likely to be satisfied in most instances (of course this conjecture would have to be confirmed by likelihood ratio tests on the demand system as a whole). In a few cases (the C equation for the United Kingdom and Canada, the CND and the CE equations for Italy and Canada), restriction R2 is not satisfied, implying negative long-run wealth elasticities. While for the United Kingdom and Italy these results are statistically insignificant (it is impossible to reject on the basis of a simple t-test the equality between a_2 and a_3), in the case of Canada the violation of the restriction is statistically significant and persistent across equations, suggesting caution in interpreting the results for this country.

Table 3. Single country regressions (1961-85)[a]: United Kingdom and Germany

A. Unrestricted estimates[b]

	Dependent variable	a_0	a_1	a_2	a3	a4	a_5	a_7	a_8	SEE	R^2	DW	F
United Kingdom[e]	CE	-0.016 (0.033)	0.118 (0.05)	0.179 (0.059)	0.177 (0.052)	0.372 (0.047)	0.35 (0.057)	0	0	0.007	0.77	1.6	14.1
	CND	0.002 (0.041)	0.13 (0.063)	0.125 (0.078)	0.131 (0.069)	0.388 (0.06)	0.337 (0.072)	0.25	0	0.009	0.68	1.2	9.4
	C	-0.002 (0.042)	0.076 (0.068)	0.257 (0.093)	0.269 (0.094)	0.57 (0.0681	0.477 (0.077)	0	0	0.009	0.77	1.6	14.3
Germany	CND	-0.076 (0.058)	-0.35 (0.127)	0.322 (0.137)	0.292 (0.120)	0.304 (0.094)	0.435 (0.083)	0	0	0.008	0.72	1.8	13.1
	C	-0.069 (0.067)	-0.37 (0.147)	0.332 (0.1581	0.308 (0.138)	0.482 (0.108)	0.66 (0.0961	0	0	0.01	0.78	1.8	18.0

B. Tests of hypotheses

Test	F^c				J^d					
Hypothesis	H_0	Unrestricted estimate			Basic		Hicks		Barro	
	H_1	Basic	Hicks	Barro	Hicks	Barro	Basic	Barro	Basic	Hicks
United Kingdom	Dependent variable									
	C	0	0.7	7.3	0.01	0.05	1.1	0.2	3.7	3.5
	CND	0.1	0.01	5.8	0.2	-0.6	0.5	-0.6	3.3	3.3
	C	0	1.5	10.7	-0.5	-0.2	1.7	-0.1	5.8	5.0
Germany	CND	0	0.5	2.5	-2.0	0.2	2.3	0.4	2.3	2.0
	C	0	0.5	4.8	-2.4	0.3	2.7	0.4	3.3	3.0

Key: See Table 1.
a/ See Table 2.
b/ See Table 1.
c/ See Table 2.
d/ See Table 1.
e/ A dummy variable was added to account for the income and tax policies of 1975-76; the coefficient and standard error associated with the dummy in the CT, CND and C equations was 0.02 (0.007).

As to the interest rate effect (a_1), the coefficient estimates show a strong and negative effect in Germany and France (with long-run elasticities of consumption to the expected real rate of interest respectively of –0.03 and –0.01), an insignificant effect in Italy, Belgium and Japan, and a significant and positive effect in the United States, the United Kingdom and Canada. The equilibrium framework in which the model was derived does not suggest *a priori* the sign on this variable, since a_1 combines offsetting income and substitution effects of uncertain rnagnitudes.

Table 4. Single country regressions (1961-85)[a]: United States and Canada

A. Unrestricted estimates[b]

	Dependent variable	a_0	a_1	a_2	a_3	a_4	a_5	a_7	a,	SEE	R^2	DW	F
United States	CE	−0.23 (0.086)	0.32 (0.086)	0.489 (0.122)	0.372 (0.079)	0.542 (0.074)	0.399 (0.049)	1	0.25	0.005	0.78	1.8	17.7
	CND	0.271 (0.93)	0.292 (0.081)	0.547 (0.128)	0.407 (0.083)	0.51 (0.072)	0.413 (0.055)	1	0	0.006	0.76	1.8	16.4
	C	−0.222 (0.095)	0.323 (0.097)	0.747 (0.211)	0.671 (0.174)	0.746 (0.089)	0.595 (0.067)	0.25	0.25	0.007	0.8	1.6	20.2
Canada	CE	0.183 (0.062)	0.363 (0.187)	0.163 (0.061)	0.32 (0.072)	0.444 (0.112)	0.404 (0.093)	0.25	0.25	0.011	0.65	1.9	9.8
	CND	0.217 (0.043)	0.459 (0.131)	0.135 (0.043)	0.317 (0.05)	0.442 (0.078)	0.42 (0.064)	0.75	0.25	0.008	0.82	2.0	22.5
	C	0.178 (0.042)	0.328 (0.131)	0.182 (0.06)	0.334 (0.069)	0.67 (0.077)	0.636 (0.067)	1	0.25	0.008	0.87	1.9	34.0

B. Tests of hypotheses

Test		F^c			J^d					
Hypothesis	H_0	Unrestricted estimate			Basic		Hicks		Barro	
	H_1	Basic	Hicks	Barro	Hicks	Barro	Basic	Barro	Basic	Hicks
	Dependent Variable									
United States	CE	25	0.1	4.2	2.1	1.7	−0.4	1.2	2.4	3.1
	CND	3.1	0	4.9	2.7	1.5	−1.0	0.9	2.3	3.2
	C	1.1	2.4	25	0.9	2.4	1.8	2.4	2.8	2.3
Canada	CE	0.2	0.4	1.6	−0.3	0.8	0.6	0.9	1.9	1.8
	CND	0.6	0.7	3.9	0.02	1.2	0.4	1.2	2.8	2.8
	C	1.7	1.4	6.6	0.8	1.6	−0.4	1.6	3.4	3.5

Key: See Table 1.
a) See Table 1.
b) See Table 1.
c) See Table 2.
d) See Table 1.

Similarly, no definite sign would be expected in an error-correction interpretation of the model. However, Hall's Euler-equation approach, on which much of recent research is based, predicts a positive relationship between the growth of consumption and the real rate of interest. This is of some interest in interpreting the results for the United States, the United Kingdom and Canada since Muellbauer

Table 5. Single country regressions (1961-85)[e]: Italy and Belgium

A. Unrestricted estimates[b]

	Dependent variable	a_0	a_1	a_2	a_3	a_4	a_5	a_7	a_8	SEE	R^2	DW	F
Italy	CE	0.015 (0.056)	0.149 (0.096)	0.136 (0.059)	0.152 (0.044)	0.507 (0.11)	0.331 (0.074)	–	1	0.012	0.76	1.5	16.5
	CND	0.044 (0.049)	0.139 (0.083)	0.096 (0.051)	0.128 (0.038)	0.505 (0.095)	0.392 (0.064)	–	1	0.01	0.82	1.6	22.8
	C	-0.085 (0.06)	0.098 (0.08)	0.38 (0.103)	0.349 (0.081)	0.498 (0.1)	0.427 (0.66)	–	1	0.01	0.85	1.8	27.8
Belgium[e]	CND	−0.058 (0.087)	0.122 (0.139)	0.39 (0.093)	0.39 (0.097)		0.37 (0.096)	1	0.5	0.011	0.63	2.4	11.0
	C	-0.082 (0.084)	0.041 (0.132)	0.387 (0.089)	0.361 (0.093)		0.51 (0.092)	1	0.5	0.011	0.72	2.5	16.5

B. Tests of hypotheses

Test	F^c				J^d					
Hypothesis	H''	Unrestricted estimate			Basic		Hicks		Barro	
	H_1	Basic	Hicks	Barro	Hicks	Barro	Basic	Barro	Basic	Hicks
	Dependent variable									
Italy	CE	6.6	4.4	0	2.7	4.1	-1.9	3.3	-0.9	-0.1
	CND	8.3	6.1	0	2.6	4.4	-2.0	3.7	-1.0	-0.5
	C	10.8	8.4	0	1.6	4.9	-0.5	4.2	-1.1	-0.7
Belgium	CND	5.5	0.7	1.3	3.0	3.8	1.0	1.9	0.08	1.3
	C	5.3	0.9	1.1	3.1	3.6	-1.2	1.9	0.7	1.7

Key: See Table 1.
a/ See Table 1.
b/ See Table 1.
c/ See Table 2.
d/ See Table 1.
e/ No distinction between anticipated and unanticipated income growth.

(1986) has shown that models like [3] can be derived from Euler-equations under the hypothesis of non separable preferences (habits formation)[23].

On the whole, the estimates in Tables 2 to 5 are encouraging. The specification of the model seems in most cases to be supported by the data and, in light of the differing behaviour *vis-à-vis* the real interest rate and the income and wealth variables, the adoption of a flexible functional form seems justified. The results do not favour the rational expectations-permanent income approach. Lagged and anticipated variables always play an important role in predicting consumption. This

suggests that models containing lagged responses (both in the adjustment of stocks and in the formation of expectations) are more appropriate depictions of reality for the countries examined in this study.

Turning now to the evidence concerning the inflation-correction and tax-discounting hypotheses, the results of the scanning and of the tests of hypotheses suggest a subdivision of the countries into three broad groups. In the first group – Japan, Germany, United Kingdom and France – the statistical identification of the inflation-correction and tax-discounting effects (a_7 and a_8) is difficult. This problem is particularly acute for Japan and France (Table 2) in which, notwithstanding the sizeable magnitudes characterizing the estimates of a_7 and a_8, it is impossible to discriminate on the basis of the *F*- and *J*-tests among any of the model specifications nested in equation [3][24]; in the case of Germany and the United Kingdom (Table 3), where the estimates of a_7 and a_8 are nil, the tests cannot discriminate among the basic and Hicks models but decisively reject the Barro model. The second group of countries – the United States and Canada – yields estimates of a_7 close to one and low, but not negligible, estimates of a_8 (Table 4). The tests are more powerful in this case. They reject the Barro model and, in the case of the United States, also the basic model, suggesting full inflation correction and a small degree of tax discounting. In the third group of countries – Italy and Belgium (Table 5) – the joint estimates of a_7 and a_8 are strongly significant and of important magnitudes (both close to unity in Italy and respectively one and 0.5 in Belgium)[25]. The basic model and, in the case of Italy, the Hicks model are decisively rejected by the tests of hypotheses, while the Barro model cannot be rejected. It seems therefore that private sector consumption behaviour is characterised in these countries by the absence of money illusion and a strong degree of tax discounting.

Overall, these results provide considerable support to the Hicksian correction hypothesis while showing that, with the remarkable exceptions of Italy and Belgium, the ultrarationality hypothesis can generally be rejected. In a number of cases, however, the joint estimates of a_7 and a_8 suggest that fiscal expectations could play an important role in determining the behaviour of aggregate consumption. In particular, the inflation-correction and tax-discounting effects appear to be higher and statistically more reliable in countries with a persistent inflationary environment and with an explosive behaviour of debt and deficits. Moreover the estimates of a_7 and a_8 always respect the intuitive ranking according to which the degree of tax-discounting should not exceed the degree of inflation-correction. Indeed, a *priori* reasoning suggests that these effects should be higher in countries that have experienced a long history of inflation and in which the sustainability of public debt and deficits has raised serious concerns. In such situations one would expect agents to anticipate quite correctly the inflation tax levied on the value of their government bond holdings and, possibly, to foresee the chance of a more restrictive fiscal stance in the future. Both these expectations should affect consumption negatively by reducing perceived disposable income and, perhaps, by inducing precautionary

saving. Moreover, one would expect that agents who can recognise the consequences of future budget adjustments on their lifetime resources have an even clearer recognition of the short-run losses due to the inflation tax, implying that the degree of inflation-correction cannot be smaller than the degree of tax-discounting.

Two elements are important for a_7 to be significantly positive, the level of the inflation losses on the outstanding value of public debt and the variability of these losses over time. The table below shows, for the eight countries in the cross-section, the sample means of (expected) inflation and of net debt and inflation losses (both in percentage of national income):

	USA	Japan	Germany	France	United Kingdom	Italy	Canada	Belgium
Inflation %	**5.0**	**5.3**	**3.9**	**6.9**	7.5	**9.6**	5.2	**5.4**
Debt-ratio	0.37	**0.08**	**0.01**	0.15	**0.43**	**0.6**	0.2	**0.8**
Inflation losses	**0.015**	**0.003**	**-0.001**	**0.009**	0.025	**0.049**	**0.008**	0.04

With the exception of the United Kingdom, in countries where expected inflation and/or the debt ratio (and hence inflation losses) were relatively high over the sample period – Belgium, Italy and the United States – inflation correction is clearly supported by the data. This confirms the presumption, consistent with basic economic reasoning, that agents perceive correctly the inflation tax levied by the government. On the contrary, in Germany and Japan, where inflation losses have been quite low, the data are unable to support any significant inflation correction. This of course does not mean that in these countries money illusion prevails, but simply that aggregate data are uninformative in this respect. In fact, at least for Germany, evidence from the personal sector behaviour suggests that inflation losses on this sector's liquid asset holdings are perceived quite correctly by agents.

In other countries such as Canada, France and, especially, the United Kingdom, differences in the estimates of a_7 are more difficult to interpret. The higher and more reliable estimate of a_7 obtained for Canada relative to France can partly be explained by the differences between the variability of inflation losses in these countries over the sample period (the coefficient of variation of inflation losses relative to that of national income was 0.58 in Canada and 0.41 in France, the lowest among the eight countries).

In the United Kingdom, inflation levels, debt ratios and inflation losses were among the highest during the sample period. However, definite inflation-correction effects could not be detected. Earlier studies found evidence of full inflation-correction of liquid asset stocks by the personal sector in the United Kingdom. The estimates in this paper contradict both these findings and the tentative taxonomy suggested above. It seems therefore that more work is needed on the equation for the United Kingdom before assessing the scope for inflation-correction of disposable income in this country.

With regard to the tax-discounting issue, the indications delivered by the data are more clearcut. Estimates of a_8 tend to be sizeable and statistically sound only for Italy and Belgium. In the case of Italy it is even impossible to reject the "pure" Barro model on the basis of the tests. In these countries, the recent history of debt and deficits is characterised by unprecedented peace-time levels of the debt ratios, steep downward trends of the government balances and widening gaps between the net and gross-of-interest budget deficits. To a lesser extent, some of these features are present for the United States and Canada as well. However, estimates of a_8 for these countries are much less precise and of a smaller magnitude. One is tempted to relate the difference in the estimates to the relatively lower debt and deficit ratios in the last two countries. If this were true the tax-discounting effect would depend both on the dynamics and on the levels of debt and deficits[26]. Unsurprisingly, in countries as France and the United Kingdom where debt problems are perceived by many observers as being less urgent, and Japan and Germany, where the debt outlook is relatively less dramatic, no tax-discounting effects could be detected.

c) Effects of government consumption

As noted earlier, in general when the rate of growth of government consumption is added to the explanatory variables, this variable is insignificant and its introduction does not affect in any appreciable way either the results of the scanning or the other coefficient estimates. In only two cases is a_6 significant: in the C equation for the United States, with a negative sign, and in the CND equation for Germany, with a positive sign. The positive coefficient for Germany implies a long-run elasticity of consumption of 0.75, which is too high to be ascribed to the complementarity between public and private consumption. This estimate probably reflects also spurious elements linked to the distributional effects of government transfers.

For the United States, the government consumption coefficient is consistently negative across the three consumption equations. The estimates of the short-run semi-elasticity of the various consumption measures to government consumption are -0.16 for CND, -0.24 for CE and -0.5 for C. These coefficient magnitudes are coherent with earlier findings yielding estimates of the direct substitution effect ranging between -0.2 and -0.4 (see, for estimates based on CE, Kormendi, 1983; for estimates based on CND, Aschauer, 1985; and for estimates based on C, Seater and Mariano, 1985). In addition the results suggest that, in the United States, this direct crowding-out effect mainly operates through the consumption of durables.

The government consumption coefficients are negative, although insignificantly *so,* in a number of other cases but, apart from the United States, there is very little evidence of a crowding-out effect operating through this channel. As for the

interaction between a_6 and a_8, there is some evidence that, as suggested earlier, the omission of the government consumption variable can affect the estimates of the tax-discounting parameter. This is probably true in the United States where the estimate of a_8 drops from 0.25 to zero when this variable is added to the regressions. In general, however, the bias due to the omission of government consumption seems to be negligible.

The inability to detect a sizeable crowding-out (or crowding-in) effect of government consumption suggests that further investigations of this issue should replace this variable by narrower aggregates reflecting a closer relationship with particular components of private consumption.

SUMMARY AND CONCLUSIONS

The "ultrarationality" hypothesis states that, because economic agents correctly perceive the current and future constraints faced by the public sector, increases in government deficit financing reduce the stimulus to private consumption implied by tax cuts. In its most extreme formulation, which we called the Barro model, this hypothesis implies that government debt has no impact at all on private consumption and that government deficits are exactly offset by increased private savings. While there are strong theoretical and empirical reasons for rejecting this extreme view of agents' rationality, it would be inconsistent with basic economic thinking to assume that the private sector is completely unaware of the constraints that bind government actions, especially in periods of rising concern about the sustainability of public debt and deficits.

A joint assessment of the quantitative estimates of the inflation correction and tax-discounting effects and of the results of the tests suggests several interesting considerations:

a) The hypothesis that agents correctly perceive the inflation tax levied by the government cannot be rejected either at the single-country level or in the pooling. Indeed, in at least half of the countries considered in this study, as well as in the pooling, the hypothesis is supported by the data. Countries with relatively high average levels of the inflation rate and of the debt ratio – as Belgium, Italy, the United States and Canada – yield estimates of the inflation-correction parameter close to unity and reject the basic model at conventional significance levels when it is opposed *to* the Hicks model. In the remaining countries, it is impossible to distinguish between the two model specifications on the basis of our tests. For Japan and Germany, this can be attributed to the relatively low and stable levels of the inflation tax over the sample period. For France and especially for

the United Kingdom, this result is puzzling and remains to be explained. On the whole, there is evidence that disposable income as commonly defined in most econometric models of consumption (i.e. gross of the inflation-premium component of the interest transfers) performs at best as well as and often worse than our measure of inflation-adjusted income. The absence of this kind of money-illusion of agents is consistent with the basic rationality hypotheses concerning consumer behaviour in an inflationary environment.

b) With the remarkable exceptions of Italy and Belgium, the full tax-discounting hypothesis does not receive much support from the data. In the majority of the countries, as well as in the pooling, the Barro model is strongly rejected when it is opposed to the basic and Hicks models and to the equations resulting from the scanning. Moreover, most single-country estimates of the tax-discounting parameter are close to zero. This overwhelming rejection of the pure Barro model should not obscure the fact that for half of the countries – the United States, Canada, Italy and Belgium – the estimates of the tax-discounting parameter are non-zero, taking sizeable and statistically significant magnitudes in the case of Italy, Belgium and in the pooling. These countries display striking common features. Canada and the United States, which provided estimates close to 0.25, and Belgium and Italy, which provided estimates of respectively 0.5 and 1, all share fiscal stances that are deemed to be unsustainable by most analysts. Moreover, the last two countries, for which it was impossible to reject the Barro model, have reached unprecedented peace-time debt ratios and display explosive debt dynamics.

The results on tax discounting pose two related problems, one of interpretation and the other of policy. As to the first, the data clearly show a relationship between the perceived urgency of the budget adjustments and the saving behaviour of agents. Should one conclude that this is evidence in favour of the Barro model and of the tax-discounting hypothesis? As already mentioned, this hypothesis establishes a mechanical relationship between the intertemporal budget constraint of the government and the lifetime resources of dynastic agents by stating that ***sooner or later*** taxes will have to be levied in order to satisfy the government budget constraint. By ignoring the ***timing*** of taxation, the implications of this hypothesis are valid only in extremely unrealistic situations. In particular it relies heavily on the absence of non-neutral taxation and of liquidity constraints and on the existence of important private intergenerational transfers. In addition it implies that offsetting private savings should be observed whenever persistent deficit financing is employed, irrespectively of the levels of debt and deficits and of their implied dynamics. The results presented in this paper contradict both these features of the tax-discounting hypothesis.

On the one hand, the countries yielding sizeable estimates of the tax-discounting parameter can hardly be characterized as having perfect capital markets. There is substantial evidence, for instance, that in Italy, but also in the United States, liquidity constraints affect large sectors of the population (see, for the United States, the recent study by Hubbard and Judd, **1986;** and, for Italy, a similar study by Jappelli and Pagano, **1987).** Similarly, taxation has important distortionary effects in all countries and, in some cases (as in Italy with the recent taxation of the interest from Treasury Bills) distortionary taxes are directly designed to slow down the explosive dynamics of the debt. On the other hand, instead of supporting the tax-discounting hypothesis in all cases of prolonged deficit financing, the results establish a pattern in which only the countries where budget restrictions appear likely in the near future display a negative effect of deficits on consumption.

Rather than supporting the tax-discounting hypothesis per se, this evidence suggests that agents may interiorize a policy reaction function of the fiscal authorities in periods in which the sustainability of the fiscal stance is questioned both by the government and in the press. This behaviour, which can lead to increased precautionary savings, is independent of the restrictive assumptions of the Barro Model but is broadly consistent with the rational expectations approach to the analysis of the effects of economic policy. Indeed it is surprising that, while a lot of attention has been paid to the implications of this approach for the effects of monetary policy, virtually no studies exist that assume the knowledge by agents of the policy rule of the fiscal authorities. The results of the present study, despite their limitations, provide some evidence that such an analysis could be motivated on empirical grounds.

If the interpretation of the evidence attempted above is correct, its policy implications differ substantially from those of the Barro model. Far from being neutral, debt accumulation induces precautionary savings precisely when it surpasses the threshold beyond which its consequences on the economy (in terms of high real interest rates, unwanted redistribution of income, current account deficits, etc.) are felt to be unsustainable. These additional private savings are unable to compensate fully for the dissavings of the government since in "normal" times debt and deficits have the traditional wealth and income effects on consumption and, even if at the margin new debt were fully offset, the problems created by the earlier accumulation of government liabilities will remain.

NOTES

1. Apparently, the only cross-country analyses of the tax-discounting hypothesis are in Koskela and Virèn (1983), Kessler *et* al. (1986) and Bernheim (1987).
2. Miller and Upton (1974). Buiter (1977) and Barro (1984) have developed this approach. An early investigation of its empirical implications is in David and Scadding (1974).
3. Carmichael (1982) showed that the absence of replacement effects in private agents' portfolios implies that government debt policies are neutral even when they do not require future compensating taxation, as in the case of a long-run interest rate smaller than the growth rate of the economy.
4. Ricardo was the first to remark that, in a world in which the private and public sector are consolidated and agents have perfect foresight, no "fiscal illusion" can exist. However he rejected this depiction of the economy as of no empirical relevance (O'Driscoll, 1977).
5. When the level of bequests rather than the welfare levels of each generation's offspring appears in individual utility functions, public intergenerational transfers cannot be offset by agents without altering the optimal path of consumption. If agents' lifetimes are uncertain and annuities markets are imperfect, Barro's results break down (Blanchard, 1985). To what extent capital market imperfections affect Barro's neutrality results is not yet clear: Hayashi (1985) and Yotsuzuka (1986) show that the neutrality result can still be valid when liquidity constraints are endogenous; Bernheim (1987) questions the relevance of such examples. Finally, although in general the "Ricardian" financing regime excludes income taxation and monetisation, the equivalence proposition can still hold if income taxes do not affect private choices or if the rate of monetisation remains unchanged over time.
6. This assumption rules out the possibility that the government can borrow in real terms at a rate which is permanently higher than the real rate of return on government bonds.
7. Some authors include estimates of social security wealth as an additional regressor in the consumption equation. Conceptually, this variable is to be treated as government debt: in a fully-funded social security system, agents will view social security taxes and benefits as neutral transfers; in an unfunded system they will discount the future liabilities associated with the stream of social security benefits, implying that social security wealth is excluded from private health in the Barro model.
8. Modigliani and Sterling (1986) and Leiderman and Razin (1986) tested more general consumption functions, allowing for a varying life horizon and capital market imperfections. For a survey of the literature, see Bernheim (1987) and Nicoletti (1988).
9. Time aggregation can aggravate the endogeneity problem. For instance, if the dependent and independent variables are annual averages, low order lags of the regressors may be correlated with the error term (Hall, 1985). An additional source of mismeasurement of debt is its valuation procedure. Seater (1985) shows for the United States that the measurement errors implied by inflation and market value adjustments can be very large. Another likely

candidate for mismeasurement is social security wealth, a variable whose lack of significance is used by many authors as evidence in favour of the Barro model.

10. The differential approach yields a flexible functional form that is a first order approximation in the parameter space instead of the space of variables.

11. The random walk model (Hall, 1978), combined with the rational expectations hypothesis, asserts that only past consumption levels, current relative prices and unexpected changes in wealth are useful to predict current consumption. The error-correction model (Davidson, Hendry et al., 1978) assumes that agents adjust slowly toward a desired consumption-to-wealth ratio and attributes an important role to lagged and anticipated wealth and income in the determination of consumption. Flexible functional forms have been very rarely used in time-series analysis of consumption. Diewert (1974) estimated an intertemporal translog consumption function; while, only recently, Rossi (1986) and Attfield and Browning (1985) used the differential approach to study consumption behaviour over time.

12. A detailed derivation of equation [1] is available from the author on request.

13. In a setting with only one good and no government consumption, Rossi and Schiantarelli (1985) show that the joint assumptions of homotheticity, rational expectations and a constant real interest rate reduce equation [1] to the consumption function estimated by Hall (1978).

14. Of course the equation for $\hat{c}^E$ could be substituted by an equation in terms of the services from durables, $\hat{c}^D_t$, the coefficients of the equation for $c^D(b_t^D)$ being related to the coefficients of the equations for $c^E(b_t^E)$ and for the consumption of non-durables $c^N(b_t^N)$ in the following way:

$$b_t^D = b_t^E + (b_t^E - b_t^N)(c^N/c^D)$$

15. Defining the discount factor,

$$P_{t+i} = 1 / \Pi_{s=1}^{i} (1 + r_{t+s}) \text{ for } i \geq 1$$
$$= 1 \text{ for } i = 0$$

and imposing the boundary condition,

$$\lim_{t \to T} (w_t + b_t)\, \rho_t = 0$$

y^T and τ^T can be defined as follows for $T \leq \infty$:

$$y_t^T = \Sigma_{i=0}^{T-t}\ y_{t+i}\ \rho_{t+r}$$
$$\tau_t^T = \Sigma_{i=0}^{T-t}\ \tau_{t+i}\ \rho_{t+i}$$

Similarly, by imposing the intertemporal solvency constraint,

$$\lim_{t \to TG} (w_t + b_t)\, \rho_t = 0$$

g^{TG} and τ^{TG} can be defined as follows for $TG \leq \infty$:

$$g_t^{TG} = \Sigma_{i=0}^{TG}\ g_{t+i}\ \rho_{t+i}$$
$$\tau_t^{TG} = \Sigma_{r=0}^{JG}\ \tau_{t+1}\ \rho_{t+i}$$

16. In this case, the solvency constraint does not imply that the growth of debt is bounded or that there exists a finite stationary value for b. As shown by McCallum (1984) in the context of a general equilibrium model, the constraint can be satisfied even if b grows indefinitely, provided that its growth rate is less than the real interest rate.

17. The decomposition of Q_{t-1} is obtained using the following approximation formula (Gandolfo, 1981, pp. 98-9):

$$\log(x+y) = \log(e^{\log x} + e^{\log y})$$
$$= (\log(x^o + y^o) + (1/(x^o + y^o))(x^o(\log x/x^o)) + y^o(\log y/y^o))$$

where x^o and y^o are initial conditions.

18. Labelling the steady state rates of growth of income and government consumption respectively n and λ, the long-run expression for **[3]** is:

$$c = \exp((a_0/a_2) + (a_1/a_2)\, r + ((a_4 - 1)/a_2)\, n + (a_6/a_2)\, \lambda) \cdot w^{*} \cdot (a_2 - a_3)/a_2 \cdot y^{d*} \cdot a_3/a_2$$

19. This assumption implies that National Accounts disposable income need not be modified. Net stock series for durable goods in the 1961-85 period were found only for the United States, France, the United Kingdom, Italy and Canada. Due to the lack of data estimations for Germany and Belgium, only concerned CND and C and estimations for Japan were limited to C.

20. A net worth approach would have been more consistent with the spirit of the hypotheses being tested. However, this approach raises formidable conceptual and measurement problems which are beyond the scope of this study. For a discussion of these problems and some estimates of government net worth, see Chouraqui ***et al.*** (1986).

21. Due to missing data all expected variables were equated to actual realisations in the case of Belgium; for the other countries, inflation expectations were equated to actual values from 1961 to 1965.

22. For the United States, the model performs better than most of the models used in earlier studies of the tax-discounting hypothesis. See, for instance, among the studies using the *log*-changes specification, Blinder and Deaton (1986), Kormendi (1983) and Modigliani and Sterling (1986).

23. The empirical evidence based on Euler-equation models is mixed. Hansen and Singleton (1983), Summers (1984), Mankiw (1981) and Wickens and Molana (1983) all find positive and significant estimates of the interest rate effect. In criticizing these studies, Hall (1985) attributes these results to simultaneity bias. He presents instrumental variable estimates showing an insignificant or negative real rate effect. Deaton (1986) questions, on the basis of aggregation problems, the existence of a stable relationship between consumption and the real rate in Euler-equation models. Finally, Attfield and Browning (1985) find a positive relationship between consumption growth and the real rate of interest in a differential demand system. Independently of the interpretation of model [3], the coefficients on aggregate consumption and economic consumption would be expected to be lower than that on the consumption of non-durables, since there are both empirical and theoretical reasons to believe that the expenditure on durables and the consumption of durable services are negatively affected by the real interest rate (Mankiw, 1985). Using the relation between the estimated c^E and c^N coefficients and the coefficients of c^D given in Note 14, one can actually derive negative real interest rate effects on the consumption of services from durables for the United Kingdom and Canada. The same, however, cannot be obtained for the United States.

24. Estimates for France suggest a very high collinearity between the explanatory variables at values of of a_8 different from zero. Although the likelihood surface is flat with respect to a_7 and a_8, the magnitude and the significance of the crucial coefficients a_2 and a_3 are very sensitive to changes in the tax discounting parameter. The basic and Hicks specifications, whose fit is virtually undistinguishable from that of the unrestricted estimate, yield the following estimates of a_2 and a_3:

	Basic			Hicks		
	CE	CND	C	CE	CND	C
a_2	0.16	0.16	0.22	0.15	0.15	0.19
	(0.065)	(0.07)	(0.11)	(0.062)	(0.066)	(0.095)
a_3	0.14	0.13	0.18	0.13	0.12	0.16
	(0.053)	(0.054)	(0.082)	(0.05)	(0.05)	(0.075)

BIBLIOGRAPHY

Aschauer, D.A. (1985), "Fiscal policy and aggregate demand", *American Economic Review* (March), pp. 117-27.

Attfield, C.L.F. and M.J. Browning (1985), "A differential demand system, rational expectations and the life-cycle hypothesis", *Econometrica,* Vol. 53, No. 1 (January), pp. 31-48.

Bailey, M. (1962), *National Income and the Price Level,* New York: McGraw Hill.

Barnett, W.A. (1979), "Theoretical foundations for the Rotterdam model", *The Review of Economic Studies,* pp. 109-30.

Barro, R. (1974), "Are government bonds net wealth?", *Journal of Political Economy,* Vol. 82, No. 6 (November/December), pp. 1095-117.

Barro, R. (1984), *Macroeconomics,* Wiley.

Becker, *G.* (1974). "A theory of social interactions", *Journal of Political Economy,* Vol. 82, No. 6 (November/December), pp. 1063-93.

Bernheim, B.D. (1987), "Ricardian equivalence: an evaluation of theory and evidence", *NBER Working Paper No. 2330* (July).

Blanchard, O. (1985), "Debt, deficits and finite horizons", *Journal of Political Economy,* Vol. 93 (April), pp. 223-47.

Blinder, A. and A. Deaton (1986). "The time series consumption function revisited", *Brookings Papers on Economic Activity,* No. 1, pp. 465-511.

Buiter, W. (1977), "Crowding out and the effectivenss of fiscal policy", *Journal of Public Economics,* Vol. 7 (June), pp. 309-28.

Carmichael, J. (1982). "On Barro's theorem of debt neutrality: the irrelevance of net wealth", *American Economic Review,* Vol. 71 (March), pp. 202-13.

Chouraqui, J.C., B. Jones and R.B. Montador (1986), "Public debt in a medium-term perspective", *OECD Economic Studies,* No. 7 (Autumn).

David, P.A. and J.L. Scadding (1974), "Private savings: ultrarationality, aggregation and Denison's law", *Journal of Political Economy,* Vol. 82 I (March/April), 225-49.

Davidson, J.E.H., D.F. Hendry, F. Srba and S. Yeo (1978), "Econometric modelling of the aggregate time-series relationship between consumers' expenditure and income in the U.K.", *The Economic Journal,* Vol. 88 (December), 661-92.

Davidson, R. and J.G. MacKinnon (1981), "Several tests for model specification in the presence of alternative hypotheses", *Econometrica,* Vol. 49, No. 3, 781-93.

Deaton, A. (1986), "Life-cycle models of consumption: is the evidence consistent with the theory?", *NBER Working Paper No. 1910* (April).

Diewert, W.E. (1974), "Intertemporal consumer theory and the demand for durables", *Econometrica,* Vol. 42, No. 3 (May).

Feldstein, M. (1982), "Government deficits and aggregate demand", Journal of Monetary Economics, Vol. 9, pp. 1-20.

Gandolfo, G. (1981), Qualitative Analysis and Econometric Estimation of Continuous Time Dynamic Models, Amsterdam, North Holland, pp. 98-9.

Hall, R.E. (1978), "Stochastic implications of the life cycle-permanent income hypothesis: theory and evidence", Journal of Political Economy, Vol. 86, pp. 971-87.

Hall, R.E. (1985), "Real interest and consumption", NBER Working Paper No. 1694 (August).

Hansen, L.P. and K. Singleton (1983), "Stochastic consumption, risk aversion, and the temporal behavior of asset returns", Journal of Political Economy, Vol. 91 (March), pp. 249-65.

Hayashi, F. (1985), "Tests for liquidity constraints: a critical survey", NBER Working Paper No. 1720 (October).

Hendry, D.F. and T. Von Ungern-Sternberg (1981), "Liquidity and inflation effects on consumers' behavior" in A. Deaton (ed.), Essays in the Theory and Measurement of Consumers' Behaviour, Cambridge University Press.

Hubbard, R.G. and K.L. Judd (1986), "Liquidity constraints, fiscal policy and consumption", Brookings Papers on Economic Acitivity, No. 1, pp. 1-50.

Jappelli, T. and M. Pagano (1987), "Liquidity constraints and capital market imperfections: an international comparison", Working Paper Consiglio Nazionale delle Ricerche (June), Progetto Finalizzato Economia, Rome.

Jump, G.V. (1980), "Interest rate, inflation expectations, and spurious elements in measured real income and saving", American Economic Review, Vol. 70, No. 5, 990-1004.

Kessler, D., S. Perelman and P. Pestieau (1986), "L'hypothèse d'équivalence entre impôt et emprunt: un test sur les pays de l'OCDE", Annales d'économie et de statistique, No. 3 (juillet/septembre), pp. 141-9.

Kmenta, J. (1971), Elements of Econometrics, McMillan, New York.

Kormendi, R.C. (1983), "Government debt, government spending and private sector behavior", American Economic Review, Vol. 73, pp. 994-1010.

Koskela, E. and M. Virèn (1983), "National debt neutrality: some international evidence", Kyklos, Vol. 36, No. 4, pp. 575-88.

Lecaldano Sasso La Terza, E., G. Marotta and R. Masera (1984), "Consumo, risparmio e tasso d'interesse: la correzione per l'inflazione", in Moneta ed Economia Nazionale, Cassa di Risparmio di Torino.

Leiderman, L. and A. Razin (1987), "Testing Ricardian neutrality with an intertemporal stochastic model", NBER Working Paper No. 2258 (May).

Mankiw, G.N. (1981). "The permanent income hypothesis and the real interest rate", Economics Letters, Vol. 7, pp. 307-11.

Mankiw, G.N. (1985), "Consumer durables and the real interest rate", Review of Economics and Statistics, Vol. LXVII, No. 3 (August), pp.353-62.

Marotta, G. (1983), "Un'indagine econometrica sui consumi privati in Italia (7102-8004)", in Ricerche sui modelli per la politica economica, Vol. I, Rome, Bank of Italy.

Marotta, G. (1984), "Un'indagine econometrica sui consumi nazionali (7201-8104)". in Ricerche quantitative per la politica economica, Vol. II, Rome, Bank of Italy.

McCallum, B. (1984), "Are bond financed deficits inflationary? A Ricardian analysis", Journal of Political Economy, Vol. 92 (February), pp. 123-35.

Miller, M. and C. Upton (1974), ***Macroeconomics: A Neoclassical Introduction,*** Homewood, Illinois.

Modigliani, F. (1961), "Long run implications of alternative fiscal policies and the burden of the national debt", ***The Economic Journal,*** Vol. 71 (December), pp. 207-10.

Modigliani, F. (1986), "Life-cycle, individual thrift and the wealth of nations", ***American Economic Review,*** Vol. 76, No. 3, 297-313.

Modigliani, F. and A, Ando (1963). "The 'life-cycle' hypothesis of saving: aggregate implications and tests", ***American Economic Review,*** Vol. 53 (March), pp. 55-83.

Modigliani, F. and A. Sterling (1986), "Government debt, government spending and private sector behavior: comment", ***American Economic Review,*** Vol. 76 (December), pp. 1168-79.

Modigliani, F. and T. Jappelli (1986). "Fiscal policy and saving in Italy since 1860", paper presented at the ***International Conference on "Private Saving and Public Debt,*** Alghero.

Modigliani, F., T. Jappelli and M. Pagano (1985), "L'impatto della politica fiscale e dell'inflazione sul risparmio nazionale: il caso italiano", ***Moneta e Credito,*** pp. 123-62.

Muellbauer, J. (1986), "Habits, rationality and myopia in the life-cycle consumption function", ***CEPR Discussion Paper No. 112*** (June).

Nicoletti, G. (1988), "Private consumption, inflation and the 'debt neutrality hypothesis': the case of eight OECD countries", ***OECD Department of Economics and Statistics Working Paper,*** No. 50 (January).

O'Driscoll, G.P. Jr. (1977), "The Ricardian nonequivalence theorem", ***Journal of Political Economy,*** Vol. 85, No. 1 (February), pp. 208-9.

Onofri, P. (1988), "Analisi empirica delle relazioni tra consumo e debito pubblico in Italia (1970-84)", in ***La Spirale del debito pubblico,*** A. Graziani (ed.), Bologna: Il Mulino.

Pesaran, M.H. and R.A. Evans (1984), "Inflation, capital gains and U.K. personal savings: 1953-1981", ***The Economic Journal,*** Vol. 94 (June), 237-57.

Poole, W. (1972), "The role of interest rates and inflation in the consumption function", ***Brookings Papers*** on ***Economic Activity,*** No. 1, pp. 211-19.

Poterba, J.M. and L.H. Summers (1987), "Recent U.S. evidence on budget deficits and national savings", ***NBER Working Paper No. 2744*** (February).

Rossi, N. (1986), "Spesa pubblica, tasso d'interesse reale e risparmio delle famiglie", Working Paper ***Consiglio Nazionale delle Ricerche,*** Progetto Finalizzato Economia.

Rossi, N. and F. Schiantarelli (1988), "Error-correction, 'surprise' models and the differential approach to the consumption function", ***Metroeconomica*** (forthcoming).

Rossi, N. and F. Schiantarelli (1982). "Modelling consumer expenditure in Italy 1965-77", ***European Economic Review,*** Vol. 17, No. 3 (March), pp. 371-91.

Seater, J.J. (1985), "Does government debt matter? A review", ***Journal of Monetary Economics,*** Vol. 16, No. 1 (July), pp. 121-31.

Seater, J.J. and R.S. Mariano (1985), "New tests of the life cycle and tax discounting hypotheses", ***Journal of Monetary Economics,*** Vol. 15, No. 2 (March), pp. 195-215.

Summers, L. (1984), "The after-tax rate of return affects private savings", ***American Economic Review Papers and Proceedings,*** Vol. 74 (May), pp. 249-253.

Theil, H. (1975), ***Theory and Measurement of Consumer Demand,*** Vol. 1, Amsterdam: North Holland, pp. 205-7.

Theil, H. (1980), ***The System Wide Approach to Microeconomics,*** Basil Blackwell, Oxford.

Yotsuzuka, T. (1986), "Ricardian equivalence in the presence of capital market imperfections", ***mimeo,*** MIT.

Von Ungern-Sternberg, T. (1981), "Inflation and savings: international evidence on inflation induced losses", ***The Economic Journal,*** Vol. 91 (December), 961-76.

Von Ungern-Sternberg, T. (1987), "Infiation and the consumption function", ***Weltwirschaftliches Archiv,*** pp. 741-4.

Wickens, M.R. and H. Molana (1983), "Stochastic life-cycle theory with varying interest rates and prices", ***The Economic Journal,*** pp. 133-47.