Tax discounting and direct crowding-out in Belgium : Implications for fiscal policy

Lorenzo Pozzi

Social Economics Research Group

nr. 99/72
August 1999

Correspondence:
Lorenzo Pozzi, Universiteit Gent, Hoveniersberg 24, 9000 Gent, Belgium.
Telephone: +32-(0)9-264.34.83
Fax: +32-(0)9-264.89.96
E-mail: lorenzo.pozzi@rug.ac.be

Thanks to Freddy Heylen, Gerdie Everaert, Geert Bekaert and Lucia Goubert for useful comments and suggestions. Also thanks to Paul De Grauwe and Wim Moesen for comments on the earlier version of this paper. All remaining errors are mine.

D/1999/7012/10

Abstract.

We show that the representative Belgian consumer is (at least partially) rational, where rational must be interpreted as opposed to myopic with respect to government behaviour (that is, he or she takes into account the government budget constraint). This does not imply however that Ricardian Equivalence holds for Belgium since we show that Belgian consumers save out of precaution (and/or have fairly short planning horizons). We argue that these factors in combination with a high debt ratio could render the effect of tax changes (for given government expenditures) on private consumption unconventional. We also show that, for Belgium, government expenditures and private consumption are neither substitutes nor complements. We use a model in which a clear alternative to Ricardian Equivalence is nested: this leads to an easier interpretation of the results and to a clear identification of the source of the possible failure of Ricardian equivalence. Moreover we try to deal with some important econometric problems, which have often been disregarded in the past.

I. Introduction.

Future fiscal policy in the EMU member states will be conducted at the nation or state level and not at the federal, European level. This makes an assessment of the effectiveness of fiscal policy at the state level necessary. If in some states fiscal policy is less effective than in other states, it will be harder for those states to stabilize their economy when hit by an idiosyncratic shock, especially if they operate within the limits of the rules imposed by the Stability Pact. More specifically, assuming low labour mobility and wage rigidity, if a country with Ricardian characteristics were hit by a negative shock, attempts of the state to stabilize the economy by lowering taxes would induce expectations of higher taxes in the future, diminishing the impact of the fiscal policy action. The Ricardian Equivalence theorem, restated by Barro (1974), has been subject to an enormous stream of research. Excellent surveys have been provided by Bernheim (1987) and Seater (1993). Basically the theorem says that rational consumers will 'pierce the government veil', because they will notice that if the government for instance lowers taxes today it is bound to satisfy an intertemporal budget constraint and will thus have to raise taxes tomorrow, given a stream of government expenditures. Under a set of assumptions (see below) this rational consumer behaviour will not lead to changes in consumption when for instance taxes are lowered today because private savings will be used to exactly offset this tax change. These savings will be used for future government debt service. Thus no changes in interest rates and in aggregate demand will occur : the real economy will be unaffected. The theorem is based on a number of highly questionable assumptions of which the most important are:

1) *agents form rational expectations,*

2) *taxes are lump-sum,*

3) *the government and the consumers have infinite horizons*[1],

4) *capital markets are perfect (no liquidity constraints),*

5) *the economy is characterized by certainty equivalence behaviour by the consumers (thus no precautionary savings motive),*

6) *the economy is characterized by no-Ponzi game constrained behaviour by the government*

In the model we use in this paper, which is based on Hayashi (1982) and Graham & Himarios (1991), two alternatives to Ricardian behaviour are nested. First, there is the possibility that consumers do not discount future taxes and do treat government bonds as net wealth (they suffer from myopia). The second possibility is that consumers have a precautionary savings motive. In that case they will respond to current tax changes by changing consumption because of uncertainty (the certainty equivalence hypothesis no longer holds). Moreover, the introduction of uncertainty in this model coincides with the introduction of the hypothesis of finite lives as in Blanchard (1985).

We follow the so-called 'consolidated approach': we incorporate not only the tax-discounting hypothesis, but it also allows for ex-ante substitution between government expenditures and private consumption (direct crowding-out). Consumers derive utility from private consumption but also from certain government expenditures. The possibility exists that both enter into the consumer's utility function in a non-separable way. This would for instance be the case if both are substitutes (e.g if the government reduces expenditures on education it is possible that private consumer expenditures on education will rise) or if both are

[1] The hypothesis of the infinitely lived consumer can be relaxed when assuming the existence of dynastic families with a bequest motive.

complementary (e.g roads could be seen as complementary to expenditures on cars or gasoline). Specifying consumer utility in this way allows for a more thorough investigation of Ricardian Equivalence. This is demonstrated by Aschauer (1985) who fails to reject the Ricardian Equivalence proposition for the US when using the consolidated approach. By contrast when specifying consumer utility as a function of private consumption only the Ricardian Equivalence proposition is (falsely) rejected[2]. The consolidated approach for testing Ricardian Equivalence was initiated by Feldstein (1982) and Kormendi (1983).

What about the evidence on tax discounting and direct crowding-out? The majority of relevant papers[3] have focused on the US, with highly contradictory results for the tax discounting hypothesis and only a little less controversy on crowding-out effects. An excellent overview of the direct crowding-out effects is offered by Ni (1995). He gives an overview of the different estimates obtained for the US. Nicoletti (1988), who focuses on 8 OECD countries (including Belgium), finds no evidence of substitutability for European countries. Giavazzi & Pagano (1990) provide indications of modest substitution effects for Denmark .

The tax discounting hypothesis (in the consolidated approach) in the US has been rejected by among others Feldstein (1982), Nicoletti (1988) and Graham & Himarios (1991).It has not been rejected by among others Kormendi (1983) and Aschauer (1985). Nicoletti (1988, 1992) and Graham & Himarios (1991) test whether consumers are myopic or not with respect to

[2] When specifying (quadratic) utility as a function of private consumption only, maximization leads to a consumption function relating consumption in t to its level in period t-1. To test for Ricardian Equivalence lagged variables of the government deficit are added to this specification; Aschauer obtains significant coefficients on these variables, apparently rejecting debt neutrality. The real reason for their significance stems from the fact that past deficits help to predict current government spending. If government spending substitutes for private consumption, the coefficients on the past deficits in the consumption function are biased.

[3] The evidence we discuss is limited to papers investigating Ricardian Equivalence using the private consumption Euler approach, except for Feldstein (1982) and Kormendi (1983). Some follow the consolidated approach, others are based on Blanchard (1985).

future government taxes. Besides the ‘consolidated approach’, another important line of research on tax discounting and consumer behaviour has surged from Blanchard’s (1985) model of finite horizons. It is the first model incorporating an alternative hypothesis to Ricardian Equivalence, making the results easier to interpret. Depending on whether a parameter in the model (the constant probability of death) is zero or positive, consumers have infinite horizons and behave in a Ricardian manner or have finite lives and treat government debt as net wealth. Evans (1988) uses a discrete version of this model and cannot reject Ricardian Equivalence for the US (he rejects it in his 1993 paper however). Graham and Himarios (1996) re-estimate Evans’s model using a constructed market value for wealth and are able to reject Ricardian behaviour. For Europe Nicoletti (1988) rejects tax discounting for the UK and Germany and does not reject it for Belgium and for Italy. Evans (1993) rejects the Ricardian Equivalence for 19 countries using the (discrete) Blanchard model. Nicoletti (1992) cannot reject the Ricardian Equivalence proposition for Belgium.

Seater (1993) has stated that papers on Ricardian Equivalence often suffer from the following methodological problems: (1) misspecified regression equations and (2) problems with non-stationary variables. The first problem can be circumvented by using a model based on micro-economic foundations and optimization. To avoid the second problem it is necessary to conduct unit root tests and stationarity tests. Another potential problem when estimating consumption functions or Euler equations is the possibility of simultaneity. Using instrumental variables can serve as a remedy against this problem, although it has been argued by many authors that there is no simultaneity problem when estimating Euler equations (Seater (1993), Himarios (1995)). This is reflected by the fact that estimation by OLS / NLLS often leads to the same conclusions as estimation by IV / NLIV (Hayashi (1982), Evans (1988), Himarios (1995)). Moreover, as shown by Nelson and Startz (1990), the IV estimator tends to be biased in small samples when the correlation between the instruments and the 'instrumented variables' is low (i.e when the instruments are bad). The choice of 'good instruments' is thus of critical importance when using a small sample of observations. To take into account the possibility of a small sample bias, we have conducted some Monte Carlo simulations.

The paper is organised as follows: in section II we discuss the model leading to the consumption function to be estimated. In section III data problems and methodological problems are tackled and the empirical results are given. Section IV concludes.

II. The model.

Suppose a representative rational consumer, infinitely lived, maximizes the following objective function,

$$(1)\quad V = E_t \sum_{j=t}^{\infty} \alpha^{j-t} u(c_j^*)$$

where α represents a discount factor capturing time-preference ($0<\alpha\leq 1$), E_t is the expectations operator conditional on information available at time t, u( ) is the instantaneous utility function (concave). c^* denotes the level of effective consumption, which is a linear combination of private consumption c and (certain categories of) government expenditures g,

$$(2)\quad c^* = c + \lambda g$$

Maximization occurs subject to a set of budget constraints. In period t the budget constraint is given by,

$$(3)\quad c_t + \frac{w_{t+1}}{1+r} = y_t - t_t + w_t$$

where c is private consumption, w_t is financial wealth at the beginning of the period t (including government bonds b), r is the return on financial wealth (assumed non-stochastic implying that all assets considered are riskless), y is labour income (augmented with transfers) and t are lump-sum tax payments. The representative agent is allowed to borrow freely and capital markets are perfect. The individual 'pierces the government veil' and thus also takes into account the set of government budget constraints. In period t the government budget constraint is given by,

$$(4)\quad g_t + b_t = t_t + \frac{b_{t+1}}{1+r}$$

where b_t denotes the 1-period government debt (government bonds) at the beginning of the period and g_t denotes government expenditures (excluding intrest payments on the 1-period bonds).

If as in (2) effective consumption is a linear combination of private consumption and government expenditures, equations (3) and (4) define the effective intertemporal budget constraint sets. Maximizing (1) with respect to effective consumption and subject to the budget constraint sets in (3) and (4) leads to the following first-order condition (Euler equation),

(5) $E_t\{\alpha(1+r)u'(c^*_{t+1})\} = u'(c^*_t)$

This result is basically the solution to a dynamic programming problem, which can be found in appendix a. Equation (5) defines the optimal time path for effective consumption. Equation (2) is the most commonly used specification of effective consumption, as used by Feldstein (1982), Kormendi (1983), Aschauer (1985) and Graham and Himarios (1991). If we define $u(c^*)=U(c,g)$ then the substitutability between c and g is reflected by Ucg, the change in marginal utility of private consumption with respect to a change in government expenditures or vice versa. From (2) it is easily seen that c and g will be substitutes if $\lambda>0$; c and g will be complements if $\lambda<0$; c and g will be independent if $\lambda=0$[4]. Given that U(c,g) = u (c*) and that u'>0 and u''<0 , we can state :

1) Ucg<0 ⇔ c and g are substitutes ($\lambda>0$),
2) Ucg>0⇔ c and g are complements ($\lambda<0$),
3) Ucg=0⇔ c and g are independent ($\lambda=0$).

This follows directly from Ucg = λu''(c*). From Ug = λu'(c*) it follows directly that sgn(Ug)=sgn(λ) (note that this does necessarily imply that marginal utility of g will be negative if c and g are complements – suppose for instance that U(c,g) = u(c*) + v(g) where

4 Take the total differential of (2) and set equal to zero. This leads to $\frac{dc}{dg} = -\lambda$.

v'(g) >0, then Ug could be positive whereas the first order condition would still be identical as the consumer has no control over g).

If we want to impose certainty equivalent behaviour we can assume that utility is quadratic in effective consumption[5]. Suppose the utility function is given by $u(c_t^*) = -\frac{(c_b^* - c_t^*)^2}{2}$, where c_b* denotes the bliss level of effective consumption which is a parameter capturing the critical value of effective consumption at which marginal utility becomes negative. Using the derivative of this utility function in (5) yields, $E_t c_{t+1}^* = -\frac{1-\alpha(1+r)}{\alpha(1+r)} c_b^* + \frac{1}{\alpha(1+r)} c_t^*$. If we make the additional assumption that the rate of return on financial wealth equals the subjective rate of time preference, this leads to Hall's (1978) martingale model for effective consumption,

(6) $E_t c_{t+1}^* = c_t^*$

When confronting this first-order condition with the budget constraints (3) and (4), as is done in appendix b, we obtain the following consumption function,

(7) $$c_t^* = \frac{r}{1+r}\left[\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^j E_t\left[y_{t+j} - (1-\lambda)g_{t+j}\right] + (w_t - b_t)\right] + u_t$$

where {r/(1+r)} reflects the propensity to consume out of permanent income.

[5] Quadratic utility implies linear marginal utility and thus a third derivative of utility equal to zero: it rules out precautionary savings and it avoids dealing with Jensen' inequality; moreover it makes aggregation from micro-economic optimization to the macro-level straightforward.

The term in large brackets on the RHS of (7) reflects permanent income, as implied by the model. The error term u_t reflects transitory consumption, as implied by the stochastic nature of the permanent income hypothesis.

We now introduce an alternative hypothesis to Ricardian Equivalence in the model. As in Graham and Himarios (1991) this is done by changing the specification of permanent income to allow for myopia on the part of consumers. As shown in appendix b this leads to the following consumption function,

$$(8)\quad c_t^* = \frac{r}{1+r}\left[\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^j E_t\left[y_{t+j} - \theta(1-\lambda)g_{t+j}\right] + (w_t - \theta b_t)\right] + u_t$$

where θ in the specification of permanent income is a parameter capturing myopia on the part of the consumers. If θ=1 equation (8) reduces to (7) where the consumer is assumed 'rational' because he completely internalizes the government budget constraint. Notice that in this case private consumption depends on (w_t-b_t) where w_t is financial wealth including government debt; thus non-myopic consumers do not treat government debt as a part of their permanent income. If θ=0 consumers are completely myopic; permanent income includes all of government debt and private consumption depends on w_t . Any value of θ between zero and one implies partial myopia. Different combinations of θ and λ will imply different effects of fiscal policy on private consumption.

There are basically two problems with the permanent income hypothesis as stated in consumption functions as (8) where consumption (effective consumption in our model) is seen as the annuity value of human and financial wealth. The first one is the absence of an explicit relationship between asset returns and consumption growth. As argued by Deaton (1992) both the theoretical and empirical evidence on such a relationship is inconclusive. From a theoretical point of view substitution and income effects tend to cancel out the effects of unanticipated changes in real rates[6]. Empirically, it seems that time-series studies have provided no answers to the influence of real interest rates on consumption growth (Deaton, 1992). Therefore it seems that this problem is not of major importance in the model. It should be noted however that the effects of real rates on consumption should be captured through their effects on the market value of financial wealth and government debt. As we will see in section III however we have to rely on book values for these variables. The second problem is the absence of precautionary savings motives (prudent behavior). The permanent income hypothesis as in (8) is based on certainty equivalence; in reality however an increase in uncertainty about future income (future taxes, future government expenditures) might lead to higher savings today. To capture precautionary savings, we can rely on an iso-elastic utility function (constant relative risk aversion, CRRA)[7] of the form $u(c_t^*) = \frac{c_t^{*1-\sigma}}{1-\sigma}$ where σ is the coefficient of relative risk aversion. Muellbauer and Lattimore (1995) show that expected future income in the certainty equivalence case is approximately equal to expected future income in the CRRA case discounted by a factor reflecting risk. Put differently, in the CRRA case future labour income (future taxes, future government expenditures) in (8) will be discounted by more than the real rate of return (the real rate of return + a risk premium). To see this intuitively consider what happens if the derivative of the iso-elastic utility function is

---

[6] If the real interest rate is anticipated, the income effects will already be incorporated in the consumption decisions, so that planned consumption will respond to anticipated real interest rates.

[7] Iso-elastic utility functions imply convex marginal utility: a mean preserving spread of future income raises future marginal utility and leads to an increase in savings today.

used in (5) to obtain $\alpha(1+r)E_t c_{t+1}^{*\ -\sigma} = c_t^{*-\sigma}$. By Jensens inequality[8] we can say that $\alpha(1+z)(E_t c_{t+1}^{*})^{-\sigma} = c_t^{*-\sigma}$, where z > r (the difference reflecting a risk-premium). Higher uncertainty operates like a higher real interest rate. No closed-form solution for consumption can be found in this case [9]. To maintain the characteristics of (8) while capturing precautionary savings we have to give up the optimization principle. The consumption function takes the form,

$$(9)\ c_t^* = \beta\left[\sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[y_{t+j} - \theta(1-\lambda)g_{t+j}\right] + (w_t - \theta b_t)\right] + u_t$$

where ρ is the discount factor, which is an increasing function of z and σ [10]. Notice however that (9) reduces to (8) in the case of certainty equivalence, which will be the case if z = r (and equal to the subjective rate of time-preference), if the coefficient of relative prudence 1+σ equals zero and if $\beta = \frac{r}{1+r}$. This will imply ρ = r. In the case of uncertainty ρ will be larger than r. Only in the certainty equivalent case and if θ = 1, the consumption function (9) will coincide with the Euler-equation (7).

It is important to notice at this point that (9) is consistent with the consumption function used by Blanchard (1985) in his model of finite lives if utility is separable in c and g (λ=0), if

[8] Jensens inequality says that for u' convex (which is the case for CRRA-utility) we have that $E_t(u'(c_{t+1}^*)) > u'(E_t c_{t+1}^*)$. For our iso-elastic function, this implies that $E_t c_{t+1}^{*\ -\sigma} > (E_t c_{t+1}^*)^{-\sigma}$.

[9] Deaton (1992) shows how under certain distributional assumptions for the return and the log of (in our case) effective consumption, an approximate closed-form solution for consumption can still be obtained when utility is iso-elastic.

[10] We refer to Muellbauer & Lattimore (1995). Notice that z is an increasing function of the variance of future income and an increasing function of the coefficient of relative risk aversion σ.

consumers are rational (θ=1) and if the fact that ρ > r does not follow from uncertainty but from the fact that the representative agent faces a constant positive probability of death (thus is finitely lived). We show the link between the two models in appendix c.

To remove the unobservable components from equation (9) we use the backwards differencing method as used by Hayashi (1982). This means that a first-order difference equation is used for 1) the sum of current and expected future labour income (discounted) and for 2) the sum of current and expected future government expenditures (discounted). These difference equations take the following form,

$$(10)\ \sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{j}E_t y_{t+j}=(1+\rho)\left[\sum_{j=0}^{\infty}E_{t-1}y_{t+j-1}-y_{t-1}\right]+\sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{j}(E_t y_{t+j}-E_{t-1}y_{t+j})$$

$$(11)\ \sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{j}E_t g_{t+j}=(1+\rho)\left[\sum_{j=0}^{\infty}E_{t-1}g_{t+j-1}-g_{t-1}\right]+\sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{j}(E_t g_{t+j}-E_{t-1}g_{t+j})$$

The second term on the RHS of (10) and (11) represents the expectation revisions made by the agents as they move from t-1 to t. We denote these surprise terms by e_{1t} and e_{2t} respectively. The fact that expectations are rational implies that e_{1t} and e_{2t} are serially uncorrelated and that $E_{t-1}e_{jt}=0$ (for j=1,2). In appendix d (10) and (11) are used in (9) to obtain a consumption function that can be estimated,

$$(12)\ \begin{aligned}c_t &= (1+\rho)c_{t-1}-\lambda(g_t-(1+\rho)g_{t-1})+\theta\beta(1-\lambda)(1+\rho)g_{t-1}+\beta(n_t-(1+\rho)n_{t-1})\\ &+\beta(1-\theta)(b_t-(1+\rho)b_{t-1})-\beta(1+\rho)y_{t-1}+v_t\end{aligned}$$

where $v_t = u_t - (1+\rho)u_{t-1} + \beta e_{1t} - \theta\beta(1-\lambda)e_{2t}$

$n_t = w_t - b_t$ denotes financial wealth (excluding government bonds).

III. Estimation, results and implications of the results.

1. Data considerations.

To implement the variables in equation (12) empirically we use different concepts and proxy variables. For private consumption (c_t) we use total aggregate private consumption (CO) as used by Nicoletti (1988). Most studies have used expenditures on non-durables and services (Aschauer (1985), Nicoletti (1988), Evans (1988), Graham & Himarios (1996)). The most appropriate concept for consumption however is expenditures on non-durables and services with a service flow from consumer durables, the latter being generally derived from the stock of consumer durables. Hayashi (1982), Kormendi (1983) and Graham & Himarios (1991) use this concept, but Nicoletti (1988) who focuses on other countries than the US also, cannot always use this measure because of lack of data. Graham (1992) shows that alternative measures of consumption used with the same empirical procedure can lead to rejection of Ricardian Equivalence when one measure of consumption is used and to non-rejection when another measure is used. Constructing a service flow from consumer durables for Belgium is difficult if not impossible for reasons of data availability ; therefore we use aggregate consumption (CO). Aggregate consumption is the sum of expenditures on non durables and services and expenditures on durables.

In the model we have labeled g_t as government expenditures (excluding interest payments on the 1-period government bonds). It therefore includes government consumption (wage- and non-wage consumption), government investment (including military spending) and transfers. This is compatible with the budget equation (4) but not with the concept of 'effective consumption' as used in the utility function (1). There seems to be a disparity between the government expenditures measure which should be used in (1) and the one that should be used in (4). In (4) both wage and nonwage consumption should be used to make the budget constraint complete; in (1) it is evident that wage consumption should not be included since its influence will operate through private consumption. Moreover it is also included in labour income and could thus lead to potential problems of multicollinearity in (12) when included in government consumption. A similar reasoning can be applied to transfers. We do not include them in g since they have no use in the utility function and are included in y. We thus will use two concepts for g : non-wage consumption (GN) and non-wage consumption and investment (GI). Nicoletti (1988) uses public consumption of goods and services, most other studies based on the consolidated approach use government expenditures on goods and services (e.g Graham & Himarios, 1991) ; still others use total expenditures (Aschauer, 1985). All government data are for the general government, taken from OECD Economic Outlook (1999).

Perelman & Pestieau (1993) proxy private financial wealth n_t at the beginning of the year by the sum of the money stock in the economy (M3) and the capital stock of the business sector . The problem with this approach is that the money stock is not 'net wealth' since it is the result of loans granted (i.e. the money multiplier). Therefore we conduct estimations with a wealth variable containing only the capital stock of the business sector and with a wealth variable containing the capital stock of the business sector and the stock of high powered money. We only report the results for the latter variable since the conclusions are the same for both proxies.

Rational consumers will most likely incorporate the government's net claims on the private sector. Thus net government debt (BN) should be used in the consumption function (12) for b_t. However, an additional test for the robustness of our results could consist of using the gross government debt. Since using the gross government debt does not change the conclusions, we do not report the results.

For these variables (N, BN) ideally we would prefer a measure for their market values as in for instance Graham and Himarios (1991, 1996). Due to the lack of data we use the more readily available book values published in OECD Economic Outlook (1999).

Pre-tax labour income augmented with transfers (y_t) is calculated as follows : government wage consumption is added to the product of the wage rate in the business sector and employment in the business sector. We augment this with the social security benefits paid by the government. We name this variable Y. The model suggests to use labour income, which means that items like rents, dividends and interest receipts are left out. We have also estimated (12) with two different income concepts : pre-tax labour income without any transfers and pre-tax labour income with the total of transfers received by households. Using these different concepts does not change the conclusions ; therefore we do not report these results. All data are taken from OECD Economic Outlook (1999), except the stock of high powered money, which is taken from IMF (1998). We do not take into account labour income of the self-employed, due to the difficulties in imputing labour earnings to the self-employed.

Equation (12) is estimated using yearly data and using different measures for the variables for Belgium. The total sample runs from 1970 to 1997 [11]. To investigate the small sample properties of the estimators used we have conducted some Monte Carlo simulations (see below).

All variables are in real per capita terms. CO, the stock of high powered money, BN, and Y are deflated by the consumer price index (1990 = 100). Government non-wage consumption is deflated by the implicit price deflator for government consumption and government investment is deflated by the price deflator for total investment. Per capita measures are obtained after dividing by total population. Total population and deflators are from OECD Economic Outlook (1999).

2. Methodology.

We estimate (12) in levels since it approximates an expression in first differences, i.e. it is quasi-differenced [12]. The problem with the quasi-differencing argument is that, as argued by Muellbauer and Lattimore (1995), important information on the levels of the variables is lost. Quasi-differencing may well remove the unit roots from the data, it will also put a lot of weight on the high frequencies. Graham & Himarios (1996) for instance develop a model to test the long-run implications of Ricardian Equivalence.

We can add that the validity of estimating (12) in levels is supported by the fact that - as we shall see – autocorrelation is not a problem and the estimation results are quite invariable and robust to the use of different variables : government nonwage consumption (GN) or government nonwage consumption and investment (GI), our measure for labour income (Y),

[11] Although this is a short period for time series analysis, it is certainly no exception in the literature (Nicoletti, 1988 ; Giavazzi & Pagano, 1990, 1995 ;…).

labour income without transfers or with total transfers (results not reported), our proxy for financial wealth (N) or the proxy used by Perelman and Pestieau (1993) (results not reported), gross government debt (results not reported) or net government debt (BN) [13].

Since equation (12) is non-linear in its parameters (ρ, λ, θ and β) we use a non-linear estimation method. We will first estimate (12) by non-linear least squares (NLLS). To take into account the possibility of simultaneity we will also estimate (12) by non-linear instrumental variables (NLIV). Simultaneity can for instance be illustrated by noting that news of an increase in future government spending in period t (a positive shock in e_{2t} which is part of the error term v_t) could coincide with an increase in government spending in period t ; thus g_t and v_t would be correlated. Moreover it is possible that transitory consumption (u) is correlated with labour income and wealth. To obtain consistent estimates of the parameters in the model we need to use instruments. These instruments need to be correlated with the variables in the model but uncorrelated with the error term. The most obvious choice, which also excludes data mining, is to use the variables of (12) as instruments but lagged. We use a constant and the once lagged values of c, g, n, b and y as instruments. This could lead to problems because the error term v_t contains an MA(1) component in terms of transitory consumption. Autocorrelation could thus be present, making the once lagged instruments endogenous. We have no indications however that there is autocorrelation present in the error term so that the use of these instruments is legitimate.

---

[12] We have conducted unit root tests and stationarity tests on all variables. These results are available on request.

[13] Moreover recent estimations of similar consumption functions (Giavazzi & Pagano, 1995 ; Graham & Himarios, 1996) have been conducted in level form.

To test for autocorrelation we conduct a Breusch Godfrey LM test for serial correlation. This test is justified because of the appearance of the lagged dependent variable in (12) and because it is fit for autocorrelation of the moving average form, as well as of the auto-regressive form. The test statistic is asymptotically chi-square distributed with degrees of freedom equal to the order of serial correlation. The test will have low power in small samples. We still argue that autocorrelation is not present however, since we find no indications of autocorrelation of any form when investigating the autocorrelation function and the partial autocorrelation function of the residuals (not reported).

To test the restrictions implied by the model we use Wald-tests : the use of these is justified for both NLLS and NLIV. The computed test statistic is asymptotically chi-square distributed with degrees of freedom equal to the number of restrictions tested.

3. Results.

The results from estimating (12) with NLLS and with government non-wage consumption (GN) are presented in table 1. The estimates of all coefficients have the correct sign. The estimates of ρ, θ, and β have economically sensible values and are significantly different from zero at the 5% level ; λ is not significantly different from zero. This could indicate that government non-wage consumption expenditures are neither substitutes nor complements to private consumption, which would imply that utility functions are separable in both arguments.

Table 1.

Autocorrelation does not seem to be a problem, as indicated by the Breusch-Godfrey test. The point estimate of ρ is larger than any reasonable value for the real rate of return (e.g. 3%, 4%, 5%). It is measured precisely enough to test the restriction that ρ is significantly different from any reasonable value for the real rate of return (see below). Certainty equivalence / Infinite lives is apparently rejected. The value for θ is 0.707, significantly different from zero, implying that the representative Belgian consumer is not myopic. This is confirmed by the Wald test which, despite the rather large standard error on θ (0.314 - unadjusted), decisively rejects myopia, and cannot reject complete rationality. We have also estimated equation (12) under the restrictions $\theta = 0$ and $\theta = 1$. The restricted equation where $\theta = 1$ performs much better than the restricted equation where $\theta = 0$.

To check and see whether these results are robust to a change in variables we estimate exactly the same equation with government non-wage consumption and investment (GI) instead of GN. We definitely prefer using GI over GN since it is a much better approximation of g_t both in the utility function (1) and in the government budget constraint (4). The results of this estimation still using NLLS are presented in table 2. A quick look reveals that not only conceptually but also as far as the results are concerned this is the most interesting regression. The point estimate of θ is now 0.929, close to 1, with still a large standard error but not too large so that we can reject the hypothesis of complete myopia. The t-value for this estimate has increased considerably in comparison to table 3. The estimates for ρ and β and their t-values in table 4 are similar to those in table 3. GI is neither a substitute nor a complement to private consumption as was the case with GN. Our result for λ is thus in line with Nicoletti (1988). We can also see that ρ is quite precisely estimated. This allows us to test the hypothesis of certainty equivalence for a number of values for the real rate of return. We find that we can reject a discount factor as high as 0.08. We cannot reject 0.09. Since the real rate of return has never attained such values over the sample period, we can easily reject the hypothesis of certainty equivalence and argue that the representative Belgian consumer is prudent and saves out of precaution. He or she thus discounts future income (and future taxes, since he or she is not myopic) at a rate higher than the real rate of return. Alternatively we can interpret this result in terms of the Blanchard (1985) model. We can reject the hypothesis of an infinitely lived representative Belgian consumer.

Table 2.

To deal with potential problems of simultaneity we now estimate (12) with instruments (NLIV). As noted above we use the first lags of CO, GN (GI) , N, BN and Y and a constant as instruments. The results for estimation with GN are presented in table 3 ; the results for GI are presented in table 4. Notice also that in all equations the absence of autocorrelation justifies the use of once lagged instruments, despite the MA(1) term in the model's error term.

The point estimates of ρ and β are of the same magnitude as the estimates obtained with NLLS. Again certainty equivalence / infinite lives is rejected and again private consumption and government expenditures are found to be neither substitutes nor complements (for both GN and GI). The conclusions for θ however are not the same. The point estimate for θ takes on a value smaller than 1 (0.65, 0.73) , while myopia (i.e $\theta = 0$) cannot be rejected (at the 5% level for both GN and GI).

Table 3.

Table 4.

A possible explanation for this inconclusive result is that the NLIV estimates are biased. If the assumed asymptotic distribution is a poor approximation to the actual finite sample distribution, then this could invalidate our results. Especially the distribution of the parameter θ under the null hypothesis of 0 and under the null hypothesis of 1 is relevant if we want to draw conclusions about consumer behaviour. In the next section we simulate the small sample distributions of our estimates, and we conclude that θ is indeed biased when estimated with NLIV. We show that our estimates for θ obtained when estimating with NLIV are most probably taken from the $\theta = 1$ distribution.

4. Monte Carlo simulations.

To obtain the small sample distributions of ρ, λ and θ for our sample with 27 observations, we conduct some Monte Carlo simulations. We assume that the sample error terms we obtained when estimating (12) are i.i.d normal with variance equal to the variance from the residuals obtained after estimation. Basically there could be a problem with this assumption because of the structure of the error term as implied by the model. If we would like to replicate the error term, there is an identification problem, since we need to know the variance of at least two disturbances out of u, e1 and e2. Because of the observed lack of autocorrelation in the error term, we feel that simply assuming i.i.d is justified. Normality of errors can be justified by pointing to the absence of outliers and by pointing to the fact that we work with low frequency data, although (given the small sample size) a formal test has too little power to reject the null of normality. Normality of shocks to consumption is for instance assumed by Nelson and Startz (1990).

We generate 10 000 consumption series using (12) under 1) the null hypothesis $\theta = 0$, $\lambda = 0$ and $\rho = 0.04$ (which is a plausible value for the real rate of return over the sample period) and under 2) the null hypothesis $\theta = 1$, $\lambda = 0$ and $\rho = 0.04$. These series are then used to estimate the model both with NLLS and with NLIV (always with GI [14]).

We first focus on NLLS. In table 5 we present the percentiles of the distribution of ρ, λ, and θ and their t-statistics (under both null hypotheses). These t-statistics are calculated with unadjusted standard errors. The distribution of ρ is fairly tightly concentrated around 0.04 and the distribution of its t-ratio approximates the standard normal distribution. The median values of the distributions of both λ and θ are approximately equal to their values under the null hypotheses, though the dispersion in the distributions of λ and θ is quite large. Using the empirical distributions of ρ, λ and θ or the distribution of their t-values under the null we can easily confirm the results obtained above. For instance in table 2 (NLLS, GI) we find a value for θ of 0.929 and a t-value (based on unadjusted standard errors) of 3.299 under the null $\theta = 0$ and of -0.252 under the null $\theta = 1$. At the 5% level of significance we find simulated t-values in table 5 of 2.067 if $\theta = 0$ and of 1.742 if $\theta = 1$. Since $3.299 > 2.067$ and $-0.252 < 1.741$ we can confirm our conclusion that the value of 0.929 is more likely to be taken from the $\theta = 1$ distribution than from the $\theta = 1$ distribution.

Table 5.

[14] The conclusions for GN are identical.

In table 6 we present the results for NLIV. The results for ρ and λ obtained in table 4 are confirmed, although the median value of λ is -0.717 (if $\theta = 1$) and -0.370 (if $\theta = 0$). θ is also biased : the median value is 0.628 if $\theta = 1$ and -0.248 if $\theta = 0$. There is a considerable overlap between the two distributions and the value of 0.732 (table 4) could be drawn from both, although it is more likely that it is taken from the $\theta = 1$ distribution. If we look at the t-values in table 6 we can reject that 0.732 is taken from the $\theta = 0$ distribution. From table 4 we find t-values (based on unadjusted standard errors) of 1.792 under $\theta = 0$ and of -0.656 under $\theta = 1$. At the 5% level of significance we find simulated t-values in table 6 of 1.131 if $\theta = 0$ and of 0.640 if $\theta = 1$. We find : $1.792 > 1.131$ and $-0.656 < 0.640$.

Table 6.

Based on this evidence we conclude that our estimate of θ in table 4 is taken from the $\theta = 1$ distribution.

5. Implications of the results.

What do these results about myopia and precautionary savings imply for Belgian fiscal policy actions aimed at the tax side of the budget ? Nicoletti (1988) and Sutherland (1997) argue that consumers in debt-ridden countries will be more aware of the government budget. The high debt level in Belgium may have increased the awareness of consumers for future government liabilities and may have dissuaded them from treating government bonds as net wealth, as we showed $\theta > 0$. If taxes are cut in this situation consumption will not change. In addition, given the existence of a precautionary savings motive (as we showed $\rho > r$), the tax reduction could lead to an increase in uncertainty about the future after tax income and thus lead to a decrease in consumption.

To avoid these unconventional effects a sustained debt reduction is thus necessary. The Stability Pact could achieve this goal. Paradoxically the Stability Pact on the one hand limits the possibilities for future stabilization efforts in the EMU, but on the other hand could make these stabilization efforts more effective.

Given this combination of a high debt, non-myopic consumers and the existence of precautionary savings we would expect that the past consolidation effort in Belgium (which was partially based on tax increases) lead to a decrease in uncertainty about future after tax income and thus to a decline in precautionary savings. This does not show in the figures however, since the household saving rate as a percentage of disposable income even increased during the first years of the consolidation episode (from 18,1 % in 1991 to 18,8% in 1992 and 20,6% in 1993) (OECD, 1999).

The fact that we can reject $\rho = r$ can also be interpreted differently. As argued before, the model we have discussed coincides with the Blanchard (1985) model of finite lives. More specifically the fact that $\rho > r$ reflects the fact that the representative consumer faces a positive constant probability of death in each period (he or she is finitely lived). This was shown in appendix c. We can say that the higher the probability of death and the larger the difference between ρ and r, the more the current consumer feels disconnected from future generations. Like uncertainty, the finite lives result is a deviation from Ricardian Equivalence. An important possible implication of this combination of rational consumers, finite lives and a high debt ratio has been modelled by Sutherland (1997). He shows theoretically how under finite lives for instance tax reductions (for given expenditures ; thus changes in debt) lead to a less than one for one increase in expected future taxes if the debt level is around its theoretical mean level of zero. This happens because since the debt level is 'low' (in absolute value) consumers know that a tax decrease will not immediately be followed by a stabilization ; thus they will discount expected future taxes more heavily, which will lead to an increase in permanent income and thus in consumption. On the other hand, if the debt level moves towards either a lower or an upper limit, once a critical level of debt is reached a further increase or decrease will lead to a more than one for one change in expected future taxes. If taxes are reduced and the debt level is 'high' (in absolute value) consumers expect a *severe* stabilization soon ; thus they will discount *high values* of expected future taxes less heavily, which induces a decrease in permanent income and thus in consumption. Thus both the precautionary savings motive and the finite lives case have the same implications for the effects of fiscal policy actions (via the tax side) on private consumption if consumers are rational and forward looking and if the debt level is high (even though the model we have estimated cannot discriminate between the precautionary savings effect and the finite lives effect). As argued above however, there is no evidence of unconventional fiscal policy effects on private consumption during the recent fiscal consolidation episode.

IV. Conclusions.

We argue that the representative Belgian consumer is not myopic with regard to the government financing decisions. This means that his or her permanent income is at least partially determined by the expectations of future after tax labour income, implying that changing expectations about future taxes will influence consumption. We have also shown that there is uncertainty about future *after tax* income (or alternatively that lives are finite), meaning that Ricardian Equivalence in its strict form will not hold. However, the combination of a high debt and non-myopic consumers on the one hand and the uncertainty or finite lives result on the other hand could render the effects of tax changes (for given government expenditures) on private consumption unconventional. There is no clear evidence to suggest that this was the case during the past consolidation episode in Belgium however. We have also argued that these factors could make future stabilization efforts on the tax side of the budget less effective (or even pro-cyclical). A further reduction of the government debt is necessary and the Stability Pact will be a useful tool to achieve this goal.

Finally, our results suggest that private consumption and government expenditures (nonwage consumption and investment) enter into the consumer's utility function in a separable way, implying that they are neither substitutes nor complements.

References.

Aschauer, D.A. (1985). Fiscal policy and aggregate demand. American Economic Review, 75(1) :117-127.

Barro, R.J. (1974). Are government bonds net wealth ? Journal of Political Economy, 82(6) : 1095-1117.

Bernheim, B. (1987). Ricardian Equivalence : an evaluation of the theory and evidence. In Fisher, S., editor, NBER Macroeconomics annual 1987, pages 263-304. MIT Press, MA, USA.

Bertola, G. and Drazen, A. (1993). Trigger points and budget cuts : explaining the effects of fiscal austerity. American Economic Review 83(1) :11-26.

Blanchard, O.J. (1985). Debt, deficits and finite horizons. Journal of Political Economy, 93(2) :223-247.

Blanchard, O.J. (1990). Comment on Giavazzi and Pagano. In Fischer, S., editor, NBER Macroeconomics Annual 1990, pages 111-116. MIT Press, MA, USA.

Campbell, J.Y. and Mankiw, G.N. (1990). Permanent income, current income and consumption. Journal of Business and Economic Statistics, 8 : 265-279.

Deaton, A. (1992). Understanding Consumption. Clarendon Press, Oxford, UK.

Evans, P. (1988). Are consumers Ricardian ? Evidence for the United States. Journal of Political Economy, 96(5) :983-1004.

Evans, P. (1993). Consumers are not Ricardian : evidence from nineteen countries. Economic Inquiry, XXXI : 534-548.

Feldstein, M. (1982). Government deficits and aggregate demand. Journal of Monetary Economics, 73 :994-1010.

Giavazzi, F. and Pagano, M. (1990). Can severe fiscal contractions be expansionary ? Tales of two small European countries. In Fischer, S., editor, NBER Macroeconomics Annual 1990, pages 75-122. MIT Press, MA, USA.

Giavazzi, F. and Pagano, M. (1995). Non-Keynesian effects of fiscal policy changes : international evidence and the Swedish experience. NBER Working Paper, number 5332.

Graham, F.C. and Himarios, D. (1991). Fiscal policy and private consumption : instrumental variables tests of the 'consolidated approach'. Journal of Money, Credit and Banking, 23(1) :53-67.

Graham, F.C. and Himarios, D. (1996). Consumption, wealth and finite horizons : tests of Ricardian Equivalence. Economic Inquiry, XXXIV : 527-544.

Graham, F.C. (1992). On the importance of the measurement of consumption in tests of Ricardian Equivalence. Economics Letters 38 : 431-434.

Hall, R.E. (1978). Stochastic implications of the life cycle-permanent income hypothesis : theory and evidence. Journal of Political Economy, 86(6) :971-987.

Hayashi, F. (1982). The permanent income hypothesis : estimation and testing by instrumental variables. Journal of Political Economy, 90(5) :895-916.

Himarios, D. (1995). Euler equation tests of Ricardian Equivalence. Economics Letters, 48 : 165-171.

IMF, International Financial Statistics Yearbook 1998.

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

Muellbauer, J. and Lattimore, R. (1995). The consumption function : a theoretical and empirical overview. In Pesaran, M.H. and Wickens, M., editors, Handbook of Applied Econometrics, pages 221-311. Blackwell Publishers, Oxford, UK.

Nelson, C.R. and Startz, R. (1990). The distribution of the instrumental variables estimator and its t-ratio when the instrument is a poor one. Journal of Business, 63(1) : 125-140.

Ni, S. (1995). An empirical analysis on the substitutability between private consumption and government purchases. Journal of Monetary Economics, 36 :593-605.

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, number 50.

Nicoletti, G. (1992). Is tax-discounting stable over time ? Oxford Bulletin of Economics and Statistics, 54(2) : 121-144.

OECD, Economic Outlook, june 1999.

Perelman, S. and Pestieau, P. (1993). The determinants of the Ricardian Equivalence in the OECD countries. In H.A.A Verbon and F.A.A.M van Winden, editors, The political economy of government debt, pages 181-193. Elsevier.

Seater, J. (1993). Ricardian Equivalence. Journal of Economic Literature, 31 :142-190.

Sutherland, A. (1997). Fiscal crises and aggregate demand : can high public debt reverse the effects of fiscal policy ? Journal of Public Economics, 65 : 147-162.

Table 1 NLLS with GN

	Unrestricted	Restricted θ = 0	Restricted θ = 1
ρ	0.236 (2.719) [3.775]	0.147 (3.254) [3.207]	0.231 (3.399) [6.102]
λ	0.900 (0.638) [1.187]	1.044 (0.744) [1.481]	0.559 (0.901) [1.176]
θ	0.707 (2.250) [2.170]	0	1
β	0.113 (4.501) [5.606]	0.079 (5.366) [4.659]	0.120 (6.169) [10.122]
R^2 adj.	0.988	0.987	0.990
D.W.	1.663	1.423	1.733
B.G. (2)	1.300		
Wald (θ = 0)	4.710		
Wald (θ = 1)	0.809		

Note: t-values between normal brackets are unadjusted; t-values between square brackets are based on heteroskedasticity and autocorrelation consistent standard errors (Newey-West). D.W = Durbin – Watson statistic. B.G (2) = Breusch - Godfrey statistic for serial correlation of second order ; distributed chi-square with 2 degrees of freedom. Wald coefficient statistic is distributed chi-square with degrees of freedom equal to the number of restrictions tested (Wald is based on Newey-West standard errors).

Table 2 NLLS with GI.

	Unrestricted	Restricted θ = 0	Restricted θ = 1
ρ	0.226 (3.087) [5.028]	0.141 (2.623) [3.818]	0.231 (3.399) [6.102]
λ	0.535 (0.824) [1.034]	0.374 (0.558) [0.610]	0.559 (0.901) [1.176]
θ	0.929 (3.299) [3.053]	0	1
β	0.117 (4.825) [6.232]	0.075 (4.471) [5.445]	0.120 (6.169) [10.122]
R^2 adj.	0.989	0.987	0.989
D.W.	1.747	1.474	1.733
B.G. (2)	0.990		
Wald (θ = 0)	9.323		
Wald (θ = 1)	0.054		

Note: t-values between normal brackets are unadjusted ; t-values between square brackets are based on heteroskedasticity and autocorrelation consistent standard errors (Newey-West). D.W = Durbin – Watson statistic. B.G (2) = Breusch - Godfrey statistic for serial correlation of second order ; distributed chi-square with 2 degrees of freedom. Wald coefficient statistic is distributed chi-square with degrees of freedom equal to the number of restrictions tested (Wald is based on Newey-West standard errors).

Table 3 NLIV with GN.

	Unrestricted	Restricted θ = 0	Restricted θ = 1
ρ	0.240 (2.335) [2.887]	0.166 (2.933) [3.305]	0.229 (2.007) [3.025]
λ	-0.452 (-0.218) [-0.337]	-0.118 (-0.061) [-0.089]	-1.146 (-0.550) [-0.702]
θ	0.648 (1.737) [1.667]	0	1
β	0.108 (4.001) [4.607]	0.080 (5.555) [5.718]	0.111 (3.738) [5.338]
R^2 adj.	0.987	0.987	0.987
D.W.	1.834	1.575	1.766
B.G. (2)	1.232		
Wald (θ = 0)	2.780		
Wald (θ = 1)	0.821		

Note: t-values between normal brackets are unadjusted; t-values between square brackets are based on heteroskedasticity and autocorrelation consistent standard errors (Newey-West). D.W = Durbin – Watson statistic. B.G (2) = Breusch - Godfrey statistic for serial correlation of second order ; distributed chi-square with 2 degrees of freedom. Wald coefficient statistic is distributed chi-square with degrees of freedom equal to the number of restrictions tested (Wald is based on Newey-West standard errors). Used instruments are a constant, the first lags of CO, GN, N, BN, Y.

Table 4 NLIV with GI.

	Unrestricted	Restricted θ = 0	Restricted θ = 1
ρ	0.211 (2.849) [4.082]	0.166 (2.451) [3.937	0.222 (3.124) [5.122]
λ	0.390 (0.410) [0.434]	0.123 (0.139) [0.138]	0.557 (0.629) [0.721]
θ	0.732 (1.792) [1.641]	0	1
β	0.108 (4.303) [5.114]	0.082 (5.208) [7.198]	0.117 (5.686) [9.016]
R^2 adj.	0.988	0.987	0.989
D.W.	1.746	1.543	1.722
B.G. (2)	1.147		
Wald (θ = 0)	2.692		
Wald (θ = 1)	0.359		

Note: t-values between normal brackets are unadjusted ; t-values between square brackets are based on heteroskedasticity and autocorrelation consistent standard errors (Newey-West). D.W = Durbin – Watson statistic. B.G (2) = Breusch - Godfrey statistic for serial correlation of second order ; distributed chi-square with 2 degrees of freedom. Wald coefficient statistic is distributed chi-square with degrees of freedom equal to the number of restrictions tested (Wald is based on Newey-West standard errors). Used instruments are a constant, the first lags of CO, GI, N, BN, Y.

Table 5 Empirical distribution ρ, λ and θ and t-values – NLLS (GI) – 10 000 replications.

	H_0 : ρ = 0.04 , λ = 0, θ = 0.					
Percentiles	ρ	t-value (ρ)	λ	t-value (λ)	θ	t-value (θ)
2.5	0.035	-1.896	-1.291	-2.209	-1.468	-1.553
5	0.036	-1.559	-1.086	-1.811	-1.144	-1.372
10	0.037	-1.179	-0.851	-1.379	-0.844	-1.117
25	0.038	-0.553	-0.466	-0.723	-0.422	-0.643
50	0.040	0.105	-0.015	-0.023	0.008	0.012
75	0.042	0.731	0.449	0.651	0.392	0.712
90	0.044	1.305	0.867	1.247	0.733	1.354
95	0.045	1.663	1.129	1.600	0.941	1.756
97.5	0.046	2.002	1.368	1.952	1.126	2.067
	H_0 : ρ = 0.04 , λ = 0, θ = 1.					
Percentiles	ρ	t-value (ρ)	λ	t-value (λ)	θ	t-value (θ)
2.5	0.033	-1.977	-1.461	-2.235	-0.226	-1.785
5	0.034	-1.618	-1.241	-1.844	0.006	-1.551
10	0.036	-1.251	-0.970	-1.401	0.240	-1.257
25	0.038	-0.635	-0.539	-0.753	0.610	-0.688
50	0.040	0.042	-0.028	-0.038	0.999	-0.002
75	0.043	0.669	0.487	0.654	1.377	0.670
90	0.045	1.223	0.939	1.283	1.754	1.209
95	0.047	1.528	1.208	1.649	2.006	1.487
97.5	0.048	1.817	1.468	2.003	2.228	1.742

Note : t-values based on unadjusted standard errors.

Table 6 Empirical distribution ρ, λ and θ and t-values – NLIV (GI)- 10 000 replications.

	H_0 : ρ = 0.04 , λ = 0, θ = 0.					
Percentiles	ρ	t-value (ρ)	λ	t-value (λ)	θ	t-value (θ)
2.5	0.034	-1.683	-2.063	-2.362	-2.852	-1.294
5	0.035	-1.342	-1.829	-2.042	-2.199	-1.166
10	0.036	-0.990	-1.502	-1.639	-1.622	-1.022
25	0.038	-0.394	-0.982	-1.005	-0.886	-0.740
50	0.040	0.181	-0.370	-0.339	-0.248	-0.268
75	0.043	0.699	0.310	0.252	0.261	0.302
90	0.045	1.161	0.956	0.677	0.705	0.761
95	0.047	1.465	1.420	0.927	0.986	0.978
97.5	0.049	1.731	1.844	1.123	1.263	1.131
	H_0 : ρ = 0.04 , λ = 0, θ = 1.					
Percentiles	ρ	t-value (ρ)	λ	t-value (λ)	θ	t-value (θ)
2.5	0.030	-1.832	-2.779	-2.409	-1.278	-1.522
5	0.032	-1.510	-2.485	-2.105	-0.847	-1.376
10	0.034	-1.187	-2.093	-1.751	-0.412	-1.211
25	0.037	-0.669	-1.462	-1.145	0.140	-0.923
50	0.039	-0.079	-0.717	-0.509	0.628	-0.450
75	0.043	0.436	0.083	0.053	1.064	0.072
90	0.046	0.846	0.933	0.541	1.523	0.421
95	0.049	1.092	1.499	0.800	1.953	0.545
97.5	0.052	1.350	2.140	1.039	2.619	0.640

Note : t-values based on unadjusted standard errors.

Appendix a: derivation of the Euler equation (5).

Starting from (1) but assuming a finite lifetime (from t to T),

(A1) $V = E_t \sum_{j=t}^{T} \alpha^{j-t} u(c_j^*)$

allows us to work backwards starting from T. If we assume total financial wealth (state variable) is consumed in period T (no bequests), lifetime utility which is a function of the state variable in T is equal to the instantaneous utility in T. We then go back 1 period, where a choice has to be made between effective consumption in T-1 and a transfer of financial wealth to T. This choice is based on the transfer of financial wealth obtained from T-2 and the (effective) labour income obtained in T-1. If we reiterate this procedure until for instance we arrive in period t, we can analyze the complete problem by looking at t and t+1. In each period t the agent receives w_t from the past (state variable) and transfers w_{t+1} to the future; the agent follows an optimal path from t+1 onwards and thus w_{t+1} uniquely determines lifetime utility from t+1 onwards (this optimal lifetime utility path from t+1 on is represented by the value function V_{t+1}). The value function for t is,

(A2) $V_t(w_t) = \max_{w_{t+1}} \left[u(c_t^*) + \alpha E_t V_{t+1}(w_{t+1}) \right]$

where from (3), (4) and $c_t^* = c_t + \lambda g_t$ we obtain, (A3) $c_t^* = y_t^* + w_t - \frac{w_{t+1}}{1+r}$

with $y_t^* = y_t - (1-\lambda)g_t - b_t + \frac{b_{t+1}}{1+r}$

Equation (A2) represents the maximum lifetime utility at t given financial wealth w_t from the past, 'effective' labour income y_t^* and the optimal policy from t+1 onwards given by V_{t+1}.

Maximizing the term between brackets on the RHS of (A2) with respect to c_t^* subject to (A3) gives the following interior solution,

(A4) $u'(c_t^*) = \alpha E_t \left[V'_{t+1}(w_{t+1})(1+r) \right]$

If we analyze the behavior of V_t for changes in w_t we can neglect the indirect effect of changes in w_t on the optimal value of w_{t+1} because the objective is at a maximum at this point. Thus taking the partial derivative of V_t with respect to w_t and using (A4) we can write (envelope theorem),

(A5) $V'_t(w_t) = u'(c_t^*)$

To derive (A5) it is important to emphasize that we assumed that the rate of return is non-stochastic. Taking (A5) one period further for t+1 and plugging this into (A4) we obtain equation (5) in section II.

To generalize this result for an infinitely lived agent, simply impose the following solvency conditions on (3) and (4),

$$\text{(A6)} \qquad \begin{aligned} &\lim_{j\to\infty} \frac{w_{t+j}}{(1+r)^j} = 0 \\ &\lim_{j\to\infty} \frac{b_{t+j}}{(1+r)^j} = 0 \end{aligned}$$

The first condition follows from consumer optimization (positive marginal utility); the second condition is the no-Ponzi game constraint for the government.

Appendix b: derivation of the consumption functions (7) and (8).

Starting from the one-period budget constraints (3) and (4), which we solve forwards while imposing the solvency conditions (A6), we obtain,

$$\text{(B1)}\quad \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_t c_{t+j} = w_t + \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_t(y_{t+j} - t_{t+j})$$

$$\text{(B2)}\quad \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_t t_{t+j} = b_t + \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_t(g_{t+j})$$

Substitution of (B2) into (B1) and solving for effective consumption, using (2), leads to,

$$\text{(B3)}\quad \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_t c^*_{t+j} = (w_t - b_t) + \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_t(y_{t+j} - (1-\lambda)g_{t+j})$$

The first-order condition is given by (5). As we have noted in the main text, if utility is quadratic and if the return is assumed equal to the subjective rate of time preference, (5) reduces to the martingale process for effective consumption, namely (6) $E_t c^*_{t+1} = c^*_t$. This also implies that $\forall$j ,

$$\text{(B4)}\quad E_t c^*_{t+j} = c^*_t$$

Plugging (B4) into the LHS of (B3), using the fact that $\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} = \frac{1+r}{r}$, we obtain

$$(B5)\quad c_t^* = \left(\frac{r}{1+r}\right)\left[\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^j E_t\left[y_{t+j} - (1-\lambda)g_{t+j}\right] + (w_t - b_t)\right]$$

Adding an error term, we obtain equation (7) in the main text.

To allow for an alternative hypothesis to Ricardian Equivalence, we can rewrite permanent income (Y_t) as,

$$(B6)\quad Y_t = w_t + \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^j E_t\left[y_{t+j} - \theta(t_{t+j} - \lambda g_{t+j})\right]$$

As seen in the text, depending on sgn(λ), government expenditures and private consumption will either be substitutes or complements. When e.g they are substitutes ($\lambda>0$) it can be seen from (B6) that current and future government consumption will increase permanent income. For a given private consumption expenditure, an increase in current and future government expenditures will have a positive wealth effect on consumers. Notice that the introduction of the parameter reflecting myopia (θ) implies no asymmetry as to which aspect of fiscal policy is discounted by the consumer. Substitution of (B2) into (B6) leads to the specification of permanent income that is implied in the consumption function (8) (The term in large brackets on the RHS).

Appendix c : link with the Blanchard (1985) model.

We establish the link between the consumption function (9) and the consumption function from Blanchard (1985), but put in discrete form by Evans (1988) and used by among others Evans (1988, 1993), Graham & Himarios (1996) and Sutherland (1997). We start by setting λ =0 (the Blanchard model does not follow the consolidated approach) and by setting $\theta = 1$. Using (B2) from appendix b, we obtain

$$\text{(C1)} \quad c_t = \beta\left[\sum_{j}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[y_{t+j} - t_{t+j}\right] + w_t\right] + u_t$$

where $\rho > r$. This inequality in the Blanchard model does not result from uncertainty but is the result of the fact that consumers have finite lives. Since $\rho > r$ we can say that $\frac{1}{1+\rho} = \frac{1-p}{1+r}$ where $0<p<1$. We name p the constant probability of death of the representative consumer. If p=0 we obtain that $\rho = r$ where the consumer is infinitely lived and thus (abstracting from the realization of the other assumptions) Ricardian. If the consumer is finitely lived he or she will have a probability to survive for 1 period of 1-p and a probability to survive for j periods of $(1-p)^j$.

If p is high then life will be short and expectations of future after tax income will play a minor role in today's decisions . With p high it will take only a few periods before future variables are irrelevant for today's consumption. With p low the decline in the weights attached to future variables will be lower.

Appendix d : derivation of the consumption function (12).

Starting from (9) but imposing $n_t = w_t - b_t$ (financial wealth excluding government debt) we obtain,

(D1) $$c_t^* = \beta \sum_{j=0}^{\infty} \left(\frac{1}{1+\rho} \right)^j E_t y_{t+j} - \theta\beta(1-\lambda) \sum_{j=0}^{\infty} \left(\frac{1}{1+\rho} \right)^j E_t g_{t+j} + \beta n_t + \beta(1-\theta) b_t + u_t$$

If we lag this equation one period we can derive,

(D2) $$\beta \sum_{j=0}^{\infty} \left(\frac{1}{1+\rho} \right)^j E_{t-1} y_{t+j-1} =$$

$$c_{t-1}^* + \theta\beta(1-\lambda) \sum_{j=0}^{\infty} \left(\frac{1}{1+\rho} \right)^j E_{t-1} g_{t+j-1}$$

$$- \beta n_{t-1} - \beta(1-\theta) b_{t-1} - u_{t-1}$$

If we use (10) and (11) with the expectation revisions denoted by e_{jt} (for j=1,2) into equation (D1), we obtain

(D3) $$c_t^* = \beta \left[(1+\rho) \left(\sum_{j=0}^{\infty} \left(\frac{1}{1+\rho} \right)^j E_{t-1} y_{t+j-1} - y_{t-1} \right) + e_{1t} \right]$$

$$- \theta\beta(1-\lambda) \left[(1+\rho) \left(\sum_{j=0}^{\infty} \left(\frac{1}{1+\rho} \right)^j E_{t-1} g_{t+j-1} - g_{t-1} \right) + e_{2t} \right]$$

$$+ \beta n_t + \beta(1-\theta) b_t + u_t$$

Plugging (D2) into (D3) and using (2) makes it possible to get rid of the terms with summation signs ; after some rearrangements this leads to equation (12) in the main text.