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Government Debt and Private Consumption: Theory and Evidence

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Abstract

The Ricardian equivalence theorem has been widely debated since (at least) the seventies. The theorem states that households should not change their consumption path in response to changed timing of taxes, given the path of government consumption. In the paper, theoretical models giving rise to the equivalence result as well as models predicting deviations from debt neutrality are presented. In general, the Ricardian models are based on unrealistic assumptions, such as infinite horizons, perfect capital markets and lump-sum taxes. The issue of Ricardian equivalence is thus perhaps better viewed as a question concerning to what extent the equivalence hypothesis is a reasonable approximation of the real world. This could only be established by empirical studies. To formulate a test of Ricardian equivalence, it is however vital to extend the standard analysis in deterministic models to stochastic models. In a stochastic model we need to incorporate the fact that agents have to make predictions about future levels of government consumption, and that public debt might be a useful predictor for this purpose. It is therefore necessary that an empirical study distinguishes between debt as a potential source of net wealth, which is the concern of the equivalence proposition, and debt's role as a signal of future levels of government consumption, which is due to the stochastic nature of the world. It is argued that there are few empirical studies that make this distinction, and in case the distinction is made, the evidence is in favor of the Ricardian equivalence proposition, namely that public debt is not net wealth to households. Changing the timing of taxes will therefore not change private consumption. In other words, although the Ricardian equivalence hypothesis is burdened with unrealistic assumptions, it seems (historically) to provide a reasonable approximation of actual data.

Keywords: public debt, private consumption, Ricardian equivalence

JEL: H60, H31

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1. INTRODUCTION

The Ricardian equivalence proposition states that for a given path of government consumption, the timing of taxes, or equivalently, the accumulation and decumulation of public debt, does not affect private consumption. In a closed economy, it therefore also leaves the interest rate, investments and output unchanged. If this is a valid prediction, the scope of fiscal policy as a stabilization tool of the macroeconomy is very limited. The proposition stands in sharp contrast to the basic Keynesian[1] perspective, where a tax reduction/public debt accumulation in one period increases private consumption and thus also affects other macro variables like output and unemployment.

The debate about the equivalence proposition was revived with a famous paper by Barro [1974]. Barro argued that the private sector's holding of government bonds does not represent net wealth to the households, and has thus no effect on private consumption. Barro's analysis has been supported by other papers displaying the equivalence result, but there are also contributions to the literature which favor the Keynesian prediction.

In general, models that generate the equivalence result are burdened with some more or less implausible or at least questionable assumptions, where some of the most noted concern "infinite" planning horizons, perfect capital markets and lump-sum taxes. On the other hand, models that do not generate the equivalence result also depend on assumptions that can be questioned, for example regarding liquidity constraints or myopic individuals. As always, it is hard to judge from theory alone what the best/most reasonable description or approximation of the real world is.

Following Barro's paper, there have been several empirical studies aimed at describing what the effects of debt or changed timing of taxes are on private

[1]The label *Keynesian* is used for models that imply that decreased taxes today will increase consumption today, although the present value of government consumption is left unchanged. There are of course other models than the ones presented by Keynes that display this feature, but in this context, the label Keynesian will be used for models where individuals regard their holdings of government bonds as net wealth.

consumption and interest rates. Potentially, the empirical studies could provide a way of evaluating the different competing theories. However, testing Ricardian equivalence is in itself a complex task, where one first has to translate the theoretical predictions into testable hypotheses. Then the appropriate data has to be chosen, as well as a statistical method that generates valid tests or descriptions of data.

The aim of this paper is to establish a link between theoretical predictions and empirical tests of Ricardian equivalence. In the next section, some standard theoretical models, generating both Ricardian and non-Ricardian outcomes, are reviewed, and their crucial features are discussed. Then the concept of Ricardian equivalence in a stochastic world is analyzed, before the results and difficulties of some empirical studies are presented. Finally, in the concluding section, some suggestions for extensions and possible improvements of these empirical studies are discussed.

2. THEORETICAL MODELS

There are two major types of models used to analyze the equivalence theorem. First there are models where agents have an ”infinite” planning horizon, and secondly there are models where individuals for one reason or another are ”myopic”. Note however that the concepts ”infinite” and ”myopic” are only defined in connection with the planning horizon of the government. Infinite is then synonymous to agents having the same planning horizon as the government, and myopic refers to models where agents have a shorter planning horizon than the government. For example, in a model where both individuals and government plan for two periods, individuals are said to have ”infinite” horizons, while in a model where individuals plan for ten periods and the government for eleven, individuals are said to be ”myopic”.

Two standard examples of these types of models are infinite horizon representative agent models (IRA:s) and overlapping generations models (OLG:s). In this section I will give an overview of some specific models, first a Keynesian model, then a basic IRA model, a basic OLG model, an OLG model with altruism and finally Blanchard’s [1985] model. Blanchard’s model could be regarded as a mix of an OLG and IRA model, since the time of death is stochastic, but due to the stochastic properties of the death rate, all agents have the same expected planning horizon. Crucial to all of these models is that they assume that the government's actions are know for all future periods, as is the income of households and the interest rate.

2.1 A KEYNESIAN CONSUMPTION FUNCTION

The most basic version of a Keynesian consumption function states that present consumption is a function of current disposable income, or more formally

$$C_t = \beta_0 + \beta_1 YD_t \quad , \tag{1}$$

where C is private consumption, β_0 is an intercept, β_1 is the propensity to consume out of current disposable income, and disposable income is defined as $YD_t \equiv Y_t - T_t$, i.e. total income minus (net) taxes. This type of consumption function has been criticized for lacking an explicit derivation from utility maximizing individuals, although there exist motivations for why this consumption function could result from utility maximizing individuals. The most straight forward motivation is that individuals are liquidity constrained, and the best they could do then is to simply consume all their current disposable income, implying that $\beta_0 = 0$ and $\beta_1 = 1$ in the above consumption function. It is obvious from this formulation alone that it is the amount of taxes individuals pay that matters for the private consumption decision, and not the amount of real resources consumed by the government. Furthermore, changing the timing of taxes would obviously change private consumption, since there are no forward looking elements present in the consumption function.

2.2 A BASIC IRA MODEL[2]

The agent's problem is to maximize his utility from period 0 to infinity according to the following equations

[2] See for example Blanchard and Fisher [1989], ch. 2.

$$\begin{aligned} &\max_{c} \quad \int_0^{\infty} U(c_t)e^{-\delta t}dt \\ &s.t. \quad \dot{w}_t = rw_t + y_t - c_t - \tau_t \\ &\qquad \lim_{t\to\infty} w_t e^{-rt} = 0 \end{aligned} \quad , \tag{2}$$

where $U(c_t)$ represents the momentary utility derived from consuming c_t, δ is the subjective discount factor, $w_t = b_t + d_t$, is total financial wealth consisting of corporate bonds (b) and government debt (d). Labor income (y) is determined exogenously as is the lump-sum tax (###). The expression $\lim_{t\to\infty} w_t e^{-rt} = 0$ is the transversality or no-Ponzi game condition that restricts the agent from borrowing an infinite amount (i.e. letting w go to minus infinity) for consumption. More precisely it states that as time goes to infinity, the present value of the amount borrowed should go to zero. This has the implication that the agent cannot borrow resources in one period, and in future periods borrow to pay both the previous loan and the interest on this loan. Pursuing such a strategy would make the agent's debt grow at the same speed as the discount factor, and thus the product of the two would not go to zero as required by the imposed condition. If this condition (or a similar one) is not imposed, the maximization problem would not have a solution, since then the agent would choose to have an infinite consumption in each period, financed by an ever increasing personal debt (negative wealth).

The budget constraint, together with the transversality condition, can be integrated to yield the intertemporal budget constraint

$$\int_0^{\infty} c_t e^{-\delta t}dt = \int_0^{\infty} y_t e^{-\delta t}dt - \int_0^{\infty} \tau_t e^{-\delta t}dt + b_0 + d_0 \ . \tag{3}$$

The government obeys the following budget constraint

$$\begin{aligned} g_t + rd_t - \dot{d}_t &= \tau_t \\ \lim_{t\to\infty} d_t e^{-rt} &= 0 \end{aligned} \ , \tag{4}$$

where g_t is government consumption, and the second equation is again the No-Ponzi game assumption, that in this case restricts the government from running an ever growing debt. Integrating this yields the government's intertemporal budget constraint

$$\int_0^\infty \tau_t e^{-rt} dt = \int_0^\infty g_t e^{-rt} dt + d_0 \ . \tag{5}$$

In the model $\delta = r$, either as a consequence of maximization if we analyze a closed economy, or in the case of an open economy, by assumption, to prevent the economy from going to zero or infinity as time goes to infinity. Taking this into account and then substituting the government budget constraint into the agent's intertemporal budget constraint we get

$$\int_0^\infty c_t e^{-rt} dt = \int_0^\infty y_t e^{-rt} dt - \int_0^\infty g_t e^{-rt} dt + b_0 \ , \tag{6}$$

from which it is obvious that what matters for the agent is not the timing of taxes, but the total amount of resources used by the government.[3]In other words, by checking that the budget constraint remains unchanged when we conduct a policy experiment, we know that the consumption path of households will remain unchanged. In particular, this will be the case for the Ricardian experiment, where the timing of taxes is changed and the present value of government consumption is held constant.

The critical assumptions or features of the model giving rise to the equivalence result are quite a few. First of all, the individuals and the government face the same interest rate, implying perfect capital markets without, for example, liquidity constrained individuals. Also, since perfect foresight is assumed, the returns on b and d are the same, and government debt does not represent an additional investment opportunity.

[3]Since d does not appear in the equation, it is obvious that the agent cannot perceive that government bonds are net wealth.

Further, there is no gain from tax-smoothing in the model, since only lump-sum taxes are considered.

In the model we also have a representative agent, and thus heterogeneity among individuals can obviously not be considered. Finally, the infinite horizon and the assumption of no population growth imply that there is no way for individuals to evade taxes, by dying and/or levy taxes on other generations. These are only some of the strands of criticism of this model, but maybe some of the more important ones.

In general, deviations from either of the above assumptions could make consumption respond to changes in the timing of taxes. The most discussed assumption regards the planning horizon, where the conclusion is that if individuals have shorter planning horizons than the government, they will in general regard their holdings of government bonds as net wealth, implying that a tax cut today (given government consumption) will increase consumption.

2.3 A BASIC OLG MODEL[4]

In this model individuals live for two periods, they only work in their first period as young, and there is no population growth. Furthermore, as young the agent maximizes utility according to

$$\begin{aligned} &\max_{c_t^i} \quad U\left(c_t^i, c_{t+1}^i\right) \\ &s.t. \quad c_t^i = y_t - w_t - \tau_t^i \\ &\qquad\quad c_{t+1}^i = (1+r)w_t - \tau_{t+1}^i \ , \end{aligned} \tag{7}$$

where $U\left(c_t^i, c_{t+1}^i\right)$ is the utility function to be maximized by choosing consumption in the first (and thereby also second) period, c_t^i and c_{t+1}^i, where the subscripts t and t+1 stand for consumption as young and old, respectively, while the superscript i stands

[4]See for example Diamond [1965] or Blanchard and Fisher [1989] , ch. 3.

for the generation born in period i. Total wealth is again $w_t = b_t + d_t$, i.e. the sum of corporate bonds (b_t) and government debt (d_t), y_t is (fixed) labor income that is only received as young, and $\tau^i_{t,t+1}$ is the lump-sum tax paid in the two periods by generation i.

Without population growth and the possibility for the government to levy different taxes on different generations, the tax payments for a specific generation will be equal to half the tax receipts of the government. Total tax receipts for the government are then $T_t = \tau^{i-1}_{t+1} + \tau^i_t$ in period $t=i$ (when generation i is young). The Ricardian question is as usual what the effects are if the government changes the timing of taxes, but keeps the present value of taxes unchanged.

If we take the simplest case of postponing taxes for one period, the government budget constraint implies that $\Delta T_{t+1} = -\Delta T_t(1+r)$. Substituting this into the young person's budget restriction shows that the net effect is zero, thus not affecting his consumption path.[5] For the old generation the story is different, they will in fact increase consumption by the whole tax reduction they receive (in the case with undifferentiated taxes, half of ΔT_t). Thus the tax change will have an effect on aggregate consumption. The losers in this experiment are, of course, the not yet born generation $i+1$, that will have to pay for generation $i-1$'s increased consumption.

In other words, debt is not neutral in this model, since changing the timing of taxes will affect private consumption. Without specifying the production side, capital market and openness, we cannot say how this consumption change will affect other macro variables, but, in general, all variables endogenous to the economy will be affected.

We would of course obtain neutrality if the government could make sure that it is the generation which benefits from a tax cut that later pays the tax plus interest for deferring the tax. However, this type of policy is in general not considered, since it is viewed as unrealistic. In his 1974 paper, Barro ”saved” the neutrality result by introducing intergenerational links through altruism. Since then many articles have dealt with the issue. The following section presents a model with symmetric altruism in an OLG model that gives rise to debt neutrality.

2.4 An OLG model with symmetric altruism

In this type of model, the standard utility function is modified to allow children and parents to care about each other's utility. Several ways of modeling this has been proposed. Below I will consider the specification used by Burbidge [1983] where generations care about each other in a symmetric way. Other ways of treating altruism can be found in Barro [1974], Buiter [1979], Carmichael [1982], Weil [1987], Abel [1987], Kimball [1987] and Jungenfelt [1991], where most of the articles analyze when gifts or bequests are operative, in the sense that they actually will take place. In general, the altruistic motive can be too weak in some states of the economy, so that agents will then refrain from giving gifts or leaving bequests to neutralize intergenerational transfers implemented by the government. However, in the case of symmetric altruism, either gifts or bequests will be operative (unless the generations, by chance, have an efficient intergenerational allocation of wealth to start with). The way to set up the utility function is as follows, let utility be time separable and define total utility, v_t, for generation *i* that is born in period *t*, as

$$v_t = \left(\frac{1+n}{1+\delta}\right)^{-1} v_{t-1} + u\left(c_t^i, c_{t+1}^i\right) + \frac{1+n}{1+\delta} v_{t+1} \quad , \tag{8}$$

which states that total wealth for generation *i* is a weighted sum of their parents' utility v_{t-1}, the utility, $u\left(c_t^i, c_{t+1}^i\right)$, they derive from their own consumption as young and old, c_t^i and c_{t+1}^i, and their children's utility, v_{t+1}. The weights are the ratio of one plus the population growth, *n*, and one plus the subjective discount rate, δ. Note that parents' utility is ”reversely” discounted compared to childrens', (and thus the label ”symmetric” altruism, since parents live before children.) In general this is, of course,

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[5]If we consolidate the budget constraint we get $c_t^i + c_{t+1}^i / (1+r) = y_t - \tau_t^i - \tau_{t+1}^i / (1+r)$, which makes the wealth effect of the considered policy obvious.

an arbitrary discounting rule that might or might not be an appropriate description of the real world, but has analytically nice properties, since gifts and bequests will always be operative, due to this assumption.

By substituting consecutively for the v_{t+i}'s and assuming[6] (arbitrarily) that $v_{t-1} = u_{t-1}$, this can be written as

$$v_t = \sum_{i=-1}^{\infty} \left(\frac{1+n}{1+\rho} \right)^{-i} u\left(c_t^i, c_{t+1}^i\right) \quad , \tag{9}$$

which now is close in spirit to the standard infinite horizon model, the only substantial difference being the underlying assumptions made to arrive at the formulation. In this case, we interpret the model as individuals maximizing their family's utility rather than their individual utility. This utility function is to be maximized subject to the (consolidated) budget constraint[7]

$$c_t^i + g^i + \frac{c_{t+1}^i}{1+r_{t+1}} + \frac{b^i}{1+r_{t+1}} = y_t + g^{i+1} \frac{1+n}{1+r_{t+1}} + \frac{b^{i-1}}{1+n} \quad , \tag{10}$$

where g^i now stands for gifts from generation i to generation $i-1$, and b^i stands for bequests from generation i to generation $i+1$. This maximization with altruism gives rise to additional first order conditions not present in models without altruism, of the form

$$\frac{\partial u\left(c_t^i, c_{t+1}^i\right)}{\partial c_t^i} = \left(\frac{1+r_{t+1}}{1+\rho} \right) \frac{\partial c\left(c_t^{i+1}, c_{t+1}^{i+1}\right)}{\partial c_t^{i+1}} \quad \text{for } i = t-1, t. \tag{11}$$

[6]The assumption is made to avoid the Hall of mirros problem, i.e. that we get an infinite recursion.
[7]The maximization requires $n < \delta$, otherwise the utility goes to infinity with i.

This represents the utility trade-off *between* generations. In general, this condition is not satisfied unless either gifts or bequests are operative.[8] This has also the implication that a policy that redistributes wealth across generations can and will be fully offset by individuals, by changing the amount of gifts or bequests. Therefore, a policy of the type considered in the preceding section will leave the consumption paths unchanged because no redistribution of wealth will take place, or rather, the redistribution implied by government debt policy will be fully offset by intergenerational transfers in the form of gifts or bequests.

In the above analysis it was assumed that the utilities of parents and children were evaluated in a symmetric way, with children's utility discounted by $1/(1+\delta)$ and parent's ”reversely” discounted by $1+\delta$. This assumption gives rise to the fact that gifts or bequests are always operative, which in turn is crucial for the neutrality result. This type of symmetry is abandoned in for example Abel [1987], where the case of different discount factors for children and parents is analyzed. Abel shows that some restrictions on these parameters are needed to get a meaningful maximization problem, and furthermore that there exists a range of allowable parameter values that imply that neither gifts nor bequests will be operative. In this range a redistributive fiscal policy will have an impact on individuals' wealth and thus on the consumption paths.

Jungenfelt [1991] shows that this range with inoperative gifts and bequests can be made smaller if a family introduces implicit contracts in the form of pension clubs. These clubs will survive in a sub game perfect equilibrium under certain restrictions on the parameters in the model, a crucial parameter being the set-up cost for a pension club, that cannot be too low.

To summarize the above discussion, the effect that changed timing of taxes could have on private consumption is due to wealth reallocations across generations. However, in a model with symmetric altruism, gifts or bequests will always be operative, so that any redistribution implemented by the government will be fully

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[8]Unless the generations already have a wealth distribution that implies that the first order condition is satisfied.

offset by individuals. For example, if a family to begin with has an efficient allocation of wealth between generations, and the government decreases taxes today and raises them in the future, implying that today's generation will be richer, today's generation will simply increase bequests to their children (or children will reduce their gifts) to reestablish the original optimal wealth allocation.

2.5 Blanchard's [1985] model

Blanchard's model is in a way a mix between an IRA-model and an OLG-model, where we have an infinite number of generations alive in every period. This would in general make aggregation impossible in the model, due to differences in the propensity to consume as well as in the wealth of the infinite number of generations in the model. The way this is handled in OLG models is to assume that there are only a few generations alive in any period, so it is simple enough to compute the consumption for each generation and then add them together. Blanchard, on the other hand, makes an assumption about the probability of death, namely that all individuals face the same probability (p) of dying at each point in time. This has the very useful implication that all individuals have the same expected remaining life-time and thus also the same propensity to consume out of wealth, so it does not matter who holds what parts of the wealth in the economy.

Due to the above, the economy behaves as if it had only one representative consumer. This feature makes aggregation possible despite the infinite number of generations. The setup of the model is as follows. At every point in time individuals face a constant probability of dying (p), but the population is held constant by setting the birth rate at p too.[9] A perfect annuity or life insurance market is functioning, so individuals do not face the risk of dying with wealth they could have consumed. This in turn makes the return on savings equal to $r+p$, rather than simply r. In other words, there will not be any involuntary bequests, but instead the savings of a dead individual goes to the insurance company that pays the extra return p on savings to

[9]An assumption that will actually be crucial for the results, since, as Buiter [1988] points out, zero birth rate is a necessary and sufficient condition for neutrality in this model, given of course perfect capital markets and lump-sum taxes.

those alive. Individuals born in period s are assumed to maximize expected utility in period t according to

$$\begin{aligned} &\max_{c} \quad E_t\left[\int_t^\infty \log c_{s,v} e^{\delta(t-v)} dv\right] \\ &s.t. \quad \dot{w}_t = (r_t + p)w_t + y_t - c_t - \tau_t \\ &\qquad \lim_{t\to\infty} w_{s,v} e^{\int_t^v (r_\mu + p) d\mu} = 0 \quad , \end{aligned} \tag{12}$$

which states that individuals maximize the expected discounted sum of utilities over time, and the momentary utility function is the logarithm of the consumption flow. The maximization is subject to a budget constraint that states that the present value of consumption is equal to the present value of income net of lump-sum taxes (variables defined as before). Since the uncertainty comes completely from the unknown death date, this is equivalent to the following maximization problem

$$\begin{aligned} &\max_{c} \quad \int_t^\infty \log c_{s,v} e^{(p+\delta)(t-v)} dv \\ &s.t. \quad \int_t^\infty c_{s,v} e^{\int_t^v (r_\mu + p) d\mu} dv = w_{s,t} + h_{s,t} \quad , \end{aligned} \tag{13}$$

where we can note that the effect of an uncertain life time is to change the effective discount factor from δ to $p+\delta$. Furthermore, $w_{s,t}$ is non-human wealth, again defined as $w_t \equiv b_t + d_t$, where b_t is now corporate bonds and d_t is public debt. Finally, $h_{s,t}$ is human wealth, defined as

$$h_{s,t} \equiv \int_0^\infty y_v e^{\int_t^v (r_\mu + p) d\mu} dv - \int_0^\infty \tau_v e^{\int_t^v (r_\mu + p) d\mu} dv \ . \tag{14}$$

The solution to this problem, due to the logarithmic utility, is of the simple form

$$c_{s,t} = (p+\delta)[w_{s,t} + h_{s,t}] \ , \tag{15}$$

so that consumption in each period is a (constant) fraction of total discounted wealth. The government is assumed to consume *G*, that does not affect individuals' marginal utility. The path of *G* is known and the government can in any period finance *G* with either lump-sum taxes (*T*) or debt (*D*). The government's budget constraint is

$$G_t + rD_t = \dot{D}_t + T_t \ , \tag{16}$$

which, as before, together with the transversality condition,

$$\lim_{t\to\infty} D_t e^{\int_t^v r_\mu d\mu} = 0 \ , \tag{17}$$

can be integrated to yield the intertemporal budget constraint

$$\int_t^\infty T_v e^{\int_t^v r_\mu d\mu} dv = \int_t^\infty G_v e^{\int_t^v r_\mu d\mu} dv + D_t \ . \tag{18}$$

Before characterizing the effects of tax reallocation, we have to specify the aggregates in the economy. The aggregate values over all individuals alive today are computed according to

$$X_t = \int_{-\infty}^t x_{s,t}\, p e^{p(s-t)} ds \ , \tag{19}$$

which implies that the aggregate (private) consumption function can be written as

$$C_{s,t} = (p+\delta)[W_{s,t} + H_{s,t}] \ , \tag{20}$$

where $W_t = D_t + B_t$, and

$$H_t = \int_0^\infty Y_v e^{\int_t^v (r_\mu + p) d\mu} dv - \int_0^\infty T_v e^{\int_t^v (r_\mu + p) d\mu} dv \ . \tag{21}$$

Aggregate wealth evolves according to

$$\dot{W}_t = rW_t + Y_t - C_t - T_t \ . \tag{22}$$

What happens in this model, if we for a given path of G reallocate taxes from period t to $t + \kappa$? The government budget constraint gives us the following condition

$$-e^{\int_t^{t+\kappa} r_\mu d\mu} dT_t = dT_{t+\kappa} \ . \tag{23}$$

The effect of this tax reallocation on aggregate consumption in period t is due to a change in human wealth described by

$$-dT_t - dT_{t+\kappa} e^{\int_t^{t+\kappa} (r_\mu + p) d\mu} \ , \tag{24}$$

which with (23) can be written as

$$-dT_t \left(1 - e^{-p\kappa}\right) \ . \tag{25}$$

In case p (or κ) is zero, this expression is equal to zero, but not otherwise. With p equal to zero, we are of course back in the IRA-model. For $p > 0$, the expression in parenthesis is between zero and one, so a tax decrease in t leads to a positive wealth effect and thus to raised consumption in t.

Why do we get this result, or what does $1-e^{-p\kappa}$ represent? It is simply the probability that someone alive today ”evades” the taxes in $t+\kappa$ by dying before that period. In general, this feature alone would not imply that debt is net wealth, since the agents who survive have a larger tax burden in the future if nothing more happens. An alternative way of analyzing the expression is to note that it can be decomposed into one part representing the differences in returns that the government and individuals have, and one part that represents the number of agents that share the debt burden. This is not transparent in the original models, since the birth rate is assumed to be equal to the death rate, p. If we for a moment instead separate these rates and call the birth rate q, and do not impose the restriction that $p=q$, what will the expression in (25) look like then? If we concentrate on the expression in parenthesis, and abstain from canceling out exponents, it is more transparent what the expression represents. Assuming for simplicity that the interest rate is constant, the expression becomes

$$1-1e^{r\kappa}e^{-(r+p)\kappa}e^{p\kappa}e^{-q\kappa}\quad . \tag{26}$$

We could note that by setting $p=q$, and canceling terms, we get back our original expression. The question is then what the parts in the current expression represent. The first term is simply the instant wealth effect from the tax cut, neglecting changes in future tax payments. The second term then picks up the change in future tax payments, and this is where all the action is. First of all, future tax payments will increase with the interest rate, since the government is borrowing today to make the tax cut ($e^{r\kappa}$). Secondly, if the agent saves this tax cut, his return is actually the interest rate plus the return received from the insurance policy, thus his liability decreases with this amount ($e^{-(r+p)\kappa}$). We then have left the effects from changes in the population size. Here we start with the effect from people dying, which implies that the *per capita* debt to pay will increase with the factor $e^{p\kappa}$. The goods news is, however, that there are new people entering the economy, and these entrants will be part of the tax base, which reduces the per capita debt with the factor $e^{-q\kappa}$.

What have we learnt from this decomposition? First of all, if government and individuals were using the same discount factor, the effect would be zero, but since individuals take into account their probability of dying, the agents' discount factor is larger than the government's. However, this effect would totally cancel if the population size was declining at the same rate as agents were dying, i.e. if birth rates were set to zero. This has been pointed out in Weil [1987] and Buiter [1988]. In other words, the individuals currently alive need new entrants into the economy for the wealth effect of postponing taxes to be present.

One final question is how large the change in human wealth would be in response to a reallocation of taxes in this model if we use actual death rates as an estimate for *p*, and assume like the model that the population size is constant. In Table 1 simple calculations of the value of $1-e^{-p\kappa}$ for two different values of κ and with actual death rates in different age groups, as well as for the total population, are presented. The calculations are based on death probabilities for Sweden in 1988, and since the death rates used are deaths per year, the values of κ should be regarded as the number of years that taxes are postponed.

	$[1-e^{-\kappa p}]$ in percent	
Age group	$\kappa = 1$	$\kappa = 10$
20-24	0.07	0.69
40-44	0.19	1.83
50-54	0.44	4.27
60-64	1.16	11.0
75-79	5.11	41.2
Total	1.15	11.0

Table 1. *Percentage effect of tax reallocation on human wealth.*
Source: SCB [1990] and own calculations.

If we translate this into effects on consumption[10], assuming that δ, the subjective discount factor, is 0.10, these range from 0.007 percent to 4.1 percent, with an average for the total population of 1.1 percent for κ=10. In other words, creating a budget

[10]The effect on aggregate consumption is achieved by multiplying with the factor $(p+\theta)$.

deficit of 1 billion SEK that is repaid in ten years would in this model generate, on average, an 11 million SEK rise in private consumption today.

In Figure 1, we illustrate the effects that the actual budget deficit would give rise to according to Blanchard's model in comparison to total actual consumption. The interpretation presented here assumes that the actual world is Ricardian, i.e. there are no wealth effects from postponing taxes, and this is then compared to forecasts made by the Blanchard model for actual government deficits. The Blanchard forecast takes the actual consumption path as the base line, and the wealth effect induced consumption from postponing taxes is then added to the base line.

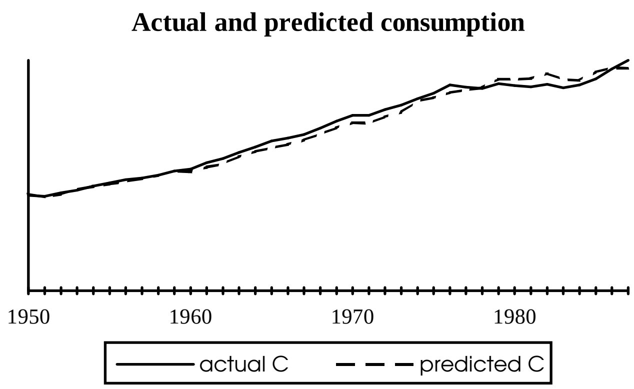

Figure 1. *The solid line represents the actual private consumption that is assumed to be generated by a Ricardian model, while the broken line represents predictions from the Blanchard model, with p for age group 74-79,* κ*=10 and* δ*=0.10.*

My conclusion after using eyeball econometrics of Figure 1 is that it seems rather unlikely that ordinary time series methods would be able to identify the three series depicted as being generated by different models. This indicates that ordinary tests of Ricardian equivalence might well accept the equivalence proposition if finite horizons is the only mechanism that creates deviations from it. Stated differently, the Blanchard model gives rise to numerically small effects in this simple minded comparison, which would probably be hard to identify by investigating data. In a more sophisticated analysis of the US, Poterba and Summers [1987] also reach the conclusion that finite life times and deficits generate effects on consumption that are numerically small.

Figure 2 compares the changes in consumption predicted by the Blanchard model with actual consumption detrended in different ways (linear trend, exponential trend and first differences.) In other words, how well do predictions made by the model match actual consumption changes? Again, all background factors are assumed to be unchanged in the illustration, and the figures do not represent a test of the theory. However, the figures might tell us something about the relevance of the model's ability to explain consumption changes in response to changes in the government's budget. The model values are calculated with the actual Swedish government sector financial net savings data, using death probabilities for people at 74-79 years of age, tax postponement of 10 years and finally a discount factor of 10 percent, all parameters chosen to make the magnitude greater and the patterns more visible, without affecting the co-variance between the model prediction and actual consumption changes.

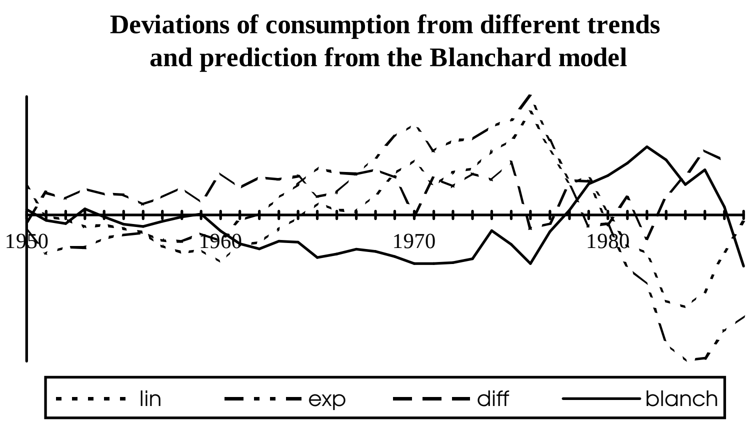

Figure 2. *Consumption changes in response to actual government financial net savings predicted by the model (blanch) compared to deviations of actual consumption from a linear trend (lin), an exponential trend (exp) and a stochastic trend, i.e. stationary first differences (diff).*

The conclusion after looking at these figures is that it seems most unlikely that we will be able to identify the *positive* relation between debt/financial net savings and consumption, predicted by most non-Ricardian models. Of course, the graphs do not take into account background factors that could influence one series negatively and the others positively, but it seems unlikely that we would be able to identify such strong background correlations that would totally change the correlation between the model's predictions and the actual data. These graphs are not intended to serve as a substitute for more precise econometrics, only as a guide to what we might expect to find.

To summarize the conclusions from the Blanchard model. First of all, to obtain a positive wealth effect from postponing taxes, which is the mechanism that creates deviations from Ricardian equivalence, finite horizons is not enough, but we need new entrants into the economy that will pay part of the postponed taxes. Secondly, the numerical magnitude of the effects generated by the model, if we use actual data as input in the model, is small. This suggests that even if the Blanchard model is the appropriate description of the real world, the Ricardian hypothesis will still be a very good approximation of the world. In other words, if we, for one reason or the other, are looking for a model that generates significant deviations from debt neutrality, the Blanchard model is probably not a good choice.

3. RICARDIAN EQUIVALENCE IN A STOCHASTIC WORLD

The above section described models where the path of future government consumption is known. What happens if we relax this rather unrealistic assumption? In the deterministic world, Ricardian equivalence is a well-defined concept; for a given path of government consumption, the timing of taxes or debt leaves private consumption unchanged. A general formulation of the equivalence proposition in the deterministic world could be made by starting with the following general consumption function

$$C_t = f\left(Y^p\right), \tag{27}$$

which simply states that consumption, C_t, is a function of permanent income, Y^p. At this stage we have not said anything about what the components of permanent income are. However, if we take the Ricardian view, we would not allow government debt or taxes to enter the permanent income, but instead the present value of government consumption will affect permanent income. On the other hand, the non-Ricardian view is that debt would represent net wealth to the agents, and is thus a part of permanent income. Here the distinction between Ricardian and non-Ricardian is clear-cut.

However, in the stochastic world, the concept of Ricardian equivalence is less clear cut, which will be discussed below. We particularly want to know how the equivalence proposition should be formulated when performing econometric tests of the proposition.

3.1 DEFINING AND TESTING RICARDIAN EQUIVALENCE IN A STOCHASTIC WORLD

In a stochastic world, we are, generally speaking, dealing with probability distributions or expected values of variables. In a study of Ricardian equivalence, we would study, for example, the probability distributions of private and public consumption as well as probability distributions of taxes, income and so on. The ultimate equivalence would then be that the probability distribution of private consumption does not change in response to changes in the probability distribution of taxes (or debt) in different periods, given that the probability distribution of government consumption remains unchanged.

If we now write down a general consumption function, it can be formulated as

$$C_t = g\left(Y_t^{pe} \middle| I_t\right), \tag{28}$$

which states that consumption today is a function of the *expected* permanent income, Y_t^{pe}, conditional on the information available today, I_t. There are now two possible interpretations of the equivalence proposition. The first would say that debt (or taxes) should not enter *neither* the expected permanent income, *nor* the information set used to make predictions of the permanent income. An important aspect of this formulation is that current debt is not allowed to be useful as a predictor of future levels of government consumption. This formulation is a very narrow definition of Ricardian equivalence, and it seems to be more restrictive than most researchers would like.

An alternative formulation is to define Ricardian equivalence as the case where debt does not have a direct effect on consumption by representing net wealth to the individuals, but is allowed to be a useful predictor of future levels of, for example, government consumption. In other words, we would define Ricardian equivalence as the case where debt is not allowed to enter the Y_t^{pe} measure directly, but is allowed to enter the information set, I_t.

Given that we actually think that the second definition of Ricardian equivalence is the most appropriate, i.e. debt is allowed to enter the information set, it is clear that an econometric study that is not able to separate between the direct and indirect effect from debt will be burdened with great interpretational difficulties. Alternatively, such a study would be occupied with the first definition of Ricardian equivalence in a stochastic world, which does not appear to be a natural extension of the Ricardian concept from the deterministic world. As the title of Barro’s 1974 paper suggests, what we want to investigate is whether or not agents regard their holdings of government bonds as net wealth and thus part of their permanent income, not if it can be used as a predictor of future levels of government consumption (although this could, of course, be an interesting question for other discussions than the one of Ricardian equivalence.)

An empirically important aspect of having to make predictions about the permanent income is that in order to evaluate how a Ricardian consumer should respond to a changed taxation or debt creation in one period that potentially implies changed levels of government consumption, we need to distinguish to what extent these effects on government consumption are expected or unexpected (a ”shock”) and if the effects are permanent or transitory. In other words, it is important to realize that the entire future path of government consumption has to be forecasted, and it is essential for the interpretations with respect to the equivalence proposition to know if a particular shock has permanent or transitory effects on government consumption, since the Ricardian predictions would be substantially different in the two cases.

For example, if an increase in debt signals a permanent expected reduction in government consumption, this would in the Ricardian world imply that private consumption is increased by the same amount that government consumption is reduced. In case the effect on government consumption instead is viewed as temporary, we need to calculate the present value of this reduction, and spread its effects out on all future private consumption. In this case there will be a less than one-to-one substitution of private and government consumption. It is then obvious that if the statistical method that we use can make this distinction between permanent and transitory shocks, the interpretation of results with respect to the equivalence will be greatly facilitated.

Furthermore, if a change in debt or taxes is fully anticipated, its realization would not represent any new information and consumption would not change, whether the equivalence proposition is true or not. This stresses the importance of a econometric study being able to separate between expected changes and shocks.

The above discussion of the general formulation of Ricardian equivalence in a stochastic world points at three key issues. First, the concept of Ricardian equivalence has to be explicitly formulated, also for the case when the path of government consumption has to be forecasted. There are then at least two different interpretations of the Ricardian proposition. One where we state that deficits or debt creation do not have neither direct effects (through affecting individuals' perceived wealth), nor indirect effects (due to potential signaling effects) on private consumption. In the second, and more interesting, definition of Ricardian equivalence in a stochastic world, debt is allowed to have indirect effects but not a direct effect on private consumption.

The second issue is that if we use the latter formulation of the equivalence hypothesis, it is central to incorporate in an empirical study how debt signals future changes in government consumption. Neglecting to incorporate this effect will either imply that we use the first definition of the equivalence proposition (which is probably not what most researchers would consider to be the interesting formulation of the proposition), or that we have serious problems in interpreting the estimated coefficients. Finally, it is also important to clearly distinguish whether effects on, for example, government consumption are permanent or transitory, since again, this is crucial in determining the relevance of the Ricardian equivalence proposition.

4. PREVIOUS TESTS OF RICARDIAN EQUIVALENCE

Since the early seventies several studies have been performed in order to analyze the equivalence proposition. In the following section, these previous studies will be divided into four main categories. First, there are studies based on single equation consumption functions. Secondly, a two-equation model with rational expectations restrictions will be discussed. In the third section, a structural model aimed at estimating deep parameters central for the theoretical derivation of Ricardian equivalence is presented. Finally, studies aimed at investigating the effects of debt policy on the interest rate are discussed.

4.1 SINGLE EQUATION METHODS

Under this label we discuss both estimation of consumption functions of a Keynesian type and estimation based on Euler equations; studies in this spirit include Kochin [1974], Yawitz and Meyer [1976], Tanner [1979], Kormendi [1983], Feldstein [1982], and Bernheim [1987]. To start with the most basic Keynesian consumption function, the following relation is postulated[11]

$$C_t = \beta_0 + \beta_1 YD_t \ , \tag{29}$$

where C is private consumption and YD is disposable income. To estimate the coefficients in this model, we have to determine what the appropriate measures of C

and YD are. As a first approximation, we could think of total consumption expenditure, and GNP minus taxes, respectively. An alternative definition of YD would be some measure of permanent income, which would fit more naturally into the equivalence world, but in most cases the discussion below would be the same. To test Ricardian equivalence, we then include public debt (D) or alternatively public deficit[12]. The following model will thus be estimated

$$C_t = \beta_0 + \beta_1 YD_t + \beta_2 D_t + \varepsilon_t \ . \tag{30}$$

The test of Ricardian equivalence is a test of $\beta_2 = 0$, which would imply Ricardian equivalence. If, on the other hand, $\beta_2 > 0$, the implication is that households regard their holdings of public debt as net wealth. The question is whether or not this is an appropriate test of the equivalence proposition.

If we assume for the moment that we can actually estimate the debt coefficient in a statistically correct way[13], and that we know the probability distribution of interest to perform tests on estimated coefficients, can we then use this approach to draw conclusions about the validity of the equivalence proposition? In general, the answer is no!

This is due to the fact that this type of hypothesis testing is derived from the theoretical models above that assume perfect foresight with respect to (in particular)

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[11] Under some special circumstances, (e.g. liquidity constraints or ”rules of thumb” near rational behvior), a similar consumption function could be derived also for utility maximizing individuals, but for the present analysis it is not really important how this formulation is obtained.

[12]It is a little odd to say that this is a test of Ricardian equivalence, since it uses a consumption function that would hardly be the result of a Ricardian model, but it could perhaps instead be viewed as a test of the magnitude of the wealth effect in a Keynesian model. However, since this type of estimation in many cases starts with an ad hoc formulation of a consumption function, there is perhaps little point in justifying it afterwards.

[13] There are potentially several statistical problems in estimating the postulated relation. To start with, there might be a problem of simultaneity bias, since it is likely that the explanatory variables are not exogenous with respect to private consumption. Another potential problem is that in practice, many more variables are introduced in the right hand side to capture different aspects of the income measure, which in turn is likely to introduce multicollinearity. Finally, issues of non-stationarity have often been neglected, which could make the inference invalid.

government consumption. The equivalence proposition states that for a *given path of government consumption*, changing the timing of taxes or debt does not affect private consumption. In reality it is, however, not plausible to assume that the households know the path of government consumption, but rather have to make forecasts of future levels of government consumption.

In the above testing, the role of debt as a predictor of future levels of government consumption is neglected. If, for example, households know that in general a deficit today will imply reductions of government consumption tomorrow, it is consistent with the Ricardian view that private consumption increases with higher debt, not because government bonds are regarded as net wealth, but rather because the expected present value of government consumption is reduced. This points out that it is crucial to take into account how expectations of government consumption are formed, which is more straightforward in a system of equations approach.

An alternative starting point for estimating a single equation is the Euler equation approach. The Euler equation is derived from utility maximizing agents as in, for example, the IRA model discussed in section 2.2, and is thus derived in a theoretically more satisfying (or at least explicit) way than the previously discussed consumption function. By using the consumption Euler equation, Hall [1978] derives the following relation between present and past consumption

$$C_t = C_{t-1} + \varepsilon_t, \tag{31}$$

which is the, since then, well known random walk in consumption implied by the permanent income hypothesis. Although this formulation is valid under rather general conditions, there are some restrictions or approximations underlying this formulation. Either the individuals will have to be risk neutral or have quadratic utility functions, or the stochastic changes will have to be small enough to motivate a linearization of the underlying concave utility function. The good news from a statistical point of view are that we do not have to incorporate more variables in the right hand side, thus avoiding multicollinearity and simultaneity bias. However, we still have the question of how this formulation could be used when testing Ricardian equivalence.

At this stage it is vital to distinguish between the Ricardian and permanent income hypothesis, and although Ricardian equivalence implies that the permanent income hypothesis is true, the reverse is *not* true. The permanent income hypothesis states that households make predictions of all their future incomes and then try to smooth consumption in such a way that they expect to consume the same amount in every period. However, the permanent income hypothesis does not tell us what the components of permanent income are. This is on the other hand the central question in the Ricardian equivalence proposition: is government debt net wealth and thus a contributor to net income or not? In other words, if the permanent income hypothesis is correct, the Ricardian proposition could still be either true or false.

What does the distinction between the two hypotheses imply for tests of Ricardian equivalence? As a first thought, we might consider including *lagged* debt and then test whether or not its coefficient is equal to zero. However, the problem with such a test is that the coefficient will become zero if the permanent income hypothesis is true, irrespectively of the validity of Ricardian equivalence. The fact that *any lagged* variable will get a zero coefficient in a regression of the Euler equation if the permanent income hypothesis is true, is one of the central insights of Hall's paper. In turn this implies that *lagged* debt cannot be used to test the validity of Ricardian equivalence in an Euler equation, since its coefficient should be zero if the permanent income hypothesis is valid, irrespectively of the validity of the Ricardian hypothesis.

What about using contemporaneous debt in the Euler equation instead? This would make it possible to avoid accepting Ricardian equivalence due to an acceptance of the permanent income hypothesis. However, this creates new problems along the lines discussed for Keynesian consumption functions, namely that debt could then be useful for predicting future levels of government consumption, as well as future levels of income. In addition to this problem with interpreting the estimated coefficient, we have again introduced some of the statistical problems that the Euler equation could otherwise avoid compared to the Keynesian formulation.

To summarize, using a single equations approach when investigating the equivalence proposition seems burdened with serious limitations, both from a purely statistical point of view, and more importantly, from the point of designing a valid test of the Ricardian hypothesis, since we need to incorporate how expectations about future levels of government consumption are formed. Perhaps not very surprisingly, the evidence from this type of studies is mixed. Some authors claim to find support for the Ricardian hypothesis, while others reject the hypothesis. This may suggest not only that it is hard in general to test theory, but also that this particular testing strategy of the equivalence hypothesis is burdened with both statistical and interpretational difficulties.

4.2 RATIONAL EXPECTATIONS AND CROSS-EQUATIONS RESTRICTIONS

One study that combines utility maximizing individuals with a government sector in order to examine Ricardian equivalence is Aschauer [1985]. The model specified is based on rational expectations, where individuals derive utility from government consumption as well as private consumption. More formally, agents maximize with respect to effective consumption, C_t^*, defined as the weighted sum of government and private consumption, $C_t^* = C_t + \theta G_t$, where θ describes a constant marginal rate of substitution between private and government consumption. Assuming also a quadratic momentary utility function, Aschauer derives the following consumption function

$$C_t = \alpha + \beta C_{t-1} + \beta\theta G_{t-1} + \theta G_t^e + u_t \ , \tag{32}$$

which he combines with a forecasting equation for government consumption

$$G_t = \gamma + \varepsilon(L) G_{t-1} + \omega(L) D_{t-1} + v_t \ . \tag{33}$$

This forecasting equation uses past values of government consumption and deficits to make predictions of government consumption. Plugging (33) into (32) and rewriting yields

$$\begin{aligned} C_t &= \delta + \beta C_{t-1} + \nu(L)G_{t-1} + \mu(L)D_{t-1} + u_t \\ G_t &= \gamma + \varepsilon(L)G_{t-1} + \omega(L)D_{t-1} + v_t \end{aligned} \quad , \tag{34}$$

which implies the following set of cross-equation restrictions

$$\begin{aligned} &\delta = \alpha + \theta\gamma \\ &\nu_i = \begin{cases} \theta(\beta - \varepsilon_i) & \textit{for} \quad i = 1 \\ -\theta\varepsilon_i & \textit{for} \quad i = 2, \ldots, n \end{cases} \\ &\mu_j = -\theta\omega_j \qquad \textit{for} \quad j = 1, \ldots, m \end{aligned} \quad . \tag{35}$$

Aschauer's interpretation of these cross-equation restrictions is then that if they do not hold, debt has an impact on private consumption which differs from the impact justified from the observed predictive power that debt has for future levels of government consumption. This interpretation of the Ricardian hypothesis is in line with the preferred definition of Ricardian equivalence in a stochastic world discussed in Section 3, where debt is allowed to enter the information set, but not the permanent income measure directly.

Another way of interpreting Aschauer is that he removes the part of debt that works as a signal of future levels of government consumption, and investigates if the remaining part of debt has an impact on private consumption. This would then be regarded as the wealth, or direct, effect debt has on private consumption. The null hypothesis of valid cross-equation restrictions, that is, no wealth effect, is interpreted as a test of Ricardian equivalence.

At this point it is vital to understand why this test will actually be able to separate between the permanent income and the Ricardian hypothesis. In the standard Euler equation presented in Section 4.1, we noted that we would *not* be able to separate between the two hypotheses. However, in this study government consumption enters the utility function via the specification of effective consumption. In the definition of effective consumption, the parameter θ describes to what extent government consumption substitutes for private consumption. When we then solve the Euler equation (which is now defined for effective consumption) for private consumption, both lagged private *and* government consumption will be present in the right hand side, with lagged government consumption multiplied by the additional factor θ. This implies that as long as government consumption actually substitutes for private consumption, so that θ is non zero, this modified permanent income hypothesis does allow for an additional variable with non zero coefficient. The central role of θ to achieve identification of this model can also be seen in the cross-equation restrictions, that all will become unidentified if θ is set to zero.

In the estimation, it is therefore vital to test if θ is actually significantly different from zero, which Aschauer concludes it is, and the point estimate indicates that a dollar spent on government consumption is worth approximately twenty cents of private consumption in utility terms. Furthermore, Aschauer concludes that he cannot reject the joint hypothesis of rational expectations and Ricardian equivalence at conventional levels of significance. In other words, debt only plays a role in explaining private consumption to the extent that it is a useful signal for future levels of government consumption, but debt has no wealth effect on consumption.

Aschauer's formulation is one of the most rigorous ones for studies using Euler equations to test the equivalence proposition. The framework incorporates the forecast equation of the government consumption, and makes use of the reasonable rational expectations concept to derive testable hypotheses that do not suffer from interpretational vagueness.

4.3 ESTIMATING DEEP PARAMETERS

This section describes the model of Leiderman and Razin [1987], which is based on Blanchard's [1985] framework, where all individuals face a probability γ to survive ($\gamma = 1 - p$, where p is the death rate in Blanchard's model) to the next period. Further, they focus on consumption expenditure (X_t) as a flow into a stock of consumption goods (C_t), and it is from this stock that consumers derive their utility. Formally, individuals maximize expected utility according to

$$\begin{aligned}
&\max_{c} \quad E_t \sum_{\tau=0}^{\infty} (\gamma\delta)^{-t} U(c_{t+\tau}) \\
&s.t. \quad c_t = (1-\phi)c_{t-1} + x_t \\
&\qquad\quad x_t = b_t + y_t - (R/\gamma)b_{t-1} \\
&\qquad\quad \lim_{t\to\infty} (\gamma/R)^t b_t = 0 \qquad ,
\end{aligned} \tag{36}$$

where $U(\cdot)$ is the momentary utility function, c_t and x_t are the per capita stock and flow of consumption goods (capital letters then represent the aggregates over households of the same variables). Moreover, the stock of consumption goods is depreciating with ϕ in each period. Again labor income is y_t and assumed to be exogenous, and $R = 1 + r$, where r is the constant interest rate. The subjective discount factor is δ, and finally, b_t are bonds issued by agents, i.e. the negative of wealth in previous models. The last line is the no-Ponzi game assumption that constrains the agents to have no remaining debt in present value terms as time goes to infinity.

In addition to the utility maximizing individuals with access to a perfect capital market, the authors allow for a part of the population $(1-\Pi)$ to be liquidity constrained according to

$$X_{c,t} = Y_{c,t-1} + \nu_t \ , \tag{37}$$

so that they use all of last period's income for consumption expenditure, except for a stochastic term v_t. Aggregate consumption expenditure is then

$$X_t = \Pi X_{u,t} + (1-\Pi) X_{c,t} \ , \tag{38}$$

where $X_{u,t}$ comes from unconstrained individuals who solve the maximization problem in (36). For the empirical implementation they also specify first order autoregressive processes for income (*Y*) and taxes (*T*) as

$$\Delta Y_t = \rho_Y \Delta Y_{t-1} + \eta_{Y,t} \tag{39}$$

$$\Delta T_t = \rho_T \Delta T_{t-1} + \eta_{T,t} \quad . \tag{40}$$

In the last part of the empirical investigation they also include government consumption (*G*) in the same manner

$$\Delta G_t = \rho_G \Delta G_{t-1} + \eta_{G,t} \ , \tag{41}$$

and adjust the budget constraint. The maximization problem is also modified to allow for substitution between private and public consumption, where government consumption is assumed to substitute for private consumption with a factor θ, i.e. a dollar of government consumption is worth θ dollars of private consumption.

The interesting feature of this approach is that it estimates deep parameters that appear as critical assumptions in the derivation of the equivalence hypothesis; the death rate, $1-\gamma$, and the fraction of liquidity constrained individuals, $1-\Pi$, should both be equal to zero according to the standard assumptions used to derive debt neutrality. In other words, the authors have allowed for two potential sources for deviations from debt neutrality, and investigate whether or not data support these standard assumptions made in Ricardian models.

The advantage of this study is that the interpretation and test of Ricardian equivalence is very straightforward once the model is formulated and the parameters estimated (which is actually not totally trivial). However, the drawback of this very structural approach, is that we can only conclude that we will not have deviations from Ricardian equivalence due to violations of these particular assumptions, but there might at the same time be other sources that in the real world will invalidate the predictions of Ricardian models. If we then do not test *all* these potential sources that could create deviations from the equivalence result, we will not be able to tell if Ricardian equivalence is totally valid. In this study, for example, we can conclude that we do not have deviations from Ricardian equivalence due to finite lives or liquidity constrained individuals, but this will only be equivalent to accepting the equivalence hypothesis if there are no other factors that can create deviations from the equivalence proposition.

Another unfortunate feature of the model is that Leiderman and Razin do not have an explicit formulation of the government sector in the form of a budget restriction, which seems natural in a study of the equivalence proposition. For example, it seems plausible that there might be some restrictions on the processes for T, G and Y in terms of common trends that would provide additional restrictions that are now neglected.

Furthermore, theory (or common sense) places restrictions on γ, Π, θ, and ϕ, but none of these restrictions seems to have been included in the estimation. In their estimation some of these obvious restrictions are violated, but the authors seem to ignore this and proceeds with the analysis. Their conclusion is that the estimated coefficients support the equivalence hypothesis, or rather, that individuals do not act as if they have finite lives or are liquidity constrained. Another study that investigates the proportion of liquidity constrained individuals is Campbell and Mankiw [1991], who find that a substantially larger fraction of households are liquidity constrained for a cross-section of countries (not including Israel that is analyzed in the above study), which of course would imply a violation of a standard assumption in Ricardian models.

4.4 Interest rates and the term structure

Most studies of RE concentrate on the consumption function, but this is in general not the only variable that is assumed to be affected by budget deficits by opponents of RE. One other key variable is supposedly the interest rate, which is assumed to be positively correlated with deficits, usually via a crowding-out mechanism. This approach then hinges on the assumption that the interest rate is not given from a world capital market, but is determined endogenously within the country. In other words, the approach might be of more relevance in for example the US than in Sweden. In a closed economy, the mechanism would be working through changes in economy wide savings in response to a change in the government's budget stance. In a Ricardian world, dissaving in the public sector would be fully off-set by increased saving in the private sector, again of course postulating that the level of government spending is unaffected by the change in the government budget. In other words, economy wide savings will be kept constant, and the interest rate would be unaffected.

In Plosser [1982] and Plosser [1987] this potential deviation from RE is investigated by using a term structure model for interest rates, which is combined with an ad hoc macro model for explaining the spot interest rate. Below, the 1982 paper will be described. Other papers investigating the effect of deficits on the interest rate are Evans [1987], Boothe and Reid [1989], and Quigley and Porter-Hudak [1994].

The model for the equilibrium expected return to an *n*-period bond is

$$E_t\left[H_{n,t+1}\right] = R_{1,t} + \phi_{n,t} \ , \tag{42}$$

where $R_{1,t}$ is the spot interest rate and $\phi_{n,t}$ is a marginal liquidity premium. To this basic rational expectations model of the term structure macro variables are added in order to explain $R_{1,t}$ according to

$$R_{1,t} = a(L)' X_t + \eta_t \ , \tag{43}$$

where X_t could consist of any variables that could predict the spot rate. By defining $Z_t = \left[X_t \vdots \eta_t\right]$ and then specifying a process for Z_t according to $Z_t = D(L)u_t$ we get

$$H_{n,t+1} - E_t\left[H_{n,t+1}\right] = b_n^{'}\left(Z_{t+1} - E_t\left[Z_{t+1}\right]\right) . \tag{44}$$

By further specifying a VAR model for X_t, we obtain the following model to be estimated

$$X_{t+1} = A(L)X_t + u_{t+1} \tag{45}$$

$$H_{t+1} - R_{1,t} = \phi + B\left[X_{t+1} - A(L)X_t\right] + \nu_t \ . \tag{46}$$

These equations state that the unexpected or excess return for bonds of different maturities is explained by a vector of liquidity premia ϕ and by unexpected changes in the policy variables in X, through the coefficient matrix B that is to be estimated. Furthermore, u_{t+1}, the innovations in X, are obtained after estimating the lag polynomial $A(L)$. The variables Plosser includes in X_t are government spending, government debt held by the public sector, and government debt held by the Federal Reserve (the monetized debt).

Plosser states that tests of the non-linear cross-equation restriction on $A(L)$ are joint tests of the market efficiency/rational expectations hypothesis and the expectations model of the term structure. To summarize Plosser's conclusions; he finds that the government spending variable is more important than the two debt variables in explaining movements in the interest rate. Further, only government consumption has a significant positive impact on the interest rate (although quantitatively the effect is small). In other words, Plosser's findings are consistent with a Ricardian model.

In his 1987 paper, Plosser uses the framework presented above, but uses new data. Further, a connection between debt shocks and *ex ante* real interest rates is analyzed, as well as the importance of expected future deficits. The vector of ”policy” variables (X), includes industrial production per capita, the inflation rate, real per capita public debt, real per capita debt held by the Federal Reserve, and real per capita military outlays, which is used as a proxy for (temporary) Federal spending, all measured as growth rates. Finally, the one-period yield $(R_{1,t})$, is now also included in the ”policy” vector.

The estimation again suggests a very small impact of the financing variables, on the interest rate, and the only noted effect is a *fall* in interest rates due to a positive debt shock. In other words, the result contradicts the conventional wisdom of a positive correlation between debt and interest rates.

The basic critique of Plosser's papers is the lack of clearly stated identifying assumptions and an ad hoc way of modeling the influence of the macro variables. What variables should be included, and what parameters can be given structural interpretations? These are issues central to the interpretation of the results. However, if we take the interpretations given in the paper, the study supports the equivalence hypothesis.

5. Conclusions and Extensions

The purpose of this paper has been to link the theoretical predictions of Ricardian equivalence to empirical tests. It is first noted that studies based on estimating a single equation consumption relation are burdened with both statistical and interpretational difficulties, and do not seem to provide a fruitful way for determining the validity of the equivalence theorem. The interpretational difficulties are to a large extent due to the fact that the implicit models underlying these tests all assume perfect foresight with respect to government consumption. In reality however, debt or deficits are likely to affect the *expected* value of future government consumption, which has to be taken into account when performing tests in a stochastic world.

Aschauer [1985] incorporates this potential signaling effect of debt when estimating a two equation model with cross-equations restrictions implied by rational expectations. The estimation methods could potentially be improved, to incorporate issues like non-stationarity and co-integrated time series. Furthermore, in the recent macro literature (see for example Zeldes [1989], Caballero [1990], or Weil [1993]), it has been popular to explain deviation from the predictions made by the standard permanent income model to risk averse individuals and precautionary savings. Since risk aversion creates an additional reason why lagged variables, for example lagged wealth, enter the Euler equation (see Sheshinski [1988]), this could be an interesting extension to Aschauer's model.

To summarize the theoretical and empirical relevance of Ricardian equivalence, there are few (if any) well formulated empirical studies that reject the equivalence proposition's predictions, although the theoretical models generating the equivalence are burdened with unrealistic assumptions. The interpretation of the evidence is that either these unrealistic assumptions cancel each other out, or the equivalence proposition is actually a decent approximation of the real world. The latter interpretation is to some extent also justified by the numerical example in Blanchard's non-Ricardian model, where the model generates modest deviations from the equivalence hypothesis.

However, there are other issues of debt policy which might not have been operating in the investigated economies in the past, since most studies deal with well developed countries. For example, when debt reaches extreme levels as proportion of GDP, and with a large amount of the debt placed outside the country, this could introduce other mechanisms than the ones we have focused on here, like exchange rate crises. It seems less likely that the Ricardian proposition would be a reasonable approximation in these cases, although it is a fair description of the real world at more moderate debt levels.

6. References

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