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Ricardian Equivalence

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I. Introduction

A FREQUENT THEME of policy discussion is the peril of the public debt. News reports alternately sober and frantic regularly point to government debt as a major cause of recessions, unemployment, inflation, high interest rates, trade deficits, gyrations in the dollar, and virtually any other unsatisfactory aspect of economic performance.¹ That the debt is a serious problem requiring discipline, tough legislation, and national bullet-biting is regarded as self-evident.

Despite this popular consensus, the effects of government debt and deficits on the economy are not obvious from either economic theory or statistical evidence. For decades, economists had a straightforward theory of public debt's effects, the well-known Keynesian model. On the one hand, an increase in debt stimulated the economy in the short run by making households feel wealthier. On the other hand, public debt competed

with private debt for available funds, thus driving up interest rates and changing the composition of output, in particular crowding out private investment with deleterious effects to long-term growth. Over the last fifteen years, this once-standard theory has been cast into doubt through revival of a theory, first explored by Ricardo, suggesting that debt policy has none of the effects accorded to it by traditional analysis.

Where traditional theory attributes to an increase in the deficit a short-term stimulus to output and employment, a rise in interest rates, and a crowding out of private investment, "Ricardian equivalence," as the revived theory has come to be called, attributes no effects at all. According to Ricardian equivalence, government purchases and marginal tax rates matter, but the debt/tax mix is irrelevant. The reason is actually quite simple. Debt implies future taxes with a present value equal to the value of the debt; rational agents, recognizing this equivalence, will proceed as if the debt did not exist, resulting in the debt having no effects on economic activity. Needless to say, so revolutionary a theory has not gone unchallenged, and its revival has led to extensive research, both theoretical and empirical, into the effects of gov-

¹ Such dire warnings are hardly new:

The biggest perils [of the debt] are . . . subtle, and they are four: 1. The dilution of the dollar. 2. The risk of boom and bust. 3. The smothering of enterprise. 4. The loss of human freedoms. (Committee on Public Debt Policy 1949, p. 140.)

Subtle?

ernment debt on the economy. The fruit of that effort is an exciting literature that is the subject of this essay.

Although the aggregate effects of public debt and deficits have not yet been fully determined, two overall conclusions are now clear. The first appears uncontroversial: it seems almost impossible that Ricardian equivalence holds exactly. The theoretical foundations for any effects of debt on the economy depend on subtle concepts such as the intensity of intergenerational altruism, the possibility of strategic behavior by individuals in their family relations, the nature and extent of liquidity constraints, and the effects of various kinds of uncertainty on the household maximization decision. Careful examination of those factors suggests that exact Ricardian equivalence is implausible.

The second conclusion is far more controversial: despite its nearly certain invalidity as a literal description of the role of public debt in the economy, Ricardian equivalence holds as a close approximation. Although there is much empirical evidence appearing to reject Ricardian equivalence, a dispassionate reading of the literature leads to the stated conclusion. Testing theories of government debt's effects is not trivial. Estimation is sensitive to the treatment of specification, simultaneity, and data stationarity, as well as simple measurement of the quantities involved, so that careful attention to interesting issues of econometric methodology is essential. Much of the published evidence on Ricardian equivalence, both favorable and unfavorable, fails to attend to those issues and is sufficiently flawed to be uninformative. When attention is restricted to the more methodologically sound studies, it is difficult to find statistically significant effects of debt, suggesting that Ricardian equivalence holds approximately.

It is important to understand the lim-

ited nature of the second conclusion. Given the way societies have behaved, especially in the way they have issued and retired debt, significant effects of the debt appear to be absent from the data. If societies continue to behave as they have, significant effects will continue to be absent and Ricardian equivalence can be taken as a good approximation. However, if societies change their behavior, especially with respect to issuing and retiring debt, significant effects of the debt might emerge. Indeed, there is a theory discussed later in this article that is quite diametric to Ricardian equivalence and consistent with the historical data but that implies significant effects of the debt under policy regimes different from those that have existed in the past. Therefore, whether one regards the apparent empirical validity of Ricardian equivalence as an indication of "truth" depends on the kinds of changes in the economic arena one is willing to entertain. Under historical regimes, Ricardian equivalence appears true; under other possibilities, it might not be.

II. Theory

In its modern form, Ricardian equivalence is a straightforward generalization of the permanent income/life cycle hypothesis (PILCH); indeed, it can be regarded as the logical completion of that hypothesis in the presence of government purchases, taxation, and debt. Given the widespread acceptance of PILCH as a framework for the analysis of household choice, it might seem that the theoretical case for Ricardian equivalence is obvious or even trivial; but in fact, the theoretical foundations for Ricardian equivalence are not at all trivial. Ricardian equivalence requires a number of assumptions about individual behavior and/or the economic environment that may well be false. To discuss the issues,

let us first review the basic theory behind Ricardian equivalence and then address the controversial aspects of it.

A. Basic Theory. Suppose there is no government and consider a representative individual facing perfect capital markets who wishes to maximize his intertemporal utility function

$$U(t) = \sum_{i=0}^{\infty} u(C_{t+i})\delta^i \quad (1)$$

subject to his lifetime budget constraint

$$\sum_{i=0}^{\infty} Y_{t+i}R^i = \sum_{i=0}^{\infty} C_{t+i}R^i \quad (2)$$

where U is the intertemporal utility function, u is the intratemporal utility function, C is consumption, Y is total income, δ is the time preference factor $1/(1+\rho)$ with ρ the rate of time preference, and R is the discount factor $1/(1+r)$ with r the real rate of interest (here assumed constant for simplicity). The model can be enriched by dividing income into human and nonhuman components and allowing a time-varying real wage, but nothing of importance is affected by sticking to the simpler form above.

The individual's maximization problem can be solved by setting up the Lagrangean

$$L = U(t) + \lambda \left(\sum_{i=0}^{\infty} Y_{t+i}R^i - \sum_{i=0}^{\infty} C_{t+i}R^i \right) \quad (3)$$

and maximizing over C , where λ is the Lagrange multiplier. The first-order condition (Euler equation) for this problem is

$$u'(C_{t+i}) = (\delta/R)^i \lambda \quad (4)$$

from which one can deduce the time path of consumption as a function of λ and r ; in particular, C rises, is constant, or falls over time as λ is less than, equal to, or greater than r .

Let us see how this first-order condition changes as government taxation and debt are introduced. Suppose there is no government debt, so that G (government purchases) equals T (tax revenue) in every period. Also suppose taxes are lump-sum; the amount of tax may vary through time. In this case, the individual's budget constraint becomes

$$\sum_{i=0}^{\infty} (Y_{t+i} - T_{t+i})R^i = \sum_{i=0}^{\infty} R^i C_{t+i}. \quad (5)$$

Replacing (2) with (5) in the individual's maximization problem leads to the first-order condition

$$u'(C_{t+i}) = (\delta/R)^i \lambda \quad (6)$$

which is the same as (4). Thus the shape of consumption's time path is unaffected by the introduction of lump-sum taxation. The level of consumption is affected because a higher value of λ will emerge for this problem, implying a lower value of C for every t compared to the case of no taxes. The reason for this outcome, of course, is that lump-sum taxation has only pure wealth effects with no substitution effects.

Now we come to the Ricardian experiment. Suppose the government decides to leave the path of purchases unchanged but to reduce taxes in the first period by B dollars per capita and issue B dollars of debt per capita instead; the debt carries the market rate of interest r and has a maturity of H years, where H may equal infinity. Both the future interest payments and the redemption of principal will be financed by lump-sum tax collections. What is the effect of this new financing scheme on the representative individual? To find out, we examine how the individual's maximization problem changes.

On the one hand, the individual gives up B dollars of his income in the initial period to buy the new debt and expects

to receive a stream of interest payments plus repayment of principal in the future. On the other hand, the individual's taxes fall in the initial period by B dollars but rise in subsequent periods to pay for the interest payments and principal redemption in the future. Table 1 summarizes the various flows affecting the individual. The crucial thing is that every new inflow is matched by an equal outflow, which means the lifetime budget constraint is unchanged and the individual will not perceive the government's refinancing scheme as altering his wealth in any way. Because of the lump-sum nature of taxation, no marginal rates of return are changed. The individual's maximization problem is completely unaltered by the refinancing scheme, and, with one exception, his choices are unaffected by it.²

The exception, of course, is the individual's saving behavior. Saving is identically equal to the difference between disposable income and consumption. Consumption is determined by the individual's optimal plan, saving is determined as a residual. In the current example, the factors determining the individual's optimal solution are unaffected by the timing of tax payments so that the individual's choice of consumption also is unaffected. Had we included labor supply as a choice variable in the problem, we would have found that it, too, was unaffected. Because the time paths of gross income and consumption are unchanged, the change in the timing of tax

² This last result may be seen more formally by noting that

$$\sum_{i=0}^{\infty} T_{t+i} R^i = \sum_{i=0}^{\infty} G_{t+i} R^i.$$

Therefore, the individual budget constraint can be written

$$\sum_{i=0}^{\infty} (Y_{t+i} - G_{t+i}) R^i = \sum_{i=0}^{\infty} C_{t+i} R^i.$$

Because the path of G is unchanged by assumption, the budget constraint is unaltered by the government's refinancing scheme.

payments must affect the time path of disposable income and therefore of saving. In particular, the individual saves more when current taxes are low and dis-saves more when they are high. Indeed, it is through this alteration in the path of saving that the individual insulates his substantive choices from trivial changes in the timing of disposable income. One way to think of these changes in saving is that, when the government cuts current taxes and issues debt, the individual recognizes that future taxes must rise to repay the principal plus the interest on the debt and that he can use his tax rebate to buy the newly issued government bonds, whose principal repayment plus interest earnings will exactly enable him to meet the future tax obligations that the bonds themselves imply. The upshot is that the private demand for savings assets moves one-to-one with changes in the supply of public debt, with no change in interest rates and none of the "crowding out" of private demand so familiar from IS-LM analysis.³

This absence of any effect of tax/bond manipulations on lifetime budget constraints and therefore on economic choices is the Ricardian proposition. It reflects nothing more than the well-

³ A concrete example may be useful. Suppose the individual initially holds no government bonds and pays \$1 each period in taxes. The government decides to issue a \$1 bond with maturity of one period paying a coupon at the market rate of interest of 10 per cent. Before the government refinancing, the individual would have paid \$1 in taxes in both period zero and period one. After the refinancing, the individual pays no taxes in period zero and \$2.10 in period one (the original \$1 plus another \$1 to repay the bond principal plus \$0.10 to pay the interest coupon on the bond). The present value of the first stream of payments is

$$PV_1 = 1 + 1/(1.1)$$

and that of the second stream is

$$\begin{aligned} PV_2 &= 0 + 2.1/(1.1) \\ &= (1.1 + 1)/(1.1) \\ &= 1 + 1/(1.1) \\ &= PV_1. \end{aligned}$$

TABLE 1

EFFECT OF A BOND-TAX SWITCH ON THE INDIVIDUAL'S RECEIPTS AND EXPENDITURES

Period	Change in Bond Holdings	Interest Received	Change in Taxes Paid
0	+ B	0	- B
1	0	+ rB	+ rB
2	0	+ rB	+ rB
3	0	+ rB	+ rB
.	.	.	.
.	.	.	.
.	.	.	.
$H - 2$	0	+ rB	+ rB
$H - 1$	0	+ rB	+ rB
H	- B	+ rB	+ B + rB
$H + 1$	0	0	0
$H + 2$	0	0	0
$H + 3$	0	0	0
.	.	.	.
.	.	.	.
.	.	.	.

known but often forgotten fact that the true measure of government's use of resources is government purchases, not any one method employed by the government to lay claim on those resources, even if that method is officially dubbed taxation.⁴ The Ricardian proposition simply states that any method of accounting for government's use of resources must reflect this fact and therefore must lead to the lack of any effects on the representative household's life-cycle wealth of refinancing schemes unaccompanied by changes in the present value of government purchases or the introduction of distortionary taxes. The proposition is called the equivalence hypothesis because it implies that, given a path of government spending, lump-sum tax and bond finance lead to the same economic choices by agents and therefore are equivalent for all issues of interest.

Ricardian equivalence may seem trivial

and hardly worth argument, and indeed it is, given the assumptions underlying the previous statement of it. Let us now examine those assumptions.

B. *Finite horizons.* In the preceding discussion, it was tacitly assumed that the individual has an infinite horizon. The theoretical foundation for Ricardian equivalence is not nearly so straightforward when individuals have a finite horizon.

Suppose the economy is of the Paul Samuelson (1958)–Peter Diamond (1965) type. Individuals live exactly two periods in a succession of overlapping generations and derive utility only from their own consumption. The government raises funds through an income tax and deficits. Ricardian equivalence will not hold because current issues of government debt, which lower the taxes of the current working generation, will be redeemed with taxes levied on future generations. The present value to the current working generation of the future tax burden imposed on it by the debt will be less than the value of the current reduction in taxes. As a result, financing

⁴ In the example of footnote 3, the path of government purchases did not change, so the present value of the resources used by government did not change, either.

schemes that alter the timing of even lump-sum taxes, such as debt-for-tax swaps, will have wealth effects and thereby alter macroeconomic activity. The same result holds in models in which individuals live more than two periods as long as some of the future taxes implied by debt are borne by future generations.

It would appear that finite horizons eliminate the possibility of Ricardian equivalence, for there always are some people whose current tax reduction will not be matched by future tax payments. Indeed, this case seems so compelling that for many years Ricardian equivalence was regarded as trivially false. However, Robert Barro (1974) showed that Ricardian equivalence holds in the finite horizon model if people regard their children as extensions of themselves. Let the utility function of a member of generation t be

$$U_t = U(C_{1t}, C_{2t}, U^*_{t+1})$$

where C_{1t} , C_{2t} are the consumption levels of the t -generation when young and old and U^*_{t+1} is the attainable utility of the $t + 1$ generation members. In this model, parents will use the increase in their disposable income created by a tax cut to bequeath upon their children enough extra wealth to allow the children to pay the future taxes implied by the current debt issue. As a result, no one alters any substantive economic decision, and Ricardian equivalence re-emerges.

The treatment of another's utility as an extension of one's own has come to be known as altruism. The presence of altruistic behavior of parents toward their children effectively converts the finite horizon model into one with an infinite horizon.

Before turning to an evaluation of the altruism assumption, let us devote a bit more attention to the issue of what hori-

zon individuals have. An honest answer to the question "How many 150 year olds do you know?" certainly suggests that the finite horizon model is a more accurate approach to problems of individual intertemporal choice than the infinite horizon model and that the latter should be regarded as merely an analytical convenience. Indeed, it seems from the literature that many economists have adopted this opinion. Nevertheless, actuaries use the infinite, not the finite, horizon model.⁵ They are betting money on their calculations, so we should think again about the relative merits of the two approaches.

What is the last possible year of life? There really is none; given any proposed terminus, there always is a positive probability of living a little longer (William Feller 1968). However, there also is a positive probability of dying by any given age. Therefore, an accurate model of intertemporal planning has an infinite horizon, a positive probability of dying at each age, and a finite *expected* lifetime. We thus have the model of uncertain lifetime that has been examined in an interesting literature. (See, for example, Menahem Yaari 1965; David Levhari and Leonard Mirman 1977; Barro and James Friedman 1977; and Eliakim Katz 1979.) It is also the model used by actuaries. Although the infinite horizon model under certainty is only an analytically con-

⁵ Although the various life tables used by actuaries end at finite lives (a printed table must end somewhere), actuaries explicitly recognize that such terminal lives are merely conventions necessitated by the finiteness of the printed tables and do not imply that the reported terminal age should be regarded as the maximum length of life; see chapter 1 of Walter Menge and Carl Fischer (1965) for an explicit statement of this recognition and chapter 3 of Newton Bowers et al. (1986) for a general discussion of the actuarial mathematics of life expectancy. Moreover, the probability of surviving another year reported in the life tables always is positive for the last reported year of life; see the tables in *The Unique Manual*, *Best's Flitcraft Compend*, and the *Life Insurance Fact Book* for a wide range of examples.

venient approximation to the finite horizon model under certainty, the latter in turn is only an analytically convenient approximation to the infinite horizon model with uncertain lifetime.

With an uncertain lifetime and no altruism, Ricardian equivalence will not hold because there is a positive probability that the individual will die before all taxes implied by current debt are collected (Olivier Blanchard 1985). Intuitively, this result is the same as in the overlapping generations model. Introducing altruism also introduces Ricardian equivalence, exactly as in the overlapping generations model. We thus are back to the importance of altruism and bequests, to which we now turn.⁶

C. Bequest Motives. Altruism is not the only reason bequests might occur; other possible motives include strategic behavior by donors, mutual insurance by family members, and simple accident arising from uncertain lifetimes.

One possible motive affecting bequests is strategic behavior. The idea is that the donors use their promise of bequests as a means of eliciting desirable behavior from the designated recipients. For example, parents might use bequests to coax attention from their children, threatening to disinherit insufficiently attentive children (Douglas Bernheim, Andrei Shleifer, and Lawrence Summers 1985), or children might threaten to do something to reduce their own welfare, and therefore also that of the parents, unless the parents are sufficiently generous (Laurence Kotlikoff, Assaf Razin, and Robert Rosenthal 1988). In both cases, a debt-for-tax swap alters the threat point of the parents and/or the children and

⁶ Altruism also is essential for Ricardian equivalence in the infinite horizon model with certainty when births occur. If parents were not altruistic in such a model, they would alter their economic decisions in response to a debt-for-tax swap and would not bequeath any extra wealth to their children to pay increased future taxes. See Phillippe Weil (1989) for more details.

therefore has real effects, negating Ricardian equivalence.⁷

Another possibility is that families act as incomplete annuities markets, providing insurance to their members against the risk of low consumption due to unexpectedly great longevity. Even if individuals are completely selfish, intrafamily transfers including bequests occur as a way of buying insurance services from the recipients. Ricardian equivalence fails because of the selfish nature of individuals, even though deliberate bequests are the rule (Kotlikoff and Avia Spivak 1981).

Still another possibility is that bequests are entirely accidental. Bequests might arise only because people have uncertain lifetimes and often die sooner than anticipated, passing on to their children their assets with no altruism intended (Andrew Abel 1985). No such model has been developed with governmental debt included, but it would seem that the introduction of taxes and debt would not be accompanied by Ricardian equivalence for the same reason Ricardian equivalence is absent from Blanchard's (1985) model: people would recognize that some future taxes would be borne, at least in probability, by people whose utility does not matter to them and so would prefer debt to current taxes.⁸

The foregoing nonaltruistic bequest motives do not cause the one-for-one compensations of changes in future taxes necessary for Ricardian equivalence. It is not clear that only altruistic bequests can generate Ricardian equivalence, but

⁷ Besides possibly leading to non-Ricardian results, strategic behavior also may lead to multiple equilibria, only one of which is the Ricardian solution (Douglas Gale 1985). Peter Streufert (1989) shows that weak restrictions on the utility function guarantee a unique solution.

⁸ Blanchard avoids consideration of accidental bequests by assuming that everyone buys insurance that makes a payment to anyone who survives the current period and collects all wealth of anyone who dies.

altruism is the only motive examined formally so far that has been able to do so.

Even under the assumption of altruism, there are difficulties with Ricardian equivalence. When altruism is sufficiently important to imply Ricardian equivalence, it also is important enough to imply some other rather implausible results. If one expands Barro's model by allowing intermarriage among families, then altruism would link all families together and render neutral all redistributive policies, including marginal tax rates (Bernheim and Kyle Bagwell 1988). Because we do not observe such extreme neutrality, Bernheim and Bagwell conclude that altruism, at least as modeled by Barro, cannot be a significant factor in people's behavior.⁹

One can argue, as Bernheim and Bagwell do, that if a fundamental assumption of a model is shown to be incorrect, then all analysis based on that model should be disregarded. However, one also can argue that virtually any model is an approximation whose underlying assumptions are known to be false from the start and which will lead to conclusions that are known to be false. In most circumstances, "realistic" models are impossibly complex, so that simpler approximations must be used. It seems beyond doubt that most parents care about their children. The nature of that concern, however, is extremely complex and difficult to describe analytically. Several possible approaches have been suggested in the literature, but none is fully satisfactory.¹⁰

⁹ In a related article, Marc Nerlove, Assaf Razin, and Ephraim Sadka (1984) show that bequests will be suboptimally small if parents fail to consider the effect of their bequests on the families to which they are potentially related by the marriage of their children.

¹⁰ See Gary Becker (1974), Alan Blinder (1976), Becker and Nigel Tomes (1976, 1979), and Tomes (1981) for formulations of family interactions different from Barro's. James Andreoni (1989) discusses impure altruism, which arises from the "warm glow" one feels by being generous and which invalidates Ricardian equivalence.

In order to make progress, simple versions of this complex phenomenon, such as altruism, must be imposed. It is not surprising that *reductio ad absurdum* arguments such as that of Bernheim and Bagwell will show that something is amiss, but do we therefore discard the model entirely and totally disregard results emerging from it? To do so would seem to make theoretical analysis infeasible.

Suppose we put aside the difficulties noted by Bernheim and Bagwell and assume that parents do regard their children altruistically. There still are theoretical difficulties with the Ricardian proposition. Altruism guarantees Ricardian equivalence only if the bequest motive is operative—that is, parents must not merely take account of their children's utility when formulating their own plans but must face a situation in which their maximization problem calls for them to confer wealth on their children. A necessary condition for operative bequests can be derived under the following altruistic utility function:

$$U_t = u(C_{1t}) + \beta u(C_{2t}) + \tau U^*_{t+1}$$

where $0 < \beta \leq 1$ is the intertemporal discount factor and $0 < \tau \leq 1$ is the intergenerational discount factor. Then the condition for the bequest motive to be operative is that

$$\tau > (1 + n)/(1 + r^*) \quad (7)$$

where $n \leq 0$ is the population growth rate and r^* is the steady-state interest rate in the absence of bequests (Weil 1987).¹¹ Given the restrictions on the pa-

¹¹ Weil also discusses transition paths to the steady state and uncertain income. The conditions applying to these cases are too complicated to discuss here, but the general flavor is the same as for the simpler case of the steady state under certainty. Weil does not consider the possibility of productivity growth, but Miles Kimball (1987), in an extension of Weil's work, finds that productivity growth does not alter the general conclusions. See Barro (1974), Allan Drazen (1978), and Jeffrey Carmichael (1982) for early discussions of operative bequest motives.

rameters, bequests do not occur under dynamic inefficiency, where $n > r^*$, and will not occur even under dynamic efficiency unless the economy is far enough inside the efficient region to make r^* large enough to satisfy (7).¹² In the inefficient case, where there is too much capital, parents would like to confer liabilities on their children (reduce the capital stock). Government debt helps them do that and so is not neutral. In the efficient case, parents may not love their children "enough" for the bequest motive to operate and Ricardian equivalence to hold.¹³

If it is reasonable to suppose an altruistic bequest motive by parents toward children, it also is reasonable to suppose an altruistic gift motive by children toward parents. Early discussions of this issue restricted attention to the existence of either a bequest motive or a gift motive and showed that either one, if operative, would produce Ricardian equivalence. Very quickly, however, investigators began to explore the possibility of two-sided altruism, where both motives operate at once. This situation is more complex than it might seem at first: if parents care about their children and children also care about their parents, the model may

cycle and have no solution (Carmichael 1982; John Burbidge 1983, 1984; Willem Buiter and Carmichael 1984; Abel 1987; and John Laitner 1988).¹⁴ A solution to this cycling problem with interesting implications for Ricardian equivalence may be obtained if we impose three reasonable restrictions on behavior: that concern for the utility of ancestors and descendants be nonnegative (i.e., that one is not happier if one's relatives are worse off), that family behavior is time consistent, and that one's indirect concern for very distant ancestors and descendants be small. The aspect of the solution relevant to Ricardian equivalence is that there is an interval of possible values for the interest rate that includes the Golden Rule solution but within which neither gifts nor bequests operate and Ricardian equivalence does not hold. Thus, if the economy is sufficiently near the Golden Rule solution, it will not display Ricardian equivalence (Kimball 1987).

The relevance of two-sided altruism is questionable. As anyone who has children knows, the altruism of parents toward children is far greater than that in the reverse direction. Indeed, the entire enterprise of rearing children can be regarded as a pure exercise in altruism. Feeding, clothing, housing, educating, and chauffeuring children absorb an enormous amount of resources but confer no direct utility, in the selfish sense of classical consumer theory, on the providers. Moreover, the return in increased future direct utility, in terms of provision for old age and so on, generally seems minuscule compared to the current cost. The investment seems a poor one in that sense, yet it is routinely undertaken by most married couples. One-sided altruism seems an accurate description of reality so that Weil's result appears to be of more practical import-

¹² Recall that dynamic efficiency, a concept from the growth literature, is a kind of Pareto optimality: an economy is dynamically efficient if it is not possible to improve one generation's welfare without reducing the welfare of another. In particular, an economy is dynamically *inefficient* if it has overaccumulated capital, for then the capital stock can be reduced to allow more consumption currently (the current generation consumes the output that would have maintained the capital stock) as well as in all future periods (future generations have a smaller capital stock to maintain and so may devote less output to investment). The Golden Rule solution (the level of capital providing maximum steady state consumption) is an example of a dynamically efficient solution.

¹³ David Altig and Steve Davis (1989) show, however, that extending the overlapping generations model to allow three-period lives weakens Weil's result in that "enough" love turns out to be much smaller than in the two-period life model. The major difference between the two kinds of models appears to be that consumption loans are possible in the three-period model but not in the two-period model.

¹⁴ Kimball (1987) calls this phenomenon a "hall of mirrors" effect, a good metaphor.

tance than Kimball's to the Ricardian equivalence debate.¹⁵

D. Childless Families. Even if families with children behave altruistically, there are families with no children. Having little or no concern for taxes levied on future generations, they will alter their economic decisions when the government swaps debt for taxes. As a result, Ricardian equivalence will not hold. There probably will be some offset to the behavior of childless families by those with children. Families with children will recognize that the existence of childless families implies a disproportionate share of future taxes to be borne by their own children, and they will increase their bequests to offset it (James Tobin 1980; Barro 1989). However, the offset is likely to be incomplete, for a complete offset would mean that the parents absorb the entire effect of the childless families themselves. This kind of corner solution does not occur in the absence of constraints, and we would expect the parents to adjust to the effects of childless couples on both their own and their children's margins, leading to an incomplete offset and violation of Ricardian equivalence (Tobin 1980).

E. Liquidity Constraints. A popular argument against Ricardian equivalence is that many households are liquidity constrained and so would be pleased to have their current taxes reduced and their future taxes raised by a current debt-for-taxes swap. The constraint generally motivating this argument is credit rationing arising from the household's inability to borrow against its future income (e.g., Walter Heller and Ross Starr 1979; Glenn Hubbard and Kenneth Judd 1986), although other types of credit ra-

tioning schemes as well as the possibility of differential borrowing rates sometimes are mentioned.

Surprisingly, the implication of a liquidity constraint for Ricardian equivalence depends very much on why the constraint occurs (Hayashi 1987; Toshiki Yotsuzuka 1987).¹⁶ The constraint may involve credit rationing, or it may involve differential borrowing rates. In either case, whether Ricardian equivalence holds depends on the reason the constraint exists. The details are beyond the scope of this article, but the common element is that Ricardian equivalence is invalidated by liquidity constraints if the issuance of government debt somehow introduces an element that private markets could not introduce on their own; otherwise, Ricardian equivalence continues to hold. For example, if liquidity constraints arise because of transactions costs and if the government faces lower transactions costs than the private sector in arranging loans, then government debt issues relax the constraint and Ricardian equivalence fails. Similarly, if differing individual risk characteristics are unobservable to lenders and thereby create an adverse selection problem, Ricardian equivalence again fails because the government, through the universal and compulsory nature of its actions, can overcome the adverse selection problem and have real effects with its debt policy.¹⁷ In contrast, if credit rationing exists be-

¹⁵ An alternative view is that of sociobiology, which would argue that altruism is merely one facet of the attempt to propagate one's genes. Under that view, altruism toward one's children would be biologically efficient, whereas reverse altruism would not be, so that one-sided altruism should be expected.

¹⁶ See also Duncan Foley and Martin Hellwig (1975), who show that certain kinds of uncertainty lead to counterintuitive responses of consumers to relaxations of credit constraints.

¹⁷ This argument tacitly assumes the government is more efficient than the private sector at collecting payment from high-risk individuals. Presumably, the tax collector simply shows up at the door and collects what is due. This presumption is false. The government cannot simply commandeer money from those unwilling to pay; it must go to court, just as the private sector must. The laws differ with respect to private and government collection of debts, but it is not obvious that the government's total costs are lower than those of the private sector.

cause all future incomes are uncertain (which would make it optimal to tie the loan rate to the size of the loan because of the possibility of default), Ricardian equivalence continues to hold because government debt issue has no effect on the state of uncertainty and merely leads to a substitution of government loans for private loans.¹⁸

How does all this apply to the most common event discussed in the Ricardian equivalence literature, the debt-for-tax swap? Government debt issues are disproportionately bought by people in the upper end of the income distribution, so a debt-for-tax swap amounts to a government-arranged loan from those at the upper end of the income distribution to those at the lower end. It frequently is argued that many lower income families are young, can expect higher incomes in the future, but cannot borrow against those expected future earnings—i.e., they are liquidity constrained. But *why* are they constrained? Is it because of transactions costs or adverse selection, in which case the government loan may be perfecting the market and thereby have real effects, or is it simply because no one is sure about their future incomes, in which case the government action will have Ricardian effects? It is likely that all elements are present, in which case Ricardian equivalence will fail in the strict sense; *some* real effects will occur.

¹⁸ Bernheim (1989b) argues that the examples of Hayashi and Yotsuzuka in which liquidity constraints do not invalidate Ricardian equivalence depend on future taxes being independent of future income and that, when such independence is absent, as seems more realistic, the presence of liquidity constraints invalidates Ricardian equivalence. This argument is inadequate. When any tax depends on income, marginal tax rates are not zero. Nonzero marginal tax rates generally mean that the timing of tax collections makes a difference to economic decisions, whether liquidity constraints are present or not. It is not clear whether these non-neutralities should be ascribed to the tax system or the government debt. These issues are discussed below.

However, if the liquidity constraints are predominately types that preserve Ricardian equivalence, then for all practical purposes liquidity constraints will not generate non-Ricardian results from a debt-for-tax swap.

Although liquidity constraints might be important in invalidating Ricardian equivalence, the mere existence of even widespread liquidity constraints is in itself insufficient to do so; more is required.

F. *Uncertainty*. For the most part, the theoretical literature on Ricardian equivalence has ignored uncertainty. Some types of uncertainty have been included in extensions of PILCH, but virtually none has been included in analyses of Ricardian equivalence. An exception is the effect of uncertain income on Ricardian equivalence. Because the individual is uncertain of what his future income will be, he also is uncertain of the amount of bequests he will want to make. As a result, he will not be indifferent between an additional dollar now and a future payment to his children that has a present value of a dollar. Ricardian equivalence therefore fails (Martin Feldstein 1988). It is quite possible that other types of uncertainty would lead to the same conclusion. Research along these lines might be a useful addition to the literature.

G. *Differential Borrowing Rates*. Related to liquidity constraints is the possibility of differential borrowing rates for individuals and the government; in particular, the government may be able to borrow at an interest rate lower than that available to individuals, in which case Ricardian equivalence fails. Suppose the government reduces taxes by a dollar today and substitutes a dollar's worth of debt, which we will suppose for simplicity to be a perpetuity. For individuals, the present value of the future tax stream implied by this debt would be $r^G/r^P < 1$, where r^G and r^P are the government

and private borrowing rates. Therefore, the present value of the government debt issue would be less than the value of the current tax reduction, leading to an increase in net wealth, and Ricardian equivalence would not hold.

Although usually presented in this simple form, differential borrowing rates require a more careful analysis. A fundamental question is how government behaves. If we assume that government is merely the agent of the people in society and if we assume individuals have identical borrowing rates, it is unclear that it makes much sense to have different interest rates for individuals and the government. If society (i.e., the collection of identical individuals) is willing to have the government intermediate loans for the purpose of reducing taxes, why shouldn't it be willing to have the government intermediate all loans, in which case the individual's borrowing rate becomes the same as the government's? In other words, why not do all borrowing through the government, in which case substituting debt for taxes has no effects on wealth?

Perhaps individuals really are not identical, with different borrowing rates applying to different individuals or at least different groups of individuals. In that case, it would be impossible for everyone to have borrowing rates equal to that of the government, and debt/tax swaps would have wealth effects. Again, however, a careful analysis leads to subtle conclusions. Suppose there are exactly two groups of people, the good credit risks, denoted as group *G* and having a borrowing rate equal to that of the government, and the bad credit risks, denoted group *B* and having a borrowing rate above that of the government. An issue of debt has no effect on the wealth position of the first group but raises the wealth of the second group, thereby stimulating aggregate demand and re-

quiring an increase in the general equilibrium value of all interest rates, including the government borrowing rate. This rise in interest rates imposes a capital loss on group *G*'s financial assets and also causes an intertemporal reallocation by group *G* away from current consumption and investment. Although these reallocations might have real effects in the aggregate and thereby invalidate Ricardian equivalence, it is not obvious what the net effects would be.

H. Distribution Effects. As we have just seen, differential borrowing rates might lead to failure of Ricardian equivalence through distribution effects. Other kinds of distribution effects also might occur. Holders of government bonds may differ systematically from the average taxpayer, in which case a change in the amount of bonds outstanding is likely to have distributional effects. The nature of these effects depends, of course, on the characteristics of the bond holders. Although it is undeniably true that any such effects will mean that strict Ricardian equivalence fails, it seems unlikely that noticeable aggregate effects of debt manipulations would arise from them.

I. Interest Rate/Growth Rate Differential. A difference between the interest rate and the growth rate might permit the government to issue bonds and never collect taxes to pay back either the interest or the principal on them. Clearly, if the steady state real interest rate is less than the economy's steady state growth rate, then the government can simply issue more debt whenever a principal or interest payment comes due and thus never collect any taxes. The debt outstanding would grow at the rate of interest, but because that rate is less than the economy's growth rate, the base against which the government borrows always exceeds the amount of borrowing the government wishes to undertake. Thus the debt would be net wealth in

the same way that Social Security is net wealth in Paul Samuelson's (1958) consumption-loan model.

Less clearly, perhaps even surprisingly, the stock of government debt can grow faster than real output and the government still never collect any taxes if the debt/output growth rate differential is less than the rate of interest. For some time, it was believed that such behavior was impossible (Barro 1976) because it would appear that, if debt were growing faster than real output, then eventually the amount of debt outstanding would exceed the tax base and the government would no longer be able to roll over its debt. However, taxes are paid out of total household income, which includes interest payments received from the government. As long as the debt grows slower than output plus interest earnings on the debt (i.e., at a rate less than the growth rate of real output plus the real interest rate), then the relevant tax base always will exceed the debt. A correct restatement of the limitation on the growth of debt is that it cannot grow faster than total household income (Bennett McCalum 1984).

J. Bounded Rationality and Selective Naivete. Obviously, the behavioral assumptions of PILCH are strong, perhaps even extreme.¹⁹

In particular, people may approximate a truly infinite horizon problem with a finite horizon problem. Such procedures actually are used in operations research textbooks (e.g., Harvey Wagner 1969); if the experts use it, one should not be surprised to find the less sophisticated average household also using it or something even simpler (Feldstein 1976). The use of a finite horizon to evaluate the

taxes implied by government debt may lead to an understatement of the relevant present value and thus invalidate Ricardian equivalence. However, this outcome is not necessary. If a finite horizon used to simplify what is known to be truly an infinite horizon problem, then the solution of the infinite problem requires terminal values for all assets and liabilities. There is no reason why those values will systematically over- or underestimate the correct values, so that on average we might well expect households to behave as if they were performing the relevant infinite horizon maximization.

Some skeptics of Ricardian equivalence, although not willing to dismiss PILCH itself, suggest that the notion of a household discounting the future taxes it will have to pay because of current government deficits is simply implausible even though other expectational aspects of PILCH are not. Suggestions include the possibility that consumers will distinguish between permanent and temporary changes in taxes but will not recognize the taxes implied by government debt (Franco Modigliani and Arlie Sterling 1990), that consumers ignore transitory changes in government purchases and deficits but respond to permanent changes (Bradford Reid 1985), and that consumers recognize the future tax implications of the path of government purchases but not the tax implications of government debt (Feldstein and Douglas Elmendorf 1990).

These arguments all assert that consumers may be very ingenious at perceiving the tax implications of government purchases or the difference between permanent and transitory changes in government spending and financing decisions and yet be very naive about the tax implications of government debt. It seems unclear what intellectually satisfying theory would explain the kind of dichotomous behavior being postulated. Why should

¹⁹ Stephen Johnson, Kotlikoff, and William Samuelson (1987) present experimental evidence that people cannot perform the basic calculations required by PILCH. For an alternative to PILCH, see Hersh Shefrin and Richard Thaler (1988).

the logic of PILCH apply to some kinds of events but not others?

K. Foreign Ownership of Debt. Foreign holdings of domestic debt are sometimes cited as a source of non-neutrality because the interest on the debt accrues to foreigners but is financed by taxes on the domestic population, leading to a transfer of wealth abroad. This argument ignores the effect of the original sale of the debt, however, which brings into the home country an amount of foreign wealth whose present value exactly equals that of the future tax outflow, leading to no net change in domestic wealth. Thus it seems unlikely that foreign holdings are a relevant consideration.

L. Distortionary Taxation. Finally, changes in government debt may be associated with changes in the timing of marginal tax rates and thereby also with real effects. For example, suppose a debt issue today is accompanied by a reduction in current marginal tax rates and an expectation that future marginal tax rates will rise when the debt matures. This rearrangement of the timing of marginal taxation induces intertemporal substitution effects, alters behavior, and so seems to violate Ricardian equivalence.²⁰ Indeed, it is sometimes said that, because of such effects, Ricardian equivalence always fails in the presence of nonzero marginal tax rates. In fact, there is no failure of Ricardian equivalence, for the substitution effects and related behavioral changes arise from changes in the path of marginal tax rates, not from changes in the path of the debt. Although debt

and marginal tax rates may change simultaneously, there is no necessity that they do so. For example, consider a simple tax function for which average and marginal tax rates differ: $T_t = m_t(Y_t - E_t)$, where T is tax paid, m is the marginal tax rate, Y is gross income, and E is lump-sum exemptions. A given change in the path of debt could be accompanied by a change in the path of the marginal tax rate m , which would be associated with intertemporal substitution effects, or by a change in the path of lump-sum exemptions E , which would have no substitution effects. It is the path of the marginal tax rate, not of the debt, that determines whether real effects are present. Ricardian equivalence concerns only the effects of the path of the debt.

One way to think about this issue is to treat Ricardian equivalence as a proposition about the coefficient on the stock of debt in a multiple regression that includes, besides the debt, the sequence of current and expected marginal tax rates. Debt and marginal tax rates will be correlated but only imperfectly because changes in each may be associated with changes in purchases, average tax rates, and the money supply. Thus the effects of the two can be separated. Ricardian equivalence states that the debt coefficient will be zero; it has no implications for the coefficients of marginal tax rates. If the debt coefficient is zero, Ricardian equivalence holds; otherwise, it does not. No other coefficient is relevant.

M. Summary of the Theory. As we have seen, the theoretical foundation for Ricardian equivalence is not the trivial issue that a first glance suggests. There are many reasons why equivalence might not hold. Some of these do not seem particularly important, but others do. Finite horizons, nonaltruistic or inoperative bequest motives, childless couples, liquidity constraints, and uncertainty all can lead to failure of Ricardian equivalence,

²⁰ The behavioral changes involved are unclear. Judd (1987) shows that, in a perfect foresight model with distortionary taxation, issuing debt and reducing taxes can stimulate investment and reduce consumption initially. In a model with uncertainty and lump-sum taxation, Louis Chan (1983) reaches the same conclusion for consumption, whereas when distortionary taxation is introduced, he as well as Robert Barsky, Gregory Mankiw, and Stephen Zeldes (1986) reach the opposite conclusion for consumption.

and it seems virtually certain that some of these sources of nonequivalence are operative. It appears likely that the world is not Ricardian.

III. Indirect Evidence

Newtonian physics is known to be false; nevertheless, physicists and engineers often treat it as true because it is an excellent approximation in many circumstances. Similarly, we have good reason to believe that Ricardian equivalence is false, but that conclusion is of limited scientific value until we know whether Ricardian equivalence is a good approximation. To find out, we now turn to an examination of the evidence on Ricardian equivalence.

There are two types of evidence to consider—direct and indirect. Direct evidence on Ricardian equivalence arises from tests of predictions emerging from the equivalence proposition—that aggregate consumption or interest rates are unaffected by the stock of government debt, for example. Indirect evidence concerns issues that have implications for Ricardian equivalence, such as the extent of liquidity constraints. It is easier to start with the indirect tests. Because that evidence is, by its nature, of limited applicability to the question of immediate interest, discussion will be abbreviated.

A. Invalidity of the Underlying Model. Because Ricardian equivalence is merely an extension of the PILCH, any deficiencies in that model call into question Ricardian equivalence itself. Several empirical problems with PILCH have appeared.

PILCH implies that households should dissave in retirement, but the evidence on whether they do is conflicting.²¹

²¹ Harold Lydall (1955), Thad Mirer (1979, 1980), Paul Menchik and Martin David (1983), Michael Darby (1979), Jonathan Skinner (1985), and Daniel Hamermesh (1984) report evidence that the elderly

Moreover, even if the elderly do not dissave as much as the simple PILCH model predicts, the reason might be uncertain lifetimes, which are ignored in the simple version of PILCH. As one ages, the probability of living to any given age increases, requiring one to save more than planned when one was younger. For plausible values of real interest rates and utility function parameters, uncertainty of lifespan (James Davies 1981) and income (Skinner 1988) can explain much of observed saving behavior and may salvage PILCH from the possibility that the elderly dissave too slowly. Whether it also can simultaneously preserve Ricardian equivalence is unclear, for it is not known what kinds of uncertainty leave Ricardian equivalence intact.²²

More problematic for PILCH and Ricardian equivalence are studies of the timing of consumption's response to policy changes. Households do not change their consumption when policy changes are announced or could be reasonably anticipated but only when those changes actually occur (James Poterba 1988; David Wilcox 1989a), contradicting the fundamental principle of PILCH that individuals are forward-looking and respond today to events they expect to happen in the future.²³ If individuals do not respond to anticipated future events, the theoretical foundation of Ricardian equivalence is undermined, for the whole point of Ricardian equivalence is that in-

do not dissave as much as PILCH predicts; A. F. Shorrocks (1975), Mervyn A. King and L.-D. L. Dicks-Mireaux (1982), Diamond and Jerry Hausman (1984), Bernheim (1987a), and Kotlikoff, Spivak, and Summers (1982) report contrary evidence.

²² Recall that Feldstein (1988) showed that Ricardian equivalence can fail under income uncertainty.

²³ Wilcox also finds that permanent changes in Social Security benefits are spent on durable goods with virtually nothing going to nondurables, which can be regarded as further evidence against PILCH or as an indication of some problem with Wilcox's decomposition of Social Security benefits into permanent and transitory components.

dividuals anticipate and respond to the future taxes implied by outstanding government debt. Further research along these lines would be worthwhile.²⁴

B. Bequests. Even if the PILCH model is accepted as fairly accurate, the Ricardian extension of it requires the existence of appreciable altruistic bequests. Ignoring for a moment the question of whether bequests are made for altruistic reasons, we may ask whether appreciable bequests are made at all. Apparently they are, although the magnitude is the subject of much debate. Estimates of the fraction of wealth passing through bequests range from 80 percent (Kotlikoff and Summers 1981, 1988; Kotlikoff 1988) to 15 percent (Modigliani 1988). In any case, there appears to be a nonnegligible amount of bequests taking place.

Are those bequests at least in part altruistic? Unfortunately, studies addressing this question have produced conflicting results. Some find behavior inconsistent with altruism (Michael Hurd 1987, 1989; Menchik and David 1983; Menchik 1980; Donald Cox 1987; Joseph Altonji, Hayashi, and Kotlikoff 1989; and Michael Boskin and Kotlikoff 1985); others find behavior consistent with it (Tomes 1981; Bernheim 1989a; D. Cox 1990). It seems most likely that some

²⁴ Other studies have examined the response of households to the timing of taxes. Even in the absence of Ricardian equivalence, PILCH implies that consumption responds more strongly to permanent than temporary changes in taxes (Robert Eisner 1969). A number of studies find that consumption's response to temporary tax changes is too large to be consistent with PILCH (Arthur Okun 1971; Walter Dolde 1979; Blinder 1981; and Poterba 1988), although some of these results have been disputed (William Springer 1975, 1977; and Okun 1977). Unfortunately, these studies all omit several important variables that are highly correlated with temporary taxes and that should have independent effects on consumption, leading to an omitted variables problem and possibly invalidating the reported results. This omitted variables issue is taken up in more detail later when the evidence on Ricardian equivalence is discussed.

nonaltruistic bequests take place, although their nature is not known; it is not clear whether or not altruistic bequests also occur.

Rather than treat altruism as the null hypothesis, one can treat a competing theory of bequests as the null. Bernheim, Shleifer, and Summers (1985) adopt this approach in testing their model of strategic bequests. Using data from the Longitudinal Retirement History Survey on visits and telephone calls to parents to construct measures of attention, they find that the amount of attention shows a strong positive relationship to the amount of bequeathable wealth held by parents, in conformity with their theory. This evidence provides only a limited test of the theory because of the nature of the data: the data concern the behavior of children, whereas the theory concerns the behavior of parents. That the amount of attention children bestow on parents seems to be related to the amount of bequeathable wealth held by the parents says nothing about the motives the parents have for holding the wealth, only perhaps something about the motives the children have for bestowing the attention. Bernheim, Shleifer, and Summers present no evidence that attempts by the children to ingratiate themselves with the parents have a significant effect on the amount of inheritance received, so it is unclear that whether the amount of bequests is determined by parental machinations or by altruism. Though provocative, the theory has not been tested adequately. Other strategic bequest theories have not been tested at all.

We thus are still mostly in the dark about the extent of altruism in determining bequests. It seems almost certain that nonaltruistic bequests occur, but it is not known how important they are relative to altruistic bequests.

Even if altruism is an important be-

quest motive, it must be operative for Ricardian equivalence to hold. As discussed above, the economy must be sufficiently inside the efficient region for there to be operative bequests. The marginal product of capital in the United States is about 10 percent, much larger than the economy's growth rate and consistent with the conclusion that the economy is well inside the efficient region (Feldstein and Summers 1977), and for Canada, England, France, Germany, Italy, Japan, and the United States, the return to capital (measured as the cash flows generated by production after the payment of wages) considerably exceeds the amount of investment, again consistent with the conclusion that these economies are well inside the efficient region (Abel et al. 1986). Although it is impossible to say from these results whether these economies are far enough inside the efficient region to permit Ricardian equivalence, it does appear that equivalence is not ruled out *a priori* by inefficiency.²⁵

C. Childless Families. Apparently, about a fifth of all families are childless in a permanent sense, although a precise figure is difficult to obtain.²⁶ This fraction is substantial, and its impact on the Ricardian proposition could likewise be substantial. The magnitude of the effect de-

pends in part on the income distribution of such families (they will have more impact if they are disproportionately wealthy, less if they are disproportionately poor) and on how great is the offset to their behavior by families with children. I have been unable to find any statistics on the income distribution of such families, but there seems no compelling reason to suppose it differs appreciably from that of the population as a whole. I also know of no evidence on the extent of any offsetting behavior by families with children. We therefore do not know how important the existence of childless families is as a possible source for invalidating Ricardian equivalence. Given the large size of the childless contingent, it seems likely that they would have a substantial effect, but we do not have evidence one way or the other on that issue.

D. Liquidity Constraints. Most, though not all, microeconomic evidence suggests that some households are liquidity constrained.²⁷ Data from the Survey of Consumer Finances that explicitly identifies individuals who have been denied credit suggests that about 12 or 18 percent of all consumers are liquidity constrained, depending on whether one excludes or includes those who failed to apply for credit because they presumed they would be rejected (D. Cox and Tulio Jappelli 1990; Jappelli 1990).²⁸ Most attempts to infer the extent of liquidity constraints from properties of consumption function estimates suggest widespread effects (Hayashi 1985a, 1985b; Zeldes 1989), although at least one finds virtually none (David Runkle 1991).

The evidence mostly suggests liquidity

²⁵ It also is impossible to say from the empirical evidence if the economy is sufficiently close to the Golden Rule solution to rule out operative bequests by Kimball's (1987) results on two-sided altruism.

²⁶ I was unable to find any direct data on childless families. However, about 10 percent of women aged 40–44 who have ever been married have had no children; these women and therefore their families are unlikely ever to have children. About 5 percent of the women and 7 percent of the men aged 40–44 have not been married. These people also are unlikely to have children (ignoring illegitimate births). Thus, assuming those unmarried at 40–44 never marry at all, about 21 percent of families aged 40–44 never have children. Assuming they are representative of the plans of all families then leads to the very crude guess that about a fifth of all families are "permanently" childless.

²⁷ See Altig (1988) for a more detailed discussion of the literature than that which follows.

²⁸ Although D. Cox (1990) and D. Cox and Jappelli (1990) find that some of these constrained households receive income transfers from family members, thus mitigating to some extent the reported constraint, most constrained households do not receive such transfers.

constraints affect an appreciable number of households, but the magnitude of that effect on aggregate behavior is unclear. Liquidity constrained households account for about 13 percent of income and 7 percent of wealth (Jappelli 1990) and about 16 percent of aggregate consumption (Randall Mariger 1987) in the U.S. One therefore might expect that aggregate consumption is significantly affected by liquidity constraints, but Hayashi (1985a) reports that liquidity constraints reduce average consumption by only 2.7 percent in the United States, which seems negligible.²⁹

The literature on "excess sensitivity" of consumption can be interpreted as demonstrating much larger effects of liquidity constraints. Many studies find that consumption is more sensitive to transitory income than PILCH implies, with excessive coefficients on either transitory or current income.³⁰ Most of these studies use aggregate data (Flavin 1981, 1985; Seater and Roberto Mariano 1985; and Campbell and Mankiw 1989), but Robert Hall and Frederic Mishkin (1982)

²⁹ One possible explanation for small effects of even rather widespread liquidity constraints is suggested by W. R. M. Perraudeau and B. E. Sorensen (forthcoming). The Survey of Consumer Finances data used by Jappelli identify those who have been denied credit. Such people may have other assets they can sell to smooth consumption, in which case their consumption follows PILCH despite their reported credit constraint.

³⁰ The time series evidence on the stochastic process generating income and consumption, such as that presented by Charles Nelson and Charles Plosser (1982), has led some investigators to suggest that consumption is excessively insensitive to movements in current income (Kenneth West 1988; John Campbell and Angus Deaton 1989). However, Robert Rossana and Seater (1991) present evidence that much of the apparent time series behavior of income and consumption may be a statistical artifact arising from temporal aggregation of the data. It is interesting that some investigators (Marjorie Flavin 1988; Campbell and N. Gregory Mankiw 1989), suggest such observed insensitivity is the result of an underlying excess sensitivity due to liquidity constraints. Jordi Gali (1990) shows that uncertain lifetime can account for part of the observed insensitivity.

obtain the same result with micro data from the PSID.³¹ Liquidity constraints are a possible reason for such excess sensitivity, although not the only one.³²

Even if liquidity constraints do have substantial effects on aggregate consumption, we must know why those constraints exist before we can draw any conclusions regarding Ricardian equivalence. The little investigation of the reasons for credit constraints that has been done (Jappelli 1990; Perraudeau and Sorensen, forthcoming) does not illuminate whether credit constraints arise for reasons that would invalidate Ricardian equivalence. For example, race of the applicant seems significant in explaining credit constraint, but what does that finding really mean? Among other possibilities, lenders might use race as an indicator of an adverse selection problem or as an indicator of uncertain future income. The implications for Ricardian equivalence depend on which possibility holds. As discussed later, Seater and Mariano (1985) find strong evidence of excess sensitivity but no evidence that government financing variables have any significant effect on consumption, suggesting that, if excess sensitivity reflects liquidity constraints, those constraints are not the type that invalidate Ricardian equivalence.

E. Summary of the Indirect Evidence. For the most part, the indirect evidence on Ricardian equivalence is inconclusive, either because it is contradictory or because crucial pieces are missing. There

³¹ However, Knut Mork and Kerry Smith (1989), repeating Hall and Mishkin's methodology on a detailed panel data set for Norway, obtain results generally less supportive of excess sensitivity, and Runkle (1991), using a refined version of Hall and Nishkin's dataset, finds no evidence of excess sensitivity at all.

³² For example, Ricardo Caballero (1990) shows that uncertainty of labor income may explain both excess sensitivity and excess smoothness. As with most other forms of uncertainty, the effect on Ricardian equivalence of introducing uncertain labor income into the PILCH framework is unknown.

are hints that Ricardian equivalence might not hold—the evidence of non-negligible inadequacies in the PILCH framework regarding the timing of policy changes, the apparent importance of nonaltruistic bequest motives, the many childless families, and the existence of liquidity constraints. However, nothing is at all definitive.

IV. Direct Evidence: Measurement and Methodology

Let us turn to the direct evidence on Ricardian equivalence. At first glance, that evidence also seems largely inconclusive, with results favorable to Ricardian equivalence in some cases and unfavorable in others. The range of reported results has led to wildly different conclusions among economists. Indeed, one large group asserts that the evidence mostly rejects the Ricardian equivalence and that the small amount of favorable evidence is obviously invalid; another large group asserts that the evidence mostly supports the proposition and that the small amount of unfavorable evidence is obviously invalid.

When I began working on this review article, I was concerned by the riot of conflicting empirical results; it really did seem, as is often asserted, that macroeconometric evidence can verify anything (or nothing, depending on how you prefer to express yourself). However, as I worked through the literature, patterns and coherence emerged. My conclusion now is that the direct evidence says quite a lot about the empirical relevance of Ricardian equivalence, although there still are some puzzles to work on. In addition, the direct evidence provides a lesson in the importance of good econometric methodology, from measurement of the relevant variables to application of appropriate estimation methods. Therefore, before discussing the empirical results themselves, we must address the relevant

measurement and methodological issues.

A. Measurement. A surprising number of studies stumble at the first step: proper measurement of the variables of interest. According to the theory, it is his anticipated total future tax liability that an individual cares about in computing his permanent disposable income; consequently, it is the total stock of government debt or the total deficit that should be used in empirical work. Nonetheless, studies often use only the federal component of the debt. This practice is problematical not simply because it omits relevant information contained in state and local debt data but because there are likely to be correlations among the various government debt series, in which case parameter estimates will be biased and inconsistent. Although I know of no studies examining the correlations among federal, state, and local debt or deficits (a rather surprising gap in the literature), there is evidence of significant relationships between federal fiscal activity on the one hand and state and local fiscal activity on the other (e.g., Feldstein and Gilbert Metcalf 1987). It is not hard to imagine that there also is some relationship among federal, state, and local deficits.

Official debt and deficit statistics are based on total nominal par values outstanding; a number of studies fail to convert them to privately held real market values. The ownership surveys reported by the U.S. Treasury permit straightforward correction for ownership of federal debt, and several studies have provided conversions of par to market values.³³

³³ Conversion of par to market values had been carried out for annual data over the period 1919–1975 by Seater (1981) and for monthly federal data by Michael Cox and Eric Hirschhorn (1983) over the period 1942–1980, which M. Cox (1985) extends through 1984. James Butkiewicz (1983) provides a simple but very accurate formula for computing market values from par, simplifying the task of extending the market value series.

Real values can be computed easily from these data.

Attending to the foregoing measurement issues can have large effects on the measures of debt and deficit, as some examples illustrate. (The following examples are taken from Seater 1985b.) In 1946, the real value of the official federal deficit in 1972 dollars was -\$47.8 billion; however, because of substantial inflation that year, the change in the real par value of federal debt outstanding was -\$130.1 billion, a whopping difference. The first figure is the real par value of the debt that the Treasury retired; the second figure adds to this the inflation-induced reduction in value of the debt that remained in the hands of the public. In 1982, the change in the real par value of outstanding federal debt was \$54.6 billion, whereas the change in the real market value was \$94.8 billion, the difference arising from changes in the interest rate. Finally, in 1980 the change in the real market value of federal debt outstanding was -\$5.2 billion, but the change in the real market value of total government debt outstanding was -\$36.5 billion.

Some measurement issues are probably intractable. For example, how does one evaluate federal loan guarantees? They are of considerable magnitude—about \$550 billion in 1990—and in an expected value sense, some fraction of them represents future tax obligations, but it is not clear what that fraction is. Other measurement issues, specific to the variables included in the regressions being run, will be discussed as the need arises rather than here.

B. Methodology. Several issues of econometric methodology—most notably specification, differencing, simultaneity, and treatment of expectations—figure importantly in interpreting the Ricardian empirical literature. They are discussed here in terms of aggregate consumption function regressions, but the same issues arise in other tests of Ricar-

dian equivalence, such as interest rate regressions.

Consider what Ricardian equivalence implies about the relationship between government activity and consumption. On the presumption that PILCH provides the right explanation for consumption behavior, we expect government purchases and marginal tax rates to influence consumption demand. Because individuals care about the present value of their disposable income, and because the true measure of the government's use of resources is government purchases, the present value of disposable income equals the present value of gross income minus the present value of government purchases:³⁴

$$\sum_{t=0}^{\infty} (Y_{t+i} - G_{t+i})R^i = \sum_{i=0}^{\infty} Y_{t+i}R^i - \sum_{i=0}^{\infty} G_{t+i}R^i.$$

Clearly, according to life cycle theory, government purchases ought to be included in any consumption function regression.³⁵ Similarly, marginal tax rates also should be included because of their effects on relative rates of return. (See Barro 1981, 1990; and Seater and Mariano 1985 for more detailed discussions.) Whether other government variables such as current tax revenue or government debt should be included depends on the validity of Ricardian equivalence.

What happens if, say, government debt is included in the regression but purchases and/or marginal tax rates are

³⁴ Equivalently, permanent disposable income equals permanent gross income minus permanent government purchases, where the latter is defined analogously to the former as that constant flow of government purchases with the same present value as the (expected) path of actual purchases.

³⁵ I have ignored the possibility that government purchases might substitute partially for privately purchased consumption. There is evidence that such substitutability is non-negligible (David Aschauer 1985; Seater and Mariano 1985; Shagil Ahmed 1986); accounting for its effects introduces government purchases into the present value expression in a way not considered here. See Barro (1981, 1990) for a theoretical discussion.

omitted? Nothing, if the correlations between debt on the one hand and purchases and marginal tax rates on the other are zero, but we have every reason to believe that those correlations are not zero. The biggest movements in government debt are associated with military expenditure; in particular, during wars both military expenditure and debt issue are high whereas during peacetime they are not. Every version of macroeconomic theory given any credence predicts that government purchases affect aggregate activity. Consequently, including government debt in a consumption regression while excluding purchases is almost certain to introduce omitted variable bias and ascribe to debt effects really caused by purchases, confounding interpretation of the debt coefficient.

Similarly, average tax rates (equivalently, total tax revenue) and marginal tax rates seem very highly correlated; the correlation of the aggregate average tax rate and the aggregate marginal tax rate is about 0.96 (Seater 1982b). Consider what omission of marginal tax rates from a consumption regression would imply for the coefficient of government debt when gross income and government purchases are included in the equation. Inclusion of income and purchases controls for their effects, so let us simplify by supposing debt rises with income and purchases unchanged. Clearly, the rise in debt is substituting for revenue collection and is associated with a fall in the average tax rate, which in turn generally is associated with a fall in the marginal tax rate. Because the theory predicts marginal tax rates to have a negative effect on consumption, this rise in debt would be associated with a change in marginal rates that should raise consumption. Therefore, debt can be expected to have a positive coefficient here even if Ricardian equivalence is true, again because of omitted variables bias.

Clearly, for consumption regressions to provide information on Ricardian equivalence, they must be specified properly to avoid spurious effects of debt.

The treatment of government purchases involves still another complexity, often overlooked in the empirical Ricardian literature. Permanent and transitory changes in government purchases are likely to have different effects on economic activity; for example, permanent changes may have no effect at all on interest rates, whereas transitory changes may raise them (Barro 1981, 1990). However, the debt is likely to be positively correlated with transitory purchases through tax-smoothing. Fluctuations in the tax rate impose costs on society, and it is desirable to keep tax rates as constant as possible to minimize those costs. If debt is issued or retired when purchases are above or below average, tax rates can be isolated from transitory purchases, thus avoiding the costs associated with fluctuations in them. In this manner, debt movements are positively correlated with transitory purchases (Barro 1979).³⁶ Consequently, in a regression using total purchases and the deficit as regressors, with no decomposition of purchases into permanent and transitory components, the deficit may proxy for transitory purchases and have a significant coefficient even if Ricardian equivalence actually holds.³⁷

A second methodological issue is treatment of "trend". Is trend deterministic or random? Deterministic trend is the type of underlying, long-term tendency exemplified by models that include time as an independent variable:

³⁶ The logic is the same as that of the permanent income model, in which consumption is divorced from transitory income in order to maximize utility.

³⁷ As we will see later, this problem does not appear to be severe in tests based on the consumption function but apparently is serious in tests based on the behavior of interest rates.

$$Y_t = a + bt + e_t. \quad (8)$$

Data exhibiting this kind of trend may deviate from the "trend line" but always tend back to it. Random trend is the type of long-term tendency exemplified by a random walk:

$$Y_t = Y_{t-1} + e_t \quad (9)$$

which is equivalent to

$$Y_t - Y_{t-1} = e_t.$$

Here, the average change in Y is a constant (zero), but the level of Y wanders with no predetermined pattern. Any given *realization* of Y , however, is likely to show some net upward or downward movement simply by chance.³⁸ A trend model such as (8) could be fit to such data and might well produce a large and statistically significant estimate of b . The estimate would be totally spurious, though, for the true model (9) contains no systematic tendency at all.

Which model actually describes the data makes a drastic difference to the way one interprets those data (Charles Nelson and Charles Plosser 1982). It also makes a drastic difference to the way one analyzes them. With deterministic trend, it is proper to include time as an independent explanatory variable and to proceed in the usual way. With random trend, it usually is necessary to first-difference all data before performing regressions; failure to do so results in biased and inconsistent estimates (Plosser and William Schwert 1978). The exception to this rule occurs when the data are cointegrated. Roughly, two variables are cointegrated if their long-term movement reflects a common cause. For example, consider an economy with a constant population, no technical progress, and constant velocity of money. From the quantity identity, we know that prices and money will

move together in lock step. Should one show a long-term drift, the other will, too. In such a case, money and prices would be cointegrated. They have no independent sources of long-term drift. Should we introduce technical progress, we would destroy this cointegration. Even if money were constant, prices could drift down as output grew. The important point here is that, when two variables are cointegrated, it is proper to regress one on the other without first differencing them. Intuitively, the common drift element cancels out of the two sides of the regression.

The main problem that arises with differencing and cointegration is that it is difficult to know whether they apply or not. So far, the tests proposed in the literature have low power, and researchers are without firm guidelines on how to proceed. Although very little of the empirical work on Ricardian equivalence has addressed the issues of differencing and cointegration, they figure prominently in one of the best-known exchanges in that literature.

A third methodological issue concerns simultaneity. Simultaneity is perhaps second only to identification in being known from econometric theory to be important but frequently ignored in practice. Every theoretically sensible specification of the consumption function includes some of the following variables: income, marginal tax rates, interest rates, the unemployment rate, tax revenue, and transfers. All those variables are likely to be endogenous, so estimation ought to proceed by simultaneous methods. Unfortunately, it often has not done so, leaving the validity of the results uncertain. Evidence from studies that have examined the issue suggest that failure to use simultaneous methods does not lead to serious bias, but the evidence is not strong because only a few tests have been performed and because no studies

³⁸ See, for example, the simulated coin-flipping game reported in Feller (1968, ch. 3, section 6).

at all use fully simultaneous methods such as three-stage least squares or full information maximum likelihood.

Finally, there is the always troublesome problem of measuring expectations, which are the essence of PILCH and Ricardian equivalence. Traditional consumption function tests must attempt to measure expected income, expected taxes, expected government purchases, and so on, for they are the explanatory variables suggested by the theory. Usually, distributed lags of past variables are used in some fashion to capture expectations of future values. This approach is quite defensible in that past values are the only data available to anybody and therefore must contain all information about the future.³⁹ The main problem is that economists cannot observe all the data that economic agents do; as a result, estimates of individuals' expectations may be highly inaccurate.

Euler equation methods are useful here for they avoid any direct measurement of expectations, relying instead on testing observable intertemporal relations implied by the theory, such as Hall's (1978) well-known random walk result for consumption, which can be tested without constructing any proxies for expected future income or the like. There have been unfortunately few such tests applied to Ricardian equivalence. Euler equation tests are not trouble-free, either; for example, if one assumes that future income is uncertain, one generally cannot obtain a closed-form solution for consumption from the Euler equation, so that the implied testable restrictions also are unobtainable (Hayashi 1985a). It

simply is impossible to derive restrictions that are both testable and reliably measurable from a reasonably general model of household behavior. The best one can hope for are restrictions that are approximations in terms of the true theoretical relationships and in terms of the quantities theory says should be measured. Consequently, it also is impossible to produce a truly definitive test of Ricardian equivalence (or anything else in economics); any feasible test can be criticized as inadequate. Whether any tests are worthwhile under such circumstances is not a question I will attempt to answer, but the reader should keep it in mind.

Let us turn now to an evaluation of the empirical studies of Ricardian equivalence. Consumption function tests have been the most extensively replicated of the empirical Ricardian equivalence literature, they generally have addressed more completely the issues of measurement and methodology just discussed, and they are free of certain open-economy problems that afflict the second-largest collection of tests, those dealing with interest rates. The consumption test literature therefore will be given pride of place and discussed first.⁴⁰ Interest rate tests and then other aggregate studies will be discussed next, and finally the few studies using micro data will be evaluated.

V. Direct Evidence: The Aggregate Consumption Function

The studies of Ricardian equivalence that deal with consumption are something of a mishmash, yielding wildly different results from one to the next.⁴¹ The

³⁹ At least this is true in continuous time, when virtually nothing is known at the instant it happens. With discretely sampled data, a problem arises in that what we measure as current values (the current quarter's GNP) in fact include data from the recent past (last month's GNP) on average. Such "current" data are known, at least in part, to agents making current decisions.

⁴⁰ Studies that have used saving as the dependent variable are grouped with the consumption studies in the following discussion.

⁴¹ Tanner (1970, 1989), Levis Kochin (1974), Barro (1978), Michael Darby (1979), Dean Leimer and Selig Lesnoy (1982), Roger Kormendi (1983), Erkki

conflicting results have led previous reviewers (Seater 1985b, Bernheim, 1989b) to diametric conclusions on what the evidence implies about the validity of Ricardian equivalence and has led some investigators (Barro 1989) to despair of the ability of consumption studies to produce informative evidence on the issue. In fact, much of the confusion in the consumption literature arises from problems with data and methodology. Although no existing study does everything just right, those that attend reasonably well to the relevant methodological issues produce similar conclusions regarding Ricardian equivalence.

Rather than discuss the merits and demerits of each article briefly, I shall do a detailed dissection of a few salient examples. Limiting the discussion this way allows us to see the forest for the trees. The consumption test literature can be divided into three groups: life-cycle models, permanent income models, and Euler equation tests. I shall begin with the first group, using the studies by Feldstein (1982) and Kormendi (1983) as my "teaching examples." They have been analyzed by subsequent researchers, and much is known about their methodological strengths and weaknesses. In addition, they are two of the most widely cited articles in the empirical literature on Ricardian equivalence. A careful reading reveals much about the importance of good econometric practice and the proper application of the life-cycle methodology, as well as about the more immediate issue of Ricardian equivalence. Most of what is said here

Koskela and Matti Viren (1983), Aschauer (1985), Seater and Mariano (1985), Kormendi and Philip McGuire (1986, 1990), and Paul Evans (1988a) present evidence favorable to Ricardian equivalence; Feldstein (1974, 1978, 1982), Jess Yawitz and Laurence Meyer (1976), Reid (1985), Modigliani and Sterling (1986, 1990), Bernheim (1987b), and Feldstein and Elmendorf (1990) present evidence unfavorable to it; and Seater (1982a). Blinder and Deaton (1985), and Alfred Haug (forthcoming a) present evidence that is mixed.

will apply to the interest rate tests of Ricardian equivalence discussed later. Feldstein's article illustrates the importance of specification and simultaneity issues. Kormendi's article nests essentially all previous work and applies tests of various restrictions implicitly imposed in the earlier attempts to test Ricardian equivalence. After discussing these articles in detail, I turn to examples of the permanent income and Euler equation approaches.

A. Feldstein. Feldstein (1982) estimates the following equation:

$$C_t = a_0 + a_1 Y_t + a_2 W_t + a_3 SSW_t + a_4 G_t + a_5 T_t + a_6 TR_t + a_7 D_t + e_t \quad (10)$$

where C is total consumer expenditure, Y is current income, W is the market value of privately owned wealth at the beginning of the period, SSW is a measure of the value of future Social Security benefits, G is total government purchases, T is total tax revenues, TR is government transfers to individuals, D is net total government at the beginning of the period and apparently measured at par, and e is the residual. Feldstein argues that Ricardian equivalence implies five hypotheses about the coefficients in (10): $a_4 < 0$, $a_5 = 0$, $a_6 = 0$, $a_3 = 0$, and $a_2 = a_7$. He estimates (10) by OLS and also by 2SLS; in the latter, T and sometimes Y are treated as endogenous and are instrumented with their own lagged values. In the OLS estimates, only the hypothesis $a_6 = 0$ can be rejected by the t -test. The 2SLS results continue to reject $a_6 = 0$ but also cannot reject $a_4 = 0$; the other three hypotheses cannot be rejected. In no case are joint tests of the hypotheses reported.⁴²

⁴² Feldstein's conclusion that the results strongly reject Ricardian equivalence simply is unwarranted, being based on unconventional testing criteria and inconsistent standards.

In discussing the 2SLS results, Feldstein notes that the hypothesis $a_5 = 0$ can be rejected at the 20 percent level and therefore should be rejected. However, 20 percent is not a conventional significance

There are several reasons to question Feldstein's results. First, Feldstein's instruments for taxes and income are limited to the once-lagged values of those variables themselves. Feldstein's reported Durbin-Watson statistics are almost always in the indeterminate range (N. Eugene Savin and Kenneth White 1977), so it would seem prudent to explore further whether or not once-lagged values of T and Y are valid instruments. Second, the most robust rejection of Ricardian equivalence reported by Feldstein is the strongly significant coefficient on TR , transfers to individuals.⁴³ Given their nature, transfers may well have a business cycle component and therefore acquire significance merely as a business cycle indicator rather than through a genuine effect on aggregate consumption. Also, transfers are significantly correlated with the federal marginal income tax

level in statistical testing; the hypothesis cannot be rejected at the 10 percent level. In addition, although Feldstein emphasizes that the point estimates of a_7 and a_2 are very different from each other in magnitude, the standard error on a_7 is so large that the hypothesis $-a_2=a_7$ in fact cannot be rejected. These deviations from standard practice are the reasons Feldstein reports four rather than two rejections of Ricardian equivalence.

Feldstein then uses inconsistent criteria to interpret the OLS and 2SLS results. Although four of the five OLS tests are consistent with Ricardian equivalence, Feldstein argues that "the results of the OLS estimation are therefore mixed and give no clear-cut answer about debt equivalence in general . . ." (p. 13). In contrast, when (by Feldstein's count) four of the five 2SLS tests are inconsistent with Ricardian equivalence, Feldstein argues that "the estimated parameters strongly contradict the [Ricardian] hypothesis" (p. 8). Thus, when four of the five tests support the hypothesis, the results are only mixed, whereas when four of the five tests reject the hypothesis, they are conclusive.

⁴³ Though strongly suggestive, the significance of the coefficient on transfers has no necessary implication for Ricardian equivalence. Transfers redistribute income among different groups of people than redistributions associated with a debt-for-tax swap. A significant coefficient on transfers suggests that they have some non-negligible aggregate effects; that fact does not imply that other kinds of redistributions necessarily have those effects as well.

rates (Seater 1989). Feldstein omits marginal tax rates and business cycle indicators from his regression, leaving the interpretation of the transfer variable's significance unclear. Third, Feldstein's measure of Social Security wealth is flawed by arbitrary adjustments for changes in the law that have the effect of largely restoring the computer error in Feldstein's (1974) original SSW series (Leimer and Lesnoy 1982). Fourth, Feldstein uses either national income or disposable income as his income variable. Those measures, of course, are obtained from total income by subtracting certain taxes, so their use in effect constrains the coefficients on total income and the relevant taxes to be the same. Such constraints should not be imposed without being tested.

Seater and Mariano (1985) repeat Feldstein's regressions and explore the first two of the foregoing issues.⁴⁴ Tests of exogeneity (De-Min Wu-Jerry Hausman 1978) suggest that Y , lagged Y , T , SSW, and a business cycle indicator UY , discussed momentarily, are endogenous. Those are not the same variables treated as endogenous by Feldstein—indeed, they include one of his instruments—so there is reason to suspect Feldstein's estimates of simultaneity bias. When instruments passing the Wu-Hausman test are used to estimate the consumption function, the results are the same as Feldstein's pro-Ricardian OLS results, with only the hypothesis of TR 's insignificance being rejected. However, that rejection appears to reflect omitted variables bias. Consider as an explanatory variable the product of the unemployment rate and Y , denoted UY . Given Y , a high value of UY means that unemployment is high and therefore that Y is abnormally low, so that Y can be expected to rise in the

⁴⁴ Exact replication was impossible because Feldstein does not identify his data sources.

future; thus, we expect UY to have a significantly positive effect on consumption (Barro 1978), which it does. Inclusion of UY greatly reduces the significance of TR ; the t -ratio barely exceeds two. TR also is highly correlated with marginal tax rates and interest rates; adding those variables to the consumption function leaves TR statistically insignificant.

Seater and Mariano's results strongly suggest that Feldstein's estimates are severely affected by misspecification and improper correction of simultaneity bias. In addition, as explained in Section V.B below, the equality constraints on taxes and income implicitly imposed by Feldstein generally are rejected by formal tests; releasing them results in estimates more favorable to Ricardian equivalence (Kormendi 1983; Kormendi and Meguire 1986, 1990). Finally, simply using correctly constructed data on SSW renders that variable insignificant in explaining consumption behavior (Leimer and Lesnoy 1982). Thus it appears that Feldstein's rejections of Ricardian equivalence stem from flaws in econometric methodology and are reversed when those are corrected. His results must be dismissed as nonevidence.⁴⁵

B. Kormendi. Kormendi's (1983) examination of Ricardian equivalence is similar to Feldstein's, embedding the estimation in a general model of consumption that attempts to account for government in a way consistent with the logic of the permanent income/life cycle hypothesis. A great virtue of Kormendi's specification is that it and its extensions by Kormendi

⁴⁵ Having said that, let me hasten to add that Feldstein's article is pathbreaking in at least two ways. It appears to have been the first to recognize and attempt to correct for the simultaneity problem. It also appears to have been the first to recognize the logical generalizations that should accompany Ricardian equivalence, such as insignificance of the coefficient on transfers. Kormendi (1983) later formalized and extended this insight, dubbing it the "consolidated approach" (see below).

and Meguire (1986, 1990) nest essentially all the previous tests of Ricardian equivalence based on the life-cycle model of consumption and therefore allow us to collapse discussion of the life-cycle evidence into discussion of this one study.

Kormendi argues that private and public expenditures are jointly determined as part of an overall maximization by individuals in society. Public expenditures can be divided into government consumption GC , government investment GI , and government dissipation GD . The first, GC , comprises all public purchases that provide utility directly to individuals; the second, GI , comprises purchases yielding utility in future periods; and the third, GD , comprises waste arising from the fact that government purchases are determined and financed in the political rather than the economic marketplace where resource cost and service value might differ. Thus, the relevant consumption function is for total consumption TC , equal to the sum of private consumption C and government consumption GC :

$$TC_t = a_0 + a_1 Y_t + a_2 GD_t + a_3 W_t + u_t \quad (11)$$

where Y is total income, W is total wealth, and u is the residual. The coefficients a_1 and a_3 are expected to be positive, and a_2 is expected to be negative. By splitting TC into its components and taking GC to the other side of the equation, (11) can be rewritten as

$$C_t = a_0 + a_1 Y_t + a_{21} GD_t + a_{22} GC_t + a_3 W_t + u_t \quad (12)$$

where $a_{21} = a_2$ of (11) and $a_{22} = -1$. Because it is difficult to divide available data on government purchases into GC , GI , and GD , a modified version of (12) is used for estimation:

$$C_t = a_0 + a_{11} Y_t + a_{12} Y_{t-1} + a_2 GS_t + a_3 W_t + u_t \quad (13)$$

where GS is total government spending and Y_{t-1} has been included on the usual grounds that it may contain incremental information about future income.⁴⁶

Equation (13) constitutes what Kormendi calls the "consolidated" approach to the aggregate consumption function; it can be compared with the "standard" approach, which supposes that consumption is based on disposable income and total wealth plus government debt:

$$C_t = a_0 + a_1 YD_t + a_2 (W_t + GB_t) + u_t \quad (14)$$

where GB is the stock of government bonds outstanding and YD is disposable income, defined as

$$YD_t = Y_t - TX_t - RE_t + TR_t + GINT_t$$

where TX is tax revenue, RE is retained earnings, TR is transfers, and $GINT$ is government interest payments on outstanding debt. A major problem with the standard approach, irrespective of the validity of the consolidated approach or Ricardian equivalence, is the use of disposable income as a regressor. According to the life cycle model, consumption depends on wealth; but because published measures of wealth capture only nonhuman wealth,⁴⁷ it is necessary to include in the consumption regression some variables that capture other unmeasured components of wealth. Because no direct measure is available, what is included instead is a collection of flow variables, such as current and lagged income, which the econometrician hopes will yield a close approximation to the consumer's expected wealth. The coefficient then estimated in the consumption func-

tion is not simply the sensitivity of consumption to the wealth proxy but rather the product of that sensitivity and the coefficient linking the flow variable to the consumer's expectation. For example, suppose the econometrician approximates consumer wealth arising from labor income by estimating, say, a univariate autoregression for labor income, using that to forecast future labor income, and then taking the appropriate present value. The estimated autoregression would have the form

$$Y_t = \sum_{i=1}^T d_i Y_{t-i} + e_t.$$

From this, the econometrician constructs the present value of Y , denoted W^* , which he then includes in the consumption function:

$$\begin{aligned} C_t &= a_0 + a_1 W_t + a_2 W_t^* + u_t \\ &= a_0 + a_1 W_t + \sum_{i=1}^T b_i Y_{t-i} + u_t \end{aligned}$$

where the b_i are products of the d_i and a_2 (as well as powers of the discount factor). When the econometrician uses more than one variable, such as taxes as well as gross income, to proxy the consumer's expected present value, he will estimate a separate time series model for each of them (Heejoon Kang 1986) and include the sets of lagged values separately in the consumption regression:

$$\begin{aligned} C_t &= a_0 + a_1 W_t + \sum_{i=1}^T b_i Y_{t-i} + \\ &\quad \sum_{i=1}^T c_i TX_{t-i} + u_i. \end{aligned}$$

The coefficients b_i and c_i will differ for a given i unless the time series models governing Y and TX happen to be the same, an unlikely event. Thus it generally is inappropriate to estimate the consumption function in the form

⁴⁶ GS appears to measure the same quantity as Feldstein's (1982).

⁴⁷ And generally not all of that because of accounting omissions such as retained earnings and because of difficulty in valuing assets such as housing and durable goods not traded on centralized exchanges.

$$C_t = a_0 + a_1 W_t + \sum_{i=1}^T b_i (Y_{t-i} - TX_{t-i}) + u_t$$

which constrains Y and TX to have the same time series model. Such constraints should be tested rather than arbitrarily imposed, but in the Ricardian literature they often have been imposed without tests.⁴⁸ Kormendi (1983) and Kormendi and Meguire (1986, 1990) test many of them.

Kormendi (1983) estimates the generalized consumption function

$$\begin{aligned} C_t = & a_0 + a_{11} Y_t + a_{12} Y_{t-1} + a_2 GS_t \\ & + a_3 W_t + a_4 TR_t + a_5 TX_t + a_6 RE_t + \\ & a_7 GINT_t + a_8 GB_t + u_t \end{aligned} \quad (15)$$

which nests the consolidated and standard approaches in accordance with good statistical practice for testing competing models. Estimation is by OLS with all variables expressed in first differences because the data are nonstationary and are not rendered stationary by linear detrending.⁴⁹ The sample period is 1930–76. Under the consolidated approach we expect $a_2 < 0$, $a_4 = a_5 = a_6 = a_7 = a_8 = 0$, whereas under the standard approach we expect $a_2 = 0$, $a_4 = -a_5 = a_6 = a_7 = a_11 > 0$, and $a_8 = a_3 > 0$. The original Kormendi (1983) estimates give somewhat mixed results, with a_2 significantly negative and a_5 , a_6 , and a_7 all insignificantly different from zero, in accordance with the consolidated approach, with a_7 significantly positive, in accordance with the standard approach, and with a_8 significantly negative

⁴⁸ For example, Barro (1978), Blinder and Deaton (1985), and Modigliani and Sterling (1986), all use disposable income without testing the implied constraint that gross income and taxes to have the same generating process.

⁴⁹ Although first-differencing in such circumstances has become standard practice in the wake of work by Plosser and Schwert (1978), Nelson and Plosser (1982), and Nelson and Heejoon Kang (1984), it was much less widely practiced when Kormendi published his study.

in accordance with neither approach. Subsequent extensions using more accurate data, a slightly longer sample period, and 2SLS estimation yield estimates upholding all of the consolidated approach's hypotheses on the consumption function's coefficients (Kormendi and Meguire 1990). In addition, extensive tests reject the coefficient equality restrictions implied by the standard approach (Kormendi, 1983; Kormendi and Meguire 1986, 1990). The results thus are almost totally consistent with the consolidated approach, a corollary of which is Ricardian equivalence, and are much like those of Seater and Mariano's (1985) replication of Feldstein (1982).

Kormendi's study has generated an unusually large number of comments, replies, and extensions. James Barth, George Iden, and Frank Russek (1986) replicate Kormendi's regressions using their own reconstructions of the data from original sources—a most commendable exercise that is especially valuable here because issues of measurement are often crucial to the outcome of Ricardian equivalence tests. In this case, the data and results are essentially the same as Kormendi's.

Feldstein and Elmendorf (1990) also attempt a replication of Kormendi, obtaining results quite different from Kormendi's but which derive entirely from data errors (Kormendi and Meguire 1990).

Modigliani and Sterling (1986, 1990) criticize Kormendi on several grounds: specification of the consumption function, failure to include a measure of temporary taxes, choice of sample period, and use of differenced data. Modigliani and Sterling argue for a consumption function specification that implicitly imposes the kind of restrictions discussed above, but those restrictions fail formal tests (Kormendi and Meguire 1986, 1990) and seem invalid. Modigliani and Ster-

ling argue for a shorter sample period that does not include World War II, but the consolidated approach is robust to the sample period choices suggested (Kormendi and Meguire 1990).

More important are Modigliani and Sterling's other two criticisms. Modigliani and Sterling present regression results suggesting that Ricardian equivalence does not survive inclusion of a temporary tax variable, whose values they report in their first (1986) article. However, both the stated justification for this variable and its reported values are unsatisfactory. Although it is worthwhile to distinguish between temporary and permanent values, it seems strange to include an explicit measure of temporary taxes but no measures of temporary income, government purchases, and so on. Modigliani and Sterling's (1990) response to this concern is that

the temporary nature of certain tax measures—especially those of 1969—was explicitly stated by the government, was widely understood, and the amounts involved were very large. We have endeavored to allow for transitory components in other variables through the device of distributed lags. (p. 600)

One problem with this justification is that when temporary taxes are not given unique treatment but are treated like other temporary variables and approximated with distributed lags, the consolidated approach is upheld (Kormendi 1983; and Kormendi and Meguire 1986, 1990). Another problem is that determination of the "temporariness" of temporary taxes from government statements and popular understanding is not nearly so unambiguous as Modigliani and Sterling assert. Several supposedly permanent changes in taxes have not lasted much longer than those announced as temporary (Dolde 1979); the temporary taxes arising from the Korean war lasted longer than originally expected (Okun

1971)⁵⁰; and the income tax surcharge of 1968, originally scheduled to end in mid-1969, was extended to mid-1970. Most pertinent of all, the 1975 tax cuts—treated by Modigliani and Sterling as pertaining only to 1975—were extended several times and still were in effect six years later (Blinder 1981)! Clearly, a more systematic approach to the decomposition of taxes into permanent and temporary components than that used by Modigliani and Sterling is required. Indeed, Modigliani and Sterling's numbers themselves are unbelievable on their face. Over the period 1949–1984, Modigliani and Sterling report nonzero values for temporary taxes in only 1968, 1969, 1970, and 1975. It simply is inconceivable that temporary taxes occurred in only four of those thirty-six years. Because Modigliani and Sterling's variable is positive in boom years and negative in recessions, its significance in their regressions may arise from its being a business cycle indicator and so be totally spurious. Modigliani and Sterling's tax variable and the empirical results stemming from it deserve little credence.

Finally, Modigliani and Sterling assert that the data should not be differenced. As mentioned earlier, differencing is unnecessary when the variables involved are cointegrated, even if they have a stochastic trend. Modigliani and Sterling perform a test for cointegration suggested by Robert Engle and Clive Granger (1987) that is based on the Durbin-Watson statistic for the residuals; that test fails to reject cointegration. The distribution of the test statistic, however, varies with the number of regressors included. The distribution reported in Engle and Granger applies only to regressions of one variable on its own lags and

⁵⁰ For example, the corporate income tax rate rose in 1951 from 42 to 50.75 percent and then in 1952 to 52 percent, where it stayed until 1964.

those of one other explanatory variable; it does not apply to multiple regressions of the type used by Modigliani and Sterling. Kormendi and Meguire (1990) perform a small Monte Carlo experiment on the multiple regression in question, finding that the Durbin-Watson statistics obtained by themselves and by Modigliani and Sterling are consistent with the absence of cointegration but not its presence, implying that differencing is appropriate. Alfred Haug (forthcoming a) independently comes to the same conclusion.

Feldstein and Elmendorf (1990) also argue against differencing on the grounds that differencing is less efficient than performing a regression in levels with an autoregressive transformation. That argument is correct if the resulting specification is correct—in particular, if there really is no unit root in the data. In that case, however, differencing introduces only inefficiency, not bias or inconsistency; consequently, large discrepancies between the differenced and undifferenced regressions are evidence that the undifferenced regression is misspecified, in which case the undifferenced estimates are biased and inconsistent (Plosser and Schwert 1978). Because the regression results are substantially different for differenced and undifferenced data, and because the variables do not appear to be cointegrated, the differenced regressions of Kormendi and Meguire seem preferable to regressions in the levels.

C. Summary of Life Cycle Evidence. We see, then, that the handling of measurement, specification, simultaneity, and differencing is crucial to the conclusions one obtains for Ricardian equivalence from life cycle consumption models. How, then, are we to evaluate the large number of studies using those models? What we would like, of course, is a formal procedure for comparing the various con-

tributions to the literature so that choices among the competing approaches and results can be based on established, objective criteria. Such a procedure, suggested by statistical theory, is to construct a model that nests all the life cycle literature and then subjects the various choices regarding specification, sample period, and so on to formal statistical tests. The models of Kormendi (1983) and Kormendi and Meguire (1986, 1990) come very close to doing just that and so supersede the earlier work on the life-cycle approach to Ricardian equivalence. The life cycle evidence, as it emerges from the exchanges over Kormendi's work, strongly supports the consolidated approach and its derivative hypothesis of Ricardian equivalence.⁵¹

D. Permanent Income Specification. The consumption function evidence discussed so far is derived from the traditional life-cycle specification. Seater and Mariano (1985) present results for a permanent income specification along the lines discussed by Barro (1981):

$$\begin{aligned} C_t = & a_0 + a_1 Y_t^* + a_2(Y_t - Y_t^*) + a_3 G_t^* \\ & + a_4(G_t - G_t^*) + a_5 AMTR_t + a_6 RS_t \\ & + a_7 RL_t + a_8 T_t + a_9 TR_t + a_{10} D_t + \\ & a_{11} SSW_t + u_t \quad (16) \end{aligned}$$

where Y^* is permanent income, Y is current income, G^* is permanent government purchases, G is current government purchases, $AMTR$ is a measure of

⁵¹ Some, such as Poterba and Summers (1987) and one of the referees, argue that aggregate data do not have enough variation to evaluate the theory or much else of interest. I very much disagree. The consolidated approach suggests that certain variables should enter the consumption function and others should not. The evidence supports both sets of implications. In particular, the null hypothesis of insignificance of some variables, such as government purchases, is strongly rejected. Clearly, the data can reject important hypotheses, so the mere fact that they fail to reject others, such as Ricardian equivalence, is not obviously a reflection of lack of power. We shall see more examples of the data's ability to reject interesting hypotheses below.

marginal tax rates (Seater 1982a, 1985b), RS and RL are short and long real after-tax interest rates, T is tax revenue, TR is transfers to individuals, D is the market value of government debt, and SSW is Social Security wealth. All dollar values are in real per capita terms, permanent values are constructed with the decomposition proposed by Stephen Beveridge and Nelson (1981), and estimation is by 2SLS. The permanent income hypothesis with Ricardian equivalence predicts $a_3, a_4, a_5, a_6, a_7 < 0 = a_2, a_8, a_9, a_{10}, a_{11} < a_1$. The estimated interest rate coefficients a_6 and a_7 are of opposite sign and statistically insignificant; the estimated transitory income coefficient a_2 is significantly positive. Both findings are frequent in consumption function studies. Otherwise, the estimates are consistent with the permanent income theory generalized to include Ricardian equivalence; in particular, none of the coefficients on the government financing variables T , TR , D , and SSW is statistically significant. This result is especially interesting because transitory income has a statistically significant positive effect on consumption, which often is interpreted as a reflection of liquidity constraint effects. If that interpretation is correct, the failure to reject Ricardian equivalence suggests that the liquidity constraints involved are not types that invalidate Ricardian equivalence.

The marginal tax rate is strongly significant. As mentioned above, the marginal tax rate is highly correlated with other explanatory variables; its significance here therefore could mean that other studies omitting the marginal tax rate suffer from omitted variables bias. However, Seater and Mariano's permanent income specification results are qualitatively the same as the results they obtain from replications of Feldstein's (1982) and Kormendi's (1983) life cycle specifications, which omit marginal tax rates,

suggesting that any bias arising from the omission of marginal tax rates is not severe. Seater and Mariano also decompose government purchases into permanent and transitory components but find no evidence that the decomposition is important for consumption, implying that other consumption studies that ignore it are not thereby invalidated.

E. Euler Equation Tests. Many investigators (e.g., Hayashi 1987) are skeptical of any regression results based on either the life cycle or permanent income specifications of the consumption function and argue instead for tests based on Euler equations. The Euler equation approach derives from PILCH, but instead of specifying the usual consumption function (an optimal contingency rule relating current consumption to the information available to the consumer), this approach advocated direct use of the Euler equations (first-order conditions arising from the consumer's maximization problem). The Euler equation for the simplest intertemporal consumption choice problem is

$$u'(C_{t+i}) = (R/\delta)^i u'(C_t). \quad (17)$$

This condition implies that the only lagged value of any variable on which consumption in period t depends is consumption in period $t - 1$; the information content of all other lagged variables is captured by once-lagged consumption.⁵² Consumption in period t also will depend on the t -period values of other variables, such as income, to the extent that those values contain new information unavailable in earlier periods (Hall 1978).

The few studies of Ricardian equivalence that use the Euler equation approach mostly support equivalence. Paul Evans (1988a) derives from Blanchard's

⁵² In fact, this condition requires quite demanding assumptions. For example, if financial portfolios or stocks of physical assets are costly to adjust, then current consumption will depend on lagged values of variables other than consumption.

(1985) model of uncertain lifetime an Euler equation condition for testing Ricardian equivalence and finds no evidence that government liabilities have positive effects on consumption. Haug (forthcoming a) finds that Ricardian equivalence is not rejected over the period 1929–1985; when the years 1942–1949 are excluded, Ricardian equivalence is not rejected if the rate of return is measured by the stock market return but is rejected if the rate of return is measured by Aaa or Baa bond rates.⁵³ Haug also rejects excess sensitivity in all cases.

F. Tests on Data from Other Countries. Most consumption tests of Ricardian equivalence have used U.S. data, but there are a few exceptions. Consumption in foreign countries seems independent of Social Security wealth there (Erkki Koskela and Matti Virén 1983). Changes in the difference between Canadian and U.S. government savings rates lead to approximately one-for-one changes in the difference between Canadian and U.S. private saving rates, as Ricardian equivalence predicts (Chris Carroll and Summers 1987). Consumption Euler equation tests for nineteen countries fail to

reject Ricardian equivalence in eighteen cases (Evans 1991).

G. Event Studies. A somewhat different approach to testing Ricardian equivalence is to examine the effects of easily identified fiscal events on consumption. Changes in Social Security benefits are publicly announced at least one month before they occur; whether they are expected to be permanent or temporary also is announced or at least implied. Seemingly permanent changes have small and statistically insignificant effects on nondurables purchases but have large and statistically significant effects on durables purchases (Wilcox 1989a). The former result is consistent with Ricardian equivalence; the latter result not only is inconsistent with Ricardian equivalence but also is difficult to reconcile with any theory of consumption. Even in the absence of Ricardian equivalence, the forward-looking logic of PILCH implies that the actual payments should be statistically insignificant in a regression of consumption on them and lagged consumption because the information about the payments already will have been incorporated into lagged consumption, but there appears to be no consumption response until payments actually are made. Such a pattern seems inexplicable in the PILCH framework. Myopia or liquidity constraints, under which consumers do not behave in a forward-looking manner, could explain why the change in consumption was delayed until the benefits changes actually occurred, but neither can explain why the additional expenditure was devoted only to durables. Wilcox's evidence on Ricardian equivalence is both mixed and puzzling.

Event studies of income tax law changes are more definitive. Households are likely to have more information about impending tax changes and their implications for debt issue than is contained in the set of regressors used by the econo-

⁵³ Haug says his tests indicate structural change if the "World War II years" 1942–1949 are included, but he does not explain clearly what test he used or what his null hypothesis was. In any case, Haug's choice of war years is incongruous. Over 1939–1950, military expenditures were:

Year	GMIL/GNP
1939	0.017
1940	0.028
1941	0.120
1942	0.317
1943	0.439
1944	0.463
1945	0.410
1946	0.103
1947	0.055
1948	0.056
1949	0.064
1950	0.066

(data are from Barro 1981). It is unclear why Haug omits 1941 from the war years or why he includes 1947–1949.

metrician. Consequently, the residuals in the econometrician's estimated consumption function should be systematically related to such fiscal events if Ricardian equivalence is false. No such systematic relationship is apparent in the data (Evans 1988a). Because income tax refunds are predetermined by past income and previous tax law, they should have no effect on current perceived wealth or marginal incentives and so should have no effect on consumption. The data show no significant effect of refunds on consumption (Wilcox 1989b). Both Evans's and Wilcox's results are consistent with Ricardian equivalence.

H. Summary of Aggregate Consumption Studies. We thus reach the end of the literature that tests Ricardian equivalence by means of the consumption function. An initial reading of that literature is both confusing and disheartening, suggesting that such tests are uninformative about Ricardian equivalence and that aggregate data are inherently unilluminating. However, virtually all the confusion arises from problems with econometric methodology. In order of apparent importance, the problems are: (1) misspecification, in the forms of inappropriate constraints and omission of relevant variables, (2) improper construction and measurement of the data, (3) treatment of trend and cointegration, and (4) least serious, perhaps even nearly unimportant (in the sense that, when both OLS and simultaneous methods are used, the results are generally much the same) failure to estimate by simultaneous methods. When those problems are addressed, the aggregate consumption data almost always fail to reject Ricardian equivalence.

VI. Direct Evidence: Other Types of Studies

A. Interest Rate Tests. As explained in Section II, Ricardian equivalence implies

that individuals respond to an issue of new government debt by increasing their demand for debt by the amount of the new issue to save toward the future taxes implied by it, leaving interest rates unaffected. Several studies have used this prediction to test Ricardian equivalence. Exactly the same methodological issues arise in these interest rate studies as in the consumption studies, but their impact has not been explored as thoroughly as in the consumption literature. There is no study like Kormendi's (1983) that nests the competing hypotheses, and there are no series of articles comparable to the exchanges over the Feldstein (1982) and Kormendi (1983) articles that replicate earlier work and explore its sensitivity to data definitions, specification, differencing, or simultaneity. Consequently, direct comparisons of results must be more tentative here.

The straightforward way to test Ricardian equivalence through interest rate behavior is to regress current interest rates on some measure of government debt policy. A number of early studies take this approach; some support Ricardian equivalence, whereas others reject it.⁵⁴ Unfortunately, those studies omit relevant variables such as government purchases and marginal tax rates, estimate by OLS,⁵⁵ generally use federal debt or deficits, and fail to decompose government purchases into permanent

⁵⁴ John Makin (1983) and Gregory Hoelscher (1983) find that deficits have statistically insignificant effects on short-term interest rates, whereas Khan Zahid (1988) finds a significant negative relationship. Barth, Iden, and Russek (1985) and Zahid (1988) find that the noncyclic component of the deficit is positively related to short rates. Angelo Mascaro and Allan Meltzer (1983) find that the stock of debt is unrelated to either short or long rates. Hoelscher (1986) finds a significant positive relationship between the interest rate and the deficit but no significant relationship between the interest rate and government purchases.

⁵⁵ Except for Hoelscher (1983), who reports some IV results but whose instruments—the output gap and the change in real debt—seem as likely to be endogenous as the variables for which they substitute.

and transitory components. Thus they suffer to an unknown extent from the same methodological problems as the early consumption tests.

The decomposition of government purchases into permanent and transitory components seems important for the behavior of interest rates, in contrast to its apparent unimportance in the consumption function. Barro (1987) examines the response of the British consol yield (the longest possible interest rate) to transitory purchases, the current deficit, and the beginning-of-period stock of government debt over the period 1730–1913, almost two hundred years long. This study is important because it is the only one in the interest rate literature to decompose government purchases into permanent and transitory components; also, its sample is unusually long. The set of current and five lags of transitory purchases has a joint marginal significance level (*p*-value) of just below two percent, whereas the deficit and debt variables have a joint marginal significance level of just below 10 percent, suggesting that these financing variables are jointly insignificant at conventional levels. Furthermore, when the transitory purchases variables are excluded, the two financing variables become strongly significant both jointly and individually, suggesting they indeed do proxy for the purchases variables when the latter are omitted.

One note of caution is that both the deficit and debt variables may have elements of simultaneity in them—the deficit variable directly and both variable indirectly through being expressed as U.S. and several other countries, including Britain (Evans 1985, 1987a, 1987b). In no case do deficits raise interest rates significantly. Of course, the only way to be sure that simultaneity bias is unimportant in Barro's estimation is to repeat his regressions using simultaneous methods; but in the absence of such repetition, the apparent unimportance of simultane-

ity bias in other interest rate studies of Ricardian equivalence suggests that such bias is not a serious problem in Barro's, either.⁵⁶

Two kinds of tests depart from the foregoing straightforward approach. The first examines the effects of government debt on steady state interest rates; the second uses term structure theory to derive testable relationships between government debt and interest rates.

Blanchard's (1985) model of uncertain lifetime yields predictions for the relationship between the steady state interest rate on the one hand and the steady levels of government purchases and debt under Ricardian and non-Ricardian alternatives. In tests of those predictions with monthly data over the periods 1941.12–1946.12 (Evans 1988b) and 1981.1–1986.3 (Evans 1989), steady state government purchases have a statistically significant positive effect, as predicted, but steady state government debt has a statistically significant negative effect, contrary to the model and also to Ricardian equivalence, which implies no effect. This finding of a significant negative effect of debt on interest rates is not unique to this pair of studies and is discussed below.

The tests of Ricardian equivalence based on term structure theory probably are the best interest rate tests published. They rely on the rational expectations theory of the term structure to examine the effect of unexpected changes in government debt on the abnormal return on financial assets. The abnormal return is the difference between the expected and actual holding period return on an asset; the holding period return is the percentage change in the asset's price between two adjacent periods. In an efficient mar-

⁵⁶ However, in none of his studies does Evans decompose purchases into permanent and transitory components, leaving open the possibility of some interaction among various biases that hides simultaneity bias—a possibility that seems remote.

ket, the expected value of this return must equal the one-period interest rate; furthermore, the abnormal return can depend only on new information. Not all new information affects asset returns; in particular, Ricardian equivalence implies that new information on the value of outstanding government debt should have no effect on asset returns.

Testing this implication requires measures of unexpected changes in the variables that might affect asset returns. Assume that changes in those variables are generated by a vector autoregression:

$$\begin{aligned} \mathbf{X}_{t+1} &= A(L)\mathbf{X}_t + u_{t+1} \\ H_{t+1} - R_{1t} &= B \\ &+ C[\mathbf{X}_{t+1} - A(L)\mathbf{X}_{t+1}] + v_{t+1} \end{aligned} \quad (18)$$

where \mathbf{X} is a vector of exogenous variables that drive holding period returns, H is the holding period returns, R is the one-period interest rate, $A(L)$ is the usual matrix polynomial in the lag operator L , B is a constant (interpretable as the "marginal liquidity premium"), C is a vector of coefficients, and u and v are errors. It can be shown that the abnormal return is negatively related to unexpected movements in current and expected future one-period rates; therefore, the abnormal return will be negatively related to changes in \mathbf{X} that cause such unexpected movements, such as an increase in government purchases.

Plosser (1982) estimates (18) with holding period returns from quarter to quarter on Treasury bills with 2, 3, and 4 quarters to maturity and on bonds with 20 years to maturity. The \mathbf{X} vector comprises the logs of government purchases, privately held debt, and debt held by the Federal Reserve. The data are quarterly; the sample period varies with the availability of holding period return data, the longest being 1954.I–1978.IV and the shortest being 1964.I–1978.IV. Government purchases generally have significantly negative effects, in conformity with macroeconomic theory, but the two

financing variables generally are individually insignificant (no joint tests are reported), in conformity with Ricardian equivalence. Subsequent extensions of the analysis to more recent experience and a broader range of tests (Plosser 1987) and to data from Canada, France, Germany, Japan, the United Kingdom (Evans 1987b; Paul Boothe and Reid 1989) find no evidence that government debt is positively related to interest rates but do sometimes indicate a statistically significant negative effect. The former result is consistent with Ricardian equivalence; the latter is not.

What do the interest rate tests imply about Ricardian equivalence? It seems clear they are inconsistent with the traditional view that government debt is positively related to interest rates, but whether they support Ricardian equivalence is less clear. Although many fail to reject Ricardian equivalence, many others find a statistically significant negative relationship between government debt and interest rates, which is inconsistent with Ricardian equivalence as well as with the traditional view.

Two possible explanations for this negative relationship concern taxes. First, there are the problems of future taxation discussed earlier—uncertainty about how much of the future tax burden a given individual will bear and any effects of rearranging the timing of distortionary taxation. Because such effects are excluded from the regressions, they may give rise to the observed negative effect whether Ricardian equivalence is true or not. Second, in a regression that includes as explanatory variables government purchases and deficits but excludes marginal tax rates, the deficit coefficient may be negatively biased. To see why, consider the effect of raising the current deficit with government purchases held fixed; this effect is what the deficit coefficient is meant to capture in a regression that includes purchases as an explanatory var-

iable. As explained earlier, such a change is associated with lower taxes and therefore lower marginal tax rates because of the high positive correlation between average and marginal tax rates. The general equilibrium relation between the pre-tax interest rate and the marginal tax rate is positive (Barro 1987), so the hypothesized increase in the deficit will be associated with lower interest rates because of the associated reduction in marginal tax rates, even if Ricardian equivalence is true. The frequent finding of a negative relationship in the interest rate tests of Ricardian equivalence therefore may reflect omitted variable bias. However, any such bias is independent of whether or not Ricardian equivalence is operative so that, even if Ricardian equivalence does not hold, the deficit coefficient may spuriously appear to be zero or even negative. Thus even the interest rate studies that seem unambiguously supportive of Ricardian equivalence are not definitive. Further interest rate tests that address the effects of uncertainty and marginal tax rates would be an important addition to the literature.⁵⁷

B. International Trade and Finance. A possible problem with any interest rate test of Ricardian equivalence is international capital flows. If international capital markets were perfect, a country's interest rates would show little or no effect of government debt irrespective of Ricardian equivalence because capital flows would hold domestic rates at world rates. Only if the home government's debt constituted a large fraction of worldwide government debt would an effect be noticeable, even in the absence of Ricardian equivalence.⁵⁸ Tests of Ricardian equivalence still are possible. If Ricardian equi-

valence were false, a government deficit would cause an incipient rise in interest rates and thereby elicit an offsetting inflow of foreign capital that prevented rates from actually rising. The capital inflow, however, also would cause an appreciation of the domestic currency, so that one would observe a positive association between exchange rates and the deficit. No such association appears in the quarterly data over the period 1965.II–1984.III for the U.S. dollar exchange rate with respect to the Canadian dollar, Belgian franc, French franc, deutschemark, guilder, Swiss franc, or British pound (Evans 1986). These findings are consistent with Ricardian equivalence; they also are inconsistent with the possibility that the interest rate tests fail to find effects of deficits on interest rates because of international capital flows. They therefore give not only direct evidence on Ricardian equivalence but also evidence of how to interpret the interest rate tests.

The absence of Ricardian equivalence implies that deficits should affect a country's terms of trade and trade balance. Data show no effects of deficits on the current account balances for Canada, France, Germany, the United Kingdom, and the United States (Evans 1988c) or on Britain's terms of trade or trade balance over the long period 1798–1913 (Ahmed 1987).⁵⁹

C. Growth Rates. In the absence of Ricardian equivalence, government deficits crowd out private investment and there-

⁵⁷ Data on marginal tax rates exist for the U.S.; see Seater (1982b, 1985a) and Barro and Chaipat Sa-hasakul (1983, 1986).

⁵⁸ An advantage of consumption tests of Ricardian equivalence, as well as other tests to be described below, is that they do not suffer from this problem.

⁵⁹ Ahmed enters the deficit directly and also as an interaction term in which it multiplies a dummy variable for the French war years (1793–1801 and 1803–1815). This interaction term has a significant negative effect, but the dummy variable has no independent effect. When the deficit variables are omitted, the dummy variable has a significant negative effect, suggesting that the interaction term in the extended regression is mostly picking up effects of the French wars. It is unclear that a dummy in any form should be used, but in any case the negative effect of the interaction term is inconsistent both with Ricardian equivalence and the usual non-Ricardian alternative.

fore reduce economic growth; in contrast, Ricardian equivalence implies that government deficits have no effect on growth. Data from thirty-four countries over the period 1957–1977 show no significant effect of deficits on economic growth, in conformity with Ricardian equivalence (Kormendi 1985).

D. *The Experience of the '80s.* Thus would we conclude our review of the aggregate evidence on Ricardian equivalence were it not for the oft-discussed "Reagan deficit experiment" of the 1980s, which many regard as a striking refutation of Ricardian equivalence. The argument is, on the one hand, that deficits in the 1980s rose sharply and were uncharacteristically high for a peacetime period, constituting a natural experiment on the effects of deficit finance unpolluted by confounding influences such as wars; on the other hand, consumption, saving, interest rates, the balance of payments, and exchange rates all changed as one would predict in the absence of Ricardian equivalence.⁶⁰

There are a number of problems with this argument. First, as should be clear from all that has gone before, it is essential in assessing the impact of government deficits to control for other variables. What happened to transitory income in the 1980s? Government purchases? What about marginal tax rates, world oil prices, and the money growth rate? Second, casual inspection of a dependent variable on the one hand and one independent variable on the other is inadequate for estimating a coefficient of a multiple regression. Indeed, by that method we may use the experience of the 1980s to establish Ricardian equivalence as easily as to refute it. Table 2 lists for the decade of the 1980s the total government

TABLE 2
DEFICIT/GNP RATIO AND EX POST REAL T-BILL RATES
IN THE 1980S

Year	Deficit/GNP	Ex Post Real T-Bill Rate
1980	0.013	0.025
1981	0.010	0.043
1982	0.035	0.043
1983	0.038	0.047
1984	0.028	0.059
1985	0.033	0.045
1986	0.034	0.033
1987	0.023	0.025
1988	0.020	0.036
1989	0.020	0.040

deficit as a share of GNP and ex post real Treasury bill rates. Any pattern of association between the two is less than obvious. (If we depart from the spirit of this analysis and actually compute the correlation between the debt ratio and interest rates, we obtain the unimpressive magnitude of 0.38, implying an R^2 of less than 0.16.) Also, the highest interest rate is not associated with the highest deficit/GNP ratio. Voila! Ricardian equivalence.⁶¹ Third, there are measurement issues to consider. For example, Poterba and Summers (1987) argue that one of the lowest saving rates in the post-World War II era occurred in the 1980s (more precisely, for the first six years of the 1980s), when the deficit/GNP ratio was highest. However, the behavior of the saving rate is sensitive to the measure of saving used. The best measure is the change in household net worth, which often differs greatly from the national in-

⁶⁰ Although this view pops up frequently in the popular press (e.g., Summers 1987), it has yet to appear in a refereed journal. Poterba and Summers (1987) advocate it in a conference-volume paper.

⁶¹ Admittedly, no correction for the effects of inflation on the deficit figures has been made and we really should examine ex ante rather than ex post real interest rates, but given the low and, for the last three-fourths of the 1980s, nearly constant rate of inflation, I doubt that the conclusion would be much affected.

come accounting definition; using it, we find that, although still low, the saving rate for the 1980s was higher than for two of the other five periods considered by Poterba and Summers. Furthermore, a comparison of this ratio to the deficit/GNP ratio shows no overwhelming pattern.⁶² Fourth, the decade of the 1980s offers only ten sample points. Basing statistical inference on such a small sample seems risky, to say the least. Finally, more rigorous examinations of the 1980s generally support Ricardian equivalence. There is no systematic effect of the Reagan tax cut of 1981.III on the residuals of a consumption equation (Evans 1988a); U.S. consumption (Darby, Robert Gillingham, and John Greenlees 1990) and world real interest rates (Barro and Xavier Sala y Martin 1990) respond significantly to transitory income, money growth, stock market returns, and oil prices but not to government debt and deficits.

Apparently, there is less to the "Reagan deficit experiment" than meets the casual eye. The events of the 1980s may represent a natural experiment, but they do not seem to offer the striking refutation of Ricardian equivalence some have suggested.

E. Studies Using Micro Data. There is unfortunately very little micro evidence on Ricardian equivalence. It does not seem possible to use existing micro data to examine the effect of either the debt or the deficit on household behavior. Given everything else in its budget constraint, the household is better off if it owns public debt than if it does not, so we would expect to see the individual household respond to variations in the amount of public debt it holds. What matters for Ricardian equivalence is whether the individual household per-

ceives the future taxes that the aggregate stock of debt implies for it, something that existing micro data apparently do not illuminate.

One approach to using micro data that initially seemed promising examines the effect of Social Security benefits on individual saving. Ricardian equivalence implies that an increase in Social Security benefits should lead to an increase in bequeathable assets because Social Security is a transfer from the young to the old that the old will want to undo by transferring back to the young. The data show some behavior consistent with the Ricardian prediction but many other examples inconsistent with it (Mordecai Kurz 1984; David and Menchik 1985; Hubbard 1986). The value of these studies for the Ricardian equivalence issue is questionable because of uncertainty and adverse selection problems. Even an actuarially fair and fully funded social security system can reduce individual saving by more than the tax paid (Hubbard 1987). Consequently, in the kinds of empirical studies just mentioned, it is impossible to disentangle the insurance aspect of Social Security, which unambiguously reduces saving irrespective of Ricardian equivalence, from the wealth aspect, which is the part relevant to testing Ricardian equivalence.

One Social Security study not subject to the insurance problem is that of Kotlikoff (1979). Using data from the National Longitudinal Survey of men aged 45–59, Kotlikoff examines the response of household net worth to variations in the lifetime wealth increment (LWI) due to Social Security. LWI is the present value of future benefits less the present value of future Social Security taxes less the accumulated value of past Social Security taxes paid. If the household were at the beginning of its "life" and if Ricardian equivalence did not hold, the theoretical value of the coefficient on LWI would

⁶² See Poterba and Summer's Figure 1 for two measures of the deficit/GNP ratio.

be zero because a new household would not yet have accumulated any wealth for Social Security to crowd out; if the household were at the end of its life, the coefficient would be -1 because in the terminal period the lifetime budget constraint must be satisfied. For the average age of the household in the sample, the coefficient should be -0.68. Ricardian equivalence implies quite a different pattern of coefficients. For preretirement households, LWI should have no effect at all on assets held; for postretirement households, assets should rise one-for-one with LWI. Because Kotlikoff's sample comprises preretirement households, Ricardian equivalence predicts a coefficient of zero. The estimated value of the coefficient turns out to be 0.24 with a standard error of 0.20, which is significantly different from -0.68, not significantly different from zero, and consistent with Ricardian equivalence.

VII. Approximate Equivalence

For the most part, the direct evidence is consistent with Ricardian equivalence. Consumption function studies essentially always fail to reject Ricardian equivalence, irrespective of functional form, sample period, or country examined. Some interest rate tests also support Ricardian equivalence, as do tests concerning exchange rates, current account balances, and economic growth. Most of the micro evidence on Social Security's effect on saving is uninterpretable because of the confounding of the insurance aspects of Social Security with its wealth effects. The one study that does not suffer from this problem supports Ricardian equivalence. The only direct tests that show any tendency to reject Ricardian equivalence are those interest rate tests that find a negative relationship between interest rates on the one hand and either

government debt or deficits on the other. That finding is inconsistent with Ricardian equivalence but also with any other usual theory and may reflect bias due to the omission of current or expected tax variables, implying that the interest rate tests, though suggestive of Ricardian equivalence, are incomplete.

So do we conclude that Ricardian equivalence is true? Not necessarily. Another view of the effects of debt and deficits, based on less ideal assumptions than Ricardian equivalence, is consistent with all the evidence presented so far. Suppose that individuals are reasonably accurate at predicting their own future tax liability but have little interest in the tax liability of future generations. Obviously, Ricardian equivalence does not hold. Nevertheless, at historical interest rates and average lifespans, most of the future tax implied by a current bond issue will be borne by people currently alive. As a result, if PILCH is even approximately true for individuals, bond issues will have near-Ricardian effects irrespective of how people behave toward future generations.

Simulations reported in the literature illustrate this conclusion. Assume a life-cycle model in which households have a constant elasticity utility function $U(c_t) = \tau^{-1}c(t)^\tau$ to be maximized subject to the usual lifetime budget constraint and where households work the first 45 years of their lives and retire for ten more (Potterba and Summers 1986). Parameters allowed to vary across simulations are the utility parameter τ , the real interest rate, and the population growth rate. First, consider a swap of one dollar of debt for one dollar of tax, with the debt principal never repaid and interest payments financed by lump-sum taxes. Such a swap would raise annual consumption by about six cents for all combinations of the free parameters. Next, consider the more re-

alistic case of repayment of principal.⁶³ The effect of the debt-for-taxes swap is somewhat less than half that for the no-repayment case, or about three cents for all combinations of free parameters. The effects of the debt are small because most of the debt gets repaid within the expected lifespan of the representative worker, so that not much wealth is created in the first place, and the marginal propensity to consume out of wealth is very small. Very similar conclusions emerge from a simulation of Blanchard's (1985) model, in which it also can be shown that there is very little crowding out of steady-state capital and very little reduction in steady-state consumption (Evans 1988d). Over the entire path of the economy, from shock to steady state, the effects of deficit financing are minuscule. Obviously, the effects would be even smaller if some altruistic concern for one's descendants were permitted.

For many purposes, this "approximate equivalence" model essentially concedes Ricardian equivalence. Although true equivalence does not hold, the approximation is so close that we might as well act as if it does. Indeed, even if approximate equivalence is the right model, the very small elasticities of consumption and labor reported in the literature, together with historical debt retirement policies, suggest it would be surprising if Ricardian equivalence were *not* a close approximation.⁶⁴

There could be a circumstance in which it would be important to know

⁶³ As James Hamilton and Flavin (1986), Jeroen Kremers (1989), and Haug (forthcoming, b) have shown, the data suggest that the government conducts its affairs to satisfy its long-run budget constraint and redeem its debt (or at least let it decline as a share of GNP), so the case where principal is repaid does seem the realistic one to consider.

⁶⁴ See Flavin (1981) and Hayashi (1982) for wealth elasticities of consumption and Thomas MacCurdy (1981) for wealth elasticities of labor.

whether the Ricardian model or the approximate equivalence model were correct. If the government were to abandon its historical debt redemption behavior and cease retiring the debt that it issued, the debt would accumulate over time and eventually become large relative to GNP. This debt growth would have no aggregate effects under Ricardian equivalence but would under approximate equivalence.⁶⁵ This difference provides a basis for testing the two competing theories. Under approximate equivalence, the stock of debt (or equivalently a distributed lag of deficits) should have significant coefficients in behavioral equations, whereas under Ricardian equivalence they should not. Evidence to date finds no such effects.⁶⁶ However, these studies have little power against the approximate equivalence alternative when the government regularly retires its debt, because in that case the long run effects of accumulated debt are avoided by never letting the debt accumulate. Because the U.S. government, at least, apparently has not allowed debt to grow relative to GNP over long time periods, it seems unlikely that U.S. data can distinguish between these alternative hypotheses.

VIII. Discussion and Conclusions

There are two important questions to ask of any theoretical proposition: is it logically consistent and is it a close approximation to reality. Ricardian equivalence clearly is logically consistent. To be sure, the restrictions required for it

⁶⁵ Modigliani (1961) provides a classic discussion of what these effects would be.

⁶⁶ Kormendi (1983), Seater and Mariano (1985), and Kormendi and Meguire (1990) find no effect of the stock of public debt on consumption, and Evans (1987a) finds no effect of a distributed lag of deficits on interest rates.

to hold are many and not likely to be met in practice, but that is not sufficient to dismiss the proposition:

Any model that is well enough articulated to give clear answers to the questions we put to it will necessarily be artificial, abstract, patently "unreal." (Robert Lucas 1980)

Given logical consistency, we can judge the usefulness of Ricardian equivalence only by its ability to explain data, which brings us to the second question.

Although tests of Ricardian equivalence do not quite give an unambiguous verdict on that proposition's validity, I think it reasonable to conclude that Ricardian equivalence is strongly supported by the data. Well-designed tests based on consumption, economic growth, foreign trade, and exchange rates virtually unanimously suggest that Ricardian equivalence describes the data well; tests based on interest rates often do so. The consumption function tests in particular are thorough and have been subjected to detailed scrutiny. The significant negative effect of debt and deficits on interest rates reported by some of the interest rate tests admittedly is inconsistent with Ricardian equivalence and demands further investigation, but that effect is inconsistent with any accepted model and implies some kind of a problem not specific to Ricardian equivalence, such as failure to account for aspects of uncertainty.

Two issues of statistical power leave room for skepticism about the data's support for Ricardian equivalence. One that is often mentioned has largely been settled, in my opinion. Most tests posit Ricardian equivalence as the null hypothesis, and therefore the statistical support for equivalence consists of failure to reject the null. It often is suggested that we know little of the power of such tests, which may be quite low, so that failure to reject easily could represent a Type

II error. However, what is overlooked in this argument is that many tests of the Ricardian hypothesis have been conducted. If each of these were independent of the others and used the 5 percent significance level, then the joint test would have marginal significance level of $1 - (0.95)^n$, where n is the number of separate tests performed. For large n , this joint significance level is much larger than 5 percent and the power of the test is correspondingly much higher than for any single test. Although the tests are not all independent (indeed, many use essentially the same data) and the foregoing calculation therefore is inaccurate, many of the tests use different sample periods, different dependent variables, different functional forms, even different countries' data, so that the basic point remains true.

A second power problem might be more serious. As mentioned above, tests of Ricardian equivalence have little power against the alternative of "approximate equivalence" and will continue to do so as long as the government acts to keep the debt/GNP ratio small. We thus do not know if the data support the altruistic Ricardian model or the selfish approximate equivalence model. Whether this ambiguity is of any practical or even scientific importance depends on how the government conducts its debt policy in the future. Should it decide to cease controlling the debt/GNP ratio, it will be important to know which theory reigns. However, should the government continue to act as it has in the past, the Ricardian model—whether literally correct or not—apparently will provide a sufficiently close approximation that we can safely assume it is the true model, which would be convenient analytically because of the model's simplicity.

Whatever one concludes about the validity of Ricardian equivalence, traditional non-Ricardian views of the effects

of government debt ought to be abandoned. The empirical literature generally supports the Ricardian prediction that debt and deficits will have no effects on any variable of interest; the tests that reject Ricardian equivalence find an effect on interest rates that is the opposite of that predicted by traditional theory. The predictions of the traditional model simply are not supported by the data. Moreover, even if one remains unconvinced about the power of the tests favorable to Ricardian equivalence and maintains that traditional non-Ricardian theory is correct, of what significance would such a conclusion be? If the data cannot produce coefficients that are significant both economically and statistically, there is no way of using this presumed knowledge of the true non-Ricardian relationship between debt and other variables. No useful theoretical developments, no subsequent estimation, and certainly no policy recommendation could be conditioned on a presumed relationship whose importance is so stubbornly unmeasurable. Is it not preferable to ignore such a theory?

The experience of preparing this review essay leads me to one final observation. The Ricardian literature is often contentious, sometimes even acrimonious, reflecting to a large extent the usual uncertainties associated with working out the theoretical and empirical aspects of a new idea. Both the theoretical and empirical validity of Ricardian equivalence depend on details that often are rather subtle, so disagreement is not surprising. At least as important, however, are two other influences that seem to me to arise frequently in economics, that interfere with scientific inquiry, and that deserve mention so they may be avoided in the future.

One problem is simply habit and historical circumstance. The order in which hypotheses are presented influences how

they are perceived. The traditional view of the effects of government debt evolved from the early IS-LM version of the Keynesian model, which is now widely regarded as theoretically and empirically inadequate and little used beyond undergraduate textbooks. In contrast, Ricardian equivalence is a natural extension of PILCH, which has been the standard approach to analyzing household intertemporal choice for at least thirty years. Both PILCH in general and Ricardian equivalence in particular receive considerable support from the data. So why is the traditional view still taken seriously? Largely because, in the words of Nathan Bedford Forrest, it got "there the fustest with the mostest" and the habit subsequently has been hard to kick. Had not the economics profession embraced the Keynesian model by the mid-1950s, when PILCH first was proposed, and had Ricardian equivalence been recognized then as a logical extension of PILCH, Ricardian equivalence and not the Keynesian model might well be the "traditional view" of government debt and deficits today. In any case, a theory's traditional acceptance should not blind one to its inadequacies or its competitors' strengths. Max Planck's observation on the nature of scientific progress was a criticism, not a recommendation.

The second problem is more serious. Any time a science has policy implications, there tends to be a perversion of that science. Limits to growth, nuclear winter, cold fusion, radon, and global warming are examples where policy implications led to policy advice before the scientific facts had been established. In several cases, subsequent investigation invalidated the advice that had been given in haste. By its nature, economics is a science with immediate implications for public policy at virtually every turn. It is hard to avoid the feeling that political ideology has affected scientific investiga-

tion of the Ricardian proposition. The philosophy of the political right leads to a general suspicion of government intervention in the economy, whereas that of the left concludes that intervention often is desirable. By denying the usefulness of perhaps the paramount aggregate fiscal policy tool, Ricardian equivalence is convenient to the right and inconvenient to the left. It seems unlikely to be merely chance that, by and large, articles supportive of Ricardian equivalence come from institutions and scholars toward the political right, whereas those not supportive come from institutions and scholars toward the political left. It is a distressing comment on the state of economic science that the outcome, or at least the interpretation, of presumably objective measurement and analysis correaltes so well with the political preference of the investigators.

This review has been a long journey through the highways and byways of research on the effects of government debt and deficits. Where do we stand when all is said and done? Theoretically, we can be almost certain that Ricardian equivalence is not literally true; it simply requires too many stringent conditions to be believable. Nevertheless, equivalence appears to be a good approximation. Although some of the early empirical literature sent conflicting signals, recent work generally supports Ricardian equivalence. It is true that existing data cannot distinguish the Ricardian model, based on altruism, from one of approximate equivalence, based on pure selfishness, but there seems little practical significance to that fact. The two models have virtually identical short-run implications for the effects of government debt on economic activity, and, although their long-run implications can differ substantially in principle, even those are essentially the same in fact, given the hsitorical patterns of government debt manage-

ment and the low wealth elasticities of households' economic decisions.

Empirical success and analytical simplicity make Ricardian equivalence an attractive model of government debt's effects on economic activity.

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