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ABSTRACT

Mr Ricardo's Great Adventure: Estimating Fiscal Multipliers in a Truly Intertemporal Model*

We estimate tax multipliers in a "Blanchard-Yaari" consumption model where Ricardian equivalence is broken because the private sector discounts the future at a faster rate than the real rate of interest. The model fits U.S. data since 1955 extremely well-entailing a discount wedge of around 20 percent a year and fiscal multipliers of 0.15-0.4 – depending on the permanence of the change in taxes/transfers, and is much superior to one that assumes some consumers are fully Ricardian and others follow simple rules of thumb. The implied high private sector rate of discount has wide implications for policymakers.

JEL Classification: E21 and E63
Keywords: discount rates, fiscal multipliers, fiscal policy and Ricardian equivalence

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I. Introduction

Over recent years, there has been a renewed interest in the use of fiscal policy as a lever for macroeconomic stabilization in industrial countries. Most notably, the United States announced a series of income tax cuts in 2001 and 2003 aimed at supporting economic recovery. In Japan, active fiscal policies were used consistently over the 1990s to foster economic activity in the face of slow economic growth and deflation that blunted the efficacy of monetary policy. Finally, in Europe, concerns about the impact of further fiscal consolidation on activity led to a revision of the Growth and Stability Pact to increase its flexibility over the business cycle.

To date, however, this increased interest in the use of fiscal policy for macroeconomic objectives by practitioners has yet to lead to a notable upsurge in empirical work on fiscal multipliers by researchers. To be sure, macroeconomic modeling groups continue to provide estimates of such multipliers, including in the context of a new breed of theoretically consistent "stochastic general equilibrium models," and others have used vector autoregressions for the same purpose.[2] There has also been a significant literature on conditions under which large fiscal contractions can be expansionary.[3] However, when

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[2] Bryant and others (1988) includes results from a range of traditional macroeconomic models. Vector autoregression analysis includes Blanchard and Perotti (2002), Fatás and Mihov (2001), Mountford and Uhlig (2002), and Perotti (2005). A summary of results is contained in IMF (2004). Bayoumi (2004) discusses the new approach to large macroeconomic models embodied in "stochastic dynamic equilibrium models", while Laxton and Pesenti (2003), Erceg and others (2004), and Smets and Wouters (2003) describe such models. The IMF's Global Fiscal Model, described in Ganelli (2004) and Botman and others (2006), is the only one of the new generation of models primarily designed for fiscal policy analysis.

[3] Giavazzi and others (2005) provide a recent review of empirical studies on expansionary fiscal contractions.

compared with recent work on monetary policy, the other main macroeconomic instrument, the volume of analysis is relatively small.

The main issue associated with the effectiveness of fiscal policy is the degree of Ricardian equivalence.[4] Full Ricardian equivalence implies that changes in taxes and transfers have no impact on rational consumers spanning an infinite lifetime. This is because optimizing agents discount the future using the interest rates on government paper, so the value of tax cuts and of subsequent tax increases offset each other. Thus, rational consumers will fully offset a tax cut by increasing their saving.

Macroeconomists have developed two main theoretical approaches to breaking Ricardian equivalence. The first, which is the focus of this chapter, assumes that consumers have finite lives and, therefore, discount the future more rapidly than implied by the government's budget constraint. As a result, individuals value tax cuts today more highly than the implied future tax increases, allowing expansionary tax and transfer policies to have an impact on consumption. Adding a life-cycle dimension to consumption provides more realistic consumption dynamics, with spending responding less to a temporary tax cut than to a long-term one, as predicted by the permanent income hypothesis. The alternative approach, which is simpler theoretically and is also investigated in this paper, assumes that some

[4] See, for example, the seminal work by Barro (1974) and the contribution by Campbell and Mankiw (1990).

proportion of individuals are fully Ricardian while others use a simple rule of thumb and simply consume what they earn.[5]

This paper provides a new approach to estimating fiscal multipliers based on an explicitly intertemporal theoretical model where households are myopic, discounting the future at a higher rate than the prevailing real rate of interest. In such a theoretical framework, the impact of any shock to income/net taxes on consumption depends on three characteristics—the persistence of the shock, whether it is anticipated or not, and the discount wedge, i.e., the consumers' excess of discount with respect to the market interest rate.

II. Some Theory

We start from the well-known "Blanchard-Yaari" model in which Ricardian equivalence is broken through consumer myopia.[6] More specifically, consumers are assumed to have a probability of death that means that they discount the future at a faster rate than implied by the government's budget constraint. In this framework, a tax cut (or and increase in transfers) raises spending because the wedge between the real interest rate and the discount

[5] Galí and others (2005) have recently extended the standard New-Keynesian sticky-price model by allowing for the coexistence of "non-Ricardian" and "Ricardian" households. In a similar vein, Coenen and Straub (2005), assume that some households have full ability to participate in financial markets and can intertemporally smooth consumption, while others are subject to credit constraints and cannot participate in any type of asset market.

[6] Basny and Mankiw (1986), Campbell and Mankiw (1990), Kimball and Mankiw (1989) based on Blanchard (1985).

rate implies that the net present value of the tax cut exceeds that of the subsequent increase in taxes needed to keep the government solvent.

Basic Model of Consumption

To simplify the modeling, we assume that the economy is in a stationary steady state, so income does not trend over time and deaths equal births each period. Utility is quadratic, which ensures certainty equivalence. Crucially, in addition to the usual discount rate, β (assumed equal to the real interest rate), consumers face an additional discount wedge, λ, reflecting the probability of death. The assets/liabilities of the dead are transferred to an outside entity which is able to borrow/lend freely from the government to service its interest costs. Finally, we assume that income follows a first order autoregressive process.[7]

The individual consumer's problem is thus:

$$\begin{aligned}
&Max\sum_{i=0}^{\infty} E_t \frac{U(c_{t+1})}{(1+\beta+\lambda)^i} \\
&s.t.\sum_{i=0}^{\infty}\frac{c_{t+i}}{(1+r+\lambda)^i} = \sum_{i=0}^{\infty}\frac{y_{t+i}}{(1+r+\lambda)^i} \\
&\Delta y_{t+i} = -\theta^y (y_{t+i-1} - y^*) + \varepsilon^y_{t+i} \\
&U(c_{t+i}) = c_{t+i} - \Gamma c^2_{t+i},\ \beta = r
\end{aligned} \tag{1}$$

[7] The model can be easily generalized to other income processes and assumptions. The current framework is utilized as it provides a simple closed form estimating equation.

where y is income, y^* is its steady state value, c is consumption, r is the real interest rate, Δ is the first difference operator, and Greek letters reflect underlying parameters. Note that the probability of death is $\frac{\lambda}{(1+\lambda)}$, a simple transformation of the discount factor, and that the income equation is written in an "error correction" form, so θ^y=0 implies a permanent shock to income and θ^y=1 a temporary one.

It should be stressed from the start that by "death" we mean economic death rather than its physical counterpart. This can occur through unexpected events that make previous consumption plans irrelevant—examples would include winning the lottery, moving from college to a job on Wall Street, or a sudden and unexpected loss of job or bankruptcy. It can also occur from more subtle factors, for example imperfect access to financial markets. Given microeconomic work suggesting that such uncertainty can create a significant wedge (Carroll, 2001), we regard this probability of "death" as an unknown parameter to be estimated.

The resulting path for consumption depends on whether the individual was "alive" last period or not. If the individual was "alive" then the following equation applies:

$$\Delta c_t = \frac{\lambda}{r+\lambda+\theta^y}\Delta y_t + \frac{r}{r+\lambda+\theta^y}\varepsilon_t^y \qquad (2)$$

The first part of this expression reflects how the wedge in the discount rates links changes in income to consumption in a predictable manner, while the second term is the familiar "random walk" effect from unanticipated changes in income. If the wedge (λ) is zero, the model collapses to a pure random walk. If the individual is "born" this period, the equation is similar except that it does not include lagged values and all income is unanticipated:

$$(c_t - y^*) = \frac{\lambda + r}{r + \lambda + \theta^y}(y_t - y^*). \tag{3}$$

Weighting the two equations by the proportion of individuals who were alive last period or were born this period produces the following aggregate consumption function:

$$\begin{aligned} \Delta c_t &= \frac{\lambda}{r + \lambda + \theta^y}(\Delta y_t + \frac{r}{\lambda}\varepsilon_t^y) \\ &\quad - \frac{\lambda}{1+\lambda}\left((c_{t-1} - y^*) - \frac{\lambda + (1-\theta^y)r}{r + \lambda + \theta^y}(y_{t-1} - y^*)\right) \end{aligned} \tag{4}$$

The change in consumption depends on the change in income (reflecting the excess discount rate), the error on income familiar from the random walk model of consumption, and an "error correction" mechanism on the difference between the level of lagged consumption and income reflecting the "birth" of new individuals whose consumption does not depend on past income.

Fiscal Policy

In this model, the government simply taxes and transfers over time (so we ignore the role of direct government consumption). The crucial difference between changes in taxes and transfers and changes in income is that the government's budget constraint needs to be satisfied. Hence, a cut in taxes (net of transfers) that boosts income will need, at some point, to be counterbalanced by a future increase in taxes. We model this by assuming that, like incomes, taxes follow a first order autoregressive process, but that the trajectory is relative to a long-term level of taxes, t^*. This moves each period, reflecting the long-term costs of this period's innovation to the tax rate. Specifically,

$$\Delta (t_t - t_t^*) = -\theta^\tau (t_{t-1} - t_{t-1}^*) + \varepsilon_t^\tau \text{ where } t_t^* = t_{t-1}^* - \frac{r}{r+\theta^\tau} \varepsilon_t^\tau .$$

Hence, an unexpected fall in taxes (rise in transfers) is simultaneously accompanied by an increase in the expected long-term tax rate. The consumer's problem is now:

$$\begin{aligned}
&Max \sum_{i=0}^{\infty} E_t \frac{U(c_{t+1})}{(1+\beta+\lambda)^i} \\
&s.t. \sum_{i=0}^{\infty} \frac{c_{t+i}}{(1+r+\lambda)^i} = \sum_{i=0}^{\infty} \frac{(y_{t+i} - t_{t+i})}{(1+r+\lambda)^i} \\
&\Delta y_{t+i} = -\theta^y (y_{t+i-1} - y^*) + \varepsilon_{t+i}^y \\
&\Delta (t_{t+i} - t_{t+i}^*) = -\theta^\tau (t_{t+i-1} - t_{t+i-1}^*) + \varepsilon_{t+i}^\tau \\
&t_{t+i}^* = t_{t+i-1}^* - \frac{r}{r+\theta^\tau} \varepsilon_{t+i}^\tau \\
&U(c_{t+i}) = c_{t+i} - \Gamma c_{t+i}^2, \beta = r
\end{aligned} \tag{5}$$

The resulting consumption function looks very much like the earlier one except that unanticipated cuts in taxes ($\varepsilon^{\tau}{}_{t}$) lower consumption through a Ricardian offset on t^*, whereas unexpected increases in income ($\varepsilon^{y}{}_{t}$) raise consumption through higher saving. In addition, there are subtle differences in the coefficients on income and taxes in the "error correction" mechanism:

$$\begin{aligned}\Delta c_t = &\frac{\lambda}{r+\lambda+\theta^y}(\Delta y_t + \frac{r}{\lambda}\varepsilon_t^y) \\ &-\frac{\lambda}{r+\lambda+\theta^\tau}(\Delta t_t - \frac{r}{r+\theta^\tau}\varepsilon_t^\tau) \\ &-\frac{\lambda}{1+\lambda}\left(c_{t-1} - \frac{\lambda + r(1-\theta^y)r}{r+\lambda+\theta^y}y_{t-1} + \frac{\lambda}{r+\lambda+\theta^\tau}\left(1-\frac{r(1-\theta^\tau)}{r+\theta^\tau}\right)t_{t-1}\right)\end{aligned} \tag{6}$$

Rule of Thumb Consumers

An alternative theoretical approach to breaking Ricardian equivalence is to assume that all consumers are infinitely lived, but a proportion, η, consume their income each period. Again, there are two consumption processes. The unconstrained (and hence fully Ricardian) consumers follow the pure random walk model and respond only to unexpected innovations in income:

$$\Delta c_t = \frac{r}{r+\theta^y}\varepsilon_t^y. \tag{7}$$

By contrast, rule of thumb individuals consume all of their current disposable income:

$$c_t = (y_t - t_t). \tag{8}$$

Aggregating produces the following consumption function:

$$\Delta c_t = \eta\left(\Delta y_t + \frac{(1-\eta)}{\eta}\frac{r}{r+\theta^y}\varepsilon_t^y\right) - \eta\Delta t_t - \eta(c_{t-1} - y_{t-1}) \tag{9}$$

Both the "myopic" consumption function (equation 6) and its "rule of thumb" equivalent (equation 9) have the same basic error correction specification in which the change in consumption is related to the change in income and taxes and a lagged term in levels. Comparing the two consumption functions, the main difference is that the "rule of thumb" version predicts that the absolute value of the coefficients on the change in income, the change in taxes, and the error correction mechanism are similar, while in the "myopic" model the change in income attracts a larger absolute coefficient than the change in taxes, and—for reasonable parameter values—both are larger than the coefficient on the error correction mechanism.

Finally, it is also possible to create a hybrid model involving myopic consumers and rule of thumb ones. The resulting equation is obtained by simply substituting the consumption process in equation (6) for the "random walk" term in equation (9).

Supply Effects

It is often argued that, in addition to their Ricardian effects, cuts in taxes (or increases in transfers) have negative supply effects coming from the need for higher taxes in the future.[8] This is relatively easy to model in our framework, as t^* reflects this long-term change in the burden of government. Assuming that long-term income falls by some proportion, γ^s, of the implied permanent level of taxes adds a further term $\gamma^s \Delta t_t^* = \gamma^s \frac{r}{r+\theta^\tau} \varepsilon_t^\tau$ to the consumption function described by equation (6). Hence, the specification becomes:

$$
\begin{aligned}
\Delta c_t &= \frac{\lambda}{r+\lambda+\theta^y}(\Delta y_t + \frac{r}{\lambda}\varepsilon_t^y) \\
&- \frac{\lambda}{r+\lambda+\theta^\tau}(\Delta t_t - \frac{r(1+\gamma^s)}{r+\theta^\tau}\varepsilon_t^\tau) \\
&- \frac{\lambda}{1+\lambda}\left(c_{t-1} - \frac{\lambda + r(1-\theta^y)r}{r+\lambda+\theta^y} y_{t-1} + \frac{\lambda}{r+\lambda+\theta^\tau}\left(1 - \frac{r(1-\theta^\tau)}{r+\theta^\tau}\right) t_{t-1}\right).
\end{aligned} \tag{10}
$$

III. Some Estimates

Our empirical strategy involves first estimating an unrestricted version of the "error correction" specification for the consumption functions derived in the last section, and then

[8] Clearly, changes in the tax wedge are also likely to affect aggregate demand through their effects on labor utilization. Such an effect will depend on the particular characteristics of the labor market at hand, e.g., the elasticity of labor supply and labor demand and the details of the wage-setting process (Coenen and others, 2005).

testing the coefficient restrictions implied by the myopic and rule of thumb models. As the myopic model proves the superior description of the data, the impact of various additional considerations, such as having consumers with different levels of myopia, adding some rule-of-thumb consumers and including supply effects, are then explored.

The model was estimated from 1955 using annual data for real consumption of nondurable goods and services, personal income excluding transfers, payments of direct taxes less transfers, and disposable income (income minus direct taxes net of transfers). Corresponding series are plotted in Figure 1. Annual data were used because taxes are levied on yearly income and it simplifies the time series characterization of the data, while 1955 was chosen to have as long a time series as possible without including the large shocks experienced by the economy over the great depression, Second World War, and immediate postwar period. While indirect taxes are not included specifically, they affect real income and consumption through the deflator. In any case, most of the active fiscal policy in the United States has occurred through the federal government, whose main tax base is personal income taxes. Similarly, we do not discuss the issue of direct government spending, which has stayed relatively constant as a ratio to GDP.[9]

Basic Model

[9] While direct government spending could be added to the model, in this paper we decided to focus on taxes net of transfers, and postpone this part of the analysis.

The unrestricted system we estimate comprises:

$$\begin{aligned}
\Delta c_t &= \alpha^c + \beta^y \Delta y_t + \beta^t \Delta t_t - \beta^{ecm}(c_{t-1} - (y_{t-1} - t_{t-1})) + \varepsilon_t^c \\
\Delta y_t &= \alpha^y + \gamma^{trend} trend - \theta^y y_{t-1} + \varepsilon_y^t \\
\Delta t_t &= \alpha^t + \gamma^y \Delta y_t - \theta^\tau t_{t-1} + \varepsilon_t^t .
\end{aligned} \tag{11}$$

where c and y are now the logarithm of consumption and income while t is the net tax rate (net taxes as a ratio to income).

These equations correspond to the specification derived in the theoretical section with the following changes to produce an estimable system:

- *In the net tax rate equation*, *first*, the growth of income is included in the model as the tax and transfer system is progressive and the rate varies over the cycle; *second*, the t^* term is made into a constant as its evolution is endogenous and hence is not amenable to standard estimation techniques.
- *In the income equation*, steady state income (y^*) is made into a time trend given the steady rise in real incomes over time—the autoregressive process refers to deviations from this trend.
- *In the consumption function*, *first* the terms in the unexpected innovation in income/net taxes (ε^y and ε^τ) were added to the coefficient on the change in income/taxes as colinearity made it impossible to estimate them separately; *second*, given strong evidence that consumption is cointegrated with disposable income, we set the

coefficient on disposable income in the error correction mechanism at unity (this is the value implied by a nonstationary process on income).

Results from estimating this unrestricted model are reported in Table 1. The model was estimated using seemingly unrelated regressions (hereafter SUR) and instrumental variable techniques (using the Generalized Method of Moments, or GMM), which should lower the impact of income on consumption by eliminating the effect of unexpected changes in income.[10] Estimating the model in two different ways provides a useful check on its plausibility. The instruments comprise all of the independent variables except the contemporaneous change in income, which was substituted by its first two lags.

The SUR results reported in the first column imply that consumers spend almost two-thirds of the change in their income, but only about one-third of any change in net taxes. It also implies that any deviation between the underlying level of consumption and disposable income is reversed at a rate of about 12 percent a year. The equation for income implies that any unexpected disturbances revert to trend at a rate of around 20 percent a year—implying a half life of some 3½ years. In the net tax rate equation, revenues rise by about one-third of a percent for every one percent change in income—indicating the personal tax and transfer system is reasonably progressive—while underlying changes in the net tax rate are relatively long-lived, reverting to trend at a rate of about 10 percent a year. The consumption and tax

[10] Taxes were not instrumented as the information available on the evolution of tax policy is generally political rather than economic. As such, instrumental variables do not seem to be well suited to differentiating between anticipated and unanticipated tax rate changes.

equations fit relatively well, with R-squares of 0.70 and 0.56, respectively, and little evidence of correlation in the residuals, while the residuals from the income equation (reported in Figure 2) correspond to conventional views of the business cycle. For example, income is particularly below trend in the recessions of the late 1950s, mid-1970s, early 1980s, early 1990s, and 2001.

The GMM results in the second column are generally similar. As expected, the estimated impact of a change in the income on consumption function falls from 64 cents on the dollar to 52 cents. In addition, the coefficient on the change in net taxes falls from 36 to 27 cents and the impact of change in income on taxes rises somewhat. Other coefficients are essentially unchanged.

Wald tests of the coefficient restriction implied by the myopic model are also reported in Table 1 (assuming a real interest rate of 4 percent a year). The restrictions (with those included in the SUR estimates but not in GMM in square brackets) were:

$$\begin{aligned} \beta^{y} &= \frac{\lambda + [r]}{r + \lambda + \theta^{y}} \\ \beta^{t} &= \frac{\lambda}{r + \lambda + \theta^{\tau}}\left(1 - \frac{r}{r + \theta^{\tau}}\right) \\ \beta^{ecm} &= \frac{\lambda}{1 + \lambda} \end{aligned} \tag{12}$$

The myopic model can be accepted at conventional levels, with the fit being particularly good for the SUR estimates. This is not surprising as the estimated coefficients—a larger coefficient on income than on taxes and an even smaller value on the error correction mechanism—corresponds to the predictions of the model.

By contrast, and for exactly the same reasons, the restrictions implied by the rule-of-thumb model are strongly rejected:

$$\begin{aligned} \beta^{y} &= \eta + \left[(1-\eta)\frac{r}{1+r} \right] \\ \beta^{t} &= \beta^{ecm} = \eta. \end{aligned} \tag{13}$$

Table 2 reports results from estimating the deep parameter of the myopic model—the wedge on the discount rate—using SUR and GMM. The specification for consumption, which explicitly includes innovations to income and net taxes, is as follows (in the GMM results, the coefficient on ${\varepsilon^{y}}_{t}$ is excluded).

$$\begin{aligned} \Delta c_t = {} & \frac{\lambda}{r+\lambda+\theta^{y}}(\Delta y_t \left[+ \frac{r}{\lambda}\varepsilon_t^{y} \right]) \\ & - \frac{\lambda}{r+\lambda+\theta^{\tau}}(\Delta t_t - \frac{r}{r+\theta^{\tau}}\varepsilon_t^{\tau}) \\ & - \frac{\lambda}{1+\lambda}\left(c_{t-1} - (y_{t-1} - t_{t-1})\right) \end{aligned} \tag{14}$$

To compare these results with the unrestricted coefficient estimates reported in Table 1, the implied coefficients on the change in income (β^y), change in net taxes (β^τ), and error correction mechanism (β^{ecm}) are reported using the restrictions from equation (12). The SUR results imply an excess private sector discount rate of 14 percent that is significantly different from zero at the 5 percent level, hence rejecting the fully Ricardian model. Changes in income are found to be more persistent in the restricted model than in the unrestricted model (the rate of convergence falls from 19 to 9 percent a year), while the dynamics of the tax rate are essentially unaffected. The implied coefficients for the unrestricted regressions are all extremely close to the freely estimated values, consistent with the results from the Wald test, and the fit of the model is largely unaffected. The GMM estimates find a somewhat higher excess discount rate of 25 percent, together with rather faster reversion of income and net taxes to long-term values. The implied coefficients on the change in income, in net taxes, and the error correction mechanism are somewhat larger (in absolute terms) than the unrestricted estimates reported in Table 1, but remain within one-and-a-half standard deviations of the unrestricted values in all cases.

Robustness Tests

A potential criticism of the model is that the assumption that all consumers have the same level of myopia is too restrictive. In practice, discount rates could vary across individuals for many reasons, such as access to capital markets (which is heavily influenced by wealth and income) and age. To investigate this issue, Table 3 compares the implied coefficients in the consumption equation when all consumers are assumed to have the same excess discount rate of 20 percent (a value about half way between the GMM and SUR estimates) with a case where half of the people have an excess discount rate of 10 percent and the other half just over 30 percent, and an even more extreme case where these rates are widened further to 5 and 40 percent. In the latter case, while half of consumers have a planning horizon (defined by the half life on discounted income) of eight years—about half of fully Ricardian consumers—the rest have one of just two years. The results suggest that in both cases the model that assumes the same level of myopia appears a reasonable approximation of the more complex model with different degrees of myopia. This suggests our results can be taken as consistent with a world in which the "average" level of myopia is 15–25 percent.

Another possibility is that adding "rule of thumb" consumers—rather than consumers with different levels of myopia—to the specification could improve the results. To investigate this possibility, an amended specification in which a proportion η of consumers are assumed to follow a rule of thumb while the remainder discount at an excess rate. The results, reported in Table 4, suggest that adding rule of thumb consumers provides no benefit to the myopic model. The estimated proportion of rule of thumb consumers is negative, insignificant, and implausibly large (over 100 percent).

We next investigated the possible role of supply effects in the estimation. We do this by adding a negative supply effect in addition to the losses to consumption from a higher long-term net tax rate. To simplify interpretation of the coefficient on the supply effect, it is calculated as a multiple of the implied permanent change in taxes $-(\varepsilon_t^{\tau}\frac{r}{r+\theta^{\tau}})$, see equation (5). Hence, for example, a coefficient of ½ implies that supply effects lower consumption by half of the long-term increase in taxes.

Unfortunately, it proved impossible to estimate the supply terms directly due to simultaneity of the repressors. Instead, we used a grid search to identify the coefficients that minimized the Wald test of coefficient restrictions on the unrestricted model. This procedure implies coefficients of 0.32 for the direct estimation and 0.64 for the instrumented regression. Both estimates are of highly plausible magnitudes—indeed, the coefficient of one-third found using SUR corresponds with the parameter on the disincentive to work from taxes assumed in many modern "dynamic stochastic general equilibrium" models based on microeconomic estimated of the Frisch elasticity of labor supply.[11]

As can be seen in Table 5, imposing these coefficients results in extremely similar estimates of the other parameters in the model. Consequently, the only real change in the properties of the equation from adding the supply effect is to lower (in absolute value) the implied impact on consumption from a change in net taxes from -0.37 to -0.27 in the direct estimation and -0.46 to -0.29 when instruments are used. In sum, plausible supply effects are statistically indistinguishable form the basic model, but significantly reduce the implied size of fiscal multipliers.

[11] See, for example, Laxton and Pesenti (2003).

The last issue we investigate is the role of automatic stabilizers. To this point, it has been assumed that all changes in net taxes follow the convergence rate of the error correction mechanism in the net tax equation. However, in practice about half of the variance in the net tax rate comes from the equation's term in the change in income. This implies that about half of the changes in the tax rate follow the rate of convergence in the income equation, rather than the tax rate equation. Estimates of the model adjusting for this effect are reported in Table 6. In practice, the coefficient estimates are almost identical to those reported for the main specification, reflecting the similarity of the rate of convergence of income and net taxes in our specifications. Unsurprisingly, Wald tests of coefficient restrictions from the unrestricted model are extremely similar to those for the baseline model.

IV. Some Analysis

A fundamental feature of the intertemporal model used in this paper is that the impact of a change in income/net taxes on consumption depends on several characteristics—its persistence, whether it is anticipated or not, and the degree to which consumers are myopic. This section explores these interactions in more detail.

We start by analyzing the impact of a change in income/net taxes for a given level of myopia. In particular, we assume that the wedge of the discount rate over the real interest rate is 20 percent, midway between the values estimated with and without using instrumental variables. Figure 3 graphs how the impact of a change in disposable income on consumption varies with its type (underlying income or net taxes), its persistence (measured on the x-axis), and whether it is anticipated or not. The upper line shows the effect of an unanticipated change in underlying income, which rises steadily from around 20 cents on the dollar for a temporary change to a one-for-one impact if the change is permanent, with rates of convergence of income disturbances of 50, 25, and 10 percent a year giving rise to consumption multipliers of one-third, one-half, and two-thirds, respectively. The impact of a fully anticipated change in income (or net taxes) follows a similar path, but the effects are shrunk by about one-sixth as there is no boost to consumption from unanticipated saving.

The effect of an unanticipated change in net taxes is still lower because of the Ricardian offset. The net tax multiplier rises from around 15 cents on the dollar to peak at just over 40 cents for a shock that converges at 10 percent a year. At convergence rates below 5 percent, the multiplier starts to fall as the Ricardian offset increases rapidly. Indeed, it falls to zero for a "permanent" shock to net taxes, as this violates the intertemporal budget constraint and hence the "change" in taxes is fully offset by the opposite movement in the long-term tax rate. The difference in consumption multipliers coming from unanticipated increases in underlying income and from equivalent changes in net taxes rises steadily as the changes become more persistent—from 3 cents for a temporary disturbance to 7, 14, and 28 cents at convergence rates of 50, 25, and 10 percent, respectively—as the Ricardian offset becomes more pertinent.

The upper panel of Figure 4 examines how the impact of an unanticipated change in income varies with the level of myopia of consumers. In this experiment, the private sector discount wedge is varied from 15 to 25 percent, the span of estimates from alternative estimation techniques. The impact of unanticipated changes in income rise as the level of myopia increases, and, even though the multipliers all converge to unity for a permanent change in income, these differences are quite persistent across plausible levels of income persistence. For example, the difference in income multipliers implied by a 15 and 25 percent wedge rises slowly from 6 cents on the dollar for a temporary income disturbance to around 10 cents for disturbances with moderate to long levels of persistence (from 40 percent a year to 10 percent). The difference falls rapidly only at persistence levels lower than 5 percent a year, but the longevity of such processes appears implausible (the half life of a change is well over a decade).

The lower panel repeats this exercise for unanticipated changes in net tax rates rather than income. Again, the impact of taxes on consumption rises with myopia. Temporary tax changes raise consumption by 12–19 cents on the dollar depending on the size of the discount wedge, and these changes peak at 36–47 cents for convergence rates slightly below 10 percent. Again, the differences in multipliers produced by different values of the wedge in the discount rate are relatively persistent—the difference between a 15 percent and 25 percent wedge is 6–10 cents on the dollar for all reasonable rates of convergence.

The model also allows for a calculation of the dynamic effects on consumption of a policy change. As can be seen in the top panel of Figure 5, a long-lived change in net taxes produces an initial boost to consumption that erodes slowly before leading to a significant permanent reduction in consumption, reflecting the substantial increase in net taxes needed to pay for the implied rise in debt. By contrast, a short-lived increase in net taxes leads to a smaller boost to consumption that dissipates much faster, but the long-term effects are also much smaller. The middle panel shows that adding supply effects with a coefficient of 0.33 (consistent with the SUR estimation reported above and microeconomic work) lowers the short-term benefits to consumption and raises the long-term losses. As these effects are larger for longer-lived change in net taxes, this also reduces the difference in multipliers between short- and long-term tax changes. Finally, the bottom panel reports the impact of a tax cut that is anticipated one period in advance. While slightly smaller than the effect of a completely unanticipated tax cut, the effects remain relatively large and similar over time. This suggests there can be powerful "anticipatory" effects of tax cuts if the cuts are considered to be almost certain. This underlines another difference from the "rule of thumb" model, in which consumption is only affected by actual tax cuts, not anticipated ones.

The final issue we discuss is the possibility that large fiscal contractions could be expansionary. This perverse effect, which has spawned a significant literature, is often ascribed to beneficial supply-side effects. Our own calculations suggest that even if the large deficit were assumed relatively long-lived, a perverse supply effect on income would need to be several times the implied long-term change in net taxes. This result strikes us as implausible. More likely, in our view, is that the economy is boosted by two further factors. First, the expected value of the real interest rate may fall. In addition to the direct boost to the economy from such a change, it would also tend to increase the Ricardian offset, thereby cushioning consumption from the impact of fiscal consolidation.

The second effect comes from expectations of the rate of future consolidation. In the model we use, the impact of fiscal policy on consumption depends on the net present value of the future path of net taxes. If a large fiscal consolidation leads to expectations that future consolidation will occur more slowly, the impact of higher taxes on the net present value of income can be offset. An example may help illustrate this effect. Suppose that a deficit of $100 is expected to be eroded at the rate of 38 percent a year (and hence be $62 next year). Assuming a discount wedge of 20 percent and real interest rate of 4 percent, the expected present value of future net taxes next year is $100. Suppose now that consolidation is one-and-a-half times larger, so the deficit falls to $43, but, in addition, the assumed subsequent rate of convergence falls by half to 19 percent a year. This too yields $100 in net present value, implying no impact on the net present value of income—and hence consumption—from the faster-than-expected consolidation. This "demand" effect seems to us to be a significant possible reason why large fiscal consolidations could be expansionary.

V. Some Conclusions

We started this paper by noting that even though theoretical work on breaking Ricardian equivalence was relatively well developed, empirical work was less so. We next developed empirical estimating equations for both a model with myopic consumers who discount the future more rapidly than the rate implied by the government's budget constraint and a model with a combination of Ricardian and rule-of-thumb consumers.

Estimation reveals that the myopic model fits the data extremely well, while the version with rule-of-thumb consumers is soundly rejected. Furthermore, the implied multipliers for changes in taxes and transfers from the myopic model (an average of 25 cents on the dollar) are consistent with the (wide-range) of empirical estimates found in the empirical literature using atheoretical estimates.

The implied excess rate of discount is of the order of 15–25 percent. We find this a highly plausible estimate for three reasons. First, it is consistent with more sophisticated microeconomic work on this topic (Carroll, 2001). Second, while everyone is assumed to have the same level of myopia in the model, these results are a good approximation to a situation in which myopia “averages” to this value, while encompassing people who are more and less forward-looking. Third, this average value is broadly consistent with macroeconomic estimates of the excess volatility of consumption with regard to income and with the interest rate on credit card debt, the main form of unsecured borrowing available to consumers, which was close to 20 percent over the sample. Strikingly, adding rule-of-thumb consumers to the myopic model does not provide sensible estimates or improve the fit. On the other hand, adding supply effects produces significant reductions in the estimated multipliers but the results are statistically indistinguishable from the base model.

The great advantage of our framework is that brings the intertemporal nature of disturbances to income, taxes, and transfers back to the fore of analysis. Our model does not produce a single estimate of the multiplier associated with net taxes. Rather, this value can vary between 12 and 40 cents on the dollar, depending on the longevity of the disturbance and the degree to which it is anticipated (as well as the assumed excess level of discount).

Thinking of fiscal policy in an intertemporal setting provides a range of insights. For example, to the extent that automatic stabilizers associated with the economic cycle are less persistent than most policy changes, they will have smaller multipliers. Analogously, while large fiscal contractions could be expansionary purely due to supply effects, we find it more likely that reductions in the real interest rate and changes in the assumed longevity of future tax changes also play a role. In addition, the model produces a well-defined path for fiscal multipliers over time, including if such changes are anticipated some time before being implemented. We think of this as a great adventure, featuring Mr. Ricardo.

Finally, it has not escaped our notice that a high discount wedge has much broader implications for one's view of the economy and the role of policy makers. Economists often comment on the short-term nature of many government decisions, generally ascribing this to the need for politicians to get reelected. If most people discount the future at a high rate, however, these policies accurately reflect the preferences of the public, not simply those of the politicians. Similarly, a high discount wedge implies that simply providing individuals with vehicles to save for retirement may not yield adequate accumulation of assets—people will prefer to spend today and worry about tomorrow later, with significant implications for public policy. Amending Keynes's famous quip, "In the medium run, we assume we will all be dead."

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Table 1. United States: Estimates of Unrestricted Model

$$\Delta c_t = \alpha^c + \beta^y \Delta y_t + \beta^t \Delta t_t - \beta^{ecm}(c_{t-1} - (y_{t-1} - t_{t-1})) + \varepsilon_t^c$$
$$\Delta y_t = \alpha^y + \gamma^{trend} trend - \theta^y y_{t-1} + \varepsilon_y^t$$
$$\Delta t_t = \alpha^t + \gamma^y \Delta y_t - \theta^\tau t_{t-1} + \varepsilon_t^t.$$

	No Instrumental Variables	***Instrumental Variables***
Consumption equation		
α^c	-.01 (.02)	-.01 (.01)
β^y	.64 (.06) **	.52 (.08) **
β^t	-.36 (.14) *	-.27 (.13) *
β^{ecm}	.12 (.06) *	.12 (.07)*
R^2	.70	.72
DW	2.21	1.96
Income equation		
α^y	.39 (.14) **	.39 (.13) **
γ^{trend}	.005 (.002) **	.006 (.002) **
θ^y	.19 (.07) **	.19 (.07) **
R^2	.11	.11
DW	1.48	1.49
Net tax rate equation		
α^t	-.01 (.00)**	-.02 (.00)**
γ^y	.39 (.04) **	.56 (.13) **
Error! Objects cannot be created from editing field codes.	.09 (.04) *	.09 (.06) *
R^2	.56	.27
DW	2.28	2.06
Wald test of coefficient restrictions		
Myopic model: $\chi^2(2)$	1.8	5.9
Rule-of-thumb consumers: $\chi^2(2)$	60.6 **	43.1 **

Notes: Instrumental variable estimates used system GMM with instruments comprising all independent variables except the change in income, plus the first two lags of this change. The non-instrumental variable model was estimated using seemingly unrelated regressions. One and two asterisks denote that the coefficient is different from zero at 5 and 1 percent significance level, respectively.

Table 2. United States: Estimates of Restricted Model with Myopic Consumers

$$\Delta c_t = \frac{\lambda}{r+\lambda+\theta^y}(\Delta y_t\left[+\frac{r}{\lambda}\varepsilon_t^y\right])$$
$$-\frac{\lambda}{r+\lambda+\theta^\tau}(\Delta t_t - \frac{r}{r+\theta^\tau}\varepsilon_t^\tau)$$
$$-\frac{\lambda}{1+\lambda}\left(c_{t-1}-(y_{t-1}-t_{t-1})\right)$$
$$\Delta y_t = \alpha^y + \gamma^{trend} trend - \theta^y y_{t-1} + \varepsilon_y^t$$
$$\Delta t_t = \alpha^t + \gamma^y \Delta y_t - \theta^\tau t_{t-1} + \varepsilon_t^t.$$

	No Instrumental Variables	***Instrumental Variables***
Consumption equation		
α^c	-.04 (.01)	-.03 (.02)
λ	.14 (.06) *	.25 (.09) **
θ^y	.09 (.03) **	.15 (.06) **
θ^τ	.10 (.04) **	.13 (.05) *
R^2	.71	.66
DW	2.01	1.55
Income equation		
α^y	.21 (.06) **	.32 (.11) **
γ^{trend}	.003 (.001) **	.005 (.002) **
R^2	.08	.10
DW	1.56	1.52
Net tax rate equation		
α^t	-.01 (.00)**	-.01 (.00)**
γ^y	.43 (.04) **	.45 (.10) **
R^2	.52	.49
DW	2.23	2.14
Implied Coefficients		
β^y	.66	.57
β^t	-.35	-.46
β^{ecm}	.12	.20

Notes: See Table 1. Restrictions on implied coefficients are provided in equation 12.

Table 3. United States: Implied Coefficients from Models with One and Two Types of Myopic Consumers

Assumptions: $r=0.04$, $\gamma^{ecm}=0.15$, $\tau^{ecm}=0.1$

	β^{ecm}	β^{y}	β^{t}
Base case, $\lambda=0.2$	0.17	0.62	-0.42
Alternative, $\lambda=0.1$ and 0.32	0.17	0.59	-0.40
Alternative, $\lambda=0.05$ and 0.40	0.17	0.56	-0.36

Notes: Coefficient restrictions are given in equation 12.

Table 4 United States: Estimates of Restricted Model with Rule-of-Thumb Consumers

$$\Delta c_t = \alpha^c + \left(\eta + (1-\eta)\frac{\lambda[+r]}{r+\lambda+\theta^y}\right)\Delta y_t$$
$$-\left(\eta + (1-\eta)\frac{\lambda\left(1-\frac{r}{r+\theta^\tau}\right)}{r+\lambda+\theta^\tau}\right)\Delta t_t$$
$$-\left(\eta + (1-\eta)\frac{\lambda}{1+\lambda}\right)\left(c_{t-1} - (y_{t-1} - t_{t-1})\right)$$
$$\Delta y_t = \alpha^y + \gamma^{trend} trend - \theta^y y_{t-1} + \varepsilon_y^t$$
$$\Delta t_t = \alpha^t + \gamma^y \Delta y_t - \theta^\tau t_{t-1} + \varepsilon_t^t.$$

	No Instrumental Variables	***Instrumental Variables***
Consumption equation		
α^c	-.02 (.01)	-.01 (.01)
η	-.85 (.62)	-1.32 (.80)
λ	1.02 (.67)	1.55 (.80)
θ^y	.18 (.05) **	.18 (.07) **
θ^τ	.08 (.03) *	.09 (.04) *
R^2	.71	.70
DW	2.07	1.84
Income equation		
α^y	.37 (.09) **	.37 (.12) **
γ^{trend}	.006 (.002) **	.006 (.002) **
R^2	.11	.11
DW	1.50	1.50
Net tax rate equation		
α^t	-.01 (.00)**	-.01 (.00)**
γ^y	.32 (.04) **	.40 (.10) **
R^2	.59	.55
DW	2.30	2.26

Notes: See Table 1.

Table 5. United States: Estimates of Restricted Model with Myopic Consumers and Supply Effects

$$\Delta c_t = \frac{\lambda}{r+\lambda+\theta^y}(\Delta y_t + \frac{r}{\lambda}\varepsilon_t^y) - \frac{\lambda}{r+\lambda+\theta^\tau}(\Delta t_t - \frac{r(1+\gamma^s)}{r+\theta^\tau}\varepsilon_t^\tau) - \frac{\lambda}{1+\lambda}\left(c_{t-1} - \frac{\lambda+r(1-\theta^y)r}{r+\lambda+\theta^y}y_{t-1} + \frac{\lambda}{r+\lambda+\theta^\tau}\left(1-\frac{r(1-\theta^\tau)}{r+\theta^\tau}\right)t_{t-1}\right).$$

	No Instrumental Variables	***Instrumental Variables***
Consumption equation		
α^c	-.04 (.01) **	-.03 (.02)
γ^s	.32 (--)	.64 (--)
λ	.15 (.07) *	.26 (.11) *
θ^y	.12 (.03) **	.16 (.06) **
θ^τ	.09 (.04) *	.11 (.04) **
R^2	.71	.67
DW	1.86	1.52
Income equation		
α^y	.26 (.06) **	.33 (.11) **
γ^{trend}	.004 (.001) **	.005 (.002) **
R^2	.09	.11
DW	1.56	1.53
Net tax rate equation		
α^t	-.01 (.00)**	-.01 (.00)**
γ^y	-.38 (.04) **	-.32 (.13) **
R^2	.59	.59
DW	2.28	2.26
Implied Coefficients		
β^y	.62	.57
β^t	-.27	-.29
β^{ecm}	.13	.21

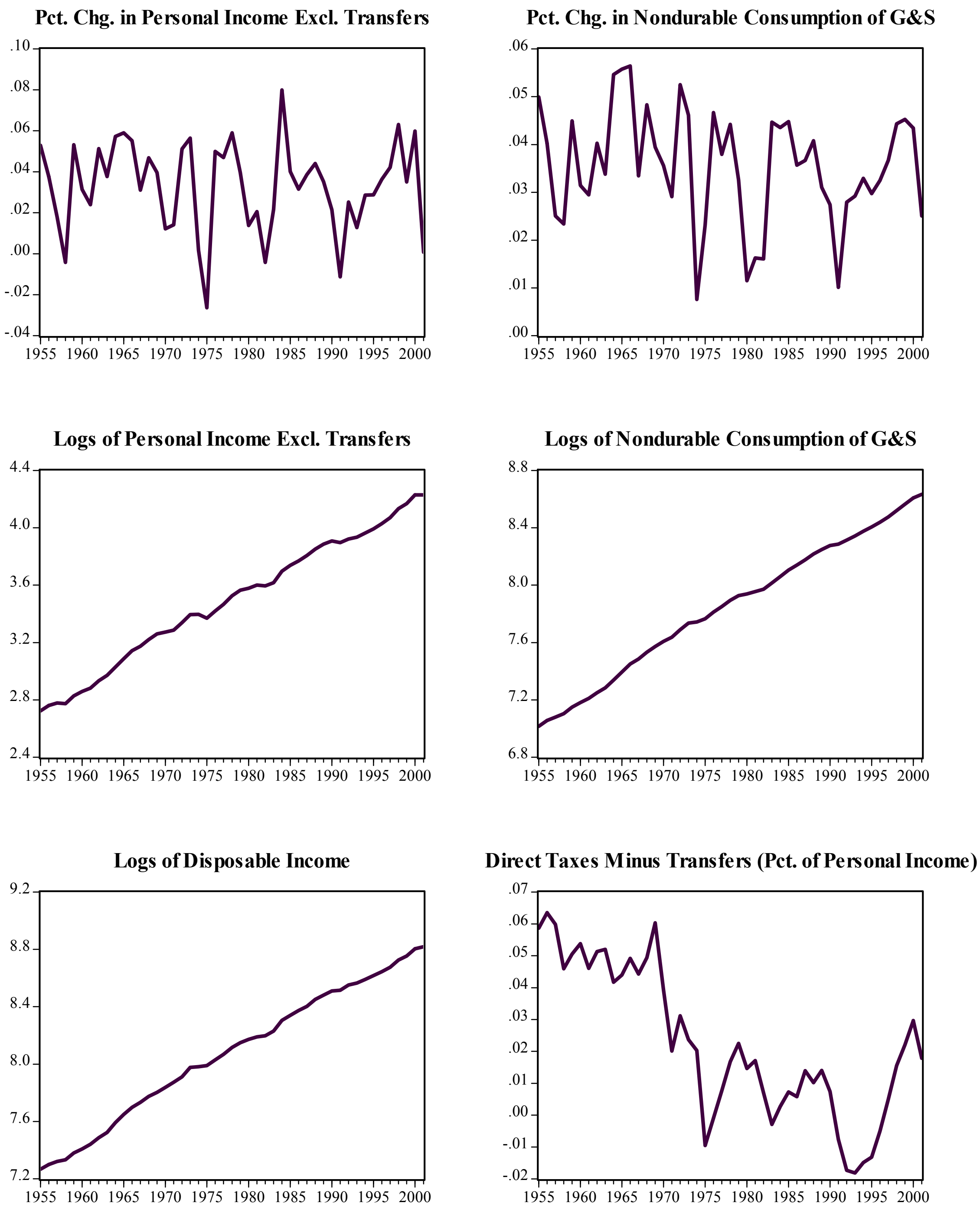
Notes: See Tables 1 and 2. γ^s was estimated using grid search methods.

Table 6. United States: Estimates of Restricted Model with Automatic Stabilizers

	No Instrumental Variables	***Instrumental Variables***
Consumption equation		
α^c	-.04 (.01)	-.03 (.02)
λ	.14 (.06) *	.27 (.10) **
θ^y	.10 (.03) **	.16 (.06) **
θ^τ	.10 (.04) **	.11 (.05) *
R^2	.71	.66
DW	1.96	1.52
Income equation		
α^y	.23 (.06) **	.34 (.11) **
γ^{trend}	.003 (.001) **	.005 (.002) **
R^2	.08	.11
DW	1.57	1.52
Net tax rate equation		
α^t	-.01 (.00)**	-.01 (.00)**
γ^y	.41 (.04) **	.45 (.11) **
R^2	.55	.50
DW	2.26	2.20
Wald test of coefficient restrictions		
Myopic model: $\chi^2(2)$	1.6	5.1
Implied Coefficients		
β^y	.65	.56
β^y	-.36	-.46
β^{ecm}	.13	.21

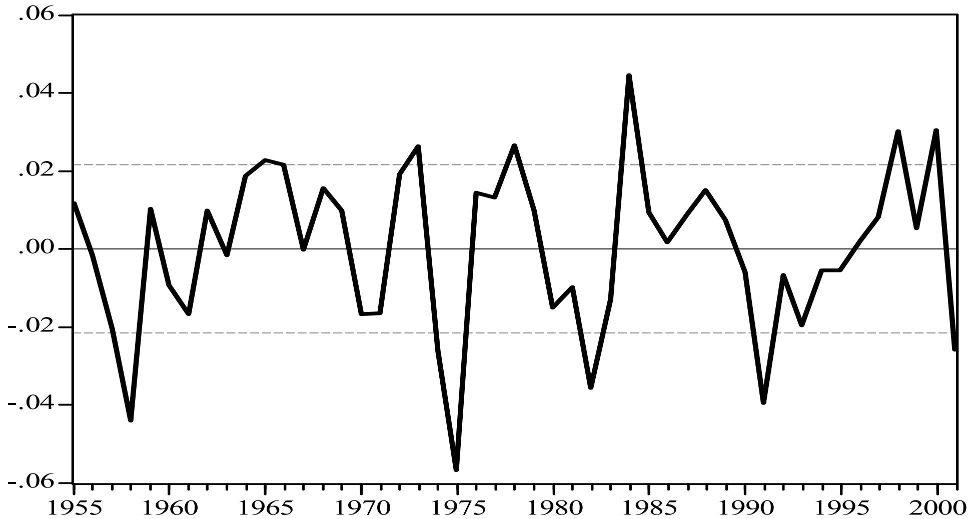
Notes: See Tables 1 and 2.

Figure 1. United States: The Data, 1955-2001



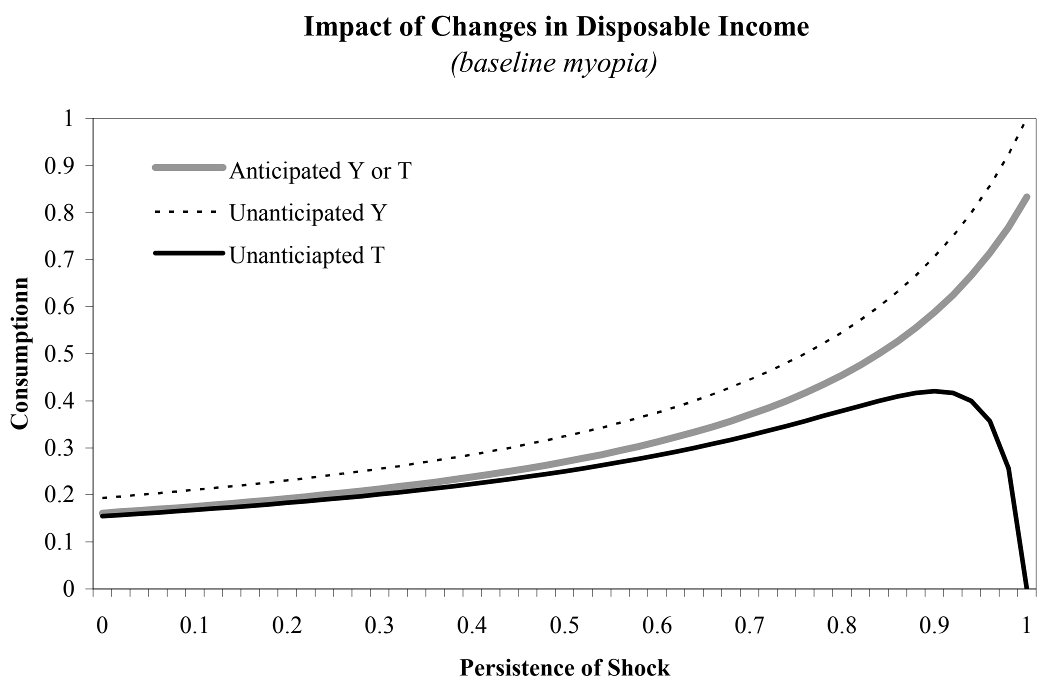
Source: United States Income and Product Accounts and IMF staff estimates.

Figure 2. United States: Income Equation Residuals



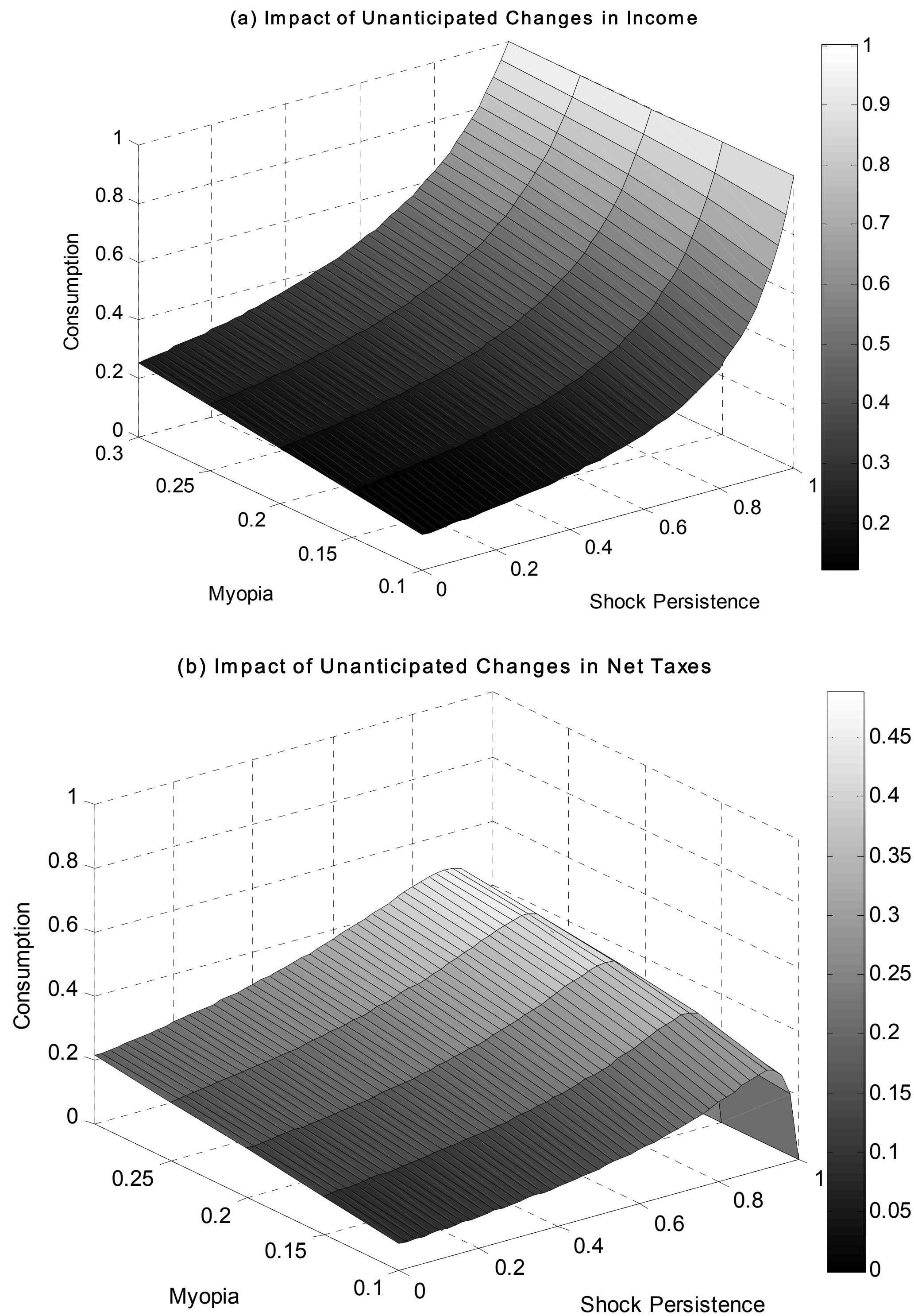
Source: United States Income and Product Accounts and IMF staff estimates.

Figure 3. United States: Impact of Changes in Disposable Income



Source: NIPA and IMF staff estimates.

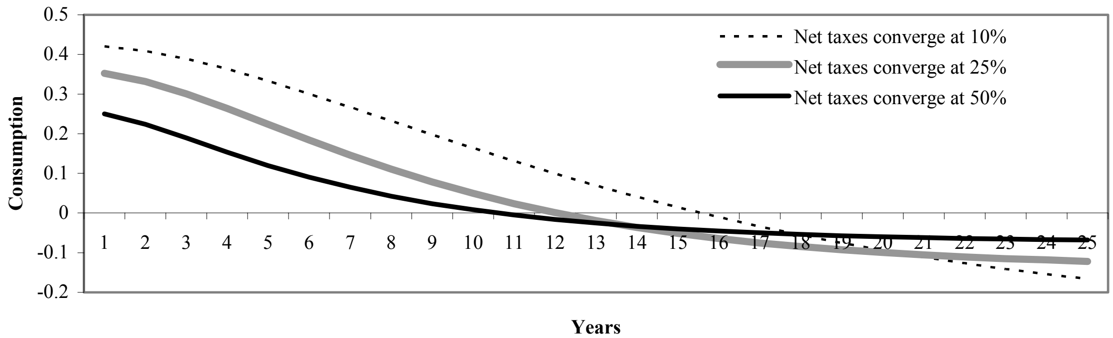
Figure 4. United States: Impact of Changes in Disposable Income for Different Degrees of Myopia



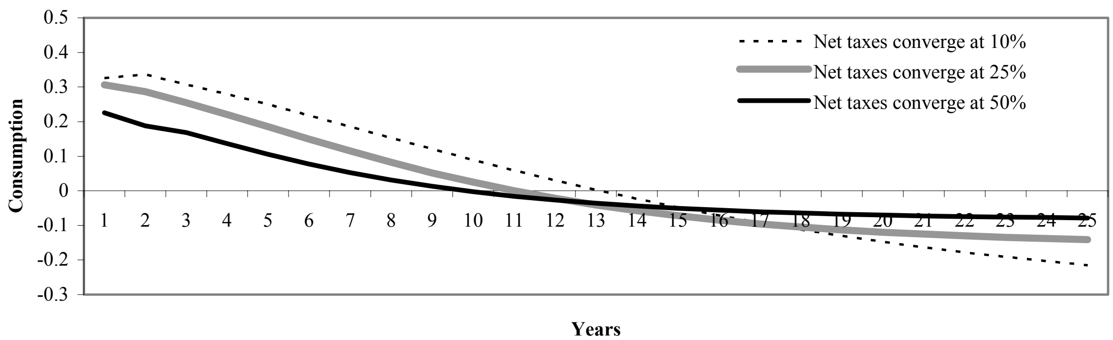
Source: IMF staff calculations.

Figure 5. United States: Impact of Lower Net Taxes

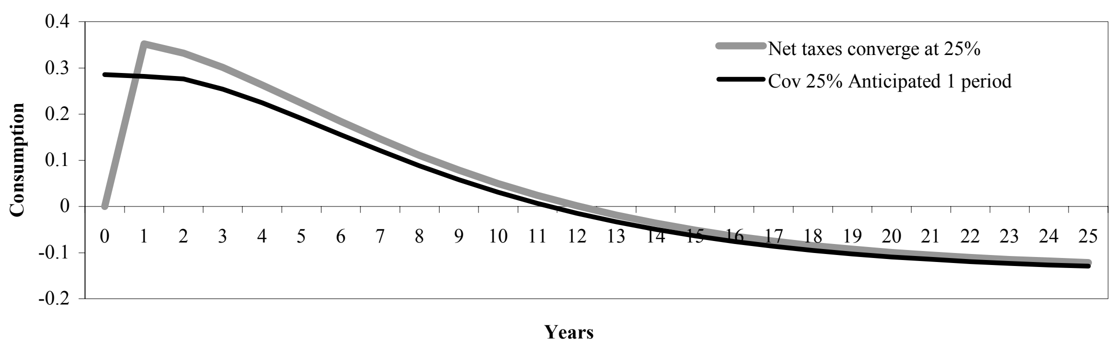
(a) Impact on Consumption Of Lower Net Taxes



(b) Impact on Consumption Including Supply Effects



(c) Anticipated Versus Unanticipated Tax Cut



Source: NIPA and IMF staff estimates.