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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Abstract

An increasing body of evidence suggests that the behavior of the economy has changed in many fundamental ways over the last decades. In particular, greater financial deregulation, larger wealth accumulation, and better policies might have helped lower uncertainty about future income and lengthen private sectors' planning horizon. In an overlapping-generations model, in which individuals discount the future more rapidly than implied by the market rate of interest, we find indeed evidence of a falling degree of impatience, providing empirical support for this hypothesis. The degree of persistence of “windfall” shocks to disposable income also appears to have varied over time. Shifts of this kind are shown to have a key impact on the average marginal propensity to consume and on the size of policy multipliers.

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¹ The views expressed in this paper do not necessarily reflect those of the International Monetary Fund or De Nederlandsche Bank.

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I. INTRODUCTION

An increasing body of evidence suggests that the behavior of the economy has changed in substantial and fundamental ways over the last decades.⁴ *Inter alia*, greater financial deregulation, larger wealth accumulation, and better policies might have helped lower uncertainty about future income and lengthen consumers' planning horizon. In an overlapping-generations model, in which individuals discount the future more rapidly than implied by the market rate of interest, evidence of a falling rate of time preference would provide empirical support for this hypothesis. Intuitively, this kind of shifts in private-sector behavior is likely to have an important impact on the average marginal propensity to consume out of windfall shocks to disposable income as well as on the size of policy multipliers. However, the direction of these changes is not clear a priori.

To look into changes in the transmission mechanism of monetary and fiscal policy, we need to pin down the structural parameters describing the private-sector behavior as well as those describing the behavior of the policymaker. Extending Bayoumi and Sgherri (2006), this is done within an overlapping-generations framework which dispenses with the assumption of the infinite-lived representative agent. The model assumes that consumers have *finite* planning horizons and, therefore, discount the future more rapidly than implied by the government's budget constraint. As a result, households value tax cuts today more highly than the implied future tax increases, allowing expansionary tax and transfer policies to have real effects on consumption, even though they are optimizing their lifetime consumption plans subject to intertemporal budget constraints.

Adding a life-cycle dimension to consumption provides more realistic consumption dynamics, with spending responding less to a temporary fiscal policy shock than to a long-term one, as predicted by the permanent income hypothesis. In such a theoretical model, the impact of any policy shock on consumption is deemed to depend on three characteristics—

⁴ See, among many others, the contributions of Blanchard and Simon (2001), Boivin and Giannoni (2006), Cogley and Sargent (2001), Primiceri (2006), Stock and Watson (2002).

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 prevailing market interest rate.

A very important feature of this model is its ability to generate testable econometric relationships between the coefficients of the consumption function and the underlying structural parameters of the model. In this way, we succeed in identifying and estimating the parameter that measures the life horizon, thereby nesting the infinite-horizon model (and Ricardian equivalence) as a special parameter configuration. Cross-equation restrictions also permit to investigate the data admissibility of alternative consumption theories within a single modeling framework. Given our focus on changes in behavior over time we look at results from rolling regressions. These results permit to identify meaningful sub-periods over which structural parameters have been relatively stable. Estimates for these samples will be subsequently used to analyze the impact of shifts in agents' behavior on the evolution of the propagation mechanisms of monetary and fiscal shocks.

To anticipate our conclusions, estimation reveals that the finite-horizon model fits post-war US data reasonably well, entailing a discount wedge of about 3 percent a year. The discount wedge appears to have fallen over time, meaning that consumers have become more far-sighted and better able to smooth consumption over their lifetime. At the same time, the degree of persistence of "windfall" shocks to disposable income has increased, whereas shocks to the real interest rate seem to have become shorter-lived than they used to. The analysis of the combined effect of these shifts on the size of income and policy multipliers suggests that fiscal stimuli have so far retained their effectiveness, as the lengthening in the longevity of changes in net taxes and public spending has offset the impact of having to cope with "more Ricardian" consumers. Notably though, as households become less and less impatient, the scope to further increase the effectiveness of "windfall" shocks to disposable income is likely to become more and more limited. At the same time, the real effects of real interest rate changes appear to have fallen dramatically over time, supporting the wide-spread view that the sacrifice ratio has ultimately come down.

The plan of the paper is as follows. Section II provides the theoretical framework for the analysis. The intertemporal model is estimated in section III. As mentioned before, implied fiscal and monetary multipliers depend on three characteristics—the persistence of the shock itself, whether it is anticipated or not, and the rate to which consumers discount the future. Section IV explores these interactions in more detail as well as time variation in the coefficient estimates. Broader implications for policy analysis are discussed in the concluding section.

II. THEORETICAL MODEL

The model used in this paper is a discrete-time, closed-economy version of the overlapping-generations framework in Blanchard (1985) and Yaari (1965), in which Ricardian equivalence is broken through the assumption that consumers face a constant probability of dying in each period. More precisely, while households make their consumption plans on the basis of a finite horizon, society (and, thereby, the government) has an infinite horizon due to the continuous entry of new generations. The difference between the time horizons relevant for individual and public decision making results in discrepancies between the private and public sectors' discount rate, meaning that individuals discount the future at a faster rate than implied by the government's budget constraint. In this context, a tax cut (or a rise in spending) boosts current consumption because the wedge between the real interest rate and the discount rate implies that the net present value of the tax cut (or the rise in spending) exceeds that of subsequent increases in taxes (or spending cuts) needed to keep the government solvent.

Monetary policy

In a closed economy, the real interest rate (r_t) is endogenously determined by the monetary authority. The central bank follows an interest rate rule, according to which the real interest rate moves each period to adjust for past deviations from its steady state level (\bar{r}):

$$\Delta(r_{t+i} - \bar{r}) = \theta^r (r_{t+i-1} - \bar{r}) + \varepsilon_{t+i}^r \quad (1)$$

where the parameter θ^r determines the degree of interest rate smoothing and ε_t^r is an unexpected monetary policy shock.⁵ Given equation (1), it should be clear that at each period t , the expected level of the real interest rate is equal to: $E_t r_{t+1} = -\sum_{i=0}^{\infty} (1 + \theta^r)^i \theta^r \bar{r} = \bar{r}$.

Consumption

Crucially, in addition to the usual discount rate (assumed equal to the expected real interest rate, $E_t r_{t+1}$), consumers of all ages face an additional discount wedge, λ , reflecting their constant probability p of dying in the next period, such that $p = \frac{\lambda}{(1 + \lambda)}$.

It should be stressed from the start that by “death” we mean economic death rather than its physical counterpart. Limited planning horizons (or “impatience”) in economic decision making can be due to disconnectness of current households from future generations or lack of an altruistic bequest motive.⁶ They can also occur through more subtle factors, for example imperfect access to financial markets. We regard the probability of “death” as an unknown parameter to be estimated.

To simplify the algebra, we assume that utility is quadratic, which ensures certainty equivalence, and that labor income follows an exogenous and quite general stochastic process, encompassing both the hypotheses of unit root behavior and trend stationarity.

⁵ This simple reaction function is consistent with a pure inflation targeting policy, in which the nominal interest rate moves one-to-one with deviations of inflation from its equilibrium value.

⁶ On this point, see also Barro (1974) and Evans (1993).

On the ground of the simple model outlined in the appendix, the maximization problem of each consumer born at time s is thus:

$$\begin{aligned}
& \text{Max } E_{t-1} \sum_{i=0}^{\infty} \frac{U(c_{t+i})}{[(1+r_t)(1+\lambda)]^i} \\
& \text{s.t. } \sum_{i=0}^{\infty} \frac{c_{t+i}}{[(1+r_t)(1+\lambda)]^i} = \sum_{i=0}^{\infty} \frac{y_{t+i}}{[(1+r_t)(1+\lambda)]^i} \\
& \Delta(r_{t+i} - \bar{r}) = \theta^r (r_{t+i-1} - \bar{r}) + \varepsilon_{t+i}^r \\
& \Delta(y_{t+i} - y_{t+i}^*) = \theta^y (y_{t+i-1} - y_{t+i-1}^*) + \mu^y + \varepsilon_{t+i}^y \\
& y_{t+i}^* = \kappa^y + \zeta^y \text{ time} \\
& U(c_{t+i}) = c_{t+i} - \frac{1}{2} c_{t+i}^2
\end{aligned} \tag{2}$$

where $U(\cdot)$ is the utility function, c is the individual's consumption level, and y is the individual's disposable income, which may either follow a random walk with drift ($\zeta^y, \theta^y = 0$) or a stationary autoregressive process ($\zeta^y \neq 0, \theta^y < 0$) around a deterministic trend (*time*). In addition, λ indicates the discount wedge, Δ is the first difference operator, and remaining Greek letters reflect underlying parameters.

It should be noted that, for each individual consumer, the first order condition of the dynamic optimizing problem (2) implies $E_{t-1} \Delta c_t = 0$, regardless of the stochastic properties of labor income. The implication that changes in *individual consumption* are unpredictable—as they are in the case of a representative consumer model with infinite lifetime—stems from the fact that the discount rate and the return on financial wealth are the same, that is $(1+\bar{r})(1+\lambda)$. That's not the case in the aggregate. In the aggregate, the discount rate is still $(1+\bar{r})(1+\lambda)$, but the return on financial wealth is just $(1+\bar{r})$, as insurance premia and wealth transfers among consumers disappear. This implies that, as long as $\lambda > 0$, changes in *aggregate consumption* become predictable, while aggregate consumption and aggregate labor income share a common trend.

To see this, notice that the expected path for aggregate consumption is defined as:

$$E_{t-1}c_t = pE_{t-1}c_{t,t} + (1-p)c_{t-1} \quad (3)$$

where the first component on the right hand side reflects the expected level of consumption of the new cohort born at time t , and the second component denotes the one-period-ahead consumption of those who were alive both at time $t-1$ and at time t .

Given the assumption that individuals are born with no financial wealth, for the newly born cohort the expected level of consumption will only depend on the discounted sum of current and future labor income. Using the expression for individual human wealth:

$$H_t = \frac{1}{(1+r_t)(1+\lambda)} \sum_{j=0}^{\infty} \left[\frac{1+\theta^y}{(1+r_t)(1+\lambda)} \right]^{-j} E_{t-1}y_{t+j} \quad (4)$$

and decomposing expected labor income into its current level (y_{t-1}) and the discounted sum of anticipated future changes ($E_{t-1}\Delta y_t$), we can derive the following expression:

$$E_{t-1}c_{t,t} = (\bar{r} + \lambda)E_{t-1}H_t = \frac{\bar{r} + \lambda}{\bar{r} + \lambda - \theta^y} y_{t-1} + \frac{(1+\bar{r})(1+\lambda)}{\bar{r} + \lambda - \theta^y} \left[\Delta y_t + \frac{\bar{r}}{\lambda} \varepsilon_t^y \right] \quad (5)$$

where $\varepsilon_t^y = \Delta y_t - E_{t-1}\Delta y_t$ denotes unexpected changes in labor income, which are boosting savings. Weighting equation (5) appropriately and substituting for into equation (3) produces the following aggregate consumption function:

$$\Delta c_t = -\frac{\lambda}{1+\lambda} (c_{t-1} - \frac{\bar{r} + \lambda}{\bar{r} + \lambda - \theta^y} y_{t-1}) + \frac{\lambda(1+\bar{r})}{\bar{r} + \lambda - \theta^y} \Delta y_t + \frac{\bar{r}(1+\bar{r})}{\bar{r} + \lambda - \theta^y} \varepsilon_t^y + \varepsilon_t^c \quad (6)$$

where $\varepsilon_t^c = c_t - E_{t-1}c_t$ indicates idiosyncratic shocks to aggregate consumption.

It should thus be clear that changes in consumption depend on three factors, namely: (i) an “error correction” mechanism on the difference between the level of lagged consumption and income due to the “birth” of new individuals, (ii) predictable changes in labor income reflecting a positive wedge in the discount rate, and (iii) the familiar “random walk” effect from unanticipated changes in income.

Importantly, the model nests the infinite-horizon model as a special case: if the discount wedge (and, thereby, the probability of dying) is zero, aggregate consumption collapses to a pure random walk and changes in aggregate consumption become unpredictable. Conversely, as long as the discount wedge is positive, aggregate consumption and aggregate labor income share a common trend. Thus, if y_t is a unit root process with drift ($\theta^y, \zeta^y = 0$), then c_t will also be; if y_t is trend stationary ($\theta^y < 0, \zeta^y \neq 0$), both series will comprise a deterministic trend. Average changes in consumption will also become proportional to expected changes in labor income, implying $E_{t-1}\Delta c_t = \frac{\bar{r} + \lambda}{\bar{r} + \lambda - \theta^y} (\mu^y + \zeta^y)$.

Fiscal policy

In this model, real public spending (expressed as a ratio to aggregate income and denoted as g) is financed by lump-sum tax payments net of lump-sum transfers (tt) and government debt (B), both expressed as ratios to aggregate income.⁷ The expected real return on one-period government bonds is equal to the market real rate, \bar{r} . Under the usual transversality condition, $\lim_{i \rightarrow \infty} \frac{B_{t+i}}{(1+r_t)^i} = 0$, the intertemporal government budget constraint is of the form:

⁷ Monetization of deficits is treated as an inflationary tax and its proceeds are included in tt .

$$\sum_{i=0}^{\infty} \frac{g_{t+i}}{(1+r_t)^i} = \sum_{i=0}^{\infty} \frac{tt_{t+i}}{(1+r_t)^i} \quad (7)$$

As the government's budget constraint needs to be satisfied, any cut in net taxes (or a rise in public spending) has, at some point, to be counterbalanced by a future increase in net taxes (or a cut in public spending). We model this by assuming that the long-term rate of taxes less transfers (denoted as tt^*) moves each period, reflecting a deterministic trend (*time*) and the long-term costs of this period's innovation to the net tax rate itself (denoted as ε^t). Hence, an unexpected fall in taxes (rise in transfers) is simultaneously accompanied by an increase in the expected long-term rate of taxes less transfers. Furthermore, we allow the net tax rate to adjust for past deviations from its long-run rate and to vary over the cycle, mimicking a progressive tax and transfer system. Akin to labor income, the net tax rate may either follow a random walk with drift ($\theta^t = 0$) or a stationary autoregressive process ($\theta^t < 0$) around its deterministic trend. Specifically:

$$E_{t-1} \Delta(tt_{t+i} - tt_{t+i}^*) = \theta^t (tt_{t+i-1} - tt_{t+i-1}^*) + \varphi \Delta y_{t+i} + \mu^t \text{ where } tt_{t+i}^* = \kappa^t + \zeta^t \text{time} - \frac{\bar{r}}{\bar{r} - \theta^t} \varepsilon_{t+i}^t.$$

Symmetrically, the long-term level of public expenditure (denoted as g^*) moves each period, reflecting a deterministic trend (*time*) and the long-term costs of this period's innovation to public spending (denoted as ε^g). Hence, an unexpected rise in public spending is simultaneously accompanied by a cut in g^* . Once again, we generalize the government spending process by letting it follow either a random walk with drift ($\theta^g = 0$) or a stationary autoregressive process ($\theta^g < 0$) around its deterministic trend. Specifically:

$$E_{t-1} \Delta(g_{t+i} - g_{t+i}^*) = \theta^g (g_{t+i-1} - g_{t+i-1}^*) + \mu^g \text{ where } g_{t+i}^* = \kappa^g + \zeta^g \text{time} - \frac{\bar{r}}{\bar{r} - \theta^g} \varepsilon_{t+i}^g.$$

Taking for granted the presence of crowding out effects on private consumption of any dollar spent by the public administration, the consumer's problem is now modified by

the presence of public expenditure in the utility function and the stream of tax payments (net of lump-sum transfers) altering the notion of disposable labor income:

$$\begin{aligned}
& \text{Max } E_{t-1} \sum_{i=0}^{\infty} \frac{U(c_{t+i}, g_{t+i})}{[(1+r_{t+i})(1+\lambda)]^i} \\
& \text{s.t. } \sum_{i=0}^{\infty} \frac{c_{t+i}}{[(1+r_{t+i})(1+\lambda)]^i} = \sum_{i=0}^{\infty} \frac{(y_{t+i} - t_{t+i})}{[(1+r_{t+i})(1+\lambda)]^i} \\
& \Delta(r_{t+i} - \bar{r}) = \theta^r (r_{t+i-1} - \bar{r}) + \varepsilon_{t+i}^r \\
& \Delta(y_{t+i} - y_{t+i}^*) = \theta^y (y_{t+i-1} - y_{t+i-1}^*) + \varphi \Delta y_{t+i} + \mu^y + \varepsilon_{t+i}^y \\
& y_{t+i}^* = \kappa^y + \zeta^y \text{ time} \\
& \Delta(tt_{t+i} - tt_{t+i}^*) = \theta^t (tt_{t+i-1} - tt_{t+i-1}^*) + \mu^t + \varepsilon_{t+i}^t \\
& tt_{t+i}^* = \kappa^t + \zeta^t \text{ time} - \frac{\bar{r}}{\bar{r} - \theta^t} \varepsilon_{t+i}^t \\
& \Delta(g_{t+i} - g_{t+i}^*) = \theta^g (g_{t+i-1} - g_{t+i-1}^*) + \mu^g + \varepsilon_{t+i}^g \\
& g_{t+i}^* = \kappa^g + \zeta^g \text{ time} - \frac{\bar{r}}{\bar{r} - \theta^g} \varepsilon_{t+i}^g \\
& U(c_{t+i}, g_{t+i}) = c_{t+i} - \Gamma c_{t+i}^2 - \gamma g_t c_t
\end{aligned} \tag{8}$$

The resulting consumption function looks very much like the earlier one except that unanticipated cuts in taxes (ε^t) and unanticipated increases in government spending (ε^g) lower consumption through a Ricardian offset on tt^* and g^* , respectively, whereas unexpected increases in income (ε^y) raise consumption through higher saving. In addition, the presence of a progressive tax and transfer system ($\varphi > 0$) is likely to lower the impact of changes in income on consumption. There may also be subtle differences in the coefficients on income and net taxes in the “error correction” mechanism due to the specific speed of adjustment of the two stochastic processes:

$$\begin{aligned}
\Delta c_t = & \frac{\lambda(1+\bar{r})}{\bar{r}+\lambda-\theta^y} \left(1 - \frac{\phi\lambda(1+\bar{r})}{\bar{r}+\lambda-\theta^y} \right) \left(\Delta y_t + \frac{\bar{r}}{\lambda} \varepsilon_t^y \right) - \frac{\lambda(1+\bar{r})}{\bar{r}+\lambda-\theta^g} \left(\Delta g_t - \frac{\bar{r}}{\lambda} \varepsilon_t^g \right) \\
& - \frac{\xi^r}{\bar{r}+\lambda-\theta^r} \Delta r_t - \frac{\xi^s}{\bar{r}+\lambda-\theta^s} \left(\Delta g_t - \frac{\bar{r}}{\lambda} \varepsilon_t^g \right) \\
& - \frac{\lambda}{1+\lambda} \left[c_{t-1} - \frac{\bar{r}+\lambda}{\bar{r}+\lambda-\theta^y} y_{t-1} + \frac{\bar{r}+\lambda}{\bar{r}+\lambda-\theta^g} g_{t-1} \right] + \varepsilon_t^c
\end{aligned} \tag{9}$$

III. EMPIRICAL ESTIMATES

The model was estimated from 1955 using annual data on (the logarithm of) real consumption (c) and real income (y), the ratio of public expenditure to income (g), (the logarithm of one minus) the net tax rate (tt , direct taxes net of transfers as a ratio to income), and the real interest rate (r). 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.

A preliminary analysis of the time series properties of aggregate consumption and aggregate income suggests that these series are better characterized as I(1) processes than as stationary deviations from a linear trend. In contrast, corresponding evidence for the net tax rate is less clear-cut, implying that tt might even be a mean reverting process. Table 1 reports results of Augmented Dickey-Fuller (1979), Phillips-Perron (1988), and Ng-Perron tests for unit roots allowing for appropriate deterministic components in the data generating process. All test statistics corresponding to c and y fall within the 95 percent confidence region and are thus consistent with the presence of a stochastic trend in those series, whereas in the case of tt the statistical support for this hypothesis is mixed.

Table 2 reports the estimated cointegrating regression between c , y , and tt , as well as two statistics corresponding to the trace and the maximum eigenvalue cointegration tests. The null of no cointegration between consumption, aggregate income, and net taxes is systematically rejected by the data. This result provides initial support for both the “finite-horizon” consumption model (equation 9), that predicts the existence of a cointegrating relation between these three series.

Basic Model

The time-invariant unrestricted system we estimate comprises:

$$\begin{aligned}
\Delta c_t &= \alpha^c + \beta^y \Delta y_t + \beta^{tt} \Delta tt_t + \beta^g \Delta g_t + \beta^r \Delta r_t + \beta^{ecm} (c_{t-1} + \gamma^y y_{t-1} + \gamma^{tt} tt_{t-1}) + \varepsilon_t^c \\
\Delta r_t &= \alpha^r + \theta^r r_{t-1} + \varepsilon_t^r \\
\Delta y_t &= \alpha^y + \theta^y y_{t-1} + \varepsilon_t^y \\
\Delta tt_t &= \alpha^{tt} + \theta^{tt} tt_{t-1} + \phi \Delta y_t + \varepsilon_t^{tt} \\
\Delta g_t &= \alpha^g + \zeta^g time + \theta^g g_{t-1} + \varepsilon_t^g
\end{aligned} \tag{10}$$

where c , y , r , g , and tt correspond to previous definitions. Assuming rational expectations, these equations reflect the specification derived in the theoretical section, except that we are now able to rule out the hypothesis that consumption and income are stationary deviations from linear trends, given their empirical time series properties.

Results from estimating this unrestricted time-invariant model are reported in Table 3. The model was estimated using both Seemingly Unrelated Regressions (SUR) over the whole sample (55-05).⁸

⁸ The model has been also estimated using GMM. The results are very similar and available upon request.

Reported estimates imply that consumers spend almost one-half of the change in their income, but a small and statistically insignificant proportion 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 10 percent a year. In addition, the hypothesis of a unit marginal propensity to consume out of disposable income appears congruent with the data. The equations for income and net tax rate imply that unexpected disturbances to both income and net taxes are likely to produce permanent effects. 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. The interest rate equation is consistent with a significant degree of interest smoothing (about 75 percent), while only 15 percent of any deviation of public expenditure from trend a year is corrected in the same year. The consumption equation fits relatively well, with R-squares of 0.76 and no evidence of correlation in the residuals.

Wald tests of the coefficient restrictions implied by the finite horizon model are also reported in Table 1 (assuming a long-run real interest rate, \bar{r} , of 3 percent a year, in line with the corresponding sample mean). Assuming rational expectations, the restrictions are:

$$\begin{aligned}
 \beta^y &= \frac{\lambda(1+r)}{r+\lambda-\theta^y} \left(1 - \frac{\phi\lambda(1+r)}{r+\lambda-\theta^t} \right) \\
 \beta^t &= -\frac{\lambda(1+r)}{r+\lambda-\theta^t} \left(1 - \frac{r}{r-\theta^t} \right) \\
 \beta^{ecm} &= -\frac{\lambda}{1+\lambda} \\
 \gamma^y &= -\frac{r+\lambda}{r+\lambda-\theta^y} \\
 \gamma^t &= \frac{r+\lambda}{r+\lambda-\theta^t}
 \end{aligned} \tag{11}$$

The finite-horizon model can be accepted at conventional levels. 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—are in line with the predictions of the model. Time-varying p -values corresponding to the joint and individual Wald restrictions are plotted in Figure 2, confirming the validity of the model over time.

Table 4 reports results from estimating the deep parameter of the finite-horizons model—the wedge on the discount rate—using SUR estimates. The specification for consumption—which excludes innovations to income under the assumption of rational expectations—is as follows:

$$\begin{aligned} \Delta c_t = & \frac{\lambda(1+\bar{r})}{\bar{r}+\lambda-\theta^y} \left(1 - \frac{\varphi\lambda(1+\bar{r})}{\bar{r}+\lambda-\theta^u} \right) \left(\Delta y_t + \frac{\bar{r}}{\lambda} \varepsilon_t^y \right) - \frac{\lambda(1+\bar{r})}{\bar{r}+\lambda-\theta^u} \left(\Delta tt_t - \frac{\bar{r}}{\bar{r}-\theta^u} \varepsilon_t^u \right) \\ & - \frac{\xi^r}{\bar{r}+\lambda-\theta^r} \Delta r_t - \frac{\xi^g}{\bar{r}+\lambda-\theta^g} \left(\Delta g_t - \frac{\bar{r}}{\bar{r}-\theta^g} \varepsilon_t^g \right) \\ & - \frac{\lambda}{1+\lambda} \left[c_{t-1} - \frac{\bar{r}+\lambda}{\bar{r}+\lambda-\theta^y} y_{t-1} + \frac{\bar{r}+\lambda}{\bar{r}+\lambda-\theta^u} tt_{t-1} \right] + \varepsilon_t^c \end{aligned} \quad (12)$$

To compare these results with the unrestricted coefficient estimates reported in Table 3, the implied coefficients on the change in income (β^y), change in net tax rate (β^{tt}), change in public spending (β^g), and change in real interest rate (β^r) are reported using the restrictions from equation (11).

The SUR results imply an excess private sector discount rate just below 2½ percent, which is significantly different from zero at the 1 percent level, hence rejecting the fully Ricardian model. The implied coefficients for the restricted regressions are all reasonably close to the freely estimated values, consistent with the results from the Wald test, and the fit of the model is largely unaffected. The dynamics of labor income, tax rate, public expenditure and interest rate are virtually unchanged, with data still favoring the hypothesis of random walk behavior for y and tt . Coherently with the results from the unrestricted model, the finite-horizon model implies that consumers spend 40 percent of their changes in income, but only 12 percent of their changes in net taxes. Interestingly, one extra dollar of

public spending is estimated to crowd out 8 cents of private consumption, while a 1 percent increase in real interest rate is estimated to trim down private consumption by about one-sixth of 1 percent.

IV. ANALYSIS AND DISCUSSION

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 average length of consumers’ planning horizon. This section explores these interactions in more detail.

In our previous study (Bayoumi and Sgherri, 2006) we showed how the impact of unanticipated changes in income and net taxes rises as the level of impatience increases. We also showed that the effectiveness of changes in income and net taxes depends on the degree of persistence of the shock: whereas the effect of an unanticipated change in underlying income rises steadily from around 5 cents in the dollar for a temporary change to a one-for-one impact if the change is permanent, the net tax multiplier rises from around 3 cents in the dollar to peak at just over 19 cents for a shock that converges at 5 percent a year. At convergence rates below 5 percent, the net tax 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.

Here we investigate these interactions along a time dimension, using rolling estimates of the finite-horizons model (Table 4) with windows of 26 years. Figure 3 shows that the degree of consumers’ impatience has fallen from 3 to 2 percent over the last 20 years, thereby lengthening households’ planning horizon from 33 to 50 years. At the same time, though, the persistence of both income and fiscal shocks has increased (Figure 4). In particular, we notice the following: (i) shocks to the income level do not show any tendency to mean revert by the end of the sample; (ii) the rate of convergence (e.g., $1+\theta$) of changes in

net taxes has slowed down from 80 to 90 percent over the last 20 years; changes in public spending have also become more persistent over the same period, with convergence delayed from 65 to 90 percent. In contrast, real interest rate shocks have become shorter-lived, as their convergence rate rose from about 85 percent in 1982 to less than 70 percent in 2005. The statistical significance of these changes can be checked by simply looking at t -statistics for the linear trends fitted through corresponding rolling estimates, as explained in Bayoumi and Eichengreen (1994). In all cases, the hypothesis of no change over time is strongly rejected at the usual 95% confidence level.⁹

Changes of this kind are expected to have an important impact on the average MPC out of windfall income shocks as well as on the size of policy multipliers. However, the direction of these changes is not clear a priori.

Time variation in the effectiveness of income shocks and policy levers on consumption is visualized in Figure 5. An extra dollar of income raises consumption by 42 cents in 2005 and only by 32 cents in 1982. Analogously, a one-dollar cut in public spending produces larger increases in private consumption today than 20 years ago (9 versus 5 cents on a dollar). On the contrary, a one-dollar rise in real interest rate induces a smaller decline in consumption in 2005 (14 cents) than it used to in 1982 (25 cents). As for tax cuts, their effectiveness has been quite volatile over the sample, and related changes are thereby negligible, despite a statistically significant upward trend in the persistence of shocks to the tax rate.

Based on counterfactual analysis, Figure 6 plots the combined effect of changes over time in consumers' impatience and in shocks' persistence on the magnitude of income and policy multipliers. It seems clear that the increase in the persistence of income and fiscal shocks has been predominant over the fall in consumers' impatience, bringing about bigger (rather than smaller) income and fiscal multipliers. Had the persistence in these shocks

⁹ Results are also available upon request.

always been at the current higher level, the effectiveness of changes in income and public spending would have fallen (rather than increased) over the sample, and so would have fallen the effectiveness of any tax cut. In the hypothetical case of no change in shocks' persistence, any change in the effectiveness of income and fiscal shocks on consumption would have been due to the fall in the discount wedge, implying smaller multipliers in 2005 than in 1982. In the case of real interest shocks, persistence has fallen drastically over the sample, implying much smaller multipliers in 2005 than in 1982. Also in this event, the impact of changes in shocks persistence on the size of the multiplier has been a lot more important than any lengthening of the households' planning horizon.

Interestingly, time variation in the effects of income changes on consumption is found to be nonlinear: as income approaches a random walk behavior, changes in the effectiveness of any extra dollar of income on consumption only occur through further drops in the degree of consumers' impatience. This seems to imply that there is only limited scope to increase the effectiveness of "windfall" shocks to disposable income, once the consumers' planning horizon becomes longer and longer.

V. CONCLUSIONS AND POLICY IMPLICATIONS

Identifying the size and impact of policy changes is a tricky business. In this paper we have developed empirical estimating equations for a structural model with rational consumers who discount the future more rapidly than the rate implied by the government's budget constraint. In this way, we attempt to reconcile theory and empirical evidence regarding the effect of income and policy shocks on private consumption.

Estimation reveals that the finite-horizon model fits US postwar data rather well. The implied excess rate of discount is of the order of 2-3 percent—a value which seems broadly in line with macroeconomic estimates of the excess volatility of consumption with regard to income and with predictions of previous life-cycle models with calibrated consumers'

expected lifetimes.¹⁰ It also appears compatible with the prevailing level of interest rate on credit card debt, the main form of unsecured borrowing available to consumers—10-15 percent (in nominal terms) over the sample—and with mortgage lengths up to 40 years.

The great advantage of our framework is that it brings the intertemporal nature of disturbances to disposable income back to the fore of analysis. Indeed, thinking of changes in the effectiveness of policy levers within an intertemporal setting provides a range of insights. First, if the marginal propensity to consume out of “windfall” shocks to disposable income is directly proportionate to the “average degree of impatience”, a progressive lengthening of the households’ planning horizon also implies a progressive drop in the average MPC over time. Hence, over time, consumers seem to have become more far-sighted and better able to smooth consumption over their lifetime, possibly thanks to larger wealth accumulation, greater financial deregulation, and a more extensive global financial integration.¹¹

Have these developments limited the effectiveness of fiscal policy over time? Not yet, as the longevity of changes in net taxes and public spending has also lengthened, indeed offsetting the impact of having to cope with “more Ricardian” consumers. In other words, our results seem to make the case that fiscal stimuli have so far retained their effectiveness. Notably though, as households become less and less impatient, the scope to further increase the effectiveness of “windfall” shocks to disposable income is likely to become more and more limited.

At the same time, the real effects of real interest rate changes appear to have fallen dramatically over time, supporting the wide-spread view that the sacrifice ratio has ultimately come down. Even in this case, a greater degree of forward-lookingness in private sector

¹⁰ See, for instance, Galì (1990).

¹¹ On this point, see also the recent contribution by Cecchetti, Flores-Lagunes, and Krause (2006).

behavior is likely to be an essential factor behind the substantial changes in (monetary) policy effectiveness.¹²

Linking policy effectiveness and shifts in private sector behavior has also a number of important implications. First, it calls into question the large body of work that assesses monetary and fiscal rules by assuming that such rules have no impact on underlying private sector behavior. While such analysis may be useful for the short-term impact of changes in policy effectiveness, the analysis in this paper suggests that it is fraught with difficulty as a guide to the longer-term consequences of a policy shift. Second, it implies that there is a direct connection between some of the more recent improvements in the U.S. economy, such as the fall in output volatility, and the conduct of fiscal and monetary policy. At the same time though, reductions in the variance of output are general phenomena across a wide range of countries, suggesting that this analysis may have wider implications than the United States.

¹² Previous work has shown that changes in the efficacy of US monetary policy may be related to shifts in the degree of forward-lookingness of price/wage setters and that these improvements in supply-side flexibility may have been instrumental in reducing the persistence and the volatility of inflation, interest rates, and output (Bayoumi and Sgherri (2004a, 2004b)).

APPENDIX

Next are described the basic ingredients of the overlapping-generations framework, originally developed in Blanchard (1985).

Domestic output is given by an aggregate production function **Error! Objects cannot be created from editing field codes.**, where K is aggregate capital, L denotes aggregate labor services, and A is an exogenous process proxying the technological level. In a closed economy where the real interest rate (r_t) is endogenously determined by the monetary authority, as in equation (1) in the main text, and assuming a constant, exogenously given, value for L (normalized to one), the aggregate labor income becomes proportional to the technology process A and is thus determined independently of any consumption/savings decision. Individual labor supply is assumed to be time invariant, so that no intergenerational redistribution of labor income occurs. However, as the exogenous technology level may follow a (stochastic or deterministic) trend, aggregate labor income grows over time.

Regardless of her age, each consumer alive in period t faces a constant probability p of dying in period $t+1$. As of t , the probability of being alive at $t+j$ is thus **Error! Objects cannot be created from editing field codes.** The size of each age cohort at birth is also normalized to p and is assumed to decline deterministically over time, at rate p . In this way, total population (say, N) at each time t is constant and equal to 1. Using s to denote the age cohort born in period s , total population at time t (where $t \geq s$) is hence equal to **Error! Objects cannot be created from editing field codes.**

As there is uncertainty about death (e.g. **Error! Objects cannot be created from editing field codes.**), there exist a market of life insurance companies. These companies make (receive) every period a premium payment to (from) each consumer holding positive (negative) financial wealth, and inherit the wealth of that consumers at his death. In other words, individuals are assumed to be born with zero financial wealth, whereas the assets/liabilities of the dead are transferred to life insurance companies operating under zero-

profit conditions and able to borrow/lend freely from the government to service their interest costs.

The presence of life insurance companies operating under perfect competition can be thus seen as an effective transfer of wealth (denoted with W) within members of the same age cohort, s . In each period t , a total wealth of **Error! Objects cannot be created from editing field codes.** is transferred to the **Error! Objects cannot be created from editing field codes.** individuals who are still alive, each hence receiving **Error! Objects cannot be created from editing field codes.**. Added to the usual return on invested wealth, this yields an effective return of **Error! Objects cannot be created from editing field codes.**, or equally **Error! Objects cannot be created from editing field codes.**, where **Error! Objects cannot be created from editing field codes.** reflects the market rate and **Error! Objects cannot be created from editing field codes.** the additional insurance premium due to life uncertainty.

In period t , each consumer born at time s maximizes her expected present discounted value of utility. Formally she solves:

$$\begin{aligned} \max E_{t-1} \sum_{i=0}^{\infty} \frac{U(c_{s,t+i})}{[(1+r_t)(1+\lambda)]^i} \\ \text{s.t.} \\ W_{s,t+i+1} = [(1+r_t)(1+\lambda)]W_{s,t+i} + y_{s,t+i} - c_{s,t+i} \\ \lim_{i \rightarrow \infty} \frac{W_{s,t+i}}{[(1+r_t)(1+\lambda)]^i} = 0 \end{aligned}$$

for $i=0,1,2,\dots$, and where c is consumption, W is financial wealth, and y is labor income.

Error! Objects cannot be created from editing field codes. denotes the expected value of a variable x at time $t-1$ for a consumer born in period s , conditional on the consumer being alive in period t , given information available at time $t-1$. The optimization problem is subject to the budget constraint and the transversality condition.

Assuming quadratic utility and that $W_{s,s}=0$, the first-order condition of the dynamic program above implies that individual consumption is a martingale with no drift, namely $E_{t-1}\Delta c_t = 0$. Noticeably, the model for the individual consumer is hence formally identical to the standard representative consumer model. The only difference lies in the presence of the discount wedge, λ , which reflects the shorter expected horizon as $\rho = \frac{\lambda}{(1+\lambda)}$.

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Table 1. United States: Unit Root Tests

	ADF ^a	PP ^b	NP ^c
c_t	-1.95	-1.71	-1.38
y_t	-2.25	-2.28	-1.85
Critical Values ^d			
5% level	-3.51	-3.51	-2.91
tt_t	-3.42	-2.76	-2.01
Critical Values ^e			
5% level	-2.92	-2.92	-1.98

^a Dickey and Fuller (1979) t-statistic. MacKinnon (1996) one-sided p-values.

^b Phillips and Perron (1988) t-statistic. MacKinnon (1996) one-sided p-values.

^c Ng-Perron (2001) t-statistic and corresponding critical values (see Ng-Perron (2001), Table 1).

^d Critical values correspond to the null of a unit root against a trend-stationary alternative.

^e Critical values correspond to the null of a unit root against a mean-reverting alternative.

Table 2. United States: Cointegration Tests ^a

# Cointegr. Relations	Eigenvalue	Statistic	5% Critical Value	P-values ^b
Trace Statistic				
None *	0.41	48.77	35.19	0.00
At most 1	0.19	20.20	20.26	0.05
At most 2	0.15	8.93	9.16	0.06
Maximum Eigenvalue				
None *	0.41	28.57	22.30	0.01
At most 1	0.19	11.27	15.89	0.23
At most 2	0.15	8.93	9.16	0.06
Implied Cointegrating Relation				
Normalized cointegrating coefficients (standard error in parentheses)				
c_t	y_t	tt_t	κ	
1	-1.00 (0.01)	0.98 (0.53)	0.52 (0.16)	
Adjustment coefficients (standard error in parentheses)				
Δc_t	-0.12 (0.05)			
Δy_t	0.05 (0.09)			
Δtt_t	-0.10 (0.05)			

^a Johansen cointegration rank test between (c_t, y_t, tt_t) allowing for a restricted constant (κ).

^b MacKinnon-Haug-Michelis (1999) p-values.

* Denotes rejection of the corresponding hypothesis at the 5% level.

Table 3. United States: Seemingly Unrelated Estimates of Unrestricted Model (Eq. 10)

<i>Sample: 1955-2005</i>	
Consumption equation	
α^c	-0.05 (.05)
β^y	.46 (.05) **
β^t	-.07 (.18)
β^g	.05 (.08)
β^r	-.13 (.05) *
β^{ecm}	.10 (.05) *
γ^y	-1.03 (.03) **
γ^t	1.07 (.66)
R^2	.76
DW	2.01
Interest rate equation	
α^r	.00 (.00)
θ^r	-.26 (.09) **
R^2	.13
DW	1.80
Income equation	
α^y	.78 (.47)
θ^y	-.10 (.06)
R^2	.09
DW	1.70
Net tax rate equation	
α^t	-.02 (.02)
ϕ	.31 (.07) **
θ^t	-.13 (.08)
R^2	.39
DW	1.84
Government spending equation	
α^g	.04 (.02) *
ζ^g	-.00 (.00)
θ^g	-.17 (.08) *
R^2	.11
DW	1.43
Finite-horizon model restrictions: $\chi^2(4)$	
	0.10

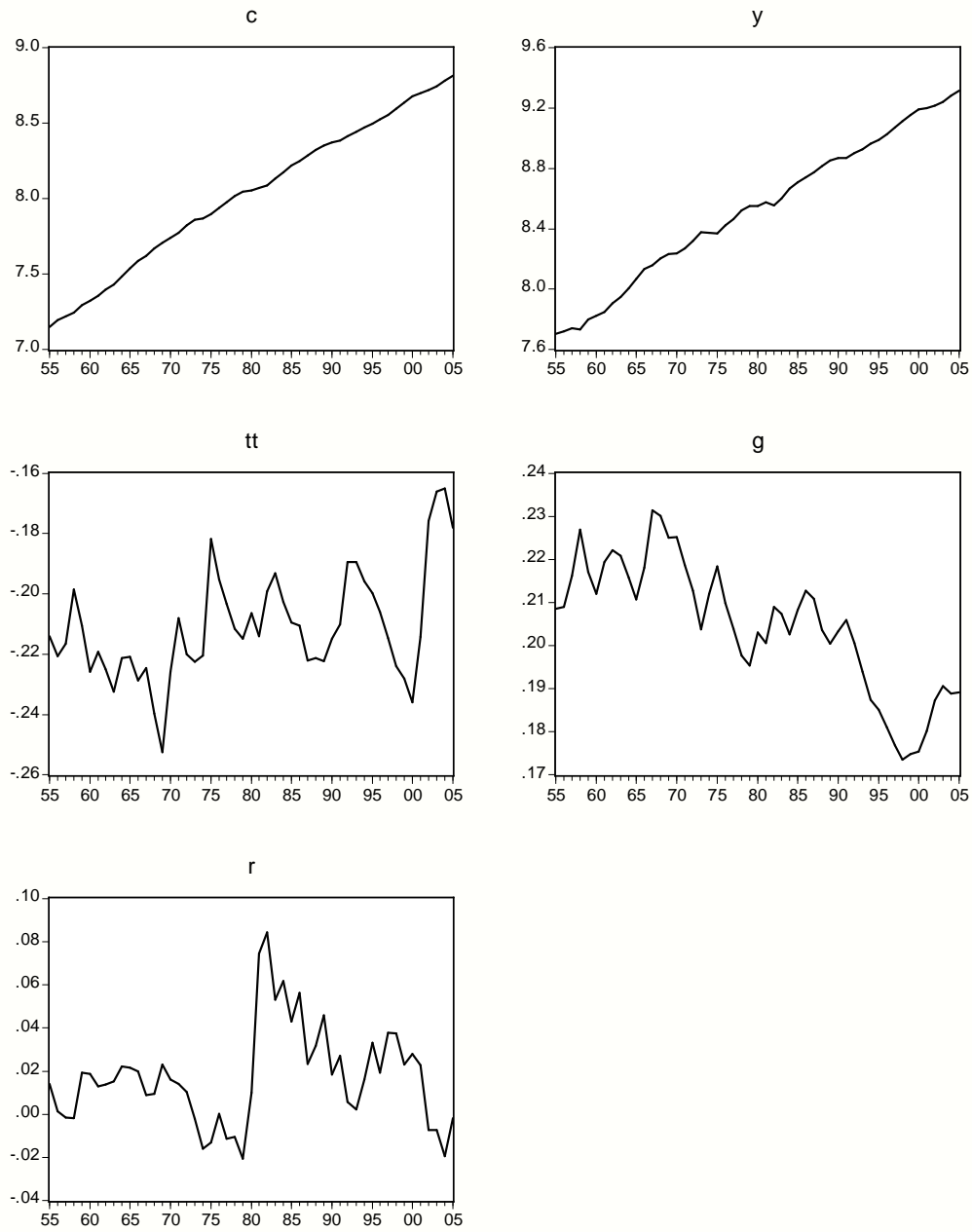
One and two asterisks denote that the coefficient is different from zero at 5 and 1 percent significance level, respectively.

Table 4. United States: Estimates of Restricted Model with Impatient Consumers (Eq. 9)

<i>Sample: 1955-2005</i>	
Consumption equation	
α^c	.04 (.01) **
ξ^g	.01 (.05)
ξ^r	-.05 (.02) *
λ	.02 (.00) **
R^2	.72
DW	1.96
Interest rate equation	
α^r	.00 (.00)
θ^r	-.26 (.09) **
R^2	.13
DW	1.80
Income equation	
α^y	.12 (.03) **
θ^y	-.01 (.00) **
R^2	.09
DW	1.70
Net tax rate equation	
α^t	-.02 (.02)
φ	.34 (.07) **
θ^t	-.13 (.08)
R^2	.39
DW	1.84
Government spending equation	
α^g	.04 (.02) *
ζ^g	-.00 (.00)
θ^t	-.18 (.07) **
R^2	.11
DW	1.43
Implied Coefficients	
β^y	0.40
β^t	-0.12
β^g	-0.08
β^r	-0.16

Notes: See Table 3. Restrictions on implied coefficients are provided in equation (13)

Figure 1. United States: The Data, 1955-2005



Source: NIPA and IMF staff estimates.

Figure 2. United States: Validity of Model Restrictions over Time

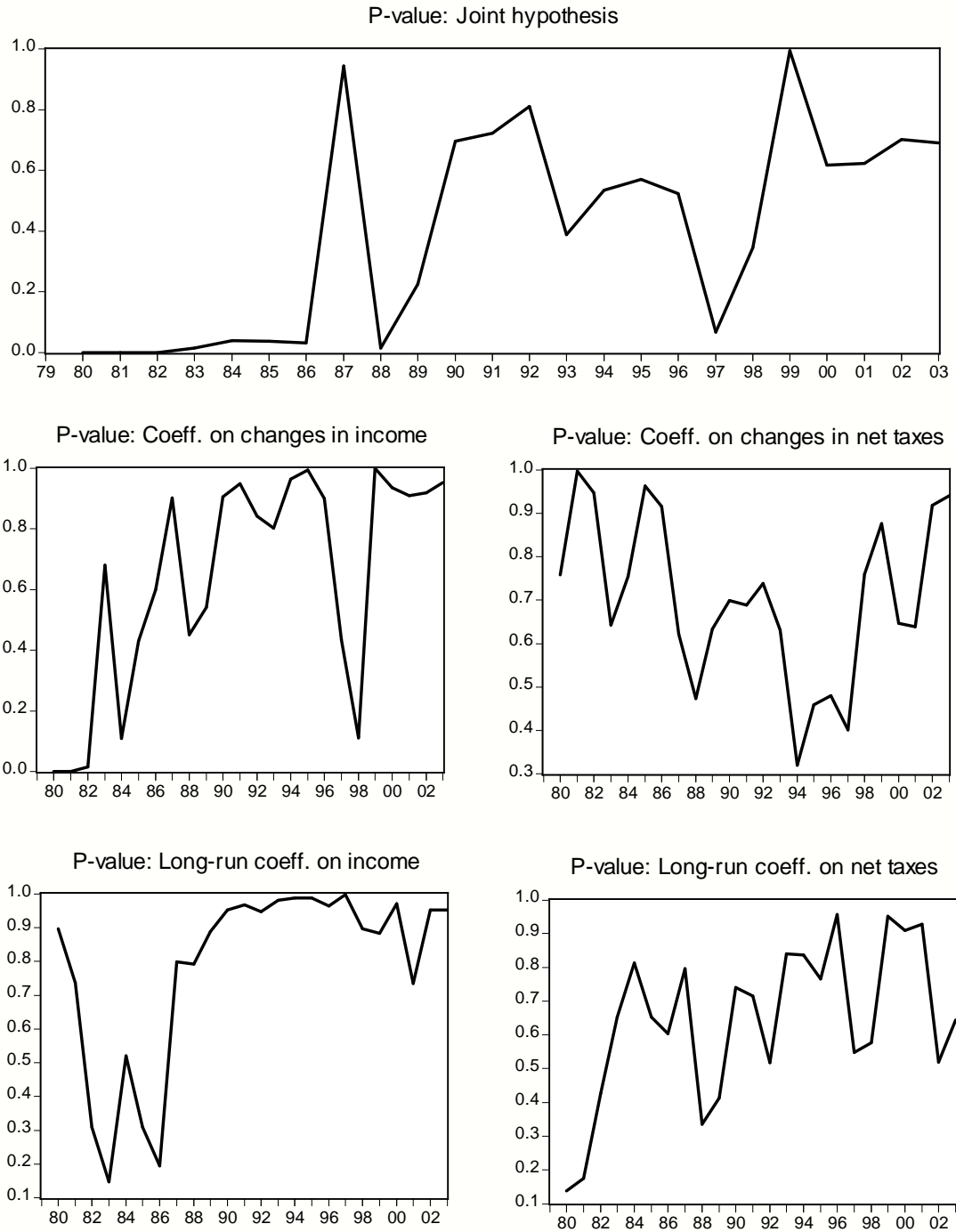


Figure 3. United States: Time Variation in the Discount Wedge

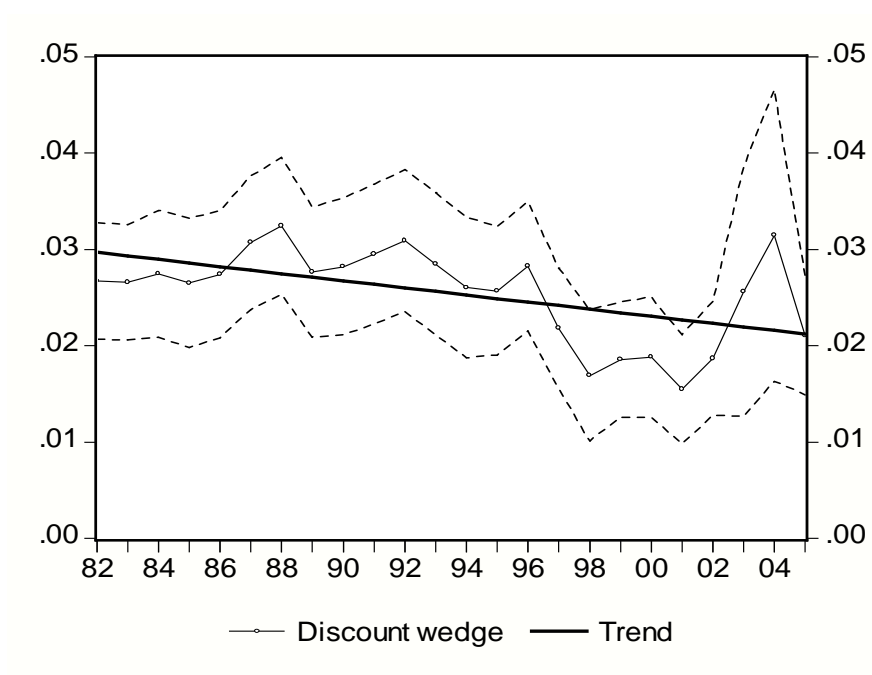


Figure 4. United States: Time Variation in Persistence of Income/Policy Shocks

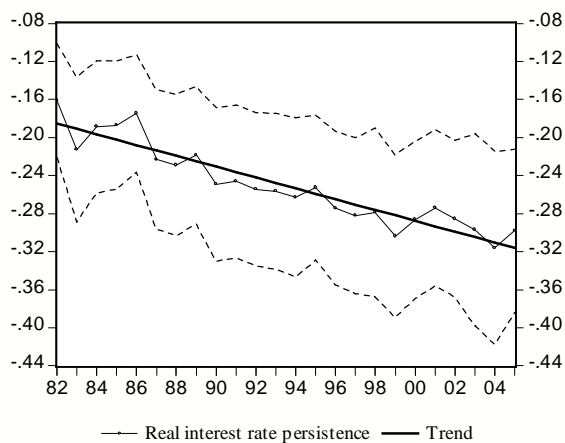
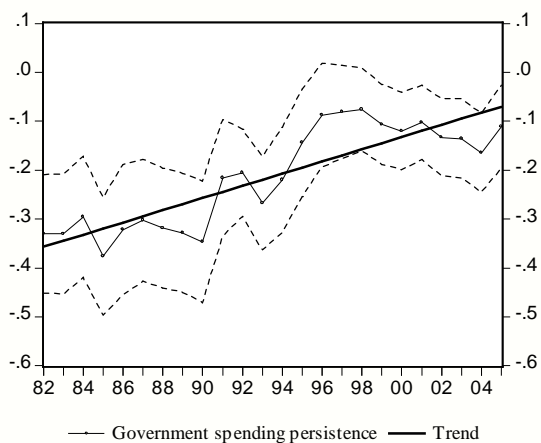
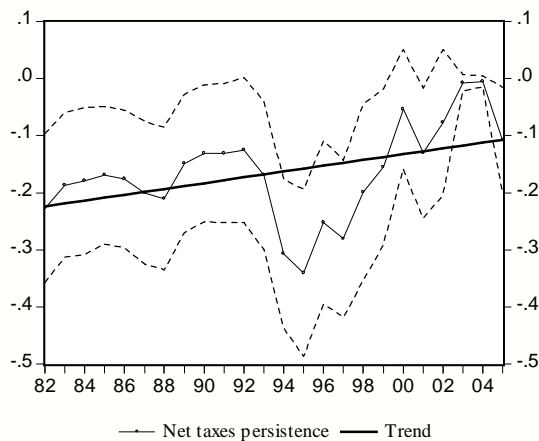
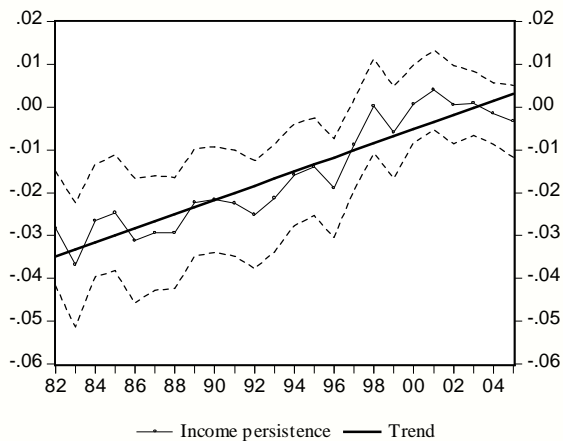


Figure 5. United States: Time Variation in Income/Policy Multipliers

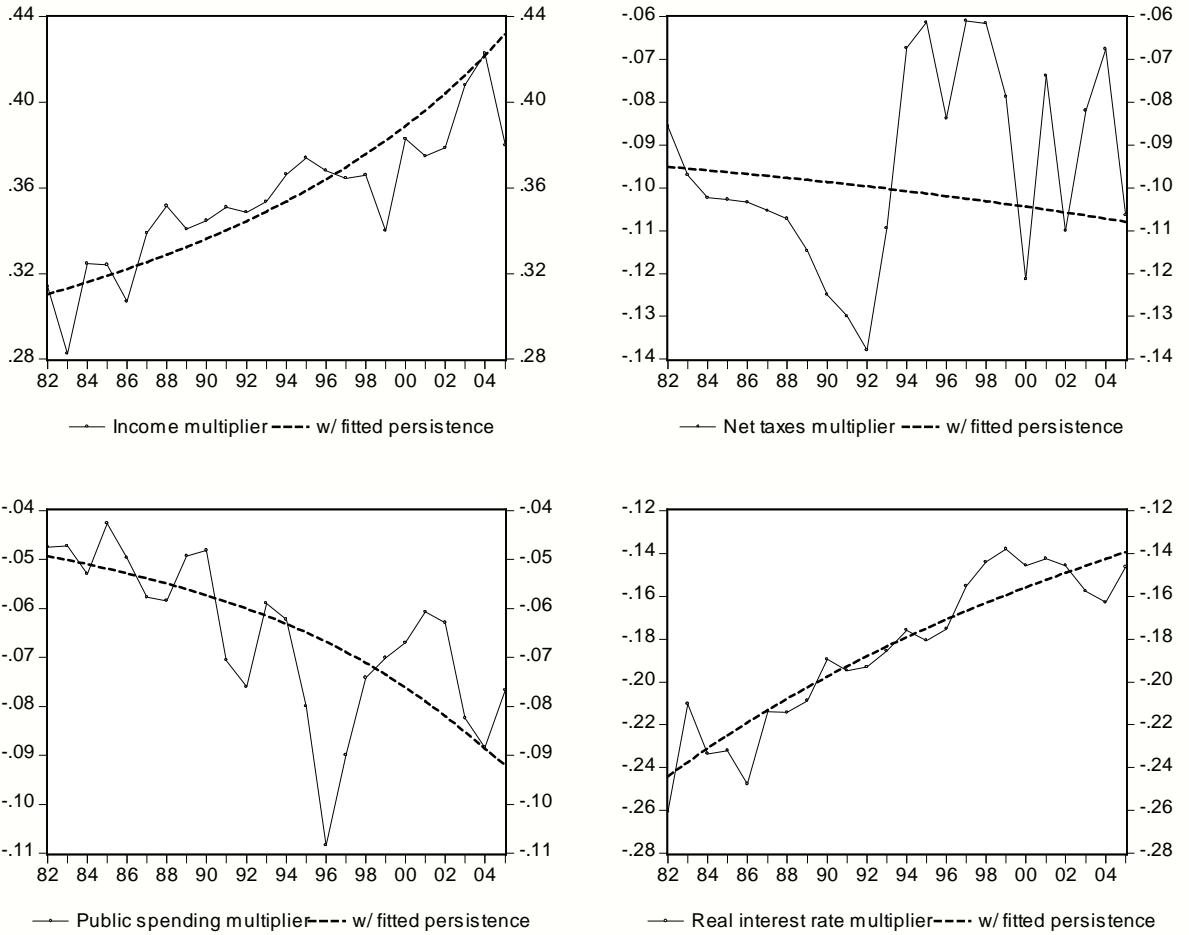
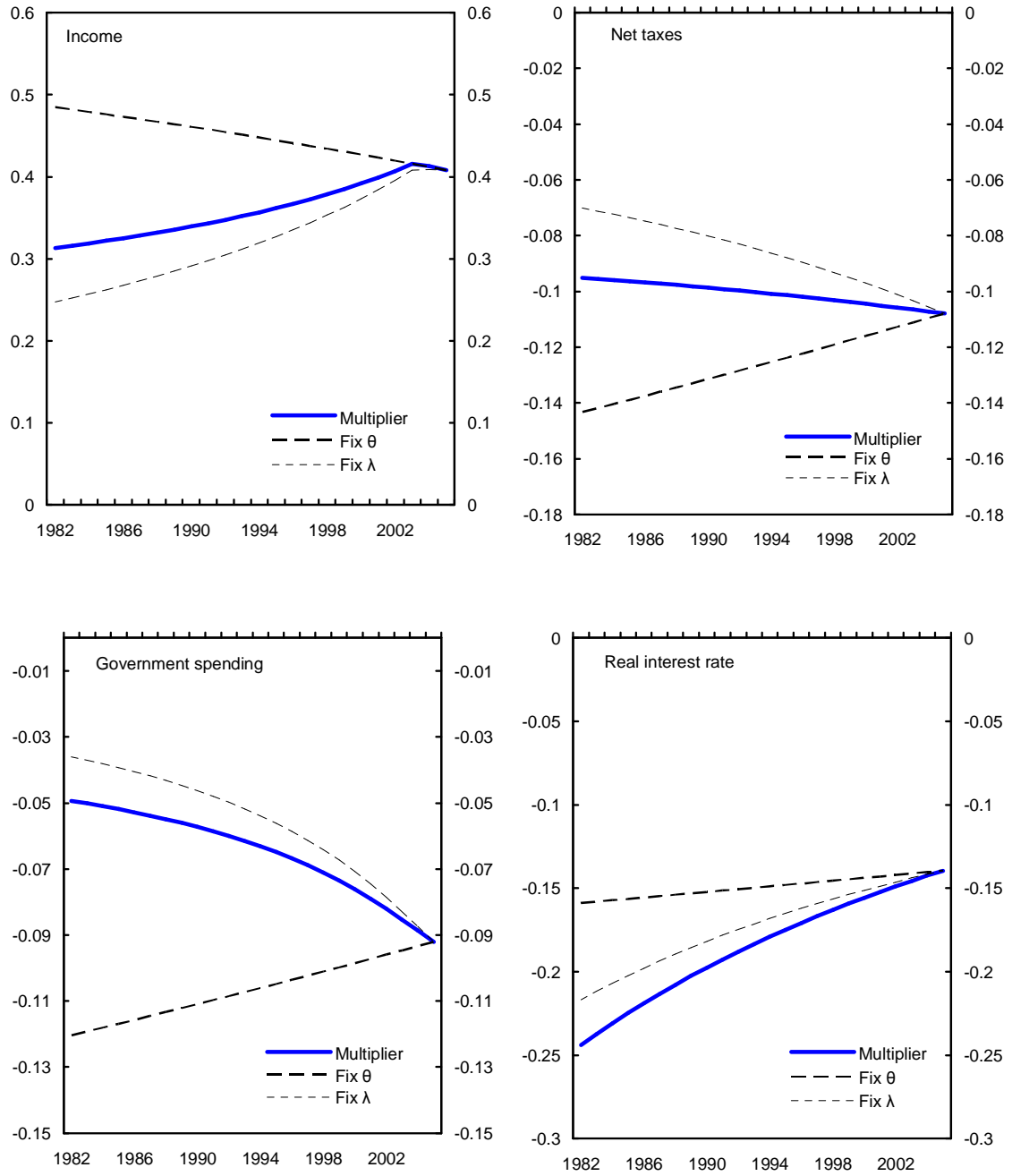


Figure 6. United States: Counterfactual Analysis



Source: NIPA and authors' calculations

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