The Wealth Effect in Empirical Life-Cycle Aggregate Consumption Equations

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This article presents an empirical model of U.S. consumer spending that relates consumption to labor income and household wealth. This specification is consistent with the life-cycle hypothesis of saving first popularized in the 1960s by Ando, Modigliani, and their cohorts.[1] My analysis here extends the previous research in several directions. First, I examine the dynamic relationship between consumption, income, and wealth using cointegration and error correction methodology. In previous research, the traditional life-cycle model has often been examined using either levels or first differences of these variables. While the use of differences does avoid the pitfall of spurious correlation due to common trending series, it tends to lead to the omission of the long-run equilibrium (cointegrating) relationships that may exist among levels of these variables. In fact, Gali (1990) goes so far as to present a theoretical life-cycle model that generates a common trend in aggregate consumption, labor income, and wealth. Therefore, my empirical work here tests for the presence of a long-run equilibrium (cointegrating) relationship between the level of aggregate consumer spending and its economic determinants such as labor income and wealth. I then examine the short-run dynamic relationship among these variables using an error correction specification proposed in Davidson et al. (1978).

The present article investigates whether wealth has predictive content for future consumption. If it does, then changes in wealth may lead to changes in

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[1] See, for example, Ando and Modigliani (1963) and Modigliani and Brumberg (1979).

consumer spending.[2] I also examine whether consumer spending is sensitive to stock market wealth. The 1990s saw an enormous increase in household wealth generated by the rising value of household stock holdings. This increase has generated considerable interest among policymakers in identifying the magnitude of the stock market wealth effect on consumption. For example, in his recent testimony before the U.S. Congress, Chairman Alan Greenspan has stated that wealth-induced consumption growth has partly been responsible for generating aggregate demand in excess of potential. The Chairman says that the wealth effect may have added on average 1 1/2 to 2 percentage points to annual growth rate of real GDP over the last few years.[3] The empirical work here addresses the wealth effect by considering aggregate consumption equations that relate consumption directly to equity wealth.

Poterba (2000) has suggested that the marginal propensity to consume out of wealth may have declined in the 1990s. According to Poterba, the main reason for this decline is the growing importance of equities in household wealth. Since the number of households holding equities is still lower than the number holding many other kinds of assets, and since a growing part of equity investments are held in tax-favored retirement accounts, the marginal propensity to consume out of equity wealth may be small. Furthermore, the marginal propensity to consume out of total wealth may appear to decline if the recent increase in household wealth reflects the growing importance of equities, as has been the case in the 1990s.[4] In order to see whether the relationship between consumption and wealth has changed during the 1990s, I estimate consumption equations over the full sample period 1959Q1 to 2000Q2 as well as two other subperiods ending in the early 1990s, 1959Q1 to 1990Q2 and 1959Q1 to 1995Q2.

The empirical results that are presented here show that aggregate consumer spending is cointegrated with labor income and wealth over the sample period 1959Q1 to 2000Q2, indicating the existence of a long-term equilibrium relationship between consumption and its economic determinants, such

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[2] The other recent work that has applied cointegration techniques to consumption equations is in Ludvigson and Steindel (1999).

[3] In his testimony Chairman Alan Greenspan notes: "For some time now, the growth of aggregate demand has exceeded the expansion of production potential. . . . A key element in this disparity has been the very rapid growth of consumption resulting from the effects on spending of the remarkable rise in household wealth. . . . Historical evidence suggests that perhaps three to four cents of every additional dollar of stock market wealth eventually is reflected in increased consumer purchases. . . . [D]omestic demand growth, influenced importantly by the wealth effect on consumer spending, has been running 1-1/2 to 2 percentage points at an annual rate in excess of even the higher, productivity-driven growth in potential supply since late 1997." (Greenspan 2000a, p. 2; Greenspan 2000b, pp. 1–4).

[4] The other suggested factor that could contribute to a lower marginal propensity to consume out of wealth is the falling cost of leaving bequests. Poterba (2000) points out that estate tax reform has been a very active topic of congressional debate in recent years, with numerous proposals calling for elimination of the "death tax." These tax changes raise the attractiveness of leaving bequests, inducing households with high net worth to reduce their current marginal propensity to consume out of wealth.

as income and wealth. The coefficients that appear on income and wealth variables in the estimated cointegrating regression are statistically significant and measure the long-term responses of consumption to income and wealth. The results thus indicate wealth has a significant effect on consumption.

In the short-term consumption equations estimated here, the error correction variable appears with an expected negatively signed coefficient and is statistically significant, indicating the presence of lags in the response of consumption to income and wealth. This result also shows that wealth has predictive content for future consumption. Hence we may conclude that a persistent decline in equity wealth can lead to lower consumer spending.

My results do indicate that the long-term marginal propensity to consume out of wealth declined somewhat during the 1990s, as suggested in Poterba (2000). However, point estimates of the long-term marginal propensity to consume out of wealth have remained in a narrow range of 0.03 to 0.04, indicating a $1 increase in equity values raises consumption by 3 to 4 cents. The long-term marginal propensity to consume out of equity wealth is small, but even with such relatively low estimates of the marginal propensity to consume out of wealth, the consumption effect of the 1990s stock market boom is substantial. Estimates that I derived using the aggregate consumption equation indicate that the equity wealth effect may have added on average about 1 percentage point to the annual growth rate of real GDP over 1995 to 1999, as noted in Greenspan's testimony (2000a, p. 2).

During 2000, household equity wealth declined about 18 percent, after rising at an average annual rate of 18 percent per year during the preceding five-year period (1995–1999). The consumption equations estimated here indicate that the decline in equity wealth is likely to depress consumer spending. Hence, the growth rate of consumer spending in the near term is likely to fall below the robust 4 percent yearly growth rate observed during the preceding five-year period.

1. THE MODEL AND THE METHOD

An Aggregate Consumption Function

The aggregate consumption function studied is given in (1a).

$$\tilde{C}_t = a_0 + a_1 Y_t + a_2 Y^e_{t+k} + a_3 W_t, \tag{1a}$$

where $\tilde{C}_t$ is current planned consumption, Y_t is actual current-period labor income, W_t is actual current-period wealth, and Y^e_{t+k} is average anticipated future labor income over the earning span (k) of the working age population. Equation (1a) simply states that aggregate planned consumption depends upon the anticipated value of lifetime resources, which equals current and anticipated future labor income and current value of financial assets. This consumption function can be derived from the well-known life-cycle hypothesis of saving popularized by Ando and Modigliani (1963). Their analysis begins at the level of an individual consumer, whose utility depends upon his or her own consumption in current and future periods. The individual is then assumed to maximize his or her utility subject to available resources, these resources being the sum of current and discounted future earnings over the individual's lifetime. As a result of this maximization, the current consumption of the individual can be expressed as a function of his or her resources and the rate of return on capital with parameters depending upon his or her age. The individual consumption functions are then aggregated to arrive at a consumption function that is linear in income and wealth variables, as in (1a). More recently, Gali (1990) has shown that this type of aggregate consumption function can also be derived from the dynamic optimizing behavior of consumers with finite horizons and life-cycle savings. His model[5] goes one step further in establishing the presence of a common upward trend in aggregate consumption, labor income, and nonhuman wealth.

The consumption function in (1a) identifies income and wealth as the main economic determinants of aggregate, planned consumption. However, actual consumer spending in a given time period may not equal planned spending for a number of reasons. The first is the presence of adjustment costs. For example, individuals may not be able to adjust within each period their spending on housing services, given large searching, moving, and finance costs. Also, if there is considerable habit persistence in consumption behavior, then individuals may adjust their spending slowly to bring it in line with the level suggested by the economic determinants in (1a). Another reason may be the presence of liquidity-constrained individuals, who cannot smooth their consumption by borrowing against their future income due to capital market restrictions. For these individuals, actual consumer spending may be more closely tied to current labor income than is suggested by equation (1a) (Campbell and Mankiw 1989).

Given these considerations, I estimate the consumption function allowing adjustment lags in consumer spending. In particular, I postulate that actual consumer spending adjusts to the planned level with the following error correction dynamic specification (Davidson et al. 1978).

$$\Delta C_t = b_0 - b_1(C_{t-1} - \tilde{C}_{t-1}) + b_2 \Delta \tilde{C}_t + \sum_{s=1}^{k} b_{3s} \Delta C_{t-s} + \mu_t \qquad (2)$$

where C_t is actual consumer spending, μ is a disturbance term, and other variables are defined as before. In this specification, changes in current period

[5] The life-cycle model of aggregate consumption and savings in Gali (1990) is a discrete-time, quadratic-utility, open-economy version of the overlapping generations framework.

consumption depend upon changes in current period planned consumption, the gap between the last period's actual and planned consumption, and lagged actual consumption. The disturbance term μ in (2) captures the short-run influences of unanticipated shocks to actual consumer spending. The magnitude of the coefficient b_1 measures how rapidly consumers close the gap between their actual and planned consumption within each period. The larger the magnitude of b_1 (in absolute), the more rapid the adjustment. If we substitute (1b) into (2), we get the short-term dynamic consumption equation (3):

$$\begin{aligned}\Delta C_t &= b_0 - b_1(C_{t-1} - a_0 - a_1 Y_{t-1} - a_2 Y^e_{t+k-1} - a_3 W_{t-1}) \\ &\quad + b_2(a_1 \Delta Y_t + a_2 \Delta Y^e_{t+k} + a_3 \Delta W_t) + \sum_{s=1}^{k} b_{3s} \Delta C_{t-s} + \mu_t \qquad (3)\end{aligned}$$

The key feature of equation (3) is that consumption depends upon levels and first differences of the determinants of planned consumption, namely labor income and wealth.

Estimation Issues and Data Properties

The empirical estimation of equation (1a) or (3) raises several issues. One issue is that expected future labor income is not directly observable. As a result of the presence of information lags, even current-period income and wealth may not be observable (Goodfriend 1986). The simple procedure I follow here is to assume that expected future labor income is proportional to expected current labor income, meaning current and expected future income move together (Ando and Modigliani 1965). Furthermore, I also assume that current-period values of income and wealth are unknown and that planned consumption therefore depends upon their anticipated values. It is assumed that consumers form expectations about their current-period income and wealth by taking into account information known to them in period $t-1$, i.e., expectations of income and wealth are rational. Under these assumptions, one may have:

$$C_t = d_0 + d_1 Y^e_t + d_2 Y^e_{t+k} + d_3 W^e_t \qquad (1b)$$

$$Y^e_{t+k} = \beta Y^e_t;\ \beta > 0; \qquad (4)$$

$$Y_t = Y^e_t + \varepsilon_{1t} = E(Y_t/I_{t-1}) + \varepsilon_{1t} \qquad (5a)$$

$$W_t = W^e_t + \varepsilon_{2t} = E(W_t/I_{t-1}) + \varepsilon_{2t} \qquad (5b)$$

where Y_t^e is anticipated current-period labor income, W_t^e is anticipated current-period wealth, E is the expectations operator, I_{t-1} is the information set used in forming expectations of current-period income and wealth, and ε_1 and ε_2 are forecast errors assumed to be uncorrelated with time $t-1$ information. Equation (1b) is similar to equation (1a) except that it makes aggregate planned consumption depend upon anticipated current and future income and wealth variables. Equation (4) states the simplifying assumption that expected future income is proportional to current-period income. Equation (5) relates actual current-period income and wealth variables to their forecasts based on past information summarized in I_{t-1}.

If we substitute (4), (5), and (1b) into (2), we get (6), which is a short-term consumption equation containing current and lagged income and wealth variables.

$$\begin{aligned}\Delta C_t &= b_0 - b_1(C_{t-1} - d_0 - (d_1 + d_2\beta)Y_{t-1} - d_3 W_{t-1}) \\ &\quad + b_2((d_1 + d_2\beta)\Delta Y_t + d_3\Delta W_t) + \sum_{s=1}^{k} b_{3s}\Delta C_{t-s} + v_t \qquad (6)\end{aligned}$$

where

$$\begin{aligned}v_t &= u_t - b_2(d_1 + d_2\beta)\varepsilon_{1t} - b_2 d_3\varepsilon_{2t} + (b_2 - b_1)(d_1 + d_2\beta)\varepsilon_{1t-1} \\ &\quad + (b_2 - b_1)d_3\varepsilon_{2t-1}.\end{aligned}$$

Short-term consumption equation (6) is similar to (3) in that it contains the levels as well as first differences of income and wealth variables. However, it differs in that the disturbance term v is now serially correlated. As can be seen, the disturbance term v_t in (6) is a linear combination of current and past values of three disturbance terms μ, ε_1, and ε_2. It can be verified that v_t is serially correlated, even if μ, ε_1, and ε_2 are not. In fact, v_t has first-order moving average serial correlation under the maintained assumption that the disturbance term μ and forecast errors ε_1 and ε_2 are not serially correlated.

Ordinary least squares are likely to provide biased estimates of the coefficients of the short-term consumption equation (6) because the disturbance term v_t is correlated with current-period income and wealth variables.[6] However, it can be verified that v_t is not correlated with period $t-2$ information used by consumers to forecast current-period income and wealth variables, as in (7):

[6] This correlation arises because the composite error term v_t consists of forecast errors ε_1 and ε_2, which are correlated with current-period income and wealth variables as indicated in equations (5a) and (5b).

$$E(v_t/I_{t-2}) = 0. \tag{7}$$

That suggests equation (6) can be estimated by instrumental variables, using variables in the information set I_{t-2} as instruments.[7] In particular, I estimate equation (6), using Hansen's (1982) generalized method of moments estimator (GMM). Under the identifying assumptions in (7), this procedure produces efficient instrumental variables estimates. Furthermore, the procedure generates a test of identifying restrictions used in estimating the consumption equation.[8]

Another key feature of short-term consumption equation (6) is that it contains lagged levels of consumption, income, and wealth variables, along with their first differences. If these variables have unit roots, then estimation of (6) would not yield consistent estimates of income and wealth parameters unless consumption were cointegrated with income and wealth variables (Engle and Granger 1987). I therefore examine the stochastic properties of data, investigating in particular whether there exists a cointegrating (equilibrium) relationship between consumption and its determinants, such as income and wealth.[9]

The investigation of the presence of a cointegrating relationship between consumption, labor income, and wealth is of interest for another reason. Namely, aggregate consumption equations in this article are estimated under the assumption that expected future labor income is proportional to current-period labor income. This assumption implies that expected future labor income will share the trend in current-period labor income. In the short run, however, expected future income may deviate from current. The presence of those short-term deviations implies the disturbance term that contains the omitted variable, namely expected future income, will be correlated with current income and wealth variables included in these regressions. This complication, however, has no effect on long-term estimates of income and wealth elasticities

[7] The extra lag in the instruments also helps meet several other potential objections. First, Goodfriend (1986) has noted that aggregate variables are not in individuals' information sets contemporaneously because of delays in government publication of aggregate statistics. Since such delays are typically no more than a few months, lagging instruments an extra quarter largely avoids this problem. Second, it has been suggested that those goods labeled as nondurable in the National Income Accounts are in fact durable. Durability would introduce a first order moving average term into the change in consumer expenditure (Mankiw 1982); this would not affect the procedure in the present article that uses twice-lagged instruments.

[8] The GMM procedure generates estimates of the coefficients under the identifying restrictions given in equation (7) and is thus more efficient than the standard instrumental variables procedure. It also yields a test of the identifying restrictions, enabling one to test the model adequacy.

[9] The traditional life-cycle model in Ando and Modigliani (1965) simply implies that aggregate consumption is linearly related to labor income and wealth. It says nothing about the cointegration properties of these variables. In contrast, the theoretical life-cycle model in Gali (1990) implies that consumption, income, and wealth variables may share a common trend. But whether this theoretical implication is consistent with actual data still needs to be tested, so one must test for the presence of cointegration.

that are derived using consumption equations involving cointegrated variables. The intuition behind this result is that if consumption is cointegrated with current income and wealth variables, then the residuals will be stationary and hence will have no effect on estimates of coefficients that capture correlation among trending variables. For that reason, aggregate consumption equations estimated using only current-period trending labor income and wealth variables would provide consistent estimates of long-term coefficients.[10]

Definition and Measurement of Variables

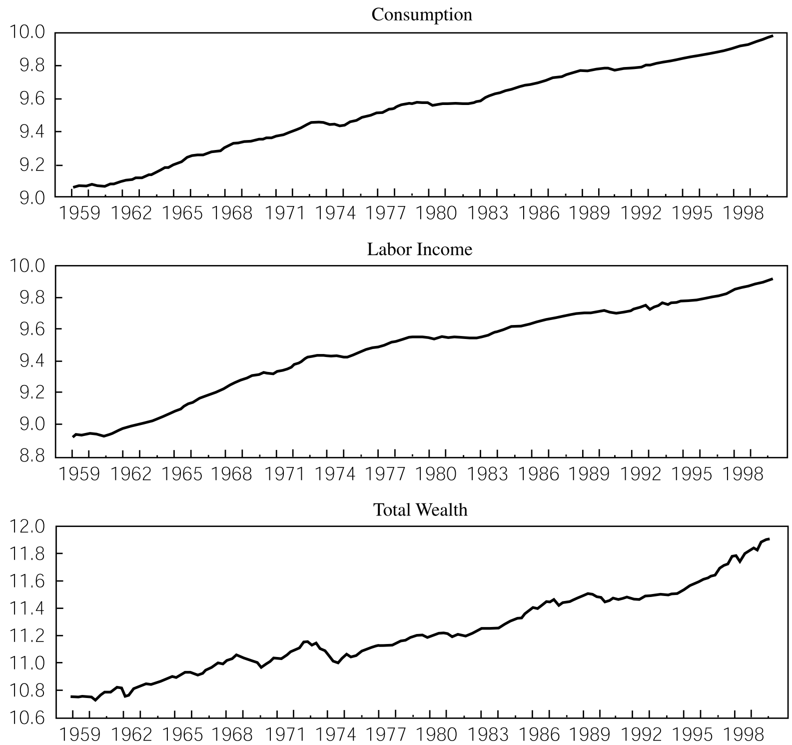
The aggregate consumption equations (1a) and (6) relate consumption to labor income and wealth. Following Ando and Modigliani (1965), I identify the income effect on consumption by including labor income (net of taxes) and identify the wealth effect by including net worth of households in the aggregate consumption function. In these specifications, wealth affects consumption directly through its market value, which provides a source of purchasing power used to iron out fluctuations in income arising from transitory developments as well as from the normal life cycle.

In order to estimate the effect of the recent stock market boom on consumption, I also consider the specification that relates consumption directly to equity wealth. As is now widely known, most of the recent increase in household wealth has been associated with the recent explosion in equity values, which are held by fewer households than many other assets. Consequently, the marginal propensity to consume out of stock market wealth may be smaller than that to consume out of total wealth.

The consumption variable implicit in standard theories of consumer behavior used to derive equation (1a) is measured as a flow rather than a stock. Expenditures on durable consumer goods are not included in the measure of consumption because they represent additions and replacements to the asset stock, whose short-term dynamics may be quite different. Hence, consumption equations have generally been estimated with consumption measured either as household spending on nondurable goods and services alone or on that item plus the (imputed) flow from the stock of durable consumer goods. Both approaches should yield similar qualitative inferences about the underlying determinants of consumption, and I have chosen to follow the first approach. However, since there is considerable interest in identifying the effect of recent stock market wealth on *actual* total consumer spending, I also estimate consumption equations with consumption measured as total consumer spending, including expenditures on durable consumer goods. I estimate only the long-term consumption equations, though, because identifying assumptions made

[10] This will not necessarily hold for short-term consumption equations.

Figure 1 Time Series: Real, Per Capita, and in Logs



here to estimate short-term consumption equations may not be valid if the measure of consumption used includes expenditures on the stock of durable goods.[11]

To estimate consumption equations, I use standard, U.S. quarterly time series data over 1959Q1 to 2000Q2. Consumption is measured as per capita consumption of nondurables and services, in 1996 dollars (rC).[12] Labor income is measured as disposable labor income per capita, in 1996 dollars ($rDLY$). Total wealth is per capita net worth of households, in 1996 dollars

[11] If consumption includes durable goods, then the disturbance term in short-term consumption equations may follow a more complicated serial correlation pattern than the one assumed in equation (6) of the text. This has no effect, however, on estimates of the long-term consumption equations that involve trending variables. Mankiw (1982) explores some other implications of including durable goods in consumption.

[12] The consumption series is scaled up so that its sample mean matches the sample mean of total consumption. This adjustment matters if one wants to predict the level of consumer spending using consumption equations that involve measures of total labor income and wealth.

(rNW). Household stock market wealth is measured as per capita corporate equities held by them, in 1996 dollars (rEQ).[13]

Accordingly, the aggregate consumption equations investigated take the following forms.

$$rC_t = r\tilde{C} + \varepsilon_t = f_0 + f_1 rDLY_t + f_2 rNW_t + \varepsilon_t \tag{8a}$$

$$\begin{aligned} \Delta rC_t &= g_0 - \lambda(rC_{t-1} - f_0 - f_1 rDLY_{t-1} - f_2 rNW_{t-1}) \\ &\quad + g_1 \Delta rDLY_t + g_2 \Delta rNW_t + \sum_{s=1}^{k} g_{3s} \Delta rC_{t-s} + v_t \end{aligned} \tag{8b}$$

$$rC_t = r\tilde{C} + \varepsilon_t = f_0 + f_1 rDLY_t + f_{21} rEQ_t + f_{22} rNWO_t + \varepsilon_t \tag{9a}$$

$$\begin{aligned} \Delta rC_t &= g_0 - \lambda(rC_{t-1} - f_0 - f_1 rDLY_{t-1} - f_{21} rEQ_{t-1} \\ &\quad - f_{22} rNWO_{t-1}) + g_1 \Delta rDLY_t + g_{21} \Delta rEQ_t \\ &\quad + g_{22} \Delta rNWO_t + \sum_{s=1}^{k} g_{3s} \Delta rC_{t-s} + v_t \end{aligned} \tag{9b}$$

where NWO is nonequity net worth and other variables are defined as before. Equations (8a) and (9a) are the long-term consumption equations that relate the level of actual consumer spending to determinants of the level of planned consumer spending. Equation (8a) relates consumption to labor income and total wealth. Equation (9a) is similar to (8a) except that total wealth is decomposed into equity and nonequity components. The estimated coefficients that appear on $rDLY$, rNW, rEQ, and $rNWO$ in (8a) and (9a) measure long-run marginal propensities to consume out of income and wealth variables. Equations (8b) and (9b) are the short-term consumption equations that relate changes in actual consumer spending to changes in income and

[13] As indicated above, consumption is measured either as total personal consumption expenditure or as expenditure on nondurable goods and services. Labor income is defined as wages and salaries + transfer payments + other labor income − personal contributions for social insurance − taxes. Taxes are defined as [wages and salaries/ (wages and salaries + proprietors' income + rental income + personal dividends + personal interest income)] personal tax and non-tax payments. Total wealth is measured by household net worth, and stock market wealth by direct household holdings of corporate equity. The quarterly data on income and consumption are from the Department of Commerce, Bureau of Economic Analysis, and the data on household net worth and corporate equities are from DRI. The latter are based on flow of funds data. The wealth component of net worth includes direct household corporate holdings, mutual funds holdings, holdings of private and public pension plans, personal trusts, insurance companies, and other nonfinancial assets. Household equity wealth is, however, direct holdings of corporate equity. The nominal labor income is deflated using the deflator for personal disposable income, and nominal wealth variables using the deflator for personal consumption expenditure.

wealth variables, allowing for the presence of lags in the adjustment of actual consumption to planned consumption.

The consumption equations discussed above are linear in levels of variables. The coefficients that appear in these equations measure the effects on consumption of a dollar increase in income and wealth variables. This specification is appropriate if these series—consumption, income, and wealth—follow homoscedastic linear processes in levels, with or without unit roots. However, aggregate time-series data on these variables appear to be closer to linear in logs of variables than levels. This can be seen in Figure 1, which charts time series for logs of real (per capita) consumption, labor income, and total wealth. In view of the apparent superiority of log modification, the consumption equations here are estimated using logs of variables, so that estimated coefficients are elasticities. The implied level responses are then backed out using the consumption-income and consumption-wealth ratios evaluated at their sample mean values. (Hereafter, lowercase letters denote log variables.)[14]

2. EMPIRICAL RESULTS

Unit Roots Test Results

Figure 1 clearly indicates that the time series for (the logs of) consumption, labor income, and wealth are nonstationary. In order to test whether these variables are stationary around a linear trend or have stochastic trends, I perform tests for the presence of unit roots. Since unit-root tests are sensitive to the presence of a linear trend, I first investigate whether these series possess a linear trend at all. The presence of a linear trend is investigated by running the following regression,

$$\Delta x_t = c_0 + \sum_{s=1}^{k} c_{1s} \Delta x_{t-s} + \eta_t, \tag{10}$$

where x stands for the pertinent variable. The variable x has a linear trend if the t-statistic for the coefficient that appears on the constant in (10) is large. Panel A in Table 1 presents t-statistics for rc, $rdly$, rnw, req, and $rnwo$. The lag length k is chosen by the Akaike (1973) information criterion (AIC). Those test results indicate that the real consumer spending, labor income, and nonequity net worth (rc, $rdly$, $rnwo$) have a linear trend, whereas other remaining variables do not. The results further indicate that unit root tests

[14] Campbell and Mankiw (1990) and Ludvigson and Steindel (1999) also estimate aggregate time-series consumption equations that are linear in logs of variables.

Table 1 Tests for Trend and Unit Roots

	Panel A	**Panel B**		
Series	t-statistic	Dickey-Fuller		Phillips-Perron
		Lag	t-test	Z_t
x	(1)	(2.1)	(2.2)	(3)
rc	3.8*	4	−2.6	−1.9
$rdly$	4.2*	1	−1.3	−1.2
rnw	0.8	0	−0.9	−1.3
req	−1.4	0	−0.5	−0.2
$rnwo$	1.7*	4	−2.6	−1.7
Δrc		4	−5.4*	−9.3*
$\Delta rdly$		0	−13.3*	−13.4*
Δrnw		0	−11.6*	−11.7*
Δreq		0	−11.8*	−11.8*
$\Delta rnwo$		0	−10.1*	−10.9*

* Indicates significance at the 5 percent level.

Notes: All variables are in their natural logarithms and on a per capita basis: rc is real consumer spending on nondurable goods and services; $rdly$ is real disposable labor income; rnw is real household net worth; req is real value of corporate equities held by households; $rnwo$ is real household net worth excluding corporate equities; and Δ is the first difference operator.

The t-statistic in column (1) tests the null hypothesis that the constant term is zero in a least-square regression of Δx on a constant, linear trend, and its own eight lagged values. If this t-value is large, then the series x has a linear trend. The t-test in column (2.2) is the standard augmented Dickey-Fuller test of a unit root. The optimal lag length used in performing the augmented Dickey-Fuller test is selected by the Akaike information criterion and is reported in column (2.1). The statistic Z_t in column (3) is the standard Phillips-Perron test of a unit root. The Phillips-Perron test reported allows for the presence of serial correlation and heterogeneity in the disturbance term. The unit root tests reported above allow for the presence of a linear trend in the pertinent series.

discussed below should be performed allowing for the presence of a linear trend, in at least some of these variables.

The presence of unit roots is investigated using Dickey-Fuller (DF) and Phillips-Perron (PP) tests.[15] The DF test is performed with the following regression.

$$x_t = d_0 + d_1 TR_t + d_3 x_{t-1} + \sum_{s=1}^{k} d_{4s} \Delta x_{t-s} + \eta_t \tag{11}$$

where TR is a linear trend. The variable x has a unit root if $d_3 = 1$ in (11). The DF t-statistic tests the hypothesis $d_3 - 1 = 0$. The DF test above relies on the

[15] See Dickey and Fuller (1979) and Phillips and Perron (1988).

Table 2 Residual Based Tests for Cointegration

Cointegrating Regression Regress rc on	Optimal Lag*	Dickey-Fuller t-test	Phillips-Ouliaris Z_t	Critical Values 5%	10%
$(C,\ TR,\ rdly,\ rnw)$	1	−3.34	−4.30	−4.16	−3.84
$(C,\ TR,\ rdly,\ req,\ rnwo)$	1	−4.37	−4.53	−4.49	−4.08

*Optimal lag is chosen using the Akaike (1973) information criterion.

Notes: All variables are defined as in Table 1. Dickey-Fuller and Phillips-Ouliaris test statistics are applied to the fitted residuals from the cointegrating regressions reported above in Table 2. The optimal lag length chosen in implementing the Dickey-Fuller test is selected by the Akaike information criterion. Eight lags are used in constructing the covariance matrix used to construct the Phillips-Perron test. Critical values reported above are from Tables IIb and IIc in Phillips and Ouliaris (1990).

assumption that the disturbance term is a finite order autoregressive process (AR). The PP test, however, does not rely on a finite order AR, but instead employs a correction for general order serial correlation and heteroskedasticity, based in part on the spectral representation of the disturbance sequence at frequency zero. The PP test statistic Z_t tests $d_3 - 1 = 0$, and it has the same limiting distribution as DF.

Panel B in Table 1 presents DF and PP tests for the presence of a unit root in variables rc, $rdly$, rnw, req, and $rnwo$. In the performance of the DF test, the lag k chosen by AIC is one. Eight autocovariance terms are used in the performance of the PP test.[16] As can be seen in Panel B of Table 1, the DF test results are consistent with the presence of a unit root, suggesting that these variables are not stationary around a linear trend. Panel B also presents DF and PP tests for the presence of a unit root in first differences of the same variables. Those test statistics indicate that first differences do not have a unit root, implying that these variables follow a first order integrated ($I(1)$) process. The unit-root test results thus suggest that we can carry tests for cointegration and thereby assess whether real consumer spending is cointegrated with its determinants, such as labor income and wealth.

Test Results for Cointegration

Table 2 reports test statistics corresponding to the Phillips-Ouliaris (1990) residual-based cointegration tests. I apply DF and PP unit root tests to the

[16] PP unit root tests using four autocovariance terms yield similar results.

Table 3 Dynamic OLS Estimates of the Aggregate Consumption Equation

Panel A: $rc_t = f_0 + f_1 rdly_t + f_2 rnw_t + f_3 TR_t$

	Elasticities		Implied Level Response Coefficients	
Sample Period	f_1	f_2	$rDLY$	rNW
1960Q2–2000Q2	0.51(32.1)	0.14(4.1)	0.62	0.03
1960Q2–1995Q2	0.49(24.9)	0.23(7.5)	0.60	0.04
1960Q2–1990Q2	0.48(20.0)	0.22(7.5)	0.57	0.04

Panel B: $rc_t = f_0 + f_1 rdly_t + f_{21} req_t + f_{22} rnwo_t + f_3 TR_t$

	Elasticities			Implied Level Response Coefficients		
Sample Period	f_1	f_{21}	f_{22}	$rDLY$	rEQ	$rNWO$
1960Q2–2000Q2	0.49(15.6)	0.02(4.1)	0.15(3.6)	0.59	0.03	0.03
1960Q2–1995Q2	0.43(14.7)	0.03(6.1)	0.21(7.1)	0.52	0.04	0.05
1960Q2–1990Q2	0.45 (15.1)	0.03(5.9)	0.12(1.4)	0.54	0.04	0.03

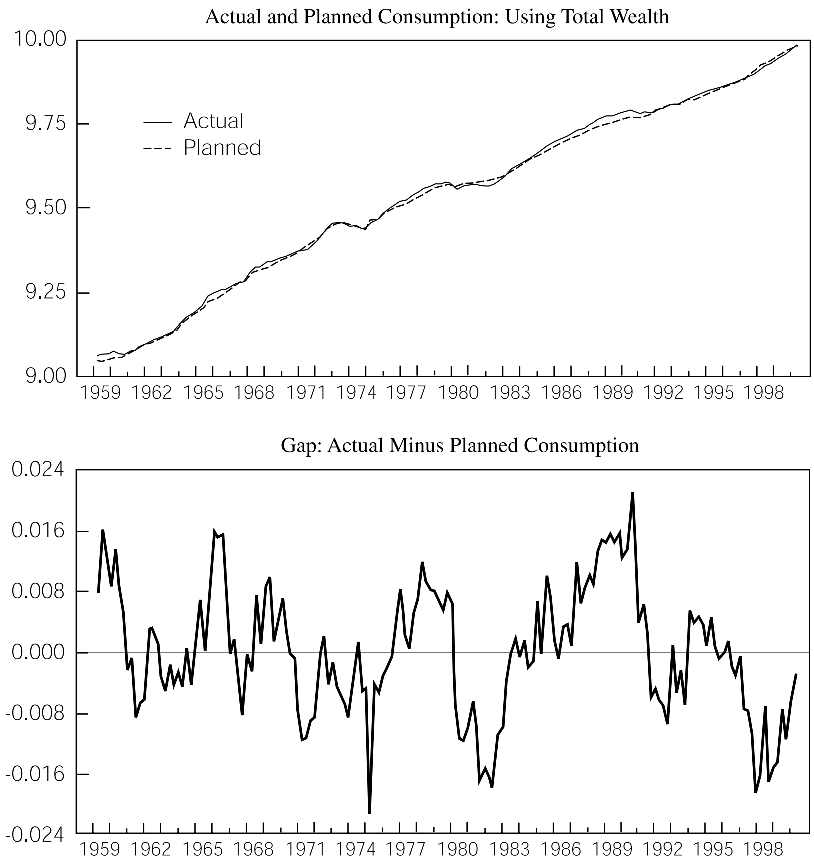
Notes: The coefficients with t-values in parentheses reported above are elasticities, estimated using dynamic ordinary least squares (Stock and Watson 1993). The t-values have been corrected for the presence of serial correlation. The consumption equations are estimated including four leads and lags of the first differences of right-hand-side explanatory variables $rdly$, rnw, req, and $rnwo$.

Implied level response coefficients are backed out by multiplying estimated elasticities with their relevant consumption-income or consumption-wealth ratios evaluated at their respective sample means. A level response coefficient measures the effect of a *dollar* increase in the relevant variable on consumption.

The uppercase variables are in levels and lowercase in their logs. All variables are defined as in Table 1.

residuals of long-term consumption equations (8a) and (9a). If real consumer spending is cointegrated with income and wealth variables, then the error term that appears in consumption equations is stationary, and one may reject the hypothesis of a unit root in ε_t. As the table shows, DF and PP tests generally reject the null hypothesis of unit root in ε_t, indicating that real consumer spending is cointegrated with labor income and wealth specified alternatively in (8a) and (9a). This is also shown in Figures 2 and 3, which chart actual consumption, the values predicted by the cointegrating regression (which are a measure of planned consumption), and the residuals from the cointegrating regression (which are a measure of the gap between actual and planned consumption). Figure 2 uses the aggregate consumption equation with total wealth and Figure 3 uses it with equity wealth (see Panels A and B, Table 3). As is evident in the figures, actual consumption moves with planned

Figure 2

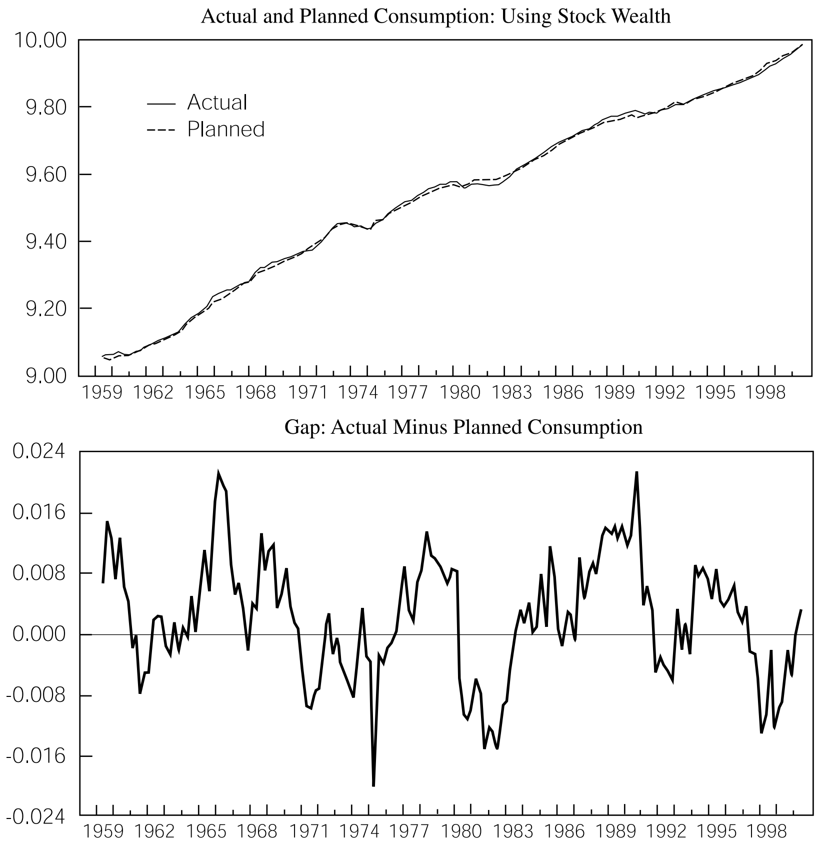


consumption over time and the gap between them is stationary during the sample period studied.

Long-term Consumption Equations: Marginal Propensities to Consume out of Income and Wealth

The cointegration test discussed above implies that consumption equations (8a) or (9a) with variables in log levels can provide reliable inferences about the long-term influences of income and wealth on consumption. These consumption equations can be estimated superconsistently by ordinary least squares, despite the fact that the expected future labor income variable is not explicitly included in these equations. However, statistical inferences cannot be carried out using the conventional standard errors since the resulting parameter esti-

Figure 3



mates have nonstandard distributions. I therefore estimate consumption equations here using Stock and Watson's (1993) dynamic ordinary least squares (DOLS), which includes leads and lags of the differences in the right-hand-side variables as additional regressors.[17] Table 3 presents the dynamic OLS estimates of the aggregate consumption equation; Panel A reports estimates for consumption equation (8a) and Panel B does so for consumption equation (9a). I present estimates for the full sample period 1960Q2 to 2000Q2 as well as for two other subperiods ending in the 1990s, 1960Q2 to 1990Q4 and 1960Q2 to 1995Q4.[18]

[17] The standard errors reported have been corrected for the presence of serial correlation and heteroskedasticity.

[18] The estimation period begins in 1960Q2, prior observations being used to allow for lagged values of income and wealth variables in consumption equations.

If we focus on full sample estimates, we can see that labor income and wealth variables have theoretically expected signs and are significant in estimated consumption equations. The point estimate of the long-term elasticity of consumption with respect to labor income is 0.51. The point estimate of the implied level response is 0.62, suggesting that the consumption effect of a dollar increase in labor income is about 62 cents.[19] The point estimate of the long-term elasticity of consumption with respect to total wealth is 0.14. The point estimate of the implied level response is 0.03, indicating that a $1 increase in wealth raises consumer spending by 3 cents. The estimates also show that the elasticity of consumption is substantially smaller with respect to equity wealth than with respect to nonequity wealth, 0.02 versus 0.15 (see estimates in Panel B, Table 3). The implied level responses, though, do not differ and both equal 0.03, indicating that a $1 increase in equity values raises consumer spending by 3 cents. These estimates of the marginal propensities to consume out of income and wealth variables are not out of line with estimates in some other recent studies. For example, in 1996 estimates from the FRB/US quarterly model placed the marginal propensity to consume at 0.03 for stock wealth and 0.075 for other net wealth (Brayton and Tinsley 1996).

Estimates for two other subperiods ending in the early 1990s suggest similar inferences about aggregate consumption behavior. Income and wealth variables remain significant in estimated consumption equations. The elasticity of consumption is smaller with respect to equity wealth than with respect to nonequity wealth, but the implied level responses are not very different from each other and did not change much during the 1990s. In particular, the point estimate of the marginal propensity to consume out of equity values is 0.04 for these two subperiods, close to 0.03 estimated using the full sample period.

Poterba (2000) has suggested that the marginal propensity to consume out of wealth may have declined in the 1990s. Much of the rise in total wealth reflects the growing importance of equities. And, since the marginal propensity to consume out of equity wealth is smaller than that for wealth as a whole, the rising share of equities in total wealth pulls down the overall marginal propensity to consume in the latter. The estimates here support Poterba's conjecture (see Table 3). The parameter that measures the elasticity of consumption with respect to total wealth does show a decline during the 1990s: its point estimate declines to 0.14 in 2000 from 0.22 in 1990. However, the parameter that measures the elasticity of consumption with respect to equity values did not decline much during that decade; its point estimate of 0.03 in 2000 is close to 0.04 in 1990. Together these estimates suggest that

[19] As shown in Gali (1990, p. 439), the presence of finite horizon and life cycle savings implies the marginal propensity to consume out of labor income will be less than one. However, in the absence of life-cycle savings as in an infinite-horizon consumption model, the marginal propensity to consume is unity. The exact magnitude of the income coefficient in a life-cycle model, however, depends upon, among other things, the age structure of population and the relative distribution of income and net worth over the different age groups (Ando and Modigliani 1965).

Table 4 GMM Estimates of the Short-term Aggregate Consumption Equation

Panel A: $\Delta rc_t = g_0 + \lambda(rc_{t-1} - \tilde{rc}_{t-1}) + g_1 \Delta rdly_t + g_2 \Delta rnw_t + \sum_{s=1}^{3} g_{3s} \Delta rc_{t-s}$
where $\tilde{rc}_t = f_0 + f_1 rdly_t + f_2 rnw_t + f_3 TR_t$

Sample Period	λ	g_1	g_2	$\sum_{s=1}^{3} g_{3s}$	SER	J-test(S)
1961Q2–2000Q2	−0.15	0.33	0.06	0.39	0.00390	29.4
	(4.5)	(4.4)	(1.7)	(4.7)		(0.49)
1961Q2–1995Q2	−0.24	0.30	0.08	0.41	0.00393	28.1
	(5.2)	(4.4)	(2.8)	(5.3)		(0.56)
1961Q2–1990Q2	−0.26	0.29	0.11	0.39	0.00405	23.1
	(5.3)	(4.6)	(3.7)	(4.8)		(0.81)

Panel B: $\Delta rc_t = g_0 + \lambda(rc_{t-1} - \tilde{rc}_{t-1}) + g_1 \Delta rdly_t + g_{21} \Delta req_t + g_{22} \Delta rnwo_t + \sum_{s=1}^{3} g_{3s} \Delta rc_{t-s}$
where $\tilde{rc}_t = f_0 + f_1 rdly_t + f_{21} req_t + f_{22} rnwo_t + f_3 TR_t$

Sample Period	λ	g_1	g_{21}	g_{22}	$\sum_{s=1}^{3} g_{3s}$	SER	J-test(S)
1961Q2–2000Q2	−0.17	0.32	0.01	0.10	0.33	0.00533	21.3
	(4.2)	(3.6)	(2.0)	(1.5)	(2.8)		(0.32)
1961Q2–1995Q2	−0.24	0.21	0.01	0.15	0.38	0.00413	19.7
	(5.1)	(2.9)	(2.0)	(2.1)	(3.6)		(0.41)
1961Q2–1990Q2	−0.26	0.26	0.01	0.10	0.39	0.00419	18.6
	(5.1)	(3.3)	(2.4)	(1.4)	(3.5)		(0.48)

Notes: The coefficients (with t-values in parentheses) reported above are GMM estimates of the short-term aggregate consumption equation. The instruments used consist of a constant, eight twice-lagged values of changes in real consumer spending Δrc_{t-2}, real disposable labor income $\Delta rdly_{t-2}$, real disposable property income, real household net worth ΔrNW_{t-2} (or its two components), and short-term nominal interest rate, and one twice-lagged value of the error correction variable $rc_{t-2} - \tilde{rc}_{t-2}$. SER is the standard error of the regression, and *J-test* (with Significance level in parentheses) is the test of overidentifying restrictions used in estimating the consumption equation and is distributed Chi-squared χ^2 (Hansen 1982).

most of the decline observed in the elasticity of consumption with respect to total wealth in the 1990s may just reflect the changing mix of wealth stocks during this decade.

Short-term Consumption Equations

Table 4 reports estimates of short-term consumption equations (8b) and (9b). Consumption equations are estimated for the full sample period as well as for two subperiods ending in the early 1990s. If we focus on full sample estimates, we can see that all estimated coefficients appear with theoretically expected signs and are statistically significant. In particular, the estimated coefficient that appears on the lagged value of the error correction variable is negative, indicating the presence of adjustment lags in consumer spending.[20] The estimated coefficients that appear on current period income and wealth variables are statistically significant, showing that consumer spending does respond to current period changes in income and wealth. The estimates also indicate that the short-term elasticity of consumption with respect to wealth differs across wealth stocks. The short-term elasticity is smaller with respect to changes in equity values than with respect to changes in total or nonequity net worth.

If we examine subperiod estimates, we reach similar conclusions about the nature of short-term consumption behavior. Income and wealth variables continue to be significant in estimated consumption equations (see Table 4). The point estimate of the short-term elasticity is substantially smaller with respect to changes in the market value of equities than with respect to changes in nonequity wealth. The estimates show too that short-term elasticities of consumption with respect to changes in wealth variables did not change much during the 1990s. In particular, the point-estimate of the short-term elasticity to consume out of current-period equity values remained around 0.01 during much of that decade.[21]

Quantifying the Stock Market Wealth Effect on Consumption

The empirical work in the above sections finds that the long-term marginal propensity to consume out of equity values appears to be quite small, with a $1 increase in the market value of corporate equities raising consumer spending only by 3 to 4 cents. However, the increase in household wealth generated by the recent explosion in equity values has been large. In order to quantify the effect of the recent stock market boom on consumer spending, I now derive estimates of consumption growth that could be attributed to increase in equity values. I focus on the 1990s and derive estimates of stock-market-induced consumption growth, using the following long-term consumption equation:

[20] The result that the error correction variable is significant in short-term consumption equations implies that past income, stock market wealth, and other wealth are useful in predicting current period changes in consumption. This finding is similar in nature to the one in Hall (1978), who finds past changes in stock prices are significant in predicting changes in current consumption.

[21] GMM estimation of short-term consumption equations use twice-lagged values of instruments. I get qualitatively similar results if instead one-period lagged instruments are used in estimation.

$$rc_t = f_0 + f_1 rdly_t + f_{21} req_t + f_{22} rnwo_t + \varepsilon_t.$$

In particular, estimates of equity-induced consumption growth over one-year horizons are calculated using the component $f_{21} \Delta req_t$. Since one is interested in quantifying the effect of stock market wealth on *actual* total consumer spending, the long-term consumption equation is re-estimated using total consumer spending, not just spending on nondurable goods and services. As indicated before, the definition of consumption used in the life-cycle hypothesis of saving should include consumption of the stock of consumer durable goods, not expenditures on their purchase.

I first present evidence in Table 5 indicating that long-term consumption equations estimated using total consumer spending provide reasonable estimates of long-term elasticities of consumption with respect to income and wealth variables. The test for cointegration continues to indicate the presence of an equilibrium relationship between consumer spending and its economic determinants, such as labor income and wealth (see Table 5). The estimates of long-term elasticities indicate that income and wealth variables have significant effects on real consumer spending. In particular, the point estimate of the long-term marginal propensity to consume out of equity values is small and has remained in a narrow 0.04 to 0.06 range in the 1990s. That estimated range is quite close to the range generated using consumer spending on nondurable goods and services.

Table 6 presents the quantitative estimate of wealth-induced consumption growth. It makes clear that the part of consumption growth that can be explained by a rise in equity values has not been trivial. Between 1990 and 1999, stock-market-induced consumption growth ranged from 0.6 to 2.1 percentage points per year. Over 1995 to 1999, real consumer spending increased at an average annual rate of about 4.0 percent per year, and the part that can be explained by stock market wealth averaged 1.5 percent per year. This wealth effect would represent an increment to the growth rate of real GDP of about 1 percentage point per year. The wealth effect is even stronger if we consider the effect on consumption of increase in total wealth, not just equity values. The estimates in Table 6 indicate that total wealth effect may have added to the growth rate of real GDP about 2 percentage points per year over 1995 to 1999. These calculations illustrate that even with relatively low estimates of the marginal propensity to consume out of stock market wealth, the consumption effect of the 1990s stock market boom is substantial.

3. CONCLUDING OBSERVATIONS

I have used cointegration and error correction methodology to estimate aggregate consumption equations that relate consumer spending either to la-

Table 5 Results Using Total Real Consumer Spending

Panel A: Residual Based Tests for Cointegration

Regress rC on	Optimal Lag*	Dickey-Fuller t-test	Phillips-Ouliaris Z_t	Critical Values 5%	10%
$(C, TR, rdly, rnw)$	1	−3.54	−4.65	−4.16	−3.84
$(C, TR, rdly, req, rnwo)$	1	−4.60	−4.81	−4.49	−4.08

Panel B: Dynamic OLS Estimates of the Aggregate Consumption Equation

$$rc_t = f_0 + f_1 rdly_t + f_2 rnw_t + f_3 TR_t$$

Sample Period	Elasticities f_1	f_2	Implied Level Response Coefficients $rDLY$	rNW
1960Q2–2000Q2	0.54 (23.6)	0.21 (5.4)	0.65	0.04
1960Q2–1995Q2	0.52 (18.3)	0.31 (6.8)	0.62	0.06
1960Q2–1990Q2	0.50 (14.9)	0.29 (6.6)	0.59	0.05

$$rc_t = f_0 + f_1 rdly_t + f_{21} req_t + f_{22} rnwo_t + f_3 TR_t$$

Sample Period	Elasticities f_1	f_{21}	f_{22}	Implied Level Response Coefficients $rDLY$	rEQ	$rNWO$
1960Q2–2000Q2	0.48 (11.1)	0.03 (3.9)	0.22 (3.9)	0.58	0.04	0.05
1960Q2–1995Q2	0.41 (9.8)	0.04 (5.1)	0.28 (6.8)	0.62	0.06	0.05
1960Q2–1990Q2	0.43 (11.2)	0.04 (5.2)	0.23 (1.7)	0.51	0.06	0.05

*See Table 2.

Notes: The estimates reported above use total consumer spending as the measure of aggregate consumption. For other details see Notes in Tables 1, 2, and 3.

bor income and total net worth or to labor income, corporate equities, and nonequity net worth. The results indicate that while wealth has a significant effect on consumer spending, the long-term marginal propensity to consume out of wealth is small. The results also show that the long-term marginal propensity to consume out of equity wealth did not change very much during the 1990s, with its point estimates staying in a narrow 0.03 to 0.04 range. But even with relatively low estimates of the marginal propensity to consume out of equity wealth, the consumption effects of the 1990s stock market boom

Table 6 Wealth-Induced Consumption Growth

Year (Q4 to Q4)	Actual Consumption Growth	Predicted Consumption Growth	Stock-Market-Induced Cons. Growth	Total Wealth-Induced Cons. Growth
(1)	(2)	(3)	(4)	(5)
1990	0.6	0.8	0.6	−0.1
1991	0.4	2.4	2.1	1.8
1992	4.2	4.9	1.4	0.9
1993	3.3	3.0	1.5	1.4
1994	3.5	2.3	0.8	1.1
1995	2.7	2.6	1.7	2.8
1996	3.1	3.4	1.3	2.4
1997	4.0	5.1	1.6	3.2
			(1.5*, 1.0**)	(2.8*, 1.9**)
1998	4.8	5.9	1.2	2.8
1999	5.4	5.5	1.5	2.8

*Mean value of equity wealth-induced consumption growth over 1995 to 1999.

**Mean value of the Increment to the Growth Rate of Real GDP over 1995 to 1999. It is simply two-thirds of wealth-induced consumption growth.

Notes: The predicted values in columns (3), (4), and (5) are generated using rolling regression estimates of the long-term consumption equation $rc_t = f_0 + f_1 rdly_t + f_{21} req_t + f_{22} rnwo_t + f_3 TR_t$ over sample periods that all begin in 1960Q2 but end in the year shown in column (1). The stock-market-induced consumption growth is $f_{21} req_t$ and total wealth-induced consumption growth is $f_{21} req_t + f_{22} rnwo_t$. Actual and predicted values are annualized rates of growth of total real consumer spending over Q4 to Q4 periods ending in the year shown.

are substantial. The estimates in this article indicate that the wealth effect may have added on average 1 to 2 percentage points per year to the growth rate of real GDP in the second half of the 1990s, which is in keeping with Greenspan’s testimony (2000a,b).

The short-term consumption equations estimated here indicate that consumption does respond to current-period changes in income and wealth. However, consumption is also correlated with lagged values of income and wealth variables; this result implies that short-term swings in household wealth generated by changing equity values could lead to short-term swings in consumer spending.

The empirical work here covers the sample period 1959Q1 to 2000Q2. The data for the third and fourth quarters of 2000 are now available and indicate that equity wealth during that year declined about 18 percent, after rising at an average annual rate of 18 percent per year during the preceding five-year period (1995–1999). The main prediction of the consumption equations that I have estimated here is that this decline in equity wealth is likely to depress consumer spending. The results indicate that the growth rate of consumer spending in the short term is likely to fall below the robust 4 percent yearly growth rate observed during the preceding five-year period.

The empirical work discussed in this article supports the presence of a significant wealth effect on consumption. However, some caveats are in order. These results indicate that estimates of the wealth elasticity were not stable during the 1990s. Also, the short-term consumption equations are estimated including variables suggested by the life-cycle model. The empirical work leaves open the question of whether consumption may be influenced by some additional factors such as consumer confidence, energy prices, and short-term interest rates.

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