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Testing the Permanent-Income Hypothesis: New Evidence from West-German States (*Länder*)

by

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Abstract

This paper investigates whether time-series data from eleven West-German states (*Länder*) provide evidence in accord with the implication of the permanent-income hypothesis (PIH) for the stochastic relationship between consumption and income innovations. The empirical results do not support this hypothesis. In particular, the response of consumption to income innovations is found to be much weaker than is predicted by the PIH. Moreover, the response was found to be asymmetric, being stronger for negative than positive income innovations. This evidence of asymmetry is qualitatively consistent with models in which consumers are liquidity constrained.

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1. Introduction

In Germany, as in most developed economies, personal consumption expenditures account for approximately two-thirds of Gross Domestic Product during the post-war period. This suggests that understanding consumption behavior is crucial for understanding the evolution of the German economy. Yet, despite the immense influence of consumption on aggregate economic activity, there is no consensus among economists on how best to model the household's consumption behavior. One leading theory, the so-called permanent-income hypothesis (PIH) of consumption, which was originally developed by Friedman (1957), posits that households base their consumption decisions not on income received in the current period but rather on expected income over a number of years, perhaps even over the entire lifetime. With the refinement of rational expectations, the PIH yields strong testable implications on the stochastic relation between consumption and income. One of these implications, first noted by Flavin (1981), is that *news* about income should induce a revision in consumption exactly equal to the revision in permanent income.

A number of studies have tested this implication using national-level data but the empirical evidence to this date has been mixed at best. For instance, Bilson (1980), using aggregate quarterly time-series data from the US, UK, and Germany, finds support for the implication. In contrast, Flavin (1981) and Kotlikoff and Pakes (1984) report that aggregate US consumption responds much more strongly to income innovations than is warranted by the PIH. Weissenberger (1984) obtains a similar result using seasonally unadjusted quarterly data for the UK and Germany. Recently, Dawson, DeJuan, Seater and Stephenson (2001) conduct a cross-country study and find that data from industrial countries support the PIH but data from developing countries do not. However, they present evidence that the developing countries' rejections of the PIH are artefacts of systematic cross-country variations in the quality of Penn World Table data. They further suggest that such data quality problems are the major force behind rejections of the PIH frequently reported in tests using cross-country data. More recently, DeJuan, Seater and Wirjanto (2004) extends the empirical analysis for the US states and find evidence in support of the PIH.

In this paper, we investigate the consumption revision-income innovation implication of the PIH using time-series data from eleven West-German states (*Länder)* over the period 1970-1997. To this date, there appears to be no empirical research relating to this issue in Germany at the state level.[1] However, such a research can both broaden our understanding of consumption behavior and provide a context in which to evaluate the findings of previous research based on national-level data. Our empirical results strongly reject the PIH across West-German states. In particular, we find that the size of the revision in consumption due to an income innovation is smaller than the size of the revision in permanent income due to the same innovation. Further examination reveals that consumption responds significantly to negative income innovation but not to positive innovation. Such asymmetry suggests that the failure of the PIH can be attributed to liquidity-constrained consumption behavior in the West-German states.

The rest of this paper is structured as follows. Section 2 reviews the permanent-income model and its testable implication. Section 3 discusses the data and section 4 presents the empirical results. Section 5 examines asymmetries in consumption behavior and section 6 offers concluding remarks.

2. The Permanent-Income Model of Consumption

We begin this section by illustrating the PIH model in its standard formulation. Suppose that an infinitely-lived representative consumer in state i (i=1,2,...11) chooses consumption in period t, C_{it}, to solve the following optimization problem:

(1) $$max\ U = E_{it}\left[\sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{j} u(C_{i,t+j})\right]$$

subject to the sequence of budget constraints:

(2) $$W_{i,t+1} = (1+r)\,W_{it} + Y_{it} - C_{it}$$

[1]Most of the consumption studies, which use West-German national-level data, typically focus on testing the sensitivity of consumption to predictable changes in income. See, for example, Campbell and Mankiw (1989) and Blundell, Browne and Tarditi (1995). In addition, Reimers (1997) examines the relationship between consumption, income and wealth using the seasonal cointegration technique.

and the constraint that rules out the possibility of Ponzi game-type behavior (i.e., borrowing to finance consumption and then borrowing indefinitely in order to service the increased debt):

$$\lim_{T\to\infty} E_{it}\left[\left(\frac{1}{1+r}\right)^{T} W_{i,T}\right]=0 \tag{3}$$

Here, E_{it} represents the mathematical expectation conditional on the information set available in period t, W_{it} is nonhuman wealth at the beginning of the period, r is the constant real interest rate, ρ is the constant rate of time preference, Y_{it} is labor income, and $u(.)$ is the instantaneous utility derived from consumption. Substituting recursively in equation (2) and taking expectations leads to the infinite horizon budget constraint:

$$\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_{it}(C_{i,t+j}) = (1+r)\,W_{it} + \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} E_{it}(Y_{i,t+j}) \tag{4}$$

Equation (4) states that the present value of lifetime consumption is equal to the present value of expected future (capital and labor) income. The solution to the foregoing optimization problem yields the familiar first-order condition:

$$E_{it}\left[u'(C_{i,t+1})\right]=\left(\frac{1+\rho}{1+r}\right) u'(C_{it}) \tag{5}$$

which implies that marginal utilities of consumption follow a first-order Markov process. This relation also ensures that reallocating consumption across periods t and $t+1$ does not yield improvements in expected intertemporal utility.

For simplicity, we assume that $r=\rho$ and that marginal utility is linear in consumption (i.e., utility is quadratic).[2] We also assume that there are no taste shifting variables. Taste shifters, such as changes in household size, seem to be important in explaining household behavior (e.g., Attanasio and Browning, 1995),

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[2]The Appendix discusses the more general cases of time-varying interest rates and risk aversion without certainty equivalence. Time-varying interest rates complicate the mathematics but change nothing important. Absence of certainty equivalence in general prevents an analytical solution for consumption. In specific cases where a solution for C is possible, again nothing important changes. Thus the simplifying assumptions of a constant interest rate and quadratic utility seem to be reasonable approximations.

but it is not clear what changes might have occurred in Germany that would cause systematic deviations from the formulas we derive.[3] Under these conditions, equation (5) can be rewritten as:

(6) $$E_{it}(C_{i,t+j}) = C_{it}$$

Substituting (6) into (4) yields the following optimal consumption function:

(7) $$C_{it} = Y_{it}^{p}$$

where

(8) $$Y_{it}^{p} = r\,W_{it} + \frac{r}{(1+r)}\sum_{j=0}^{\infty}\frac{1}{(1+r)^{j}}E_{t}(Y_{i,t+j})$$

Thus, according to this formulation of the model, consumption should equal permanent income where permanent income is defined as a constant annuity stream of income from the consumer's lifetime wealth.

Following Flavin (1981), the first difference of equation (7) can be written as:

(9) $$\Delta C_{it} = \Delta Y_{it}^{p} = \theta_{it}$$

where

(10) $$\theta_{it} \equiv \frac{r}{(1+r)}\sum_{j=0}^{\infty}\frac{1}{(1+r)^{j}}(E_{it} - E_{i,t-1})\,Y_{i,t+j}$$

Equation (9) represents a sharp, empirically testable implication of the PIH. According to it, the magnitude of the revision in consumption should be exactly equal to the magnitude of the revision in permanent income warranted by new information about the expected future path of income, represented by $(E_{it} - E_{i,t-1})Y_{i,t+j}$.

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[3]Two possiblities are the influx of foreign (notably Turkish) workers and the unification of East and West Germany. Turkish workers' households have different characteristics with regard to the kinds of taste shifting variables identified as important to consumption behavior by other researchers, such as Attanasio and Browning (1995). Their immigration into Germany then could introduce biases in our measures. However, we lack adequate data to address this issue. As for the unification of Germany, our data are restricted to German states of the former West Germany. Only if there were major migrations from East German states to West German states might there be a problem with our estimates. Again, we lack the necessary data to check such a possibility.

To test this prediction, we need to specify a model for the stochastic process generating income and express the innovation in permanent income as a function of the innovation of the observables. The typical approach in the consumption literature — as exemplified in the work of Bilson (1980), Flavin (1981), Deaton (1992), and others — has been to assume that income follows a linear stochastic process, for which there is a well-developed theory of estimation, inference, and prediction. In particular, suppose that ΔY_{it} is a stationary process with an autoregressive-moving average (ARMA) representation:

(11) $$A(L)\Delta Y_{it} = B(L)\epsilon_{it}$$

where $\Delta Y_{it} = Y_{it} - Y_{i,t-1}$, $A(L) = 1 - \Sigma a_{ij} L^j$, $B(L) = 1 - \Sigma b_{ij} L^j$, a_{ij} are the autoregressive parameters, b_{ij} are the moving-average parameters, L is the lag operator, and ϵ_{it} represents the innovation or *news* in state i's current income. Using (11) to calculate the sequence of revisions in expected incomes, $(E_{it} - E_{i,t-1})Y_{i,t+j}$, and substituting the result into (10), yields the formula for the change in permanent income:

(12) $$\theta_{it} = \frac{1 + \sum_{j=1}^{\infty} \frac{b_{ij}}{(1+r)^j}}{1 - \sum_{j=1}^{\infty} \frac{a_{ij}}{(1+r)^j}} \cdot \epsilon_{it} = \chi_i(r,b,a) \cdot \epsilon_{it}$$

Conditional on the stochastic-income process and an assumed value of r, χ_i measures the size of the revision in permanent income associated with the realization of an innovation in current income ϵ_{it}. If the PIH is true, the marginal propensity to consume out of an income innovation should be equal to χ_i.

A straightforward way of testing the PIH involves estimating the following system of equations for each state i:

(13) $$A(L)\Delta Y_{it} = B(L)\epsilon_{it}$$

and

(14) $$\Delta C_{it} = \alpha_i + \beta_i \epsilon_{it} + \xi_{it}$$

both unconstrained and constrained by a nonlinear equation:

(15)
$$\beta_i = \frac{1+\sum_{j=1}^{\infty}\frac{b_{ij}}{(1+r)^j}}{1-\sum_{j=1}^{\infty}\frac{a_{ij}}{(1+r)^j}} = \chi_i(r,b,a)$$

where α_i is the intercept term, β_i is the marginal propensity to consumption out of an income innovation, and ξ_{it} is the zero-mean random disturbance term. In the above, equation (13) specifies the time-series process for income, equation (14) describes the relation between consumption revision and income innovation, and equation (15) is a cross-equation restriction implied by the PIH. It is apparent that our interest is in ascertaining and testing whether this restriction is true for each state *i*. To this end, we use a likelihood-ratio (LR) statistic to test the null hypothesis of $\beta_i=\chi_i$.[4] If the null hypothesis is not rejected, then the response of consumption to income innovation is taken to be consistent with the prediction of the PIH.

Before closing this section, we discuss some caveats that may apply in testing the $\beta_i=\chi_i$ hypothesis. First, the theoretically-appropriate measure of consumption is consumption of nondurables, services, and the services yielded by the existing stock of durable goods. However, reliable estimates of each of these components are not available at the state level. As is common in empirical research, we use total consumption expenditure as a measure of consumption. Using this imperfect measure of consumption may bias the estimate of β_i away from its true value. For example, Bernanke (1985) argues that the presence of convex costs to adjusting durable stocks and the irreversible nature of durable purchases can lead to the observation that consumption is less sensitive to income innovations and hence, the estimate of β_i may be biased downward. Second, Y_{it} should be labor income but, in practice many studies use gross domestic product (GDP) as a proxy variable. Although GDP is expected to be highly correlated with labor income, any deviation from a one-to-one relationship can prevent β_i from being exactly equal to χ_i. Third, the univariate income generating process assumes that consumers use only their income history to predict future

[4]The likelihood ratio test statistic is defined as LR=-2[L(c)-L(u)], where L(c) is the log-likelihood value of the constrained model and L(u) is the log-likelihood value of the unconstrained model.

incomes. West (1988), Quah (1990), and Flavin (1993) among others, however, have noted that consumers may also use other information in predicting their future incomes. In such a case, the estimated income innovation, ϵ_{it}, is an errors-in-variable measure of the true income innovation. The use of ϵ_{it} as a regressor in (14), therefore, will yield a downward biased estimate of β_i. Fourth, the empirical measure of χ_i requires the imposition of an assumed constant real interest rate. If the chosen rate is too high (low), then the estimate of χ_i will be biased downward (upward). In view of all these concerns, testing the equality of β_i and χ_i may be too restrictive but we still can expect β_i and χ_i to be positively related across states if the PIH is true. Thus, in the next section, aside from testing the strict equality of β_i and χ_i, we also implement a cross-sectional method to determine whether β_i and χ_i are positively related across states.

3. Data

Annual data on real GDP, real consumption expenditure, and population for the eleven West-German states over the period 1970-1997 were collected from the *Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder*, Statistisches Landesamt Baden - Württemberg, Stuttgart.[5] Real per-capita consumption and real per-capita GDP are used as measures of consumption (C_{it}) and income (Y_{it}), respectively.

4. Empirical Results

As a first step in our empirical analysis, we examine the stationarity properties of the state-level consumption and income series, using the Augmented Dickey-Fuller (ADF) test for a unit root developed by Said and Dickey (1984). An issue that arises with the implementation of this test is the choice of the order of autoregression, *p*. Many previous studies have pre-set the order of *p*, depending on the frequency of the

[5]Data prior to 1970 are not available at the state level. For West Berlin, data are available only until 1994.

data. Yet, studies by Hall (1994) and Ng and Perron (1995) indicate that data-dependent methods for selecting the value of p are superior to making an *a priori* choice of a fixed p. In this regard, we follow the general-to-specific procedure advocated by Ng and Perron (1995), by starting with an upper bound on p. If the last included lag is significant, then we choose the upper bound. Otherwise, we reduce the order of p by one until the last lag becomes significant. If no lags are significant, then p is set equal to zero. Using Said and Dickey's (1984) $T^{1/3}$ rule (where T is the sample size), we set the upper bound on p to equal 3 and use the five percent value of the asymptotic normal distribution to assess the significance of the last lag.

Table 1 summarizes the results of the ADF tests. On the basis of the critical values calculated from the response-surface procedure advocated by MacKinnon (1991), the null hypothesis of at least one unit root for C_{it} cannot be rejected at the five percent level. Similarly for Y_{it}, the null hypothesis cannot be rejected except for West Berlin whose t-statistic is marginally significant at the five percent level but not at the one percent level. For completeness, we also carry out the ADF tests for the first difference of C_{it} and Y_{it}. As shown in columns 3 and 5, the unit-root null hypothesis can be rejected at the five percent level for ΔC_{it} and ΔY_{it}. Together these results suggest that state-level C_{it} and Y_{it} can reasonably be characterized as first-order integrated processes. In what follows, we carry out our empirical analysis using first-difference data.

The system of equations (13) and (14) are jointly estimated using nonlinear least squares. Given the limited number of time-series observations available for each state, the income generating process in first difference is parsimoniously set to follow a first-order autoregressive process, i.e., the income process itself is assumed to be generated by an ARIMA(1,1,0) process. As a robustness check, we also tried out specifications with longer autoregressive lags but they did not materially change the test results. As noted earlier, estimates of χ_i depend on the choice of interest rate. We present estimates based on a two percent rate, but similar results are obtained using the alternative values of one percent and three percent.

Table 2 reports the estimation results for each state. The estimate of β_i ranges from 0.093 for Hamburg to 0.351 for Schleswig-Holstein. Moreover, β_i is significantly different from zero at the five percent level for all states except for Hamburg and Saarland. This implies that consumers in most states revise their current consumption as a result of innovations to current income. As for the estimate of χ_i, it is significantly positive and varies considerably across states, ranging from 0.907 for Schleswig-Holstein to 1.756 for Hesse. This implies that current-income innovations contain information about future income that leads consumers to revise their estimated permanent income.

We now turn to our main empirical question: How is β_i related to χ_i? To answer this, we first look at the *p*-values of the LR statistics shown in column 4 of Table 2. It is apparent that the *p*-values are very low, mostly below 0.01, such that the null hypothesis of $\beta_i=\chi_i$ can easily be rejected at conventional levels. Comparison of the estimates also reveals that χ_i is, on average, four times the size of β_i. Thus, the evidence shows that the adjustment of consumption to income innovation is too small to be compatible with the prediction of the PIH.[6]

As discussed earlier, however, data limitations as well as specification issues may prevent β_i from being exactly equal to χ_i for each state, even if the PIH is true. For this reason, we also perform a less restrictive test of whether β_i and χ_i are positively related across states. Figure 1 displays the scatter plot of β_i and χ_i. While there are a few unusually large observations, the scatter as a whole shows a weak positive relation between the variables. A more formal test would be to estimate a cross-section regression of β_i on χ_i and obtain the following result:

$$\beta_i = \underset{(0.139)}{0.238} + \underset{(0.099)}{0.018}\,\chi_i + \upsilon_i \tag{16}$$

$$R^2=0.002 \qquad \textit{S.E. of regression} = 0.091$$

where the numbers in parentheses are heteroskedasticity-consistent standard errors. As expected, the regression fit is extremely poor, with a meager R^2 of 0.002. The estimated coefficient of χ_i is minuscule in magnitude and insignificantly different from zero at conventional levels. An alternative way of testing the

[6]This result is broadly consistent with Weissenberger (1986), who also rejects the PIH using national- level aggregate German data. Under the maintained assumption that income is stationary around a deterministic trend, he reports that consumption is excessively sensitive to income innovations.

relation between β_i and χ_i is to use the Spearman rank correlation. This statistic is of interest since it is nonparametric and, hence, does not rely on any specific distributional assumption of the data. Also and perhaps more important, it is robust to outlying observations and to the functional relation between the variables.[7] The rank correlation between β_i and χ_i is 0.127 and, with a *p*-value of 0.709, it is statistically insignificant. Overall, the results from both parametric and nonparametric tests cast serious doubt on the hypothesis that the size of the revision in consumption is positively related to the size of the revision in permanent income across states.

5. Two Alternatives to the PIH: Myopia and Liquidity Constraint

Having established in the previous section that the West-German state-level data is not consistent with the PIH, we now explore whether myopia or liquidity constraints can explain consumption behavior across the West-German states. As alluded by Altonji and Siow (1987) and Shea (1995), these two well-known alternatives to the PIH have distinct testable implications for asymmetry in the adjustment of consumption to income innovations.[8]

Under myopia, consumers simply set their current consumption equal to their current income. As a result, consumption should be equally responsive to positive and negative income innovations. Under liquidity constraints, on the other hand, consumers would like to follow their optimal consumption plan but are unable to do so because of the constraints on their ability to borrow against their future income. Given that liquidity constraints are binding only when consumers wish to borrow but not when they wish to save, consumption should respond more strongly to negative than positive income innovations. The intuition for this asymmetry is straightforward. Suppose that income is difference stationary with positively correlated

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[7]As is evident from Figure 1, Hesse is a leverage point in the sense that its χ_i value is outlying.

[8]Note however that these authors are concerned with the asymmetric response of consumption to predictable changes in income rather than to innovations in income.

first differences, such that innovations in income are expected to persist over time. Now if there is a positive income innovation, consumers would then want to increase their consumption by the size of the increase in their permanent income, which is *more than* the size of the innovation due to its persistence. In the presence of liquidity constraints, however, the increase in consumption will be limited by the size of the innovation.

Suppose instead that there is a negative income innovation. In such a case, consumers would want to decrease their consumption by the size of the reduction in their permanent income, which is again more than the size of the innovation due to its persistence. Given that consumers are free to save or reduce their consumption, one would then observe consumption to be much more responsive to a negative innovation. Thus, according to the liquidity-constraint hypothesis, consumption should respond asymmetrically to positive and negative income innovations.

To shed light on which of these two alternative hypotheses can possibly explain the failure of the PIH, we modify equation (14) to allow income innovations to exert an asymmetric effect on consumption. Specifically, we estimate the following system of equations:

(17) $$\Delta Y_{it} = a_0 + a_1 \Delta Y_{i,t-1} + \epsilon_{it}$$

and

(18) $$\Delta C_i = \alpha_i + \beta_{1i}(POS_{it} * \epsilon_{it}) + \beta_{2i}(NEG_{it} * \epsilon_{it}) + \xi_{it}$$

where *POS* is a dummy variable for periods in which ϵ_{it} is positive, and *NEG* is a dummy variable for periods in which ϵ_{it} is negative (or zero). If consumers are myopic, β_1 and β_2 are expected to be positive, significant, and of the same magnitudes. If consumers are liquidity constrained, on the other hand, β_2 is expected to be significantly positive and significantly greater than β_1.

The results of jointly estimating equations (17) and (18) are shown in Table 3. In most states, the estimate of β_1 is small and statistically insignificant at conventional levels. In contrast, the estimate of β_2 is significantly positive in all but one state, Hamburg. Moreover, the magnitude of β_2 is greater than β_1 in nine out of eleven states, suggesting that negative income innovation affects consumption more strongly than positive innovation. It should be noted, however, that due to the relatively small number of observations, our tests may have low power to detect asymmetry. Indeed, as shown in column 4, we can formally reject the null hypothesis that $\beta_1=\beta_2$ in favor of the one-sided alternative hypothesis that $\beta_1<\beta_2$ in only one state. Nevertheless, the estimates of β_1 and β_2 tell a reasonably clear story that, in most states, consumption responds significantly to negative income innovations but not to positive innovations. These results are qualitatively consistent with liquidity constraint hypothesis but not with myopic consumption behavior.

Two concerns with the liquidity constraint interpretation must be addressed. First, as we have noted above, the evidence in the literature seems more supportive of the PIH for US data than for our German data. Yet the saving rate in Germany is greater than that in the US, and the wealth distribution is more equal than that in the US. These facts suggest that liquidity constraint is likely to be less serious in Germany than in the US. A partial counter-argument is that US savings rates, as measured by the national income accounting, are less than in Germany, but it is less clear that the same relation holds when capital gains are added. Capital gains in the US have been huge over the last couple decades, but they are not included in the national income accounts. Similarly, wealth measures do not account properly for human wealth, which is the present value of labor income. Labor income in the US seems to vary more over the life cycle than in Germany, so that young families in the US may have substantially higher lifetime wealth than their tangible assets alone would indicate. They are the very kinds of families traditionally used as examples of households likely to be liquidity constrained. Our conclusion here is that this issue is a valid cause for circumspection but is not decisive. Second, risk-averse individuals whose utility functions have positive third derivatives exhibit "cautious" behavior, tending to save more of any income shock than would be implied by the quadratic utility function that we use. Depending on the shape of the utility function, it may be that large changes in permanent income elicit consumption responses of different magnitudes when those changes are positive than when they are negative, thus producing the asymmetry we observe even in the absence of liquidity constraints. For infinitesimal changes in permanent income, the changes in consumption are the same, but that might not be true for discrete changes. The characteristics of the German data suggest, however, that this issue is of little practical concern. The ratio of the change in permanent income to the level of current income is, on average, only 1.6 percent., which seems small enough to be treated as infinitesimal.

6. Concluding Remarks

This paper empirically investigated a key stochastic implication of the permanent-income hypothesis (PIH) that an income innovation generates the same size revision in consumption as in permanent income. Using time-series data from eleven West-German states (*Länder*) for the period 1970-1997, our results point to a strong rejection of the PIH. In particular, we find that the size of the revision in consumption due to an income innovation is considerably smaller than the size of the revision in permanent income due to the same innovation. Put differently, the response of consumption to *news* about income is too weak to be compatible with the PIH. Further examination reveals that, in many states, consumption reacts significantly to negative income innovations but not to positive innovations. Such evidence of asymmetry suggests the existence of liquidity-constrained consumers. In view of this, it is worthwhile, as an avenue for future research, to examine the cause(s) of liquidity constraints in the state economies.

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Table 1
Unit-Root Test Statistics for Real Per-Capita Consumption (C) and Real Per-Capita GDP (Y)

West-German *Länder*	C	ΔC	Y	ΔY
Baden-Wurttemberg	-3.442* (1)	-4.309*** (1)	-1.554 (0)	-3.902*** (0)
Bavaria	-3.009 (1)	-3.506** (1)	-2.162 (0)	-4.320*** (0)
Bremen	-2.021 (0)	-3.956*** (0)	-3.181 (3)	-4.091*** (0)
Hamburg	-1.535 (0)	-3.935*** (0)	-2.801 (0)	-6.094*** (3)
Hesse	-1.951 (1)	-2.992** (1)	-2.866 (1)	-3.102** (3)
Lower Saxony	-3.066 (1)	-3.156** (0)	-1.903 (0)	-4.068*** (0)
North Rhine-Westphalia	-3.109 (1)	-3.080** (0)	-3.146 (1)	-4.176*** (0)
Rhineland-Palatine	-2.839 (3)	-3.518** (1)	-1.274 (0)	-3.867*** (0)
Saarland	-1.232 (0)	-3.945*** (0)	-2.433 (0)	-5.220*** (0)
Schleswig-Holstein	-2.864 (1)	-4.214*** (1)	-2.319 (0)	-5.295*** (0)
West Berlin	-0.265 (0)	-3.298** (0)	-3.693** (1)	-4.745*** (1)

Notes: C is real per-capita consumption. Y is real per-capita GDP. ADF(lag) is the Augmented Dickey and Fuller t-ratio, using the general-to-specific lag length selection procedure of Hall (1994) and Ng and Perron (1995). The initial number of AR lags is set equal to 3, and the 10% critical value is used to determine significance. The finite-sample critical values for the unit-root test are calculated using the response-surface technique advocated by MacKinnon (1991). ***, **, and * indicate significance at 1%, 5% and 10% respectively.

Table 2. Estimates of β and χ for West-German *Länder*

Model: $\Delta Y_{it} = \alpha_{i0} + \alpha_{i1} \Delta Y_{i,t-1} + \epsilon_{it}$

$\Delta C_{it} = \gamma_i + \beta_i \epsilon_{it} + \xi_{it}$

subject to $\beta_i = (1 - a_{i1}/(1+r))^{-1} = \chi_i$

West-German *Länder*	β	χ	LR
Baden-Wurttemberg	0.285**	1.199**	9.120
	(0.076)	(0.220)	[0.003]
Bavaria	0.350**	1.082**	6.630
	(0.072)	(0.164)	[0.010]
Bremen	0.212**	1.200**	12.080
	(0.056)	(0.219)	[0.001]
Hamburg	0.093	1.061**	12.430
	(0.076)	(0.216)	[0.000]
Hesse	0.256**	1.756**	18.890
	(0.071)	(0.438)	[0.000]
Lower Saxony	0.287**	1.179**	9.230
	(0.077)	(0.214)	[0.002]
North Rhine-Westphalia	0.325**	1.121**	7.410
	(0.081)	(0.188)	[0.007]
Rhineland-Palatine	0.337**	1.219**	8.480
	(0.080)	(0.218)	[0.004]
Saarland	0.136	0.934**	7.940
	(0.104)	(0.164)	[0.005]
Schleswig-Holstein	0.351**	0.907**	4.310
	(0.084)	(0.124)	[0.038]
West Berlin	0.224**	1.284**	9.970
	(0.104)	(0.311)	[0.002]

Notes: The numbers in parentheses are standard errors; those in brackets are *p*-values. β is the marginal propensity to consume out of an income innovation. χ is the implied revision in permanent income due to an income innovation. LR denotes the Likelihood Ratio statistic under the H_o: $\beta=\chi$. ** and * indicate significance at the 5% and 10% levels, respectively.

Table 3. Asymmetric Response of Consumption to Income Innovations

Model:

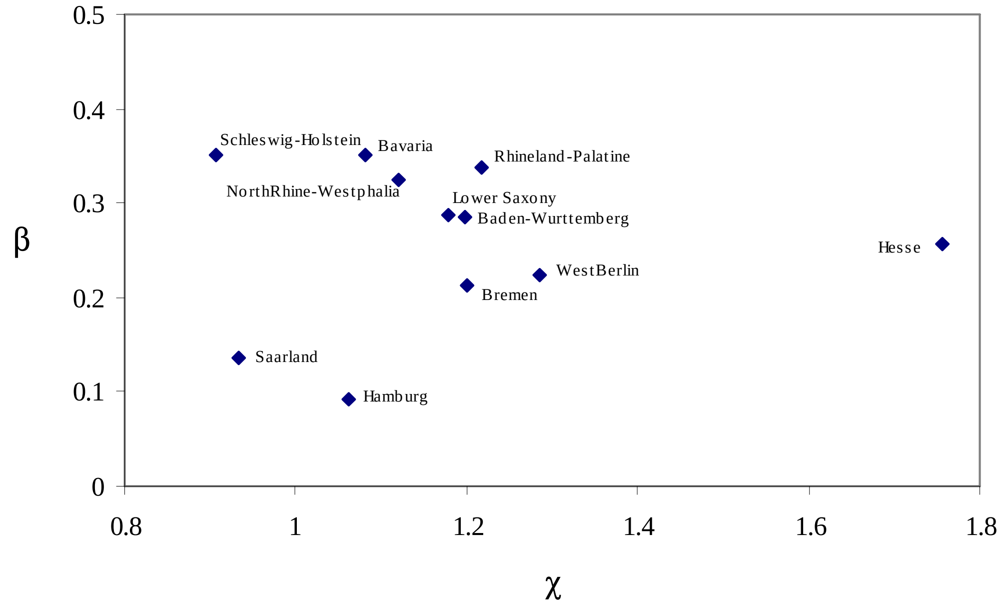
$$\Delta Y_{it} = \alpha_{i0} + \alpha_{i1} \Delta Y_{i,t-1} + \epsilon_{it}$$

$$\Delta C_{it} = \gamma_i + \beta_{1i}(POS_{it} * \epsilon_{it}) + \beta_{2i}(NEG_{it} * \epsilon_{it}) + \xi_{it}$$

West-German *Länder*	β_1	β_2	Wald β_1=β_2
Baden-Wurttemberg	0.044	0.399**	2.060
	(0.179)	(0.113)	[0.151]
Bavaria	0.349*	0.350**	0.000
	(0.176)	(0.103)	[0.996]
Bremen	0.147	0.279**	0.440
	(0.110)	(0.115)	[0.506]
Hamburg	0.317	-0.044	1.940
	(0.193)	(0.132)	[0.164]
Hesse	0.064	0.407**	2.050
	(0.152)	(0.127)	[0.152]
Lower Saxony	0.158	0.419**	1.290
	(0.134)	(0.139)	[0.256]
North Rhine-Westphalia	0.289	0.349**	0.050
	(0.174)	(0.135)	[0.822]
Rhineland-Palatine	0.388**	0.307**	0.110
	(0.167)	(0.121)	[0.739]
Saarland	-0.179	0.293**	2.730
	(0.212)	(0.138)	[0.098]
Schleswig-Holstein	0.145	0.531**	2.650
	(0.150)	(0.136)	[0.103]
West Berlin	-0.005	0.426**	1.660
	(0.209)	(0.192)	[0.197]

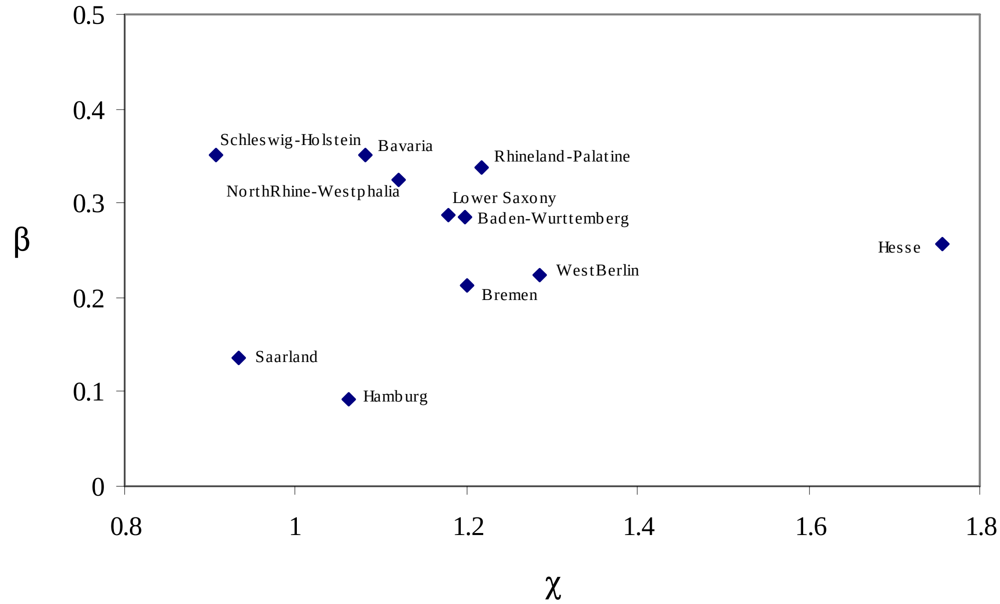
Notes: The numbers in parentheses are standard errors; those in brackets are *p*-values. β_1 denotes the estimated coefficient for ($POS_{it}*\epsilon_{it}$). β_2 denotes the estimated coefficient for ($NEG_{it}*\epsilon_{it}$). Wald reports the Wald statistics for testing the hypothesis $\beta_1 = \beta_2$. ** and * indicate significance at the 5% and 10% levels, respectively.

Figure 1



0.5
0.4
0.3
0.2
0.1
0
β
Schleswig-Holstein
Bavaria
Rhineland-Palatine
NorthRhine-Westphalia
Lower Saxony
Baden-Wurttemberg
Hesse
WestBerlin
Bremen
Saarland
Hamburg
0.8
1
1.2
1.4
1.6
1.8
χ

Figure 1


0.5
0.4
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β
0.8
1
1.2
1.4
1.6
1.8
χ
Schleswig-Holstein
Bavaria
Rhineland-Palatine
NorthRhine-Westphalia
Lower Saxony
Baden-Wurttemberg
Hesse
WestBerlin
Bremen
Saarland
Hamburg

Appendix

1. Time-Varying Interest Rates

With deterministic time-varying interest rates, the difference equation for W is

$$W_{i,t+1} = (1+r_t)\,W_{it} + Y_{it} - C_{it}$$

The value of W at any time after t is

$$\begin{aligned} W_{i,t+i} &= W_{i,t}\prod_{k=0}^{i-1}(1+r_{t+k}) + \sum_{j=0}^{i-1}\left[E[(Y_{i,t+j}-C_{i,t+j})]\prod_{m=j}^{i-1}(1+r_{t+1+m})\right] \\ &= \prod_{k=0}^{i-1}(1+r_{t+k})\left\{W_{i,t}+\sum_{j=0}^{i-1}\left[E[(Y_{i,t+j}-C_{i,t+j})]\prod_{k=0}^{j}(1+r_{t+k})^{-1}\right]\right\} \end{aligned}$$

Discounting both sides gives

$$W_{i,t+i}\prod_{k=0}^{i-1}(1+r_{t+k})^{-1} = W_{i,t}+\sum_{j=0}^{i-1}\left[E[(Y_{i,t+j}-C_{i,t+j})]\prod_{k=0}^{j}(1+r_{t+k})^{-1}\right]$$

The No-Ponzi condition is that the left side go to zero as *i* goes to infinity, which implies that

$$\begin{aligned} \sum_{j=0}^{i-1}\left[E[C_{i,t+j}]\prod_{k=0}^{j}(1+r_{t+k})^{-1}\right] &= W_{i,t}+\sum_{j=0}^{i-1}\left[E[Y_{i,t+j}]\prod_{k=0}^{j}(1+r_{t+k})^{-1}\right] \\ &\equiv A_t \end{aligned}$$

where *A* is total household assets. The general first-order condition is

$$\frac{(1+\rho)^{-1}E_t[U'(C_{t+j+1})]}{E_t[U'(C_{t+j})]} = (1+r_{t+j})^{-1}$$

For the quadratic utility function $U(C_t) \equiv aC_t - bC_t^2$, this first-order condition is

$$\frac{(1+\rho)^{-1}E_t[a-2bC_{t+j+1}]}{E_t[a-2bC_{t+j}]} = (1+r_{t+j})^{-1}$$

In period t, the value of C_t (i.e., for j=0) is known, so we can solve for $E[C_{t+1}]$ in terms of C_t:

$$E[C_{t+1}] \;=\; \frac{a}{2b}\frac{\rho - r_t}{1+r_t} + \frac{1+\rho}{1+r_t}C_t$$

We then can iterate forward to obtain the solution for any future C:

$$E^{/}[C_{t+i}] \;=\; \frac{a}{2b}\sum_{j=0}^{i-1}\left[(\rho - r_{t+(i-1)-j})(1+\rho)^j \prod_{m=(i-1)-j}^{i-1}(1+r_{t+m})^{-1}\right] + (1+\rho)^i \prod_{k=0}^{i-1}(1+r_{t+k})^{-1}C_t$$

We next substitute this solution into the budget constraint:

$$A_t \;=$$

$$\sum_{i=0}^{\infty}\left\{\left(\frac{a}{2b}\sum_{j=0}^{i-1}\left[(\rho - r_{t+(i-1)-j})(1+\rho)^j \prod_{m=(i-1)-j}^{i-1}(1+r_{t+m})^{-1}\right] + (1+\rho)^i \prod_{k=0}^{i-1}(1+r_{t+k})^{-1}C_t\right)\prod_{k=0}^{i}(1+r_{t+k})^{-1}\right\}$$

$$= \;\alpha_t + \beta_t C_t$$

where

$$\alpha_t \;=\; \sum_{i=0}^{\infty}\left\{\left(\frac{a}{2b}\sum_{j=0}^{i-1}(\rho - r_{t+(i-1)-j})(1+\rho)^j \prod_{m=(i-1)-j}^{i-1}(1+r_{t+m})^{-1}\right)\prod_{k=0}^{i}(1+r_{t+k})^{-1}\right\}$$

$$\beta_t \;=\; \sum_{i=0}^{\infty}\left\{\left[(1+\rho)^i \prod_{k=0}^{i-1}(1+r_{t+k})^{-1}\right]\prod_{k=0}^{i}(1+r_{t+k})^{-1}\right\}$$

Finally, we solve for the optimal value of C_t:

$$C_t \;=\; \beta_t^{-1}A_t - \beta_t^{-1}\alpha_t$$

From this expression, we can obtain the response of C_t to a change in any future income:

$$dC_t \;=\; \left[\beta_t^{-1}\prod_{k=0}^{i}(1+r_{t+k})^{-1}\right]dY_{t+i} \;\equiv\; \gamma_{t,i}\,dY_{t+i}$$

Notice that, when $r_{t+k} = \rho$ for all k, then $\gamma_{t,i}$ reduces to the usual $(1+r)^{-(t+1)}$. Because ρ is an attractor for the interest rate, we expect to see r fluctuate closely around ρ in any time series sample of reasonable length with an average value of approximately ρ. Thus in any such sample, we expect $\gamma_{t,i}$ to be close to $(1+r)^{-(t+1)}$. If Y follows an ARMA process, then the response of C_t to an innovation in Y involves a weighted sum of the $\gamma_{t,i}$, where the weights depend on the AR and MA coefficients. Because the $\gamma_{t,i}$ are time-varying, the weighted sum also will be time-varying, but because the $\gamma_{t,i}$ are close to $(1+r)^{-(t+1)}$, we expect the weighted sum of the $\gamma_{t,i}$ to be close to the expression given in equation (15) in the main text. For this reason, assuming that the interest rate equals ρ for all time periods is a reasonable simplification that does not alter any important results.

2. Absence of Certainty Equivalence

The general household choice problem without certainty equivalence (i.e., quadratic utility) and uncertainty in labor income is typically not solvable analytically. We can obtain analytical solutions in special cases. For example, suppose that there is uncertainty only in interest rates. Labor income either has no uncertainty or any uncertainty in it can be diversified away through life insurance, unemployment insurance, and other such schemes. We then can obtain analytic solutions for C_t for many forms of the utility function, such as members of the HARA class. For example, logarithmic utility yields the result (see Blanchard and Fischer)

$$C_t = \frac{\rho}{1+\rho} W_t$$

The problem here is how to define permanent income. Permanent income is the annuity value of lifetime wealth, but it is unclear how to compute that value with a random interest rate. One solution is to use the risk-free interest rate, R. That rate may vary over time (deterministically) but should equal the time preference rate ρ on average. We can use the average value of R to define permanent income as

$$Y_t^P = \frac{\bar{R}}{1+\bar{R}} W_t$$

$$= \frac{\rho}{1+\rho} W_t$$

We then immediately have

$$C_t = Y_t^P$$

$$\Rightarrow \quad dC_t = dY_t^P$$

which is the same result as that obtained in the main text with quadratic utility and constant interest rates. Admittedly, this case requires several strong restrictions, but it does show that our assumptions in the main text are at least defensible.