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WP 2-98

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מכון למחקר כלכלי ע"ש ד"ר ישעיהו פורדר ומכון סאקלר לכלכלה

הפקולטה למדעי החברה ע"ש גרשון גורדון

אוניברסיטת תל־אביב

PERMANENT INCOME, CONSUMPTION, AND AGGREGATE CONSTRAINTS: EVIDENCE FROM U.S. STATES*

by

Charlotte Ostergaard[1] Bent E.Sorensen[2]
and Oved Yosha[3]

Working Paper No.2-98

January, 1998

[1] Economics Department, Brown University and LSE.
[2] Economics Department, Brown University.
[3] The Eitan Berglas School of Economics, Tel-Aviv University

* We thank Karen Lewis, Nouriel Roubini and David Weil for helpful discussions on risk sharing and consumption smoothing. Sorensen acknowledges financial support from the Watson Institute, Brown University and thanks Tel-Aviv University for its hospitality. Sorensen and Yosha gratefully acknowledge financial support through a Salomon Grant, Brown University, a grant from the Armand Hammer Fund for Cooperation in the Middle East, and a United States National Science Foundation grant.

Abstract

We remove the aggregate US-wide component in US state level disposable income and consumption and find that state-specific consumption exhibits substantially less excess sensitivity to lagged state-specific disposable income than if the aggregate component is not controlled for. This is evidence that excess sensitivity of consumption in aggregate US data is driven to a large extent by US-wide effects since, in the aggregate, US net imports and investment do not adjust quickly to fluctuations in consumption demand. Ordering states by the persistence of income shocks, we find that removal of the aggregate component from the state level data reduces excess sensitivity for all states by the same amount and that the excess sensitivity of consumption is greater in states with more persistent income shocks. We also find that state-specific disposable income and consumption exhibit excess smoothness in the sense of Campbell and Deaton (1989), namely, current state-specific consumption is not sufficiently sensitive to current state-specific income; in particular for positive shocks. Finally, we study patterns of consumption smoothing via bank savings deposits and loans. Our results point to credit market imperfections as the most plausible explanation for excess smoothness and the remaining excess sensitivity.

Keywords: Permanent Income, Consumption, Regional Macroeconomics, Excess Sensitivity, Excess Smoothness, Bank Savings Deposits and Loans

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1 Introduction

Personal consumption in the United States amounts to seventy percent of Gross Domestic Product and, in spite of much serious research, the modeling of consumer behavior is still a challenge to the profession. Deaton (1992) provides an excellent survey. Traditionally, empirical work has focused on national level aggregate data, although micro-econometric studies are becoming increasingly important. US state level data is a much underutilized source of information on consumer behavior which we exploit here to shed new light on the debate.[1]

We use data on state level personal disposable income and consumption (proxied by retail sales) for the period 1963–93. State level income and consumption data are sufficiently aggregated to be regarded as macroeconomic data, and yet exhibit enough cross-sectional variation that can be exploited in empirical analysis. Endogeneity of income is not likely to be a major problem at this level of aggregation, and measurement error is less serious than in micro data. Since states can borrow from each other, each state in the panel need not be regarded as a closed economy, a feature that allows us to perform empirical tests that cannot be carried out with a time series of aggregate national level data and, most important, to distinguish empirically between the smoothing of US-wide and state-specific fluctuations in disposable income.

A strong implication of the Permanent Income Hypothesis (PIH) is that consumption is a martingale, in particular that current innovations to consumption are independent of past innovations to disposable income (Hall (1978)). Micro evidence is mixed, while the macro evidence overwhelmingly rejects this proposition, resulting in an empirical stylized fact—the excess sensitivity of current consumption to lagged income.[2]

We provide evidence suggesting that excess sensitivity of current consumption to lagged income in aggregate US data is driven to a large extent by US-wide effects. This finding is

[1]Beaudry and van Wincoop (1996) use a panel of US state level data to estimate the intertemporal elasticity of substitution in consumption.

[2]Flavin (1981) is the basic reference for studies using national level aggregate data while Hall and Mishkin (1982) is the basic reference for micro studies. Recent influential contributions include Mankiw and Shapiro (1985) and Campbell and Mankiw (1990); see Deaton (1992) for a survey.

most likely due to the fact that, in the aggregate, US net imports and investment do not adjust quickly to fluctuations in consumption demand. Our central empirical exercise can be summarized as follows. We perform, first, standard excess sensitivity tests using state consumption and disposable income series, finding considerable excess sensitivity, similar to that found using aggregate US data. We then remove the aggregate US-wide component in state level disposable income and consumption (the state-specific components of income and consumption add up to zero each year, by construction), finding that state-specific consumption exhibits substantially less excess sensitivity to state-specific disposable income than if the aggregate component is not removed from the state level data.

Our interpretation of this finding is centered on the slow adjustment of net imports and aggregate investment to fluctuations in consumption demand. In a fully integrated and frictionless world, consumers would obtain loans on international markets (through intermediaries) and aggregate net imports would increase in response to higher consumption demand. In reality, it may take time to adjust aggregate imports (not to speak of exports). For example, an increased demand for Toyota cars in the United States will typically be reflected in higher prices (no "dealer incentives") and less attractive financing opportunities, since adjustment of production runs in Japan can not be done instantaneously.[3] Furthermore, aggregate US investment is not likely to adjust quickly to desired aggregate consumption since corporate investment responds to perceived profit opportunities and is not likely to react quickly to consumption demand, and government investment is constrained by the budget and the political process surrounding it and is, therefore, also unlikely to respond quickly to changes in desired consumption patterns.

An equilibrating mechanism is the US-wide interest rate which rises when consumers wish to increase the share of National Income devoted to consumption, reflecting the increased competition for scarce resources. Therefore, in the aggregate, we should indeed expect substantial deviations from Hall's constant interest rate benchmark PIH model. Empirical work centered on PIH models with time varying interest rates, using macro data,

[3]Empirically, this is reflected in the high correlation between national level saving and investment pointed out by Feldstein and Horioka (1980). Sørensen and Yosha (1997) show that country specific GDP-shocks are not smoothed by net exports.

has been carried out by Mankiw (1981), Shapiro (1984), and Hall (1988), among others. These papers focus on testing the Euler equations of individual intertemporal optimization or on estimating the intertemporal elasticity of substitution in consumption.[4]

Our focus is different, as we are mainly interested in the implications of the model (more precisely, of the optimally chosen consumption profile) for the correlation of current consumption changes and lagged income changes. That excess sensitivity of current consumption may be driven by aggregate effects such as the slow adjustment of US net imports and aggregate investment to fluctuations in consumption demand has been noted by, e.g., Michener (1984) and Christiano (1987) who point out that the economy-wide interest rate responds to changes in the demand for consumption. The papers by Michener and Christiano are purely theoretical and do not attempt to test or quantify these "general equilibrium effects." If such effects are important, the PIH may nevertheless be a good model for describing the reaction of consumption to *idiosyncratic* disposable income shocks in individual states. There are good reasons to believe that net imports of a state within the United States can adjust much more rapidly than net imports of the United States as a whole. If, in some year, Massachusetts residents have a large idiosyncratic demand for consumption, this demand may be satisfied relatively quickly (relative to total US demand) by moving goods from stocks in other states without affecting the US-wide interest rate since, in any given year, the sum across states of state-specific shocks is zero by construction. It is imperative to allow for interest rate effects in the modeling of consumption, and to control for them in the empirical tests. Estimation of Euler equations, when the interest rate is not constant through time, is difficult due to non-linearities (indeed, both Mankiw (1981) and Shapiro (1984) estimate a Taylor approximation of the Euler equations), and due to the difficulty in constructing a proper measure of expected real interest rates. We interpret the "aggregate real interest rate" as a metaphor for all effects that hamper the adjustment of aggregate consumption to aggregate income shocks and we do not attempt

[4]The literature concerned with testing the Euler equations of individual intertemporal optimization typically rejects optimal intertemporal behavior, while that concerned with estimating the intertemporal rate of substitution in consumption (by regressing consumption changes on the interest rate) has resulted in conflicting evidence; see, for example, Hall (1988) and Campbell and Mankiw (1989).

to use any measured real interest rate in our estimations. Instead, we remove the aggregate component of state level income and consumption studying the sensitivity of state-specific consumption to state-specific income shocks.[5]

We derive a theoretical benchmark model, in which we allow the interest rate to vary over time and to respond to aggregate economic conditions, in contrast to Hall's formulation. Our central assumption is that the interest rate is uncorrelated with state-specific shocks. Since US interstate capital and credit markets are well integrated (Asdrubali, Sørensen, and Yosha (1996)), arbitrage keeps interest rates similar across regions of the United States. We believe that our assumption that there is a time varying US-wide interest rate that is uncorrelated with state-specific shocks to disposable income is a reasonable approximation of reality, stressing that this formulation is sufficient for drastically reducing measured excess sensitivity of consumption to lagged income. It is, of course, conceivable that if state-specific (or regional) real interest rate movements are controlled for, measured excess sensitivity will decrease further. For lack of reliable data we cannot carry out this test.

Another deviation from PIH behavior was recently pointed out by Deaton (1987) and Campbell and Deaton (1989), who argue that the high persistence in the income process implies that an innovation to current income entails a large innovation to discounted expected future income. Therefore, the PIH model implies that current consumption should respond strongly to current innovations in disposable income. Aggregate US consumption is excessively smooth according to Campbell and Deaton.

There is by now a large literature which attempts to find explanations for these seeming deviations from optimal consumer behavior. Credit rationing (Hall and Mishkin (1982), Zeldes (1989b)) and the presence of rule-of-thumb consumers (e.g., Campbell and Mankiw (1990)) are some of the suggested explanations for the excess sensitivity phenomenon. Other explanations have been proposed by Christiano, Eichenbaum, and Marshall (1991) who stress time aggregation biases and Heaton (1993) who emphasizes intertemporal non-

[5] In micro studies, aggregate effects have been controlled for in a manner similar to ours by, e.g., Altonji and Siow (1987) who include time dummies in their regression and Mariger and Shaw (1993) who allow for time varying coefficients, both finding little or no excess sensitivity of consumption to lagged income. It is not obvious that this finding should carry over to aggregate data.

separabilities such as durability of consumption goods or habit persistence in preferences. Many explanations of excess sensitivity also explain excess smoothness, although Gali (1991) points out that excess smoothness implies excess sensitivity, but not the other way around. Gali (1990) and Clarida (1991) suggest that aggregation over individuals with finite horizons (due to retirement and finite lifetimes) may explain excess smoothness (as well as excess sensitivity) even if all individuals satisfy the life cycle model. Pischke (1995) argues that deviations from the PIH may be due to consumers not separating between transitory idiosyncratic and permanent aggregate income shocks, while Attanasio and Weber (1995) emphasize aggregation across households and failure to control for demographic and labor supply variables in macro studies, as well as non-separabilities in consumption.[6]

Using our state level data, we perform the following test that can help narrow down the menu of potential explanations. We group states according to the persistence of shocks to income, finding that the response of consumption to lagged income is stronger in states with more persistent shocks to income. When aggregate effects are controlled for, the amount of excess sensitivity declines by about the same amount for each persistence sub-group, demonstrating that our central result is very robust.

Many of the theories described above do not predict that excess sensitivity should vary according to the persistence of income shocks. Certainly, time aggregation bias should be independent of persistence. Habit formation or other time non-separabilities also should not depend on persistence of shocks. By contrast, the presence of rule-of-thumb consumers (e.g., as a result of credit constraints) implies that excess sensitivity of consumption should be systematically related to persistence of income shocks (we provide a detailed analysis in Section 3). Our results, thus, provide indirect evidence for rule-of-thumb or credit constrained consumers against competing theories. We emphasize, however, that once aggregate US-wide effects are controlled for—which is the main point we stress in this paper—the magnitude of the excess sensitivity of consumption is considerably smaller than when aggregate effects are not controlled for.

Controlling for aggregate effects might also help explain Campbell and Deaton's (1989)

[6] Quah (1990) argues that excess smoothness may be an artifact of consumers being able to separate temporary from persistent shocks, while the econometrician does not have enough information to do so.

excess smoothness puzzle. We use our model with a time varying US-wide interest rate and our state level data to study this issue, finding significant excess smoothness of consumption. The order of magnitude can not be explained by the presence of rule-of-thumb consumers. We find that excess smoothness (for state idiosyncratic shocks) is more pronounced for positive than for negative shocks, pointing to some sort of frictions or costs in adjusting consumption rapidly, possibly combined with credit market imperfections.

It is of interest to investigate how consumption smoothing at the state level is achieved. A natural place to look is at interstate borrowing and lending. Although we do not have a complete picture of the financial portfolios of states, we can learn something by studying data on bank deposits and loans by state, available from the Federal Deposit Insurance Corporation (FDIC). In particular, we want to know whether consumption smoothing via saving is accomplished mainly through adjustment of savings deposits or via bank lending.

Studying consumption smoothing via bank deposits and loans has the advantage of providing indirect evidence regarding the PIH at the state level that is independent of the retail sales data. Furthermore, the cyclical behavior of bank deposits and loans can shed light on whether there are credit market imperfections (e.g., whether deposits and loans are used asymmetrically in the adjustment of consumption to income shocks, and in particular, in the smoothing of negative versus positive income shocks).

We find that bank savings deposits in the United States are procyclical and that home equity lending is countercyclical, both smoothing state consumption. By contrast, consumption loans and mortgage loans are typically procyclical, dis-smoothing consumption. These findings do not support the simple PIH model. According to the model, if shocks to state income are random walks then neither savings deposits nor loans should smooth consumption. If shocks to state income are more persistent than a random walk, then both savings deposits and loans should dis-smooth consumption, and if shocks to state income are mean reverting then both savings deposits and loans should smooth consumption.

The results suggest that there are market imperfections that induce individuals to use savings deposits and loans asymmetrically—savings deposits are used to smooth consumption but loans are taken in response to positive shocks (or are recalled by banks in response to negative shocks), dis-smoothing consumption. This is consistent with the presence of credit constraints (e.g., Zeldes (1989b), Deaton (1991)) as well as with recent influential work on consumption smoothing that promotes the idea that consumers cannot or do not wish to smooth negative income shocks via borrowing, and therefore maintain a buffer stock of savings that adjusts in response to income shocks (e.g., Zeldes (1989a), Deaton (1991), Carroll (1997)). Furthermore, we find considerable asymmetry in the smoothing of positive and negative shocks to disposable income via consumption loans and mortgages. We think that the borrowing and lending data by state are not well suited for more explicit testing of models of optimal consumer behavior; but we find it interesting that our results regarding consumption smoothing through bank savings deposits and loans provide support for the "imperfect credit markets" versions of the PIH. To the best of our knowledge, these empirical findings are novel in the literature.

The next section is devoted to a description of the statistical properties of the state level disposable income and consumption series. In Section 3 we study excess sensitivity of state consumption, Section 4 is devoted to testing for excess smoothness of state consumption, and in Section 5 we study smoothing (or dis-smoothing) of shocks to state disposable income through bank savings deposits and loans. Section 6 concludes.

2 Statistical Properties of State Level Data

State disposable income

We use state disposable personal income for the period 1963–93, available from the Bureau of Economic Analysis (BEA). All the data series are divided by state population to give per capita magnitudes.[7] We perform Augmented Dickey-Fuller tests for a unit root in disposable income for each state, rejecting the unit root hypothesis at the 5 percent confidence level for only two states and for no state at the 1 percent confidence level (Table I).[8] We conclude

[7]For brevity, we will often refer to state per capita personal disposable income as "income" or "disposable income."

[8]These results are for an AR(1) process for income. Allowing for an AR processes with 2 and 3 lags, we reject the unit root hypothesis at the 5 percent confidence level only for one state, and for no state at the 1 percent confidence level.

that state income is well described as an integrated process.[9]

To determine a suitable model for the state level income process, we estimate an AR(2) model for the differenced income series of each state (Table II). The coefficient of twice lagged differenced income is significantly different from zero for only 4 states (we provide the range of the t-statistics in Table II), while a simultaneous test for all the coefficients of twice lagged differenced income being zero gives a P-value of 0.04. The average value of the coefficient to twice lagged income is small, with a value of 0.04. All in all, it seems that a simple AR(1) process in differences describes state disposable state income reasonably well (Campbell and Deaton (1989) similarly find that an AR(1) in differences describes aggregate US labor income well).

Let Y_{it} denote the per capita disposable income of state i in year t. We estimate the AR(1) process,

$$\Delta Y_{it} \;=\; \alpha_i + \phi_i \Delta Y_{i,t-1} + \epsilon_{it} \;, \tag{1}$$

for each state, where α_i and ϕ_i are state-specific parameters and ϵ_{it} is a white noise process with mean zero for each state i (Table II). The average estimate of ϕ_i is 0.14, with t-statistics ranging from –1.62 to 3.35. The sample for each state is rather short and large efficiency gains can be achieved by pooling the data, provided that the income processes for different states are identical and independent across states. We test the hypothesis $\phi_i = \phi$ for all i, failing to reject it with a P-value of 0.12. Imposing an identical AR(1) parameter for all states yields a highly significant estimate of ϕ equal to 0.16 (Table II).[10] For completeness, we perform a similar estimation for the differenced log-income series, obtaining roughly similar results (not reported).

The residual variance $\text{Var}(\epsilon_{it})$ varies from state to state, and is typically larger for small states. We, therefore, normalize the series ΔY_{it} with an estimate of the state-specific variance obtained from a first stage Ordinary Least Squares estimation of (1). The transformed model satisfies $\text{Var}(\epsilon_{it}) = \sigma^2$.

[9] We further perform Augmented Dickey-Fuller tests for a unit root in aggregate US disposable income using 1,2, and 3 lags. The unit root hypothesis cannot be rejected at the 1 percent confidence level.

[10] A test of $\alpha_i = \alpha$ for all i does not reject equality, but as our data set is large we see no need to impose this restriction.

State consumption

We perform a similar exercise for state level private consumption, which we approximate by state level retail sales. Retail sales by state are published in the Survey of Buying Power in Sales Management (after 1976, Sales & Marketing Management). These data are proprietary and we thank the publishers of Sales & Marketing Management for permission to use the series. Since retail sales are only a part of total personal consumption, we rescale the retail sales data by the ratio of aggregate US private consumption to aggregate US retail sales for each year, to obtain an estimate of total personal consumption.[11]

The time series regressions reported in this section are descriptive, and are intended to give a first impression of the state level consumption series. We perform Augmented Dickey-Fuller tests for a unit root in consumption for each state, rejecting the unit root hypothesis at the 5 percent confidence level for only three states and for only one state at the 1 percent confidence level (Table I).[12] We conclude that state consumption is well described as an integrated process.[13]

We estimate AR(2) and AR(1) processes for state level differenced consumption with state-specific intercepts and coefficients (Table III). The average coefficient of lagged consumption in the AR(2) regression is 0.14. The average coefficient to twice lagged consumption is negative 0.02. A hypothesis test for this coefficient being zero for all states is easily accepted with a P-value of 0.93. The average coefficient of lagged consumption in the AR(1) regression is 0.14. We test the hypothesis that the coefficients for all states are equal, accepting it with a P-value of 0.60. Imposing an identical AR(1) parameter for all states yields a highly significant estimate of the AR(1) coefficient (ψ) equal to 0.14.

[11]We are aware that retail sales is a somewhat noisy proxy for state private consumption (e.g. travel expenses are not included in retail sales) but, to our knowledge, it is the best available. The correlation between annual increments of aggregate US retail sales and aggregate US private consumption, both measured in real (cpi deflated) terms, is 0.85.

[12]These results are for an AR(1) process for income. Allowing for an AR processes with 2 lags, we reject the unit root hypothesis at the 5 percent confidence level for five states, and for three states at the 1 percent confidence level. Allowing for 3 lags, we do not reject the unit root hypothesis for any state at either confidence level (Table I).

[13]We further perform Augmented Dickey-Fuller tests for a unit root in aggregate US consumption using 1,2, and 3 lags. The unit root hypothesis cannot be rejected at the 1 percent confidence level. At the 5 percent confidence level it cannot be rejected with 2 and 3 lags, but is rejected when only one lag is allowed.

This is *prima facie* evidence against the simple PIH model which predicts that consumption is a random walk, namely, that current consumption changes are uncorrelated with lagged consumption changes.

Decomposing state level income and consumption processes to US-wide and state-specific components

In this paper, we focus on idiosyncratic fluctuations of state level income. We write period t state disposable income as

$$Y_{it} = Y_t + y_{it}, \tag{2}$$

where Y_t and y_{it} are the aggregate US-wide and the state-specific (idiosyncratic) components of per capita disposable income. We perform Augmented Dickey-Fuller tests for a unit root in the state-specific component of disposable income for each state, rejecting the unit root hypothesis at the 5 percent confidence level for only one state and for no state at the 1 percent confidence level (Table IV).[14] We conclude that the state-specific component of disposable income is well described as an integrated process.

Similarly, we write period t state consumption as

$$C_{it} = C_t + c_{it}, \tag{3}$$

where C_t and c_{it} are the aggregate US-wide and the state-specific components of per capita consumption. Augmented Dickey-Fuller tests for a unit root in the state-specific component of consumption yield similar results to those obtained for state-specific income (Table IV).[15]

To study the behavior of the state-specific component of disposable income and consumption, we estimate AR(2) and AR(1) processes for these state-specific components (Tables V and VI). The state-specific income process is described reasonably well by an

[14]These results are for an AR(1) process for the state-specific component of disposable income. Similar results are obtained if we allow for more lags (Table IV).

[15]We further examine, for each state i, if there exists a coefficient κ_i such that $Y_{it} - \kappa_i Y_t$ is a stationary process, namely, if state income and aggregate US income are cointegrated processes. We use the Johansen maximum likelihood test (Johansen (1991)), rejecting the null hypothesis of no cointegration for two states at the 5 percent confidence level and for no state at the 1 percent level.

AR(1) in first differences (the hypothesis $\phi_{2,i} = 0$ for all i is rejected but the average point estimate is very small (0.01); imposing $\phi_{1,i} = \phi$, the AR(1) estimation yields a highly significant estimate of 0.12). All in all, we conclude that state level income and state level idiosyncratic income are reasonably well described by AR(1) processes in differences. For state level income there is little evidence against the assumption that the AR-coefficients are identical across states ($\phi_{1,i} = \phi$), while there is some evidence against this restriction for state-specific income. We proceed initially with the simplifying assumption that all states have a similar AR(1) coefficient, but we will relax this assumption in some of our later estimations.

The state-specific consumption process appears to be a random walk. The hypothesis that state-specific consumption follows AR(1) processes with identical coefficients is easily accepted, and the AR(1) estimation, imposing the same AR(1) coefficient for each state, yields an estimate of 0.03 with a t-statistic of 1.44. Thus, "pulling out" the US-wide component in consumption makes a big difference for these regressions, suggesting that the strong autocorrelation in state level consumption (which, in a sense captures the deviation from the PIH model) is driven by the common (US-wide) component of state consumption. We conjecture that the findings of excess sensitivity of consumption—ubiquitous in the literature using aggregate data—may be caused by the inability of US-wide consumption to react freely and instantaneously to US-wide income fluctuations. The remainder of the paper examines this tantalizing hypothesis in a more structured fashion.

3 Excess Sensitivity of Consumption in State Level Data

The PIH model with a time varying aggregate interest rate

We begin with a brief presentation of the PIH model with quadratic utility (as in Hall (1978)), departing from Hall's formulation by allowing the aggregate interest rate to vary through time. A detailed presentation of the model is provided in the Appendix. Here, we present the main steps, focusing on the economic intuition of the results and on their empirical implications.

The period t intertemporal budget constraint (the law of motion of wealth) of state i is

$$B_{i,t+1} = (1 + r_{t+1})(B_{it} + Y_{it} - C_{it}), \tag{4}$$

where B_{it}, Y_{it}, and C_{it} are period t per capita wealth, income, and consumption of state i, and r_{t+1} is the US-wide one year interest rate in year t. All the variables in (4) are known at time t. Using (4) recursively, we obtain the life-time resource constraint of state i,

$$C_{it} + \Sigma_{j=1}^{\infty} \frac{1}{(1 + r_{t+1}) \cdots (1 + r_{t+j})} C_{i,t+j} = B_{it} + Y_{it} + \Sigma_{j=1}^{\infty} \frac{1}{(1 + r_{t+1}) \cdots (1 + r_{t+j})} Y_{i,t+j}. \tag{5}$$

If state i chooses a consumption plan to maximize expected utility, where the per-period utility function is $u(z) = E + Fz - (G/2)z^2$, an optimal consumption plan satisfies, for any t, the following Euler equation:

$$E_t\, C_{i,t+1} = \frac{F}{G}\left(1 - \frac{1}{\beta(1 + r_{t+1})}\right) + \frac{1}{\beta(1 + r_{t+1})} C_{it}. \tag{6}$$

Decomposing state disposable income and consumption to a US-wide and a state-specific component (see (2) and (3)), and doing the same for wealth, i.e. $B_{it} = B_t + b_{it}$, with $\Sigma_i c_{it} = \Sigma_i y_{it} = \Sigma_i b_{it} = 0$ by construction, we obtain the following relations:

$$b_{i,t+1} = (1 + r_{t+1})(b_{it} + y_{it} - c_{it}), \tag{7}$$

$$c_{it} + \Sigma_{j=1}^{\infty} \frac{1}{(1 + r_{t+1}) \cdots (1 + r_{t+j})} c_{i,t+j} = b_{it} + y_{it} + \Sigma_{j=1}^{\infty} \frac{1}{(1 + r_{t+1}) \cdots (1 + r_{t+j})} y_{i,t+j}, \tag{8}$$

$$E_t\, c_{i,t+1} = \frac{1}{\beta(1 + r_{t+1})} c_{it}. \tag{9}$$

That is, quadratic utility implies that the state-specific income and consumption processes obey an intertemporal budget constraint (the law of motion of wealth), a life-time resource constraint, and an Euler equation that are analogous to those obeyed by total income and consumption processes (equations (4), (5), and (6)). In fact, the more detailed analysis in the Appendix further demonstrates that the consumption smoothing programs of the fifty states can be decomposed into an optimization program of an imaginary average US consumer who smoothes average per capita income (and holds average per capita wealth), and fifty individual consumption smoothing programs around that average.

We assume that the state-specific income and consumption processes $\{y_{it}\}$ and $\{c_{it}\}$ are independent of the US-wide interest rate process $\{r_t\}$. This is the central assumption of the paper that drives much of the remaining analysis.

Using (9) recursively we derive an expression for $E_t\, c_{i,t+j}$ as a function of c_{it} and one year interest rates for years $t+1$ to $t+j$. Taking an expectation at time t in (8), substituting for $E_t\, c_{i,t+j}$, and solving for c_{it}, we obtain the following consumption function,

$$c_{it} = \rho_t \left[b_{it} + y_{it} + \Sigma_{j=1}^{\infty} E_t \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} E_t\, y_{i,t+j} \right], \tag{10}$$

where

$$\rho_t = 1/ \left[1 + \Sigma_{j=1}^{\infty} E_t \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} \Pi_{s=1}^{j} E_t\, x_{t+s} \right] \tag{11}$$

and $x_{t+j} \equiv 1/\beta(1+r_{t+j})$. The effective period t discount factor, $\rho_t < 1$, takes into account the expected path of the future aggregate interest rate.

The consumption function (10) is interpreted as follows: The idiosyncratic component of state i's consumption in period t equals the discounted idiosyncratic component of state i's period t resources (wealth plus current income) and the discounted sum of expected future idiosyncratic innovations to the state's income.[16]

To derive a formula for Δc_{it}, substitute in (10) using (8). Then write (10) for period $t-1$ and multiply both sides by $1+r_t$. Subtract one equation from the other and rearrange,

[16] Notice that when $1/(1+r_t) = 1/(1+r) = \beta$, we have $\Pi_{s=1}^{j} E_t x_{t+s} = 1$, and the denominator in (11) equals $1 + 1/(1+r) + 1/(1+r)^2 + \cdots = (1+r)/r$, and hence $\rho_t = r/(1+r)$.

to obtain

$$\begin{aligned}\Delta c_{it} &= \Delta\rho_t(1+r_t)(b_{i,t-1}+y_{i,t-1}) + [r_t - \rho_t(1+r_t)]c_{i,t-1} \\ &+\rho_t y_{it} - \rho_{t-1}E_{t-1}\, y_{it} \\ &+\rho_t E_t\left(\tfrac{1}{1+r_{t+1}}\, y_{i,t+1}\right) - \rho_{t-1}E_{t-1}\left(\tfrac{1}{1+r_{t+1}}\, y_{i,t+1}\right) \\ &+\rho_t E_t\left(\tfrac{1}{(1+r_{t+1})(1+r_{t+2})}\, y_{i,t+2}\right) - \rho_{t-1}E_{t-1}\left(\tfrac{1}{(1+r_{t+1})(1+r_{t+2})}\, y_{i,t+2}\right) \\ &+\cdots\end{aligned} \tag{12}$$

It is immediately apparent from (12) that relaxing Hall's assumption of a time invariant aggregate interest rate creates a relation between current consumption changes and past income. There are several channels through which this effect operates. The first term in the first line of (12) describes the effect of past wealth and income on current increases of consumption. The direction of this effect depends on the intertemporal behavior of the aggregate interest rate. If the change in the effective discount factor is positive, $\Delta\rho_t > 0$, namely if the real expected return on lifetime resources increases from period $t-1$ to period t, then higher past wealth and income imply higher current consumption.[17] Symmetrically, if $\Delta\rho_t < 0$.

To understand the economic significance of the second term, consider a sharp one year increase in r_t. Since this is a temporary and short term increase in the interest rate, ρ_t is almost unaffected. Writing the coefficient of $c_{i,t-1}$ as $(1-\rho_t)r_t - \rho_t$, and recalling that $\rho_t < 1$, we see that the increase in r_t raises consumption in period t, which makes perfect sense. Since the return on saving from period $t-1$ to period t is very high, saving in period $t-1$ is high, resulting in a large change in consumption from period $t-1$ to period t.

The third channel through which the aggregate interest rate affects current consumption is manifested in the remaining terms of (12). These terms represent the effect on current consumption of news about future income. Had the interest rate been constant, these terms would involve (appropriately discounted) expressions such as $E_t y_{i,t+j} - E_{t-1} y_{i,t+j}$, the period t news regarding income in period $t+j$. When the interest rate is not constant,

[17] The reason for this is that each dollar of past wealth accumulates a higher "effective" interest rate resulting in higher current wealth, and hence in higher consumption (see the consumption function (10) where b_{it} is positively related to c_{it}).

this simple (and classic) representation is not possible, and changes in the interest rate must be taken into consideration in assessing the effect on wealth (and hence on current consumption) of news about future income.

An analogous reasoning applies to ΔC_{it}, the change in total state consumption since, as was pointed out earlier, quadratic utility implies that the intertemporal budget constraint (the law of motion of wealth), the life time resource constraint, and the Euler equation, namely, equations (7), (8), and (9), apply both to total state consumption, wealth, and income as well as to the respective state-specific magnitudes. The derivation of (12) for total state consumption, income, and wealth is, therefore, analogous.

This, however, is where the analogy ends. A standard test of excess sensitivity is to regress current consumption changes on lagged income changes. The predictions of the above PIH model with time varying interest rate for such a regression using total state consumption and income are very different from the predictions for the same regression using the state-specific components of consumption and income. The next subsection is devoted to this issue.

The covariance of current consumption and lagged income changes implied by the model

We compute the covariance of $\Delta y_{i,t-1}$ and Δc_{it}, using (12). Under our maintained assumption, that state-specific income changes are uncorrelated with the aggregate interest rate, the covariance of $\Delta y_{i,t-1}$ with the first two terms on the right hand side of (12) is $E[\Delta\rho_t(1+r_t)]\,\mathrm{Cov}(b_{i,t-1}+y_{i,t-1},\Delta y_{i,t-1})+E[r_t-\rho_t(1+r_t)]\,\mathrm{Cov}(c_{i,t-1}\,,\,\Delta y_{i,t-1})$.

We turn to the covariance of $\Delta y_{i,t-1}$ with the additional terms on the right hand side of (12). The first of these terms equals $\rho_t y_{it}-E_{t-1}\rho_{t-1}\,y_{it}$ which, adding and subtracting $E_{t-1}\rho_t\,y_{it}$, can be written as $(E_t-E_{t-1})\,\rho_t y_{it}+E_{t-1}\Delta\rho_t y_{it}$. Analogously, adding and subtracting $E_{t-1}\rho_t\,\frac{1}{1+r_{t+1}}\,y_{it}$, the second term can be written as $(E_t-E_{t-1})\,\rho_t\,\frac{1}{1+r_{t+1}}\,y_{i,t+1}+E_{t-1}\Delta\rho_t\,\frac{1}{1+r_{t+1}}\,y_{i,t+1}$, and similarly for subsequent terms. The sum of these terms can, therefore, be written as $(E_t-E_{t-1})\,\rho_t\left(y_{it}+\frac{1}{1+r_{t+1}}\,y_{i,t+1}+\cdots\right)+E_{t-1}\Delta\rho_t\left(y_{it}+\frac{1}{1+r_{t+1}}\,y_{i,t+1}+\cdots\right)$. The first term of this expression is the period t innovation regarding future income and interest rates and is, therefore, uncorrelated with $\Delta y_{i,t-1}$. The covariance of the second term with $\Delta y_{i,t-1}$ is $E(\Delta\rho_t)\mathrm{Cov}(y_{it}, \Delta y_{i,t-1}) + E\left(\Delta\rho_t \frac{1}{1+r_{t+1}}\right)\mathrm{Cov}(y_{i,t+1}, \Delta y_{i,t-1}) + \cdots$. The first of these terms is zero if ρ_t is a stationary process, but the remaining terms are not. Thus, we have

$$\begin{aligned}\mathrm{Cov}(\Delta c_{it}, \Delta y_{i,t-1}) &= E[\Delta\rho_t(1+r_t)]\,\mathrm{Cov}(b_{i,t-1}+y_{i,t-1}, \Delta y_{i,t-1}) \\ &\quad + E[r_t - \rho_t(1+r_t)]\,\mathrm{Cov}(c_{i,t-1}, \Delta y_{i,t-1}) \\ &\quad + E\left(\Delta\rho_t \frac{1}{1+r_{t+1}}\right)\mathrm{Cov}(y_{i,t+1}, \Delta y_{i,t-1}) + \cdots.\end{aligned} \tag{13}$$

This covariance is likely to be small since the terms $\Delta\rho_t$ and $r_t - \rho_t(1+r_t)$ are typically small. In the special case of a constant interest rate, $r_t = r$, we have $\Delta\rho_t = 0$ and $\rho_t = [(1+r)^2\beta - 1]/[(1+r)^2\beta]$, so that $\mathrm{Cov}(\Delta c_{it}, \Delta y_{i,t-1})$ reduces to $[(1-(1+r)\beta]/[(1+r)\beta)]\,\mathrm{Cov}(c_{i,t-1}, \Delta y_{i,t-1})$ which is equal to zero if $1+r = 1/\beta$.

In Hall's (1978) model, the covariance of Δc_{it} and $\Delta y_{i,t-1}$ is zero. Thus, the above result—namely, that in the PIH model with a time varying interest rate the covariance of Δc_{it} and $\Delta y_{i,t-1}$ evaluated at $1+r_t = 1+r = 1/\beta$ is zero—means that, "in the neighborhood of Hall's formulation," the PIH model with a time varying interest rate for *state-specific* income and consumption yields the same predictions regarding the sensitivity of current consumption to lagged income as Hall's original model.

This is no longer true if we use total state income and consumption. Then the expression for the covariance of ΔC_{it} and $\Delta Y_{i,t-1}$ is not as simple as in (13). Since r_t is likely to be correlated with $\Delta Y_{i,t-1}$, the terms $E[r_t - \rho_t(1+r_t)]$ and $E[\Delta\rho_t(1+r_t)]$ do not factor out as they do in (13). Similarly, the additional terms are more complicated than in (13), again, due to the correlation of total state income with the aggregate interest rate. It is then no longer true that the PIH model with a time varying interest rate "locally" approximates the predictions, regarding the sensitivity of current consumption to lagged income, of Hall's fixed interest rate model.

We expect the covariance of ΔC_{it} and $\Delta Y_{i,t-1}$ to be larger than the covariance in (13). The economic reasoning is as follows. According to our model, aggregate US-wide resources devoted to consumption cannot respond quickly to changes in the demand for consumption due to the inability of US net imports and investment to adjust quickly. If, for example, a negative and highly persistent income shock hits the United States in year $t-1$, consumers will want to reduce their consumption in year $t-1$ by more than the size of the shock. Since the extra resources that have been freed cannot be channeled to foreign markets or to investment instantaneously, and imports cannot be cut down fast enough, the aggregate interest rate, r_t (the return on saving made at $t-1$) will fall, inducing consumers to reduce their saving and increase consumption. Symmetrically, a highly persistent positive income shock in year $t-1$ will entail competition for scarce resources that will drive up r_t. Thus, there is a positive correlation of $\Delta Y_{i,t-1}$ and r_t. Since $\Delta Y_{i,t-1}$ is positively autocorrelated, the negative shock to period $t-1$ income is likely to entail a (smaller) negative shock to period t income, and hence, by the same reasoning, to period t consumption, resulting in a positive correlation of $\Delta Y_{i,t-1}$ and ΔC_{it}. In fact, in this extreme example, where aggregate US investment and net imports do not adjust at all, we have $\text{Cov}(\Delta C_{it}, \Delta Y_{i,t-1}) = \text{Cov}(\Delta Y_{it}, \Delta Y_{i,t-1}) > 0$.

This effect should be considerably smaller for state-specific income and consumption processes. Suppose that there is a positive and highly persistent income shock to state i's income in year $t-1$, and that consumers in that state want to increase their consumption in year $t-1$ by more than the size of the shock due its persistence. Since the year $t-1$ state-specific shocks across the United States add to zero, there are free resources (released by states that were hit by a negative state-specific shock) to satisfy the demand for consumption in state i. Therefore, if aggregate constraints are important, the correlation between $\Delta y_{i,t-1}$ and Δc_{it} will be weaker than the correlation between $\Delta Y_{i,t-1}$ and ΔC_{it}.[18]

The central empirical implication of our analysis is that if we control for aggregate US income (or consumption), the sensitivity of current consumption to lagged income should be smaller than if aggregate resources are not controlled for. The empirical results confirm this prediction.

[18] Of course, there will be a US-wide equilibrium interest rate at which intertemporal consumption smoothing transactions in year $t-1$ will take place, whether these transactions are intended to smooth state-specific or US-wide consumption. This is the reason for the presence of the terms involving r_t in (13).

Testing excess sensitivity of consumption using total and state-specific income and consumption data

In Table VII we report results of excess sensitivity tests using the panel of state level income and consumption series. Without controlling for aggregate US consumption, namely by regressing ΔC_{it} on $\Delta Y_{i,t-1}$, the coefficient of lagged income is 0.37 and is highly significant. When aggregate income and consumption are controlled for, "pulling out" the aggregate by regressing the change in state-specific consumption on the change in lagged state-specific income, the coefficient of lagged income falls drastically by more than half. The result is robust to minor changes in specification. In Table VII we report the results from three different ways of correcting for aggregate consumption: (1) subtracting aggregate US consumption and income from state level consumption and income, (2) including aggregate consumption as a regressor, and (3) including aggregate consumption as a regressor with separate coefficients for each state. The point estimates of the coefficient of lagged income vary within the narrow range of 0.14 to 0.17 and are precisely estimated. We obtain a similar result (not reported) in a regression of ΔC_{it} on $\Delta Y_{i,t-1}$ using time fixed effects that control for the time varying aggregate income and consumption levels.

The conclusion from these regressions is clear. Adjusting for aggregate income and consumption, and focusing on the reaction of state-specific consumption to state-specific income changes, dramatically reduces the excess sensitivity of consumption. Our interpretation of this result is that the "closedness" of the US economy, in the sense of large frictions to rapid adjustment of aggregate consumption, explains much of the excess sensitivity of consumption found in aggregate US data.

Excess sensitivity of consumption and the persistence in disposable income

We examine whether our finding of less excess sensitivity when aggregate income shocks are controlled for depends on the persistence of income shocks. According to our explanation much of the excess sensitivity is driven by US-wide effects and, to a first approximation, should not depend on characteristics of individual states like the persistence of state-specific income changes. We measure persistence by the coefficient ϕ_i in the regression $\Delta(Y_{it}-Y_t)=\alpha_i+\phi_i\Delta(Y_{i,t-1}-Y_{t-1})+\epsilon_{it}$, ranking states by the persistence of disposable income.[19] As shown in Table VIII, excess sensitivity of state income is robustly higher than excess sensitivity of state-specific income for each persistence sub-group, strengthening our conviction that aggregate US-wide effects are partly responsible for the high excess sensitivity of consumption found in national level US data.

A large amount of excess sensitivity is, however, still apparent in state-specific consumption, especially in states with highly persistent income changes. This is consistent with the Campbell and Mankiw (1990) model where excess sensitivity of consumption is attributed to a fraction λ of individuals who consume current income, while the rest behave according to the PIH model. To illustrate, if state level income follows the process $\Delta y_{it}=\nu_i+\phi_i\,\Delta y_{i,t-1}+v_{it}$ and the interest rate is constant over time, we will find

$$\begin{aligned}\Delta c_{it} &= \alpha_i+\lambda\,\Delta y_{it}+u_{it} &(14)\\ &= \alpha_i+\lambda(\nu_i+\phi_i\,\Delta y_{i,t-1}+v_{it})+u_{it} &(15)\\ &= \mu_i+\lambda\phi_i\,\Delta y_{i,t-1}+e_{it}\ , &(16)\end{aligned}$$

where u_{it}, v_{it}, and e_{it} are error terms uncorrelated with y_{it-1} and α_i, μ_i, and ν_i are constants. In other words, a regression of Δc_{it} on $\Delta y_{i,t-1}$ will give a coefficient of $\lambda\phi_i$.

The results in Table VIII are not literally consistent with a fixed λ, as can be seen from comparing the estimated coefficients to lagged income with the average estimated ϕ_i coefficients for each sub-group, but qualitatively, the positive relation between persistence of income shocks and measured excess sensitivity of consumption is in accordance with the Campbell and Mankiw model; although, as pointed out in the introduction, at odds with many suggested explanations of non-PIH behavior.

Relation to micro studies of excess sensitivity of consumption

Our results are consistent with results obtained in micro studies regarding the sensitivity of current consumption to lagged income. Altonji and Siow (1987) find very little excess

[19]The Campbell and Mankiw (1987) measure of persistence for this model is simply $1/(1-\phi_i)$.

sensitivity when aggregate effects are controlled for using time dummies, and Mariger and Shaw (1993) actually find no excess sensitivity when interaction between aggregate and idiosyncratic effects is allowed for (this approach is similar in spirit to allowing for state varying γ_i coefficients as we do in Table VII). By contrast, Hall and Mishkin (1982) find a *negative* and significant relation between consumption changes and lagged income changes, while Shapiro (1984), controlling for the aggregate interest rate, obtains a similar result. We interpret this finding, particularly in the light of the mixed evidence in studies that use the aggregate interest rate to study intertemporal substitution, as indicating that measured real interest rates do a poor job of controlling for aggregate effects.

Deaton (1992) devotes an entire chapter to the discussion of potential differences between macro and micro studies of consumption theory. We believe that studying consumer behavior at the regional or state level can help bridge the gap between these seemingly inconsistent approaches. Our results highlight the importance of appropriately controlling for aggregate effects in micro studies of consumer behavior and our findings across groups of states with different persistence in (first differenced) income cast doubt on explanations based on aggregation biases.

4 Excess Smoothness of Consumption in State Level Data

Deaton (1987) and Campbell and Deaton (1989) argue that the high persistence in the income process implies that an innovation to current income entails a large innovation to discounted expected future income. Therefore, the PIH model implies that current consumption should respond strongly to current innovations in income. We examine here the implications of the variable interest rate PIH model for this hypothesis.

We assume that state-specific income innovations are exogenous for current state-specific consumption innovations. This assumption seems reasonable since US states are very open. (A similar assumption, that aggregate US income is exogenous for aggregate US consumption would, however, be unpalatable.) We can, therefore, examine the sensitivity of idiosyncratic consumption changes to idiosyncratic income changes in a transparent fashion by simply regressing current state-specific changes in consumption on current state-specific changes in income.

In Section 2, we documented that state-specific income is quite close to a random walk, with an average AR(1) parameter of 0.14. To illustrate the order of magnitude of the regression coefficient predicted by the PIH model, we proceed under the assumption that state-specific income is a random walk. Notice that the random walk assumption biases our test against finding excess smoothness, since it is intuitively clear that the true implied coefficient in a regression of current consumption on current income will be larger—the positive AR coefficient in income implies that a positive (negative) income shock will be followed, on average, by a further positive (negative) income shock in the next period.

The random walk assumption implies that for any $s < s'$, $E_s\, y_{is'} = y_{is}$, and hence equation (12) simplifies to

$$\begin{aligned} \Delta c_{it} &= \Delta\rho_t(1+r_t)(b_{i,t-1}+y_{i,t-1}) + [r_t - \rho_t(1+r_t)]c_{i,t-1} \\ &\quad +\rho_t\left\{1+\left(\tfrac{1}{1+r_{t+1}}\right)+\left(\tfrac{1}{1+r_{t+1}}\right)\left(E_t\,\tfrac{1}{1+r_{t+2}}\right)+\cdots\right\}\Delta y_{it} \\ &\quad +\left\{(\rho_t-\rho_{t-1})+\left[\rho_t\left(\tfrac{1}{1+r_{t+1}}\right)-\rho_{t-1}\left(E_{t-1}\,\tfrac{1}{1+r_{t+1}}\right)\right]\right. \\ &\quad \left. +\left[\rho_t\left(\tfrac{1}{1+r_{t+1}}\right)\left(E_t\,\tfrac{1}{1+r_{t+2}}\right)-\rho_{t-1}\left(E_{t-1}\,\tfrac{1}{(1+r_{t+1})(1+r_{t+2})}\right)\right]+\cdots\right\} y_{i,t-1}. \end{aligned} \tag{17}$$

Under the random walk assumption, current changes in idiosyncratic income are uncorrelated with lagged variables, implying that

$$\begin{aligned} \mathrm{Cov}\{\Delta y_{it},\Delta c_{it}\} &= \mathrm{Cov}\left\{\Delta y_{it}, \rho_t\left[1+\left(\tfrac{1}{1+r_{t+1}}\right)+\left(\tfrac{1}{1+r_{t+1}}\right)\left(E_t\,\tfrac{1}{1+r_{t+2}}\right)+\cdots\right]\Delta y_{it}\right\} \\ &= E\left\{\rho_t\left[1+\left(\tfrac{1}{1+r_{t+1}}\right)+\left(\tfrac{1}{1+r_{t+1}}\right)\left(E_t\,\tfrac{1}{1+r_{t+2}}\right)+\cdots\right]\right\}\mathrm{var}\{\Delta y_{it}\}\,. \end{aligned} \tag{18}$$

The coefficient in the regression of Δc_{it} on Δy_{it} will, therefore, be

$$E\left\{\rho_t\left[1+\left(\frac{1}{1+r_{t+1}}\right)+\left(\frac{1}{1+r_{t+1}}\right)\left(E_t\,\frac{1}{1+r_{t+2}}\right)+\cdots\right]\right\}. \tag{19}$$

To get a feel for the magnitude of this coefficient, consider the case of a constant interest rate. The coefficient reduces to $[(1+r)^2\beta - 1]/[r(1+r)\beta]$, which is equal to unity if $\beta = 1/(1+r)$. If the variation in the real interest rate is minor, and the discount factor is not very different from $1/(1+r)$, the regression of current consumption changes on current income changes will give a coefficient near unity.

In Table IX we report the results from a regression of state-specific current consumption changes on state-specific current income changes. The coefficient is precisely estimated and equals 0.34 which is much below what can reasonably be expected from our model. Clearly, the excess smoothness finding of Deaton (1987) and Campbell and Deaton (1989) is not explained by aggregate constraints or endogeneity of the interest rate. The model of Campbell and Mankiw (1990), where a fraction λ of consumers consume current income, is not consistent with this coefficient.[20] Explanations of excess smoothness must therefore be found elsewhere. Attfield, Demery, and Duck (1992) demonstrate that adjustment costs in consumption may explain excess smoothness, and they also suggest a model where adjustments costs related to unanticipated shocks are higher than adjustment costs related to anticipated shocks. Adjustment costs may help explain the excess smoothness in state level data as well as the excess sensitivity that is not explained by the aggregate constraint. A deeper understanding of such adjustment costs is necessary, although informational asymmetries as modeled by Quah (1990) or Pischke (1995) may well be part of an explanation.

We further examine if 3-year consumption differences show higher correlation with 3-year income differences by regressing $\Delta_3 c_{it}$ on $\Delta_3 y_{it}$ (where $\Delta_3 x_t \equiv x_t - x_{t-3}$). This regression yields a coefficient of 0.73 which is much closer to unity than the coefficient in the regression with 1-year differenced data. Although the coefficient is significantly smaller than unity, it is of an order of magnitude that may not be at odds with our model. An interpretation could be that consumers are more successful in disentangling transitory from permanent shocks over longer horizons, forming a better estimate of their permanent income on the basis of 3-year income shocks. Alternatively, the longer differencing length may capture effects such as durability or habit persistence. Although the considerably higher coefficient is suggestive, more specialized studies are needed to pin down the reason for excess smoothness of consumption. Our results mainly serve to rule out the "closed economy" effect (in the sense that net exports and investment cannot adjust quickly to

[20] Assume that the change in consumption is equal to $\lambda \Delta y_{it} + (1-\lambda)\Delta c^*_{it}$, where Δc^*_t is the change in consumption derived above (equation (17)). It is immediately clear that if a regression of Δc^*_{it} on Δy_{it} gives a coefficient of about unity, so will a regression of $\lambda \Delta y_{it} + (1-\lambda)\Delta c^*_{it}$ on Δy_{it}.

consumption demand) and the endogeneity of interest rates, as explanations for excess smoothness of consumption.

In Table X, we show "excess smoothness regressions" by sub-groups of states when the states are ordered according to persistence in income. The qualitative differences across persistence sub-groups are as predicted by the PIH model: The higher the persistence of income shocks, the less consumption is smoothed. This is encouraging for PIH-type modeling, although it does not help solve the puzzle why the amount of consumption smoothing is lower than predicted by the model.

Positive versus negative shocks. If credit constraints are responsible for excess smoothness of consumption, we would expect to see relatively less smoothing of negative income shocks, since credit constrained consumers are "forced" to reduce consumption in response to negative income shocks due to lack of credit or unattractive interest rates. We estimate the regression

$$\Delta(C_{it} - C_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t)^+ + b^*\,\Delta(Y_{it} - Y_t)^- + \epsilon_{it}, \qquad (20)$$

where $\Delta(Y_{it} - Y_t)^+$ equals $\Delta(Y_{it} - Y_t)$ if in year t the disposable income of state i is above the average disposable income (across years) of state i and equals 0 otherwise. Analogously for $\Delta(Y_{it} - Y_t)^-$. The results, for smoothing of positive and negative shocks at the 1- and 3-year frequencies, are displayed in Table XI. At the 1-year frequency there is more smoothing of both positive and negative shocks, and what is more interesting, there is relatively less smoothing of negative income shocks.

We interpret these results as follows. Individuals adjust their consumption slowly in response to income shocks, but when income shocks are negative they must adjust their consumption more quickly, possibly due to credit constraints. The slow adjustment in response to positive income shocks indicates that individuals do not wish to adjust consumption immediately (maybe due to "adjustment costs"). The asymmetric adjustment is not consistent with Quah's (1990) model where deviations from PIH are due to consumers having better information than the econometrician. There is no reason to believe that such informational differences should vary according to whether income shocks are positive or negative.

5 The Role of Bank Savings Deposits and Loans

To gain a better understanding of how consumption smoothing at the state level is achieved in practice, and to identify potential credit market imperfections, we study patterns of interstate borrowing and lending using bank savings deposits and loans data by state, available from the FDIC. In particular, we want to know whether consumption smoothing through the banking system is accomplished mainly through adjustment of savings deposits or via bank lending.

We use annual savings deposits and loans data covering the period 1968–93, although some of the data series are available for later years only. The commercial bank data are from the FDIC Historical Statistics on Banking and the data are reported by the state where the bank which originates the loans or accepts the savings deposits is located. These data are collected from the Reports of Income and Condition submitted by insured institutions to the FDIC. The series used in our empirical analysis refer to domestic bank offices only.

We make the assumption that loans to individuals are made to consumers in the state where the bank which originates the loans is located, and similarly for savings deposits. This assumption seems reasonable for our sample period. The series loans to individuals includes auto loans, mobile home loans not secured by a real estate mortgage, education loans, other installment loans both secured by personal property or unsecured, and single payments loans. It does not include credit card loans and related plans.[21] Bank savings deposits consist of money market deposit accounts (MMDAs) and other savings accounts.[22] The distinguishing feature of a savings deposit is restrictive limits on the number of transfers and withdrawals that can be made to third parties or to another account of the same

[21] Credit card loans must be subtracted from the bank loan series for our results to be meaningful. Typically, a bank originating credit card loans will be located in a state different from its borrowers. This is clearly illustrated by the fact that in 1990 commercial banks in the four states of Delaware, Nevada, New Hampshire, and South Dakota jointly held credit card loans constituting between 72 and 97 percent of their stock of loans to individuals. In contrast, the US aggregate ratio for 1990 was 33 percent. In fact, in 1990 banks in Delaware and South Dakota together issued 41 percent of all commercial bank credit card loans in the United States.

[22] For example, passbook savings accounts or statement savings accounts.

depositor.[23] There is no limitation on the amount of interest that can be paid on savings deposits. Ideally, we would like to use other types of deposits besides savings deposits, but data subdividing household and business deposits are generally not available. Demand deposits, for example, include individuals, partnerships, and corporations. Savings deposits is the only categorization which we can be reasonably sure to be a good measure of household deposits.[24]

The mortgage loans series consists of permanent loans secured by real estate or other liens on 1-4 family dwelling units.[25]

Home equity loans are lines of credit secured in the owner's equity in his house and as such are an obvious instrument that can be used for consumption smoothing. Home equity loans have become increasingly popular throughout the 1980s. They are typically taken out for major expenses such as education, medical bills, or home improvements. The FDIC started to collect data on home equity loans in 1987.

To give an impression of the relative magnitudes of the variables used, we list the aggregate US per capita dollar value in 1990 for each item— (1) disposable personal income: 16,163, (2) savings deposits: 3,169, (3) demand deposits: 9,361, (4) credit card loans: 534, (5) loans to individuals: 1,069, (6) mortgage loans: 1,594, (7) home equity loans: 245.

The simplest manner to assess whether consumption smoothing through the banking system is accomplished mainly through adjustment of savings deposits or via bank lending is to regress $\Delta(Z_{it} - Z_t)$ on $\Delta(Y_{it} - Y_t)$ where Z represents savings deposits or loans according to the case, Y represents disposable income, and i is an index of states.

Results. The results, for regressions at the 1- and 3-year differencing frequencies

[23] No more than six transfers and withdrawals per statement cycle can be made. A few exemptions apply. For example, there are no restrictions on transfers made between a depositor's accounts when made by ATM, mail, or in person, or for transfers for the purpose of repaying loans at the same depository institution. For MMDAs no more than three of the six allowable transfers can be made by check, draft, debit card (or similar) by the depositor and payable to third parties. Other savings deposits permit no transfers of this type.

[24] Even if there is no regulation excluding partnerships and corporations from holding savings deposits, the restrictions applying to these accounts make it very unlikely that they are used for short term investment or cash management purposes. Indeed, the Federal Reserve Flow of Funds data for 1996 indicates that households held about 86 percent of all savings deposits, which suggests that this problem is not very severe.

[25] 1-4 family dwelling units include mobile homes, individual condominiums and co-ops, and vacant lots in established single family residential sections.

are displayed in Table XII. Changes in state-specific savings deposits are procyclical and marginally significant at the 1-year frequency, smoothing consumption. Changes in state-specific home-equity loans are countercyclical at the 1-year frequency, also smoothing consumption. The t-statistic for home-equity loans takes the very high value of 20.41, indicating that home-equity loans vary in a highly systematic fashion with income shocks. The smoothing by savings deposits and home-equity loans mirrors the overall consumption smoothing found at the annual frequency. Mortgage loans seem to dis-smooth consumption at the annual frequency (the t-value of 1.54 calls for a tentative interpretation), while consumer loans do not show much sensitivity to idiosyncratic income shocks at the annual frequency. At the 3-year frequency the point estimate for savings deposits indicates that savings deposits dis-smooth consumption, but this estimate is very imprecise. We conjecture that over the 3-year horizon our results may be perturbed by portfolio reallocations resulting from the S&L crisis during this period.[26] At the 3-year frequency, consumer loans and mortgage loans dis-smooth consumption significantly. This might reflect purchases of durable goods and houses in response to positive income shocks or banks being more reluctant to extend credit after negative shocks. We therefore turn to examining if saving and lending react symmetrically to positive and negative income shocks.[27]

Positive versus negative shocks. Our results so far suggest that bank savings deposits and loans do not mirror the overall behavior of savings in the sense that they do not vary proportionally with overall saving. To further interpret these findings, we examine whether bank savings deposits and loans smooth positive and negative state-specific income shocks. We estimate the regression

$$\Delta(Z_{it} - Z_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t)^+ + b^*\,\Delta(Y_{it} - Y_t)^- + \epsilon_{it}, \tag{21}$$

where Z_{it} is a generic variable for state level savings deposits or bank loans. Z_t denotes

[26]The S&L crisis may of course also affect the results for the 1-year horizon. We find it likely, however, that, e.g., the longer lasting recessions in Texas (oil related) and New England (real estate bust), which had dramatic effects on the banking industry, have more impact on our results for the 3-year frequency.

[27]Since home-equity loans are only reported since 1987 we do not report results for smoothing through home-equity loans at the 3-year frequency.

the corresponding US aggregate variable. The sample period is 1968–93 for consumer and mortgage loans, 1977–93 for savings deposits, and 1988–93 for home equity loans.

The results, displayed in Table XIII, provide further evidence for credit market imperfections. At the 1-year frequency there is no noticeable smoothing (or dis-smoothing) via consumer and mortgage loans, but at the 3-year frequency these loans dis-smooth consumption—the amount borrowed is unaffected by positive income shocks but decreases significantly in response to negative income shocks. We interpret the asymmetric behavior of bank lending as evidence of credit constraints.

Home equity loans smooth consumption in response to both positive and negative shocks, decreasing in response to positive shocks and increasing in response to negative shocks. Home equity loans are fully collateralized and the symmetry of the cyclical behavior of home equity loans indicates that, in the absence of credit market imperfections, consumers prefer to smooth negative and positive shocks by the same amount.

Savings deposits smooth consumption in response to negative shocks—more so at the 3-year frequency which is consistent with the interpretation of slow adjustment of consumption to income shocks—and do not smooth consumption in response to positive shocks at the 1-year frequency.[28]

As pointed out in the introduction, these findings do not support the simple PIH model that predicts that (1) both savings deposits and loans should smooth consumption if income shocks are transitory, and dis-smooth consumption if income shocks are permanent, and (2) there should be no difference in the smoothing of positive and negative shocks to disposable income. The results, therefore, suggest that there are market imperfections that induce individuals to use savings deposits and home equity loans, but not consumption loans and mortgages, to smooth consumption.

Empirical evidence suggesting that individuals face credit constraints has been provided recently by, e.g., Zeldes (1989b), Jappelli (1990), and Perraudin and Sørensen (1992). Our findings in this paper are consistent with this evidence, as well as with theories of buffer stock savings that adjust in response to income shocks (e.g., Zeldes (1989a), Deaton (1991),

[28]The high standard error of the estimate for positive shocks at the 3-year frequency does not permit us to interpret this estimate in more detail.

Carroll (1997)). We cannot identify which of these explanations fits the observed data better, but we have documented systematic patterns in lending and saving, not previously known, that future research on this issue should attempt to account for.

6 Concluding Remarks

Overall, the analysis of patterns of consumption smoothing at the state level suggests that the excess sensitivity in consumption found in aggregate US data is driven in part by aggregate US-wide effects. The remaining excess sensitivity is most likely a consequence of the inability of some consumers to smooth consumption, for example due to credit market imperfections. Our finding of higher excess sensitivity of consumption in states with more persistent income shocks is not consistent with several recent explanations of non-PIH behavior such as time aggregation bias, habit formation, or other time non-separabilities. Although the aggregate resource constraint is useful in providing a rationale for part of the observed excess sensitivity in aggregate country level data, it cannot account fully for excess sensitivity and it does not help explain the excess smoothness puzzle formulated recently by Deaton (1987) and Campbell and Deaton (1989). The level of excess smoothness found using state data is inconsistent with the rule-of-thumb model of Campbell and Mankiw (1990), and the asymmetry in the reaction to positive and negative shocks is inconsistent with (at least simple versions of) models of differential information between consumers and econometricians. Future work should attempt to explain why some consumers react to predictable income, why they under-react to current income shocks and react differently to positive and negative shocks, and why savings and loans respond differently to income shocks. Further, future tests using aggregate data should test the explanations on data sets that allow for the removal of economy-wide aggregate constraints and interest rate effects.

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Appendix: The PIH Model with a Time Varying Aggregate Interest Rate

The period t intertemporal budget constraint of state i (the law of motion of state wealth) is

$$B_{i,t+1} = (1 + r_{t+1})(B_{it} + Y_{it} - C_{it}), \tag{22}$$

where B_{it}, Y_{it}, and C_{it} are period t per capita wealth, income, and consumption, and r_{t+1} is the US-wide one period interest rate in period t. All the above variables are known in period t. Rearranging (22) and substituting recursively we obtain

$$\begin{aligned} B_{it} &= \tfrac{1}{1+r_{t+1}} B_{i,t+1} - Y_{it} + C_{it} \\ &= \tfrac{1}{1+r_{t+1}} \left(\tfrac{1}{1+r_{t+2}} B_{i,t+2} - Y_{i,t+1} + C_{i,t+1} \right) - Y_{it} + C_{it} \\ &= \cdots . \end{aligned} \tag{23}$$

Taking a limit, using $\lim_{s\to\infty} \left(\Pi_{k=1}^{s} \frac{1}{1+r_{t+k}} \right) B_{is} = 0$ which follows from the boundedness of wealth and a strictly positive interest rate, and rearranging, we have the life-time resource constraint,

$$C_{it} + \Sigma_{j=1}^{\infty} \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} C_{i,t+j} = B_{it} + Y_{it} + \Sigma_{j=1}^{\infty} \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} Y_{i,t+j}. \tag{24}$$

State i chooses in period s a consumption plan to maximize $E_s \Sigma_{j=0}^{\infty} \beta^j u(C_{s+j}^{i})$ subject to (22). An optimal consumption plan satisfies, for any t, the following Euler equation:

$$E_t\, u'(C_{i,t+1}) = \frac{1}{\beta(1+r_{t+1})} u'(C_{it}). \tag{25}$$

Letting $u(z) = E + Fz - (G/2)z^2$ (with F/G large enough), the Euler equation becomes

$$E_t\, C_{i,t+1} = \frac{F}{G} \left(1 - \frac{1}{\beta(1+r_{t+1})} \right) + \frac{1}{\beta(1+r_{t+1})} C_{it}. \tag{26}$$

Let $C_{it} = C_t + c_{it}$, where C_t is average US per capita consumption and c_{it} is the state-specific period t per capita deviation from average consumption. Similarly for income, $Y_{it} = Y_t + y_{it}$, and wealth, $B_{it} = B_t + b_{it}$, with $\Sigma_i c_{it} = \Sigma_i y_{it} = \Sigma_i b_{it} = 0$ by construction.

We assume that the state-specific income and consumption processes $\{y_{it}\}$ and $\{c_{it}\}$ are independent of the US-wide interest rate proces $\{r_t\}$. This is the central assumption of the paper that drives most of the analysis.

Using (33) recursively we derive an expression for $E_t c_{i,t+j}$. To simplify notation, define $x_{t+j} \equiv 1/\beta(1+r_{t+j})$ and write (33) as $E_{t+j-1}c_{i,t+j} = x_{t+j}\ c_{i,t+j-1}$. Taking an expectation at time t we have

$$\begin{aligned} E_t c_{i,t+j} &= (E_t x_{t+j})\ c_{i,t+j-1} \\ &= (E_t x_{t+j})(E_t c_{i,t+j-1}) \\ &= (E_t x_{t+j})(E_t x_{t+j-1})(E_t c_{i,t+j-2}) \\ &= \cdots \\ &= \left(\Pi_{s=1}^{j} E_t x_{t+s}\right) c_{it}\ . \end{aligned} \tag{34}$$

Taking an expectation at time t in (30) we have

$$c_{it}+\Sigma_{j=1}^{\infty}\, E_t \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} E_t c_{i,t+j} = b_{it}+y_{it}+\Sigma_{j=1}^{\infty}\, E_t \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} E_t y_{i,t+j}. \tag{35}$$

Substituting for $E_t c_{i,t+j}$ using (34) and solving for c_{it}, we have

$$c_{it} = \rho_t \left[b_{it} + y_{it} + \Sigma_{j=1}^{\infty}\, E_t \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} E_t y_{i,t+j} \right] \tag{36}$$

where

$$\rho_t = 1/\left[1 + \Sigma_{j=1}^{\infty} E_t \frac{1}{(1+r_{t+1})\cdots(1+r_{t+j})} \Pi_{s=1}^{j} E_t x_{t+s} \right]. \tag{37}$$

Using (27), write (36) as

$$\begin{aligned} c_{it} \ = \ \rho_t \ \Big[& (1+r_t)(b_{i,t-1}+y_{i,t-1}-c_{i,t-1}) + y_{it} + \tfrac{1}{1+r_t} E_t y_{i,t+1} \\ & + E_t \tfrac{1}{(1+r_{t+1})(1+r_{t+2})} E_t y_{i,t+2} + \ \cdots \Big] \end{aligned} \tag{38}$$

Write (36) for period $t-1$, multiply both sides by $1+r_t$, and rearrange (recalling that r_t

is known at $t-1$) to get

$$c_{i,t-1} = -r_t c_{i,t-1} + \rho_{t-1}\left[(1+r_t)(b_{i,t-1}+y_{i,t-1}) + E_{t-1}y_{it} + \left(E_{t-1}\frac{1}{1+r_{t+1}}\right)E_{t-1}y_{i,t+1} + \cdots\right] \tag{39}$$

Subtract (39) from (38) to obtain,

$$\begin{aligned}
\Delta c_{it} &= \Delta\rho_t(1+r_t)(b_{i,t-1}+y_{i,t-1}) + [r_t - \rho_t(1+r_t)]c_{i,t-1} \\
&\quad + \rho_t y_{it} - \rho_{t-1}E_{t-1}\, y_{it} \\
&\quad + \rho_t E_t\left(\tfrac{1}{1+r_{t+1}}\, y_{i,t+1}\right) - \rho_{t-1}E_{t-1}\left(\tfrac{1}{1+r_{t+1}}\, y_{i,t+1}\right) \\
&\quad + \rho_t E_t\left(\tfrac{1}{(1+r_{t+1})(1+r_{t+2})}\, y_{i,t+2}\right) - \rho_{t-1}E_{t-1}\left(\tfrac{1}{(1+r_{t+1})(1+r_{t+2})}\, y_{i,t+2}\right) \\
&\quad + \cdots
\end{aligned} \tag{40}$$

The economic interpretation of the consumption function, (38), and its first difference, (39), are provided in the main text.

Table I

Augmented Dickey-Fuller Unit Root Tests in State Level

Disposable Income and Consumption

	Lags	Mean t-value	Range of t-values	Number of Non-Rejections: 5 percent confidence level	Number of Non-Rejections: 1 percent confidence level
Income :	1	–2.47	[–4.01 , –1.32]	48	50
	2	–2.34	[–3.76 , –1.19]	49	50
	3	–2.14	[–3.48 , –0.81]	49	50
Consumption :	1	–2.44	[–4.34 , –0.32]	47	49
	2	–2.43	[–4.73 , 0.12]	45	47
	3	–2.13	[–3.49 , 0.75]	49	50

Notes. Augmented Dickey-Fuller statistics for unit root tests in state level disposable personal income and consumption processes. The critical t-values for an estimated autoregressive process with 1 lag at the 1 and 5 percent confidence level are –4.09 and –3.46 respectively. Sample period: 1963–1993.

Table II

US State Level Disposable Income Processes

	Mean	Range
Model: $\Delta Y_{it} = \alpha_i + \phi_{1,i}\,\Delta Y_{i,t-1} + \phi_{2,i}\,\Delta Y_{i,t-2} + \epsilon_{it}$		
$\phi_{1,i}$:	0.13	[-0.24 , 0.47]
t-statistics:		[-1.60 , 2.82]
$\phi_{2,i}$:	0.04	[-0.26 , 0.48]
t-statistics:		[-1.52 , 3.12]
P-value for the null of $\phi_{2,i} = 0$ for all i : 0.04		
Model: $\Delta Y_{it} = \alpha_i + \phi_{1,i}\,\Delta Y_{i,t-1} + \epsilon_{it}$		
$\phi_{1,i}$:	0.14	[-0.24 , 0.44]
t-statistics:		[-1.62 , 3.35]
P-value for the null of $\phi_{1,i} = \phi$ for all i : 0.12		
Model: $\Delta Y_{it} = \alpha_i + \phi\,\Delta Y_{i,t-1} + \epsilon_{it}$		
ϕ :	0.16	
t-statistic:	7.34	

Notes. Y_{it} denotes the year t per capita disposable personal income of state i. Sample period: 1963-1993.

Table III

US State Level Consumption Processes

	Mean	Range
Model: $\Delta C_{it} = \alpha_i + \psi_{1,i}\,\Delta C_{i,t-1} + \psi_{2,i}\,\Delta C_{i,t-2} + \epsilon_{it}$		
$\psi_{1,i}$:	0.14	[–0.13 , 0.74]
t-statistics:		[–0.88 , 3.85]
$\psi_{2,i}$:	–0.02	[–0.28 , 0.37]
t-statistics:		[–2.65 , 1.79]
P-value for the null of $\psi_{2,i} = 0$ for all i : 0.93		
Model: $\Delta C_{it} = \gamma_i + \psi_{1,i}\,\Delta C_{i,t-1} + \epsilon_{it}$		
$\psi_{1,i}$:	0.14	[–0.14 , 0.70]
t-statistics:		[–0.92 , 4.54]
P-value for the null of $\psi_{1,i} = \psi$ for all i : 0.60		
Model: $\Delta C_{it} = \alpha_i + \psi\,\Delta C_{i,t-1} + \epsilon_{it}$		
ψ :	0.14	
t-statistic :	6.34	

Notes. C_{it} denotes the year t per capita personal consumption of state i. Sample period: 1963-1993.

Table IV

Augmented Dickey-Fuller Unit Root Tests in State-Specific Disposable Income and Consumption

	Lags	Mean t-value	Range of t-values	Number of Non-Rejections: 5 percent confidence level	1 percent confidence level
Income :	1	–1.92	[–3.94 , 0.96]	49	50
	2	–2.01	[–4.38 , 0.12]	49	49
	3	–2.05	[–3.71 , 0.97]	48	50
Consumption :	1	–2.06	[–3.69 , 0.49]	47	50
	2	–2.23	[–4.84 , 0.23]	46	48
	3	–2.12	[–3.60 , 1.31]	46	50

Notes. Augmented Dickey-Fuller statistics for unit root tests in state-specific disposable personal income and consumption processes. The critical t-values for an estimated autoregressive process with 1 lag at the 1 and 5 percent confidence level are –4.09 and –3.46 respectively. State income is decomposed as follows: $Y_{it} = Y_t + y_{it}$, where Y_t and y_{it} are the aggregate US-wide and the state-specific components of per capita disposable income. Analogously for state consumption, with $C_{it} = C_t + c_{it}$. Sample period: 1963–1993.

Table V

State-Specific Income Processes

	Mean	Range
Model: $\Delta(Y_{it} - Y_t) = \alpha_i + \phi_{1,i}\,\Delta(Y_{i,t-1} - Y_{t-1}) + \phi_{2,i}\,\Delta(Y_{i,t-2} - Y_{t-2}) + \epsilon_{it}$		
$\phi_{1,i}$:	0.09	[−0.42 , 0.63]
t-statistics:		[−2.58 , 3.32]
$\phi_{2,i}$:	0.01	[−0.34 , 0.48]
t-statistics:		[−2.26 , 3.06]
P-value for the null of $\phi_{2,i} = 0$ for all i : 0.01		
Model: $\Delta(Y_{it} - Y_t) = \alpha_i + \phi_{1,i}\,\Delta(Y_{i,t-1} - Y_{t-1}) + \epsilon_{it}$		
$\phi_{1,i}$:	0.10	[−0.36 , 0.54]
t-statistics:		[−2.17 , 3.77]
P-value for the null of $\phi_{1,i} = \phi$ for all i : 0.00		
Model: $\Delta(Y_{it} - Y_t) = \alpha_i + \phi\,\Delta(Y_{i,t-1} - Y_{t-1}) + \epsilon_{it}$		
ϕ :	0.12	
t-statistic :	4.68	

Notes. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. Sample period: 1963-1993.

Table VI

State-Specific Consumption Processes

	Mean	Range
Model: $\Delta(C_{it} - C_t) = \alpha_i + \psi_{1,i}\,\Delta(C_{i,t-1} - C_{t-1}) + \psi_{2,i}\,\Delta(C_{i,t-2} - C_{t-2}) + \epsilon_{it}$		
$\psi_{1,i}$:	0.04	[–0.48 , 0.49]
t-statistics:		[–3.22 , 2.54]
$\psi_{2,i}$:	-0.01	[–0.48 , 0.34]
t-statistics:		[–3.48 , 1.76]
P-value for the null of $\psi_{2,i} = 0$ for all i : 0.25		
Model: $\Delta(C_{it} - C_t) = \gamma_i + \psi_{1,i}\,\Delta(C_{i,t-1} - C_{t-1}) + \epsilon_{it}$		
$\psi_{1,i}$:	0.04	[–0.33 , 0.46]
t-statistics:		[–1.92 , 2.68]
P-value for the null of $\psi_{1,i} = \psi$ for all i : 0.77		
Model: $\Delta(C_{it} - C_t) = \alpha_i + \psi\,\Delta(C_{i,t-1} - C_{t-1}) + \epsilon_{it}$		
ψ :	0.03	
t-statistic :	1.44	

Notes. C_{it} and C_t denote state i and US aggregate year t per capita personal consumption. Sample period: 1963-1993.

Table VII

Sensitivity of State Level Consumption to Lagged Income

	Estimate	t-statistic
Model: $\Delta C_{it} = \alpha_i + b\,\Delta Y_{i,t-1} + \epsilon_{it}$		
b :	0.37	14.41
Model: $\Delta(C_{it} - C_t) = \alpha_i + b\,\Delta(Y_{i,t-1} - Y_{t-1}) + \epsilon_{it}$		
b :	0.17	4.87
Model: $\Delta C_{it} = \alpha_i + \gamma\, C_t + b\,\Delta(Y_{i,t-1} - Y_{t-1}) + \epsilon_{it}$		
γ :	0.94	32.36
b :	0.17	4.70
Model: $\Delta C_{it} = \alpha_i + \gamma_i\, C_t + b\,\Delta(Y_{i,t-1} - Y_{t-1}) + \epsilon_{it}$		
γ_i (average):	0.93	
Range:	[0.51 , 1.44]	[1.81 , 9.83]
b :	0.14	4.06

Notes. C_{it} and C_t denote state i and US aggregate year t per capita personal consumption. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. Sample period: 1963–1993.

Table VIII

Sensitivity of State Level Consumption to Lagged Income:

States with High versus Low Persistence in Income

Model: $\Delta C_{it} = \alpha_i + b\,\Delta Y_{i,t-1} + \epsilon_{it}$

	Low Persistence	Medium Persistence	High Persistence
Average ϕ_i	−0.20	0.11	0.43
b :	0.13	0.53	0.53
t-statistic:	3.21	11.76	12.96

Model: $\Delta(C_{it} - C_t) = \alpha_i + b\,\Delta(Y_{i,t-1} - Y_{t-1}) + \epsilon_{it}$

	Low Persistence	Medium Persistence	High Persistence
Average ϕ_i	−0.21	0.11	0.41
b :	−0.04	0.27	0.45
t-statistic:	0.92	3.78	7.95

Notes. C_{it} and C_t denote state i and US aggregate year t per capita personal consumption. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. Sample period: 1963–1993. States are classified according the persistence of the state-specific component of disposable income, as measured by the coefficient ϕ_i in the regression $\Delta Y_{it} = \mu_i + \phi_i \Delta Y_{i,t-1} + u_{it}$, estimated for each state i separately. Similarly for state-specific income. "Average ϕ_i" is the average of the ϕ_i coefficients over the states in the group.

Table IX

Sensitivity of Consumption to Current Income

	Estimate	Standard Error
Model: $\Delta(C_{it} - C_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t) + \epsilon_{it}$		
b :	0.34	(0.03)
Model: $\Delta_3(C_{it} - C_t) = \alpha_i + b\,\Delta_3(Y_{it} - Y_t) + \epsilon_{it}$		
b :	0.73	(0.07)

Notes. C_{it} and C_t denote state i and US aggregate year t per capita personal consumption. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. Sample period: 1963–1993.

Table X

Sensitivity of Consumption to Current Income:

States with High versus Low Persistence in Income

Model: $\Delta(C_{it} - C_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t) + \epsilon_{it}$

	Low Persistence	Medium Persistence	High Persistence
Average ϕ_i	–0.21	0.11	0.41
b :	0.07	0.51	0.51
t-statistic:	1.51	7.48	8.98

Notes. C_{it} and C_t denote state i and US aggregate year t per capita personal consumption. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. Sample period: 1963–1993. States are classified according the persistence of the state-specific component of disposable income, as measured by the coefficient ϕ_i in the regression $\Delta Y_{it} = \mu_i + \phi_i \Delta Y_{i,t-1} + u_{it}$, estimated for each state i separately. Similarly for state-specific income. "Average ϕ_i" is the average of the ϕ_i coefficients over the states in the group.

Table XI

Sensitivity of Consumption to Positive versus Negative Shocks to State-Specific Disposable Income

Regression	Differencing Interval	Positive Shocks (b)	t-statistic	Negative Shocks (b^*)	t-statistic
Δc_{it} on Δy_{it}	1 year	0.13	(1.95)	0.43	(6.16)
	3 year	0.83	(8.53)	0.73	(6.08)

Notes. Regression: $\Delta(C_{it} - C_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t)^+ + b^*\,\Delta(Y_{it} - Y_t)^- + \epsilon_{it}$, where C_{it} and C_t denote state i and US aggregate year t per capita personal consumption and Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. $\Delta(Y_{i,t-1} - Y_t)^+$ equals $\Delta(Y_{i,t-1} - Y_t)$ if in year t the disposable income of state i is above the average disposable income (across years) of state i and equals 0 otherwise. Analogously for $\Delta(Y_{i,t-1} - Y_t)^-$. The sample period is 1963–1993.

Table XII

Sensitivity of Bank Savings Deposits and Loans to Current Income at the 1-Year and 3-Year Differencing Frequencies

	Estimate	t-statistic
Model: $\Delta(Z_{it} - Z_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t) + \epsilon_{it}$		
Consumer Loans :	–0.01	–0.59
Mortgage Loans :	0.01	1.54
Home Equity Loans :	–0.05	–20.41
Savings Deposits :	0.06	1.83
Model: $\Delta_3(Z_{it} - Z_t) = \alpha_i + b\,\Delta_3(Y_{it} - Y_t) + \epsilon_{it}$		
Consumer Loans :	0.05	3.04
Mortgage Loans :	0.05	3.34
Savings Deposits :	–0.05	–0.47

Notes. Z_{it} is a generic variable for year t state level per capita savings deposits or bank loans. Z_t denotes the corresponding US per capita aggregate variable. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. The sample period is 1968–1993 for consumer and mortgage loans, 1977–1993 for savings deposits, and 1988–1993 for home equity loans. $\Delta_3 x_t \equiv x_t - x_{t-3}$.

Table XIII

Smoothing Positive versus Negative Shocks to State-Specific Disposable Income

Regression	Diff. Interval	Positive Shocks (b)	t-statistic	Negative Shocks (b^*)	t-statistic
Δ Consumer Loans on Δy_{it}	1 year	0.02	(1.25)	0.01	(0.38)
	3 year	0.01	(0.18)	0.08	(2.46)
Δ Mortgage Loans on Δy_{it}	1 year	0.02	(1.37)	0.01	(0.64)
	3 year	–0.01	(0.43)	0.05	(1.92)
Δ Savings Deposits on Δy_{it}	1 year	0.00	(0.01)	0.18	(2.09)
	3 year	–0.29	(1.76)	0.40	(2.91)
Δ Home Equity Loans on Δy_{it}	1 year	–0.05	(9.90)	–0.05	(11.62)

Notes. Regression: $\Delta(Z_{it} - Z_t) = \alpha_i + b\,\Delta(Y_{it} - Y_t)^+ + b^*\,\Delta(Y_{it} - Y_t)^- + \epsilon_{it}$, where Z_{it} is a generic variable for year t state level per capita savings deposits or bank loans. Z_t denotes the corresponding US per capita aggregate variable. Y_{it} and Y_t denote state i and US aggregate year t per capita disposable income. $\Delta(Y_{it} - Y_t)^+$ equals $\Delta(Y_{it} - Y_t)$ if in year t the disposable income of state i is above the average disposable income (across years) of state i and equals 0 otherwise. Analogously for $\Delta(Y_{it} - Y_t)^-$. The sample period is 1968–1993 for consumer and mortgage loans, 1977–1993 for savings deposits, and 1988–1993 for home equity loans.

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