Edinburgh School of Economics
Discussion Paper Series
Number 161

Did Household Consumption Become More Volatile?

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Date
January 2007

Published by
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http://www.ed.ac.uk/schools-departments/economics

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Did Household Consumption Become More Volatile?*

[Job Market Paper]

Olga Gorbachev†

January 11, 2007

Abstract

We show that volatility of household consumption, after accounting for predictable variation arising from movements in real interest rates, preferences and income shocks, increased between 1970 and 2002. For single parent households, and households headed by nonwhite or poorly educated individuals, this rise was significantly larger. This stands in sharp contrast with the dramatic fall in aggregate volatility of the US economy, and may have significant welfare implications. A spectacular fall in average covariances of consumption growth rates across households over this period accounts for the diverging paths of aggregate and household level volatilities.

Keywords: consumption risk, volatility decomposition, aggregate volatility, panel data

JEL Classification: D80, D91, E21

*I am grateful to Graciela Chichilnisky, Brendan O'Flaherty, and Bernard Salanié for their unwavering support, constant encouragements and invaluable discussions. I would also like to thank Richard Blundell, Janet Currie, Wojciech Kopczuk, Anton Korinek, Alexei Onatski, Bruce Preston, Eric Verhoogen, Till vonWachter, Michael Woodford, Stephen Zeldes and seminar participants at Columbia University for their constructive criticism and very useful comments and suggestions.

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1 Introduction

Over the past several decades, the US economy has become more stable. The volatility of real GDP fell by 60 percent since its peak in 1984. On the other hand, the volatility of individual transitory income has been growing since the 1980s, and married couples, and especially single-parent families, now face an ever increasing financial risk. Greater income uncertainty, however, may not necessarily translate into welfare losses if people can find ways to smooth consumption. Having a good measure of the volatility of household consumption is thus fundamental to assessing whether, and to what extent, welfare was affected.

Our main contribution is the novel way in which we propose to construct the measure of consumption volatility. In particular, we focus on consumption risk, or volatility of consumption after accounting for predictable variation arising from movements in real interest rates, preferences and income shocks. An increase in consumption risk has direct welfare implications. In research up until now, the effect of increased uncertainty on welfare was inferred from the study of the time evolution of the cross-sectional properties of income and consumption. These studies find that while inequality of income increased, inequality of consumption increased by much less over the 1980-2002 period.[1] Since the change in social welfare depends on the changes in mean level of household consumption, inequality and volatility of consumption, looking at the evolution of volatility of consumption computed on a time-series of household level data will provide a missing piece of the puzzle.

We use data from the Panel Study of Income Dynamics (PSID), the only source of panel data in the US that provides information on consumption, income, wealth and demographic characteristics at the level of disaggregation that this study requires. Given that the PSID consumption data is restricted to food, rather than other types of consumption,[2] our exercise focuses on food consumption.[3] Our unit of observation is the household, the level at which consumption data is collected, and the unit relevant to most consumption decisions. Our estimation recognizes and con-

[1]See Attanasio et al. [2004] and Krueger and Perri [2006] for the most recent findings.

[2]Expenditures on utilities, vehicles, and repairs are also available but very sparse. PSID also provides data on housing costs.

[3]Another frequently used source of consumption data on household level, Consumer Expenditure Survey, is unsuitable for this study as it has a very short time dimension of only four quarters. CES data would require implementation of synthetic cohort techniques, which are inappropriate for this study as discussed in some detail in the next section.

sciously controls for the fact that household consumption might change with changes in household composition.[4]

We find that after accounting for predictable variations in consumption due to changes in family composition and structure, real interest rates and income uncertainty, and after controlling for measurement error in consumption, mean volatility of household food consumption increased between 1970 and 2002. Year-to-year fluctuations in volatility of consumption,[5] increased from 0.30 in 1971 to 0.36 points in 2002. Since a part of 0.30 and 0.36 points is due to measurement error, the growth rate in volatility is likely to understate the actual percentage change. Hence, in this paper we do not make any claims on the levels or the growth rates in volatility series, and instead focus on changes in percentage points. We find that for single parent households, and households headed by nonwhite or poorly educated individuals, rise in volatility was significantly larger than for the average household. For single parent households, the consumption risk increased by 9 percentage points; for households whose head was nonwhite and poorly educated it increased by 13 percentage points; while for a family with a white head who had at least a Bachelor's degree or for cohabiting households, the rise in volatility was 6 percentage points. These findings stand in sharp contrast to the dramatic fall in aggregate volatility of the US economy, and might have significant welfare implications.

Our work is directly related to the literature on income and consumption inequality. Moffitt and Gottschalk [1994, 2002], Katz and Autor [1999], Blundell and Pistaferri [2003], Gyourko and Tracy [2003], Primiceri and vanRens [2006] all find that income inequality in the United States has increased over the last several decades and that this increase was at least partly attributable to the rise in transitory income shocks. Studies of consumption inequality suggest, however, that increased income inequality did not translate into an equally large increase in consumption inequality.

Krueger and Perri [2006] claim that since the increase in within-group consumption inequality did not rise to the same extent as within-group income inequality (which is in part a measure

[4]We control for household composition through a 'change in family type' variable. A different concern is that some household decisions are not necessarily collective. Without priors on how the intricacies of intra-household decision making should affect the consumption volatility measure, we do not attempt to establish or disentangle this possible decision making effect.

[5]Year-to-year fluctuations are measured by the square root of volatility, with volatility being computed on the squared residuals from the log linearized Euler equation.

of income uncertainty), and was actually flat after the early 1980's,[6] agents were able to smooth consumption. They conjecture that the increased income uncertainty was not only an important reason for the increased income inequality, but also helped the development of financial institutions which in turn allowed consumers to better insure against income risk. Our result, that realized consumption risk, computed using a *temporal* measure of volatility, *increased* for the median household between 1970 and 2002, sharply contradicts Krueger and Perri's findings.

The theoretical literature on consumption volatility suggests that consumption is volatile because its growth rate responds to changes in permanent income and to unanticipated changes in transitory shocks (Campbell [1987]). For individuals who are liquidity constrained, consumption growth tracks some predictable changes in income (Meghir [2004]).[7] The implications for volatility of consumption are clear. If agents are unable to smooth consumption, volatility will be high. Volatility will also be high if shocks to consumption are unpredictable and agents do not have enough wealth to smooth these shocks.

We use the log linearized Euler equations from standard consumption model to decompose, for each household, the volatility of food consumption growth into the sum of three predictable components: preference shocks, real interest rate shocks, and changes in precautionary savings motive, and an unpredictable component, idiosyncratic shocks. Our decomposition strategy takes into account measurement error in consumption and corrects for it using standard assumptions.[8] This method of decomposing consumption volatility is very similar to the exercise proposed by Parker and Preston [2005], where they decompose average consumption growth rather then household level consumption volatility into proximate components.

[6]Cutler and Katz [1991a,b] and Johnson et al. [1997] document that the sharp increase in income inequality of the early 1980s has been accompanied by an increase in consumption inequality. But Krueger and Perri [2006] point out that the increase in consumption inequality was less than that of income inequality, which is also consistent with Slesnick [2001]. Attanasio et al. [2004] using more detailed data on consumption found that consumption inequality increased by 4.5 percent, while income inequality rose by closer to 15 percent over the same period.

[7]Zeldes [1989] finds that for liquidity constrained households, defined by low asset holdings, growth rate in consumption responds to lagged income, while it does not for unconstrained households. Jappelli et al. [1998] show that using more direct measures of liquidity constraints than simple asset splits, the response of consumption growth to lagged income for the liquidity constrained households is even more significant than what Zeldes [1989] had demonstrated.

[8]We follow Alan et al. [2005] in assuming that measurement error is uncorrelated with all the regressors, and that its variance is stationary.

As a part of our identification strategy we look at liquidity unconstrained households. Identifying households who are liquidity constrained is difficult because information on access to credit is usually unavailable to the researcher. We follow the current literature on the subject and split the sample based on the amount of savings households have.[9] We are agnostic on the possibility of asset holdings being endogenous.

We decompose volatility of consumption for the unconstrained households into predictable and unpredictable parts, and note that unpredictable variations account for more than 90 percent of consumption volatility.[10] Thus, we focus our attention on examining the evolution of consumption risk, computed as the square of the unpredictable component. We disaggregate consumption risk by different groups, such as by race, marital status, and education, and study the between-group differences in their evolution.

While mean household volatility of consumption increased, aggregate volatility of real GDP fell by 60 percent since its peak in 1984.[11] Volatility of aggregate food consumption fell by 73 percent since its peak in 1976. We reconcile these diverging trends by showing that average covariances of food consumption growth rates across households fell dramatically between 1970 and 2002.

Even though the aggregate economy became more stable, an increase in household consumption volatility could well be detrimental to social welfare. The estimates of welfare costs from volatility of consumption range from near zero (Lucas [1987]) to 7.5 percent of aggregate consumption per year (Beaudry and Pages [2001], Krebs [2003], Storesletten and Yaron [2004], Barlevy [2004]).[12] The magnitude of the increase in volatility and its concentration among the disadvantaged groups, that our work documents, suggests a substantial increase in social cost during this period, between 1 and 2 percent of aggregate consumption per year.[13]

[9] This strategy is very similar to the one employed by Zeldes [1989] or more recently by Parker and Preston [2005]. Splitting the sample according to asset holdings could lead to under-counting of households who are actually unconstrained. But Jappelli et al. [1998] find that only 12 percent of the households classified as liquidity constrained by this method are actually unconstrained. Loosing these households will lower the power of our tests, but will not bias our results.

[10] This finding is consistent with the literature, see for example Parker and Preston [2005]

[11] See for example McConnell and Perez-Quiros [2000], Blanchard and Simon [2001], Stock and Watson [2002] who find that the US economy became more stable since 1984. Aggregate volatility in these studies is constructed from National Income and Product Accounts data.

[12] See Barlevy [2005] for a comprehensive survey on the subject.

[13] These numbers are indicative of the order of magnitude only. A full welfare analysis is left for future research.

The rest of the paper is organized as follows. We begin by describing the data used in the analysis and documenting the trends in volatility of household consumption using a descriptive statistic, the five-year moving variance of consumption disaggregated by different groups. In section 3, we present a standard consumption model that is used for the decomposition of the volatility of consumption into predictable and unpredictable components. Sections 4 and 5 contain our central contribution. In Section 4, we explain our two-stage least-squares estimation strategy for volatility decomposition, and in Section 5, we provide the results of the decomposition by documenting the evolution of household consumption risk for the sample as a whole and when disaggregated by different groups. Section 6 provides a way to reconcile trends in aggregate versus household level volatility series, and Section 7 concludes.

2 Description of the Volatility of Household Food Consumption

In this section, we describe the data used in the estimation and then document the trends in volatility of food consumption for a median household and for different groups of households. We show that volatility for a median household increased between 1974 and 2002, and that for single parent households, households headed by a nonwhite or poorly educated individuals, this increase was more pronounced, both in terms of observed levels of volatility and its growth rates. These findings motivate our main methodological contribution: a semi-structural consumption model that allows us to decompose volatility into two parts, variations in consumption due to predictable shocks and consumption risk.

2.1 Data and Variables

To analyze evolution of volatility of individual welfare we use the Panel Study of Income Dynamics (PSID). The PSID is the only cross-sectional time-series survey that collects data on household consumption. The Consumer Expenditure Survey (CEX) collects a more complete inventory of consumption data, but its structure as a repeated cross-section makes it impossible to construct individual volatility measures that track volatility for the same household over periods of time longer than one year.[14] Due to this major limitation, we use PSID data in this study.

[14] Current work on inequality utilizes CEX data by constructing synthetic cohorts. This strategy is inappropriate here as our main concern is to provide a measure of temporal volatility for each household. Synthetic cohort techniques

Consumption data in PSID are limited to food and shelter. We discuss potential data extensions and their limitations in the Data Appendix. We compute all our consumption volatility measures on food consumption calculated as a sum of food consumed at home plus away from home plus food stamps received. Food consumption is also the choice variable in other studies of household consumption behavior,[15] and we feel that its use here enables complementarity and comparability with these studies.

Our core sample contains data from 1970 to 2002, and consists of heads of households (both male and female) who are not students and are not retired. We keep households whose head is at least 25 years old but less than 65. We drop all the households that belonged to the Latino sample, and those that were drawn from the Survey of Economic Opportunity (SEO).[16] Households that report negative or zero food consumption levels (that is a sum of food at home plus away from home plus food stamps) are also eliminated. In order to minimize effects of outliers on the results, we follow the literature by dropping households who report more than 300 percent change in family income or food consumption over a one year period as well as those whose income or consumption fall by more than 33 percent (see for example Zeldes [1989]). Definitions of all the variables used are included in the Appendix. Summary statistics can be found in Table 3.

2.2 Increase in Volatility of Household Food Consumption

We first construct a descriptive statistic that captures how the volatility of household food consumption evolved over the 1970-2002 period. The most common measure of volatility is variance based on the history of an economic variable. To examine possible changes in volatility over time, we look at the five-year moving variance of log consumption.[17] This method of computing volatility allows for historical comparisons, and thereby to our main inquiry: has consumption risk faced by

would require aggregation within cohorts, which in itself introduces a lot of data smoothing, and is exactly what we want to avoid. We plan to extend our study, at later date, by combining information from both PSID and CEX surveys. The information obtained from the two surveys will provide a more complete understanding of uncertainty faced by households in the US.

[15]See Hall and Mishkin [1982], Zeldes [1989] for earlier studies, and Hurst and Stafford [2004], Cox et al. [2004] for examples of recent work.

[16]We test the robustness of our results by including SEO sample.

[17]Blanchard and Simon [2001] use this measure to compute volatility of aggregate detrended real GDP growth, and Comin and Mulani [2006] use it to construct firm level volatility.

Table 1: Annualized Percentage Change in Volatility of Food Consumption Levels

	1978-2002†	1978-1986	1986-1996	1996-2002†
Median	1.0%	0.3%	0.2%	3.4%
By Race of Head				
White	0.9%	0.2%	0.1%	3.4%
Nonwhite	0.9%	0.7%	1.5%	0.3%
By Family Type				
Single	-0.4%	2.2%	-2.9%	0.6%
Single Parent	2.7%	10.5%	-1.1%	-0.8%
Married/Cohabiting	1.0%	-0.7%	0.0%	5.2%
By Education of Head				
Some College or less	1.1%	0.8%	0.5%	2.6%
At least BA Degree	0.4%	-2.8%	0.1%	5.1%
By Housing Tenure				
Rent	1.6%	3.0%	-1.4%	4.8%
Own	0.7%	-0.4%	1.0%	1.5%

Notes: By volatility of food consumption *levels* we mean volatility computed using the median over the levels of consumption, or as $\sigma^2_{h,t} = median_t(\frac{1}{5}\sum_{\tau=1}^{5}(lnC_{h,t-\tau} - \overline{lnC_h})^2)$. † indicates that growth rates between these years is computed using hypothetical biannual survey as described in the main text. Each number in this table indicates an average percentage change in volatility observed during the period specified by the column name.

households in the US changed over the 1974-2002 period?

Volatility of consumption for household h, *over the previous five years*, is given by:

$$\sigma^2_{h,t} = \frac{1}{5}\sum_{\tau=1}^{5}\left[lnC_{h,t-\tau} - \overline{lnC_{h,t}}\right]^2 \qquad \forall t = 5...T \tag{1}$$

where $lnC_{h,t}$ is the natural log of food consumption for household h at time t, and $\overline{lnC_{h,t}} = (\frac{1}{5}\sum_{\tau=1}^{5} lnC_{h,t-\tau})$ is the average household consumption over a five year period. A rise in $\sigma^2_{h,t}$ signifies an increase in volatility experienced by household h. To fix the idea, if $\sigma^2_{h,1990} > \sigma^2_{h,1989}$, it indicates that during the five years from 1986 to 1990, the amplitude of fluctuations in consumption for this household increased in comparison to that over the 1985-1989 period.

Since our measure of consumption volatility is based on food consumption alone, we first check whether by aggregating food consumption across households and then constructing 'aggregate' food consumption volatility measure, we get patterns similar to that of aggregate food consumption volatilities computed on NIPA data.[18] We find that 'aggregate' food volatility in PSID is

[18]Volatility for aggregate series is detrended using HP-filter.

quite highly correlated with aggregate volatility of food consumption from NIPA, with correlation coefficients of 0.60.[19]

While aggregate volatility of the US economy fell substantially since 1984, average household consumpiton volatility rose. Table 1 documents percentage change in volatility of household food consumption for a median household. Median volatility of household food consumption computed on levels of consumption as $median_t(Var_t lnC_{h,t})$ rose on average 1 percent per year between 1978 and 2002. Between 1978 and 1986 and between 1986 and 1996, volatility went up by 0.2 and 0.3 percent per year respectively, and increased dramatically between 1996 and 2002, rising by an average of 3.4 percent per year. In addition, as illustrated in Table 7 of the Appendix, household volatility computed on food consumption growth rates as $median_t(Var_{h,t}\Delta lnC_{h,t+1})$, strikingly parallels volatility of household food consumption computed on levels, with correlation coefficient of 0.75 between the two series. The volatility of the growth rate of food consumption, however, is twice as high as that computed using log levels.

Disaggregating data further, we discover other interesting patterns. Looking first at the decomposition by education, we notice that for households headed by a person with less than a Bachelor's degree, volatility of food consumption increased by on average 1.1 percent per year between 1974 and 2002. In comparison, households headed by a person with at least a Bachelor's degree saw an increase of only 0.4 percent per year over the same period. Between 1996 and 2002, though, highly educated households saw a sharper increase in volatility of food consumption than less educated ones, 5.1 versus 2.6 percent per year, respectively.[20] It is possible that the economic downturn around the a burst of the technology bubble in 2001 accounted for some of the diverging trends in volatilities between highly and poorly educated households.

Figure 1 depicts volatility of consumption disaggregated by race and educational attainment. On the y-axis we depict economies of scale adjusted mean of the log of real food consumption, and on the x-axis volatility of food consumption. It is immediately apparent that white households experienced a lower level and a lower growth rate in volatility than nonwhite households.[21] While mean volatility increased across all groups, mean household consumption increased for the white

[19]'Aggregate' volatility of family income in PSID also closely follows that of real GDP from NIPA, with correlation coefficient of 0.65.

[20]As can be seen from Table 6 in the Appendix, volatility levels by educational categories remained similar throughout the sample period.

[21]In what follows, whenever we refer to a family by a demographic category, we always refer to the head of the household. Thus, if we call a family white, we mean that the family is headed by a white individual.

Figure 1: Volatility of Consumption by Race and Educational Attainment

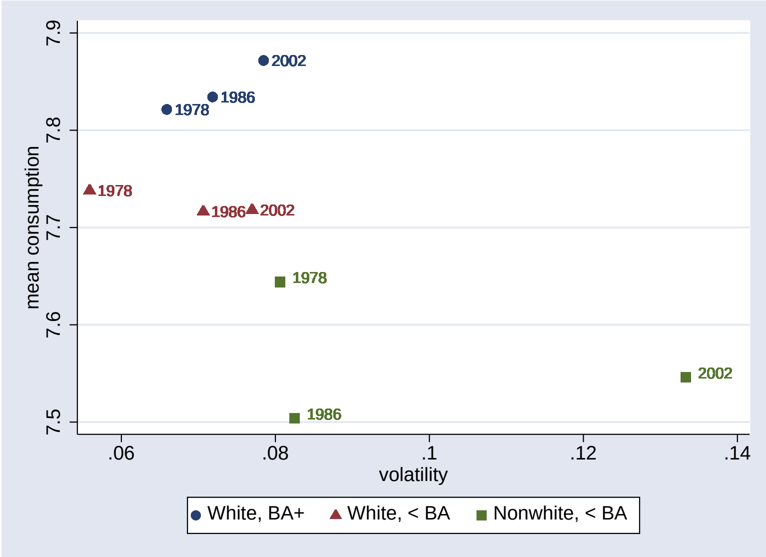
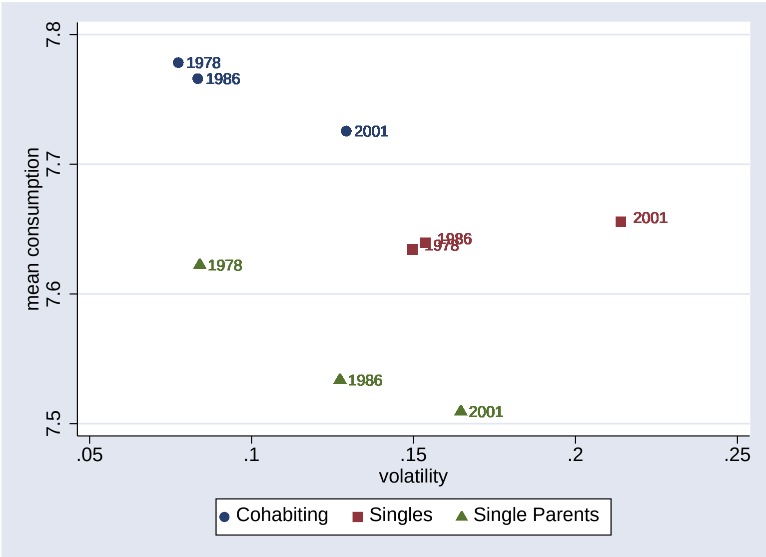


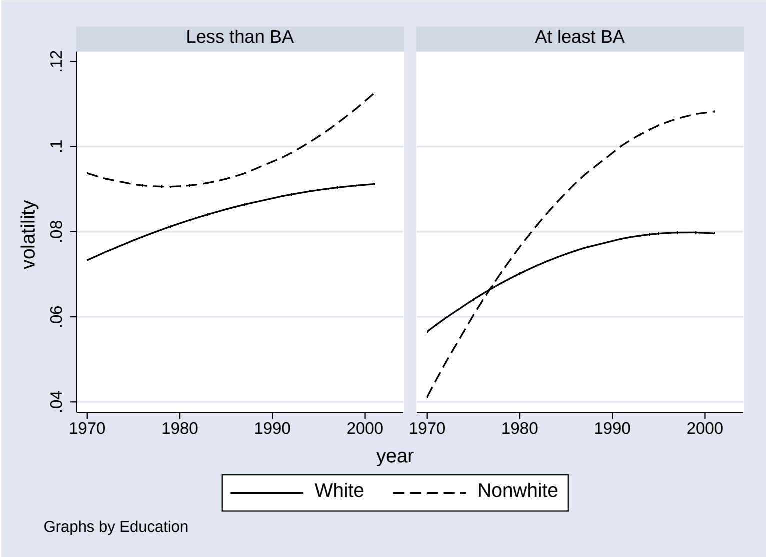
Figure 2: Volatility of Consumption by Family Type



and highly educated households, but fell for the nonwhite (independent of their education) and the less educated whites between 1976 and 2002.

Turning to disaggregation by family type, we see that married or cohabiting households experienced a much lower increase in volatility of consumption than single parent households, 1 percent per year versus 2.7 percent per year, respectively. In addition, as seen from Figure 2 (and from Table 6 in the Appendix), the volatility level for married households was much lower than that for

Figure 3: Quadratic Trend in Income Volatility by Race and Educational Attainment

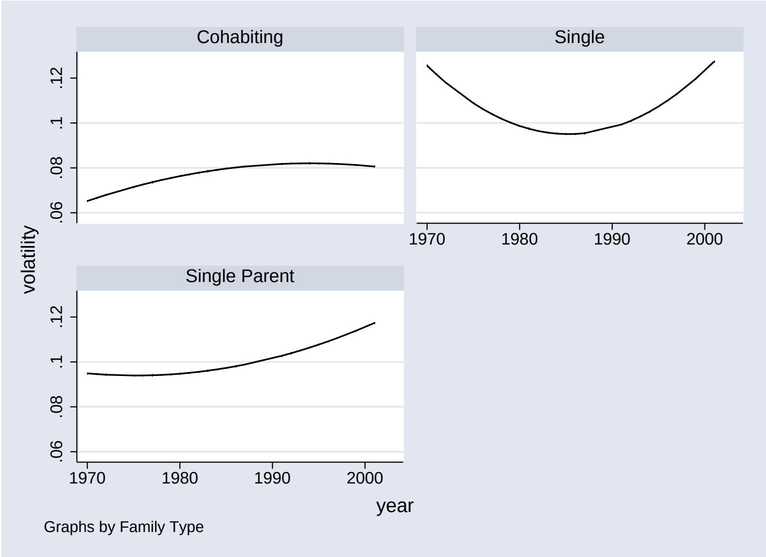


single parent households and was between 45 and 80 percent of the corresponding magnitude for single parent households, depending on the year considered.[22]

Mean volatility of family income also increased between 1970 and 2002, rising on average by 0.7 percent per year. Volatility of income measures a combination of unanticipated transitory and permanent shocks to household's income, and is computed according to equation (12) below. Patterns in volatility of income also differed by group. Figure 3 illustrates the different trends in income uncertainty by race and educational attainment. Several points are worth mentioning. First, the level of income volatility for white households was smaller than that for nonwhite. Second, volatility increased for both racial groups, but the increase for nonwhite households was steeper. The figure also shows that households whose head had at least a Bachelor's degree experienced lower levels of volatility than those that had less education. But if this household was headed by a nonwhite person, this difference was much less pronounced. Figure 4 illustrates mean income volatility trends disaggregated by family status. Again, as for volatility of food consumption, single parents experienced higher levels of volatility of income than cohabiting households did, and the

[22]Volatility fell by 0.8 percent per year for single parent households between 1996 and 2002 in comparison to married households for whom it increased by 5.2 percent. When we consider volatility computed on growth rates, this difference in trends is much less significant, an increase of 3.7 percent per year for single parents versus 4.3 percent per year for cohabiting households. And as will be discussed below, when we account for predictable variations in preferences, interest rates and income uncertainty, volatility for single parents versus for cohabiting households continued to increase even during the 1996-2002 period. We also check whether our results are due to changes in the composition of the sample and find that they do not. These results are not reported, but are available upon request.

Figure 4: Quadratic Trend in Income Volatility by Family Type



growth rate in income uncertainty was also higher.

The measure of volatility of food consumption presented in this section is purely descriptive and might suffer from mismeasurement (or it could be too high or too low): consumption is measured with error, using a 5-year moving variance could be over smoothing the actual consumption shocks, or alternatively, we might be observing an increase in volatility that is due to increased skill premium or simply life-cycle considerations, or preference shocks, all of which will have different welfare implications. In the next two sections we present a semi-structural model that we use to decompose variations in the growth rate of consumption into predictable (those due to anticipated shocks to preferences, interest rates, and precautionary saving motive) and unpredictable components. In section 5, we show that the descriptive statistic used here gives the same result as volatility of household consumption computed on unpredictable shocks, or on consumption risk.

3 Standard Consumption Model

To understand what volatility of household consumption growth measures, we revisit some insights from consumption theory. A household's consumption responds to predictable and unpredictable changes in preferences or demographics (including family composition, labor decisions, health status, and others), discount rates, real interest rates, current and future labor income and other wealth, and idiosyncratic shocks. Households are unable to insure against unpredictable shocks, with the consequence that an increase in unanticipated risk would directly increase volatility of consumption. Since families desire to smooth consumption, such an increase in volatility would have a negative impact on welfare, other things being equal. Thus, it is critical to study the evolution of unpredictable, in addition to, predictable uncertainty of household consumption. The standard consumption model outlined below will allow us to do exactly that.

Consumption growth in this model varies with preferences or demographics, the risk free interest rate, anticipated income shocks, cash-on-hand relative to future wealth, and idiosyncratic risk. To see this, consider a typical Euler equation.

$$E_t\left[\frac{U'(C_{h,t+1};\theta_{h,t+1})(1+r_{h,t+1})}{U'(C_{h,t};\theta_{h,t})(1+\delta_h)}\right](1+\lambda_{h,t}) = 1 \tag{2}$$

where h stands for household and t for time; $C_{h,t}$ is real consumption of family h in period t; $\theta_{h,t}$ are family $h's$ tastes; δ_h is its rate of time preference and is assumed to be household specific but time invariant; E_t is the expectation operator, conditional on information available at time t; $r_{h,t+1}$ is the ex post real return on risk free asset held by family h between periods t and $t+1$; $\lambda_{h,t}$ is the extra utility that would result from borrowing an extra dollar, consuming it, and reducing consumption the next period accordingly to repay the debt. If $\lambda_{h,t} > 0$, the liquidity constraint is binding and the family cannot borrow, and thus will have to consume out of current labor income, since end-of-period financial assets must be zero.[23]

In order to allow for precautionary savings, we postulate that the utility function takes the constant relative risk aversion form,

$$U(C_{h,t};\theta_{h,t}) = e^{\theta_{h,t}}\left[\frac{C_{h,t}^{1-\alpha_g}}{1-\alpha_g}\right] \tag{3}$$

where α_g is the coefficient of relative risk aversion, or the inverse of the intertemporal elasticity of substitution, and is allowed to vary by groups, g, but not over time.[24]

It is well known that consumption is measured with error. To control for this error, so that we can later exclude it from our volatility calculations, consider that true consumption $\widetilde{C}_{h,t}$ given by:

$$\widetilde{C}_{h,t} = C_{h,t}\psi_{h,t} \tag{4}$$

[23] As pointed out by Zeldes [1989], if end-of-period financial assets were positive, families could always transfer resources at the margin by consuming part of these assets.

[24] The assumption of the iso-elastic form for the utility function means that, in a world without uncertainty, an increase in lifetime wealth will lead to a proportionate increase in consumption. This form also assumes that utility is time additive.

where $C_{h,t}$ is measured consumption of household h at time t, and $\psi_{h,t}$ is measurement error.

Rewriting (2) using above information and assuming rational expectations:

$$\frac{e^{\theta_{h,t+1}}}{e^{\theta_{h,t}}}\left[\frac{C_{h,t+1}\psi_{h,t+1}}{C_{h,t}\psi_{h,t}}\right]^{-\alpha_g}\frac{(1+r_{h,t+1})(1+\lambda_{h,t})}{(1+\delta_h)} = 1+\epsilon_{h,t+1} \tag{5}$$

Taking natural logs of (5) and then a second-order Taylor expansion of expectations error or $ln(1+\epsilon_{h,t+1})$ around $\epsilon_{h,t+1}=0$, we can log linearize the Euler equation as:[25]

$$\Delta ln(C_{h,t+1}) = \frac{1}{\alpha_g}\Big[\Delta\theta_{h,t+1} + ln(1+r_{h,t+1}) - ln(1+\delta_h) + ln(1+\lambda_{h,t})\Big] + u_{h,t+1} \tag{6}$$

where

$$\begin{aligned}
\Delta ln(C_{h,t+1}) &= ln(C_{h,t+1}) - ln(C_{h,t}) \\
\Delta\theta_{h,t+1} &= \theta_{h,t+1} - \theta_{h,t} \\
u_{h,t+1} &= \frac{1}{2\alpha_g}V_t\epsilon_{h,t+1} + \frac{1}{\alpha_g}\xi_{h,t+1} - \kappa_h - \zeta_{h,t+1} \equiv \frac{1}{2\alpha_g}V_t\epsilon_{h,t+1} - \kappa_h - \varsigma_{h,t+1}
\end{aligned}$$

where $\xi_{h,t+1}$ subsumes higher order terms, variances of interest rate and preference shocks as well as covariance terms, that are assumed to be of smaller magnitude. $E_t(\varsigma_{h,t+1}) = 0$ and $V_t(\epsilon_{h,t+1})$ is the variance of the expectation error conditional on information available at time t, which in turn is used as a proxy for precautionary saving as it captures the effect of risk on household's consumption.[26] We follow Alan et al. [2005] in assuming that measurement error is stationary and independent of all the regressors, including lagged values of the measurement error and expectations error, consumption levels and interest rates. Thus, we do not require a specific distribution or a unitary mean. These assumptions allow us to write the expectations of the growth rate of the measurement error as $E_t(\Delta ln\psi_{h,t+1}) = E_t(\kappa_h + \zeta_{h,t+1}) = \kappa_h$.

To summarize, the growth rate of household consumption, $\Delta ln(C_{h,t+1})$, depends positively on personal discount rate $ln(1+\delta_h)$, anticipated risk free interest rate $ln(1+r_{h,t+1})$, anticipated changes in demographics or preferences given by $\Delta\theta_{h,t+1}$, the shadow price of borrowing an extra dollar $ln(1+\lambda_{h,t})$, on precautionary saving motive, $V_t(\epsilon_{h,t+1})$, on measurement error, κ_h and on idiosyncratic shocks to consumption growth, $\varsigma_{h,t+1}$.

[25] Attanasio and Low [2004] show that a log-linearized Euler equation for consumption yields consistent estimates of the preference parameters when utility is isoelastic and a sample covers a long time period. The requirement on the length of the panel is imposed in order to tackle estimation problems that arise due to the presence of liquidity constraints.

[26] See Browning and Lusardi [1996] for a comprehensive review of the literature on the precautionary saving motive.

The decomposition of consumption growth into predictable and unpredictable parts using this Euler equation (6), is the first step in our volatility decomposition strategy. In the next subsection we discuss our estimation strategies for each component of the Euler equation, and in section 5 we present the results of the decomposition.

4 Estimation

In order to take equation (6) to the data, we first need to explain how we estimate each of its parameters. First we simplify the Euler equation by considering only the households that are not liquidity constrained. Second, we discuss how we model preference shocks $\Delta\theta_{h,t+1}$. Third, we explain our proxy for precautionary savings, $V_t(\epsilon_{h,t+1})$.

4.1 Liquidity Constraints

When liquidity constraints are not binding, $\lambda_{h,t} = 0$, and equation (6) simplifies to:

$$\Delta ln(C_{h,t+1}) = \frac{1}{\alpha_g}\Big[\alpha_g \kappa_h - ln(1+\delta_h)\Big] + \frac{1}{\alpha_g}\Big[\Delta\theta_{h,t+1} + ln(1+r_{t+1}) + \frac{1}{2}V_t(\epsilon_{h,t+1})\Big] + \varsigma_{h,t+1} \quad (7)$$

We separate our sample into liquidity constrained and unconstrained households. We use information on the amount of savings each household made during the year.[27] We perform two different splits. One counts households as unconstrained if they had any amount of positive savings (save=1). The second is more restrictive and includes households if they saved at least 2 months' worth of family income (2mnths=1). These splits might be too restrictive in a sense that we might be counting as constrained households those that are actually unconstrained, since households with zero savings could still be able to borrow. But Jappelli et al. [1998] find that only 12 percent of the households classified as liquidity constrained by the asset split method are actually unconstrained.[28] Loosing these unconstrained households will lower the power of our estimated coefficients, but it will not bias our results. Resolution of problems associated with endogeneity of asset holdings is left for future research.

Households can transition between these categories as time passes. Thus, if a household with positive savings one year has zero savings the next year, it will instantly be a part of the uncon-

[27]This strategy is very similar to the one employed by Zeldes [1989] or more recently by Parker and Preston [2005].

[28]Jappelli et al. [1998] find that households with less than college education, unemployed, or younger than 38 are more likely to be turned down for a loan. Lyons [2003] finds that borrowing gap has narrowed since 1983 and most dramatically between 1992 and 1998. But that individuals younger than 35, who are black, or poorly educated continued to be constrained, though the constraints have loosened for them as well.

strained and then a part of the constrained group. In practice, according to the first split (save=1) only 5 percent of households moved from the unconstrained to the constrained group, while about 35 percent moved from being constrained to unconstrained in our sample. If we consider the second split, (2mnths=1), these numbers are more pronounced: 24 percent of households transitioned from having savings of at least 2 months of family income to having less than 2 months worth of savings; and only 11 percent transitioned from being constrained to becoming unconstrained. On average, about 13 percent of households are counted as constrained in 1980 and 14 percent in 2001 according to our first measure; and 50 versus 80 percent, respectively, according to the second measure. Summary statistics for constrained and unconstrained households, as well as a more detailed discussion of how we split our sample, can be found in Table 5 of the Appendix. The sample, according to the first split, contains 29,530 observations on unconstrained households, and is an unbalanced panel.

4.2 Preference Shocks

We postulate that preferences, $\theta_{h,t}$, are a quadratic function of age and family structure, and can be modeled as follows:

$$\theta_{h,t} = b_0 age_{h,t} + b_1 age_{h,t}^2 + b_2 N_{h,t} + b_3 MS_{h,t} + b_4 Edu_h + \omega_h + \eta_t + u_{h,t} \tag{8}$$

where $N_{h,t}$ is a measure of size of the household h at time t which is proxied by adjustment for economies of scale factor[29] (see Appendix Table 4 for details); $MS_{h,t}$ is a dummy for household's marital status (we consider 4 different types of family structures: cohabiting, never married and single, divorced/separated, and widow/widower), Edu_h is a dummy for all but one of the four educational attainment categories;[30] and $(\omega_h + \eta_t + u_{h,t})$ are unobserved shocks to preferences that include household specific shock ω_h, aggregate shock η_t and idiosyncratic shock $u_{h,t}$.

Taking time difference of (8),[31] preference shocks can be modeled as:

$$\begin{aligned}\Delta\theta_{h,t+1} &= b_0 + b_1 + 2b_1 age_{h,t} + b_2 \Delta N_{h,t+1} + b_3 \Delta MS_{h,t+1} + \Delta\eta_{t+1} + \Delta u_{h,t+1} \qquad (9)\\ &= c + \tau_t + 2b_1 age_{h,t} + b_2 \Delta N_{h,t+1} + b_3 \Delta MS_{h,t+1} + \Delta u_{h,t+1}\end{aligned}$$

[29] We also check the robustness of our results by including number of adults and number of children as proxies for household size and structure. The results do not differ with these specifications.

[30] In our sample, education is time invariant since we include households during their midlife, 25 to 65, and exclude students. We consider four educational attainment categories: no high school diploma, high school diploma, some college education but no Bachelor's degree, and at least a Bachelor's degree.

[31] Notice that $b_1(age_{h,t+1}^2 - age_{h,t}^2) = b_1(1 + 2age_{h,t})$.

Thus, preference shocks are a function of lagged age, changes in family size and its structure, aggregate shocks, that we account for by introducing time-dummy variables, τ_t and idiosyncratic shocks. An important point is that we will distinguish between the predictable and unpredictable household changes in these parameters for our volatility disaggregation, as we will discuss below.

4.3 Precautionary Savings

The precautionary saving motive depends on the household's expectations about the uncertainty associated with future exogenous variables, such as for example, uncertainty about income and/or health. Families with higher uncertainty of future family income will have higher savings and therefore lower consumption today. Some families might have higher uncertainty of medical expenses and thus lower consumption. But, as pointed out by Browning and Lusardi [1996], precautionary savings also depend on the current level of cash-on-hand, $A_{h,t}$, relative to expected future income. Families with identical income volatilities but lower current wealth will have higher precautionary savings.

A large body of research has focused on the effect of income uncertainty on precautionary savings.[32] Following this work, and in particular, Banks et al. [2001],[33] we postulate that the precautionary saving motive can be proxied by the stochastic variance of the unexpected shocks to family income, $(\sigma^{\widetilde{Y}}_{h,t})^2$, adjusted by $\left[\frac{Y_{h,t-1}}{C_{h,t-1}}\right]^2$ as a way to account for cash-on-hand relative to expected income.

We model family income process in a standard way as:[34]

$$\Delta ln(Y_{h,t+1}) = X_{h,t}\beta_g + \nu_{h,t+1} \tag{10}$$

where $X_{h,t}$ captures the predictors of income growth, and $\nu_{h,t+1}$ the idiosyncratic shocks to income. In individual labor income models, these regressors are usually proxied by age, age squared, dummy variables for education, occupation and industry categories, and interactions between age, age squared and education, sex and race indicators. Since in the present case we are interested in the family income process, we redefine these parameters as those pertaining to the head of household,

[32]See Carroll and Samwick [1997, 1998], Carroll [2000], Carroll et al. [2003], Banks et al. [2001], Hurst et al. [2006] just to name a few.

[33]Banks et al. [2001] explicitly solve for the effect of income uncertainty on growth rate in consumption, and propose to use a scaled version of income risk, such that $V_t(\epsilon_{h,t+1}) = \omega\left[\frac{Y_{h,t-1}}{C_{h,t-1}}\right]^2(\sigma^{\widetilde{Y}}_{h,t})^2$, where ω is a positive coefficient.

[34]This is a standard model of the income process, see for example MaCurdy [1982] or Hall and Mishkin [1982] for the early treatment, or Banks et al. [2001] for a more recent study.

and include additional parameters, such as head's marital status, a dummy variable for whether his partner works, and the number of children in the household. We allow the coefficient β_g to be group specific and define groups by 5-year birth cohort$\times$4 educational attainment categories.

The disturbance term, $\nu_{h,t}$ is composed of aggregate shocks and household specific shocks to permanent and transitory family income, all of which are not distinguishable by households,[35]

$$\nu_{h,t+1} = \rho_{g,1}\mu_{h,t-1} + \rho_{g,2}\mu_{h,t} + \mu_{h,t+1} \tag{11}$$

$\nu_{h,t+1}$ is the change in the shocks to income that follows an MA(2) process[36] with group specific coefficients $\rho_{g,1}$ and $\rho_{g,2}$ and a white noise shock $\mu_{h,t}$ that has stochastic variance given by a GARCH(p,q) process:[37]

$$(\sigma^{\widetilde{Y}}_{h,t})^2 = \gamma_{g,0} + \sum_{i=1}^{p}\gamma_{g,i}\mu^2_{h,t-i} + \sum_{i=1}^{q}\pi_{g,i}\sigma^2_{h,t-i} \tag{12}$$

We tested several specifications and found that, on average, GARCH(2,2) with MA(2) followed the data best, according to both Akaike (AIC) and Bayesian (BIC) information criteria.[38]

The stochastic variance of shocks to income, $\mu_{h,t}$, computed using (12), and adjusted for cash-on-hand relative to current income is our measure of volatility of income, $\left[\frac{Y_{h,t-1}}{C_{h,t-1}}\right]^2(\sigma^{\widetilde{Y}}_{h,t})^2$ and its expectation, is a proxy for precautionary saving motive.

4.4 Euler Estimation Equation Revisited

Putting together (7), (9), and (12), the Euler equation for the unconstrained households that we estimate is:

$$\begin{aligned}\Delta ln(C_{h,t+1}) &= \frac{1}{\alpha_g}\Big[c + \alpha_g\kappa_h - ln(1+\delta_h)\Big] + \frac{1}{\alpha_g}\tau_t + \\ &+ \frac{1}{\alpha_g}\Big[2b_1 age_{h,t} + b_2\Delta N_{h,t+1} + b_3\Delta MS_{h,t+1} + ln(1+r_{t+1}) + \frac{b_4}{2}\Big(\frac{Y_{h,t-1}}{C_{h,t-1}}\Big)^2(\sigma^{\widetilde{Y}}_{h,t})^2\Big] + \\ &+ \varsigma_{h,t+1}\end{aligned} \tag{13}$$

[35] By 'not distinguishable' we mean that a household observes a shock to income, but is neither able to distinguish between the three different shocks, nor able to disentangle the size of each shock.

[36] MaCurdy [1982], using PSID data on individual labor income, and growth in individual labor income, showed that the income process can be modeled as a MA(2) or an ARMA(1,1), and that these two processes are indistinguishable.

[37] Banks et al. [2001] model the income process for cohorts rather than individual households. Their estimates of volatilities of income are for cohort averages (they compute cohort-level income as a geometric mean of individual incomes), and not for individual households as we do here. In addition, their specification of stochastic variance of income is MA(1) with ARCH(1) as opposed to MA(2) with GARCH(2,2) that we found to be more appropriate for our data.

[38] Results differ for some cohort-education groups, and are available upon request.

The estimation strategy thus allows for household fixed effects to account for measurement error, group effects to account for preference shocks and discount factors, and time effects to account for aggregate shocks to preferences. To control for the possibility that labor decisions are not separable from the marginal utility of consumption, we include total number of hours worked by the head of the household and a dummy variable for whether partner's labor income was positive.[39] To address endogeneity that arises due to the second and higher-order terms in the residual, it is typical to estimate the above equation with instrumental variables, using as instruments information known at time t.[40] The instruments set includes lagged terms of all the parameters in the Euler equation, in addition to lagged food consumption growth and lagged family income growth.

Our estimates of the coefficients of the Euler equation are consistent with the literature. In particular, we estimate the intertemporal elasticity of substitution, $(\frac{1}{\alpha_g})$, to be 0.65 with standard error of 0.10, if we do not allow for group variation in the coefficient and use unconstrained households according to our first split (save=1).[41] The coefficient changes slightly when we allow it to differ by groups and when we use a more restrictive definition of liquidity constraints. The coefficient of intertemporal elasticity of substitution ranges from 0.5, for less educated white households, to 0.75 for cohabiting couples and 0.9 for highly educated nonwhite households.[42]

The above specification explains less than 10 percent of the variation in the growth rate of consumption for the unconstrained households.[43] Given that at least 90 percent remains unexplained, we concentrate our attention on the evolution of volatility computed on the unpredictable component, $\varsigma_{h,t+1}$. In what follows, we use the term 'consumption risk' to denote this type of volatility.

[39]The inclusion of the information on the labor supply decision is important for the identification purposes, see Attanasio [1999] for a discussion of the literature. It is also similar to a strategy employed in Parker and Preston [2005], where they use number of hours worked by a woman head of household.

[40]See Attanasio and Low [2004] for a detailed discussion of issues involved in estimating log linearized Euler equations.

[41]This number is very close to 0.61 with standard error of 0.09 estimated by Parker and Preston [2005]. Attanasio [1999] documented that research up to that point found this coefficient to be 'just below' 1.

[42]These statistics are not reported here but are available upon request.

[43]This result is also consistent with the findings of Parker and Preston [2005], who find that their nonlinear GMM specification on synthetic cohort data from CEX explains between 3 and 8 percent of the variation in consumption growth rate depending on the specification used.

5 Evolution of Consumption Risk

In this section we show that the volatility of household consumption computed on the unpredictable component, or consumption risk, has increased for an average household, and that this increase was especially pronounced for the disadvantaged groups. This confirms the results outlined in section 2 where we used a descriptive statistic, namely of a 5-year moving variance, to compute consumption volatility.

We construct our estimate of the unpredictable shocks to consumption, or consumption risk, $\widehat{\varsigma_{h,t+1}}$, for each household h, at each point in time t,[44] from the estimated Euler equation as follows:

$$\begin{aligned}
\widehat{\varsigma_{h,t+1}} &= \Delta ln(C_{h,t+1}) - E_t \Delta ln(C_{h,t+1}) \\
&= \Delta ln(C_{h,t+1}) - \widehat{\beta_{g,0}} - \widehat{\kappa_h} - \widehat{\beta_{g,1}} age_{h,t} \\
&- \frac{1}{\widehat{\alpha_g}} E_t ln(1+r_{t+1}) - \widehat{\beta_{g,2}} E_t \Delta N_{h,t+1} - \widehat{\beta_{g,3}} E_t \Delta MS_{h,t+1} - \widehat{\beta_{g,4}} E_t (\sigma^{\widetilde{Y}}_{h,t})^2
\end{aligned} \tag{14}$$

We include in our risk measure only the unpredictable variations in consumption, and take out from the residual of the Euler equation all the predictable components: those due to predictable movements in real interest rate, $E_t ln(1+r_{t+1})$; due to predictable variations in the family composition and structure, $E_t \Delta N_{h,t+1}$ and $E_t \Delta MS_{h,t+1}$; and due to predictable income uncertainty, or precautionary saving, $E_t(\sigma^{\widetilde{Y}}_{h,t})^2$. In addition, we adjust for measurement error by subtracting out household fixed effects, κ_h, though our results are *not* dependent on this specification.

Figure 5 illustrates the evolution of consumption risk for liquidity unconstrained households (according to the positive saving split) belonging to groups defined by race and educational attainment. To measure volatility of the unpredictable component, we look at the mean of the squared residuals. We aggregate by groups of size G_t, such that consumption risk for group g is given by $(\widehat{\varsigma_{g,t+1}})^2 = \frac{1}{G_t} \sum_{h \in g} (\widehat{\varsigma_{h,t+1}})^2$.

To summarize the time trend in the data for each group g in a simple way, we run a pooled regression that allows for a quadratic time trend:

$$\widehat{\varsigma^2_{h,t+1}} = \beta_{g,0} + \beta_{g,1} t + \beta_{g,2} t^2 + \omega_{h,t+1} \tag{15}$$

where $\beta_{g,0}$ reflects the variance of the measurement error, which we assumed to be stationary for

[44] Note that we no longer use the 5-year moving variance specification, but are looking at dispersion for groups aggregated on household level data at each point in time, t.

Figure 5: Consumption Risk by Race and Educational Attainment

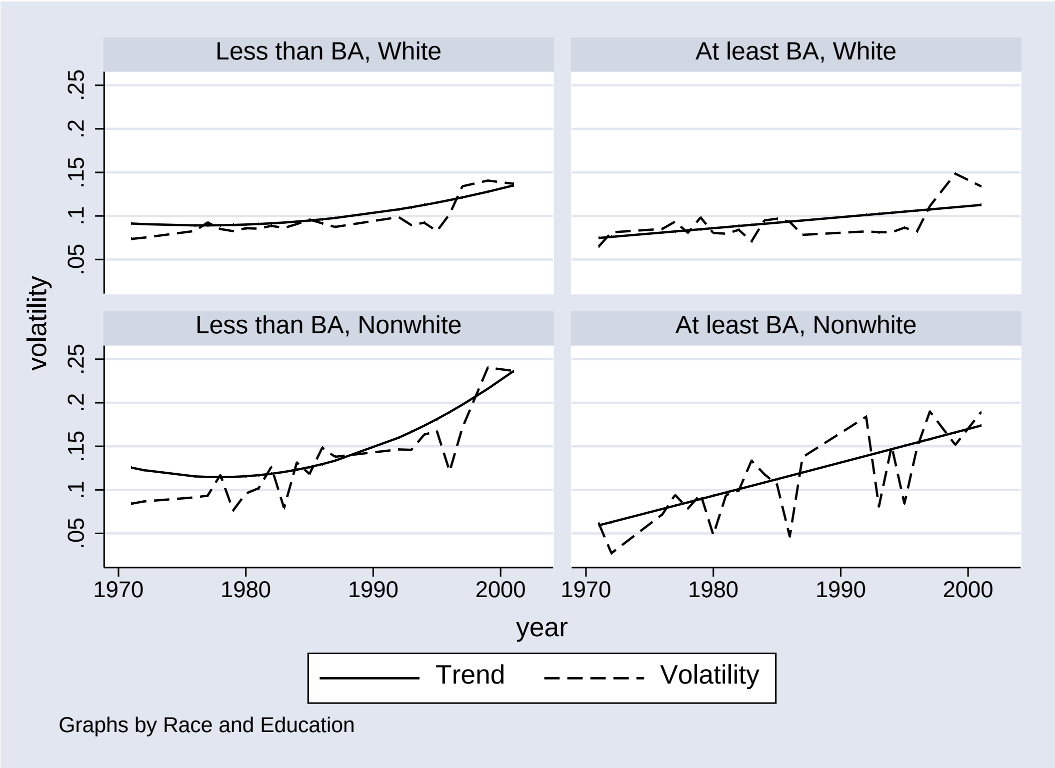


Table 2: Time Evolution of Consumption Risk

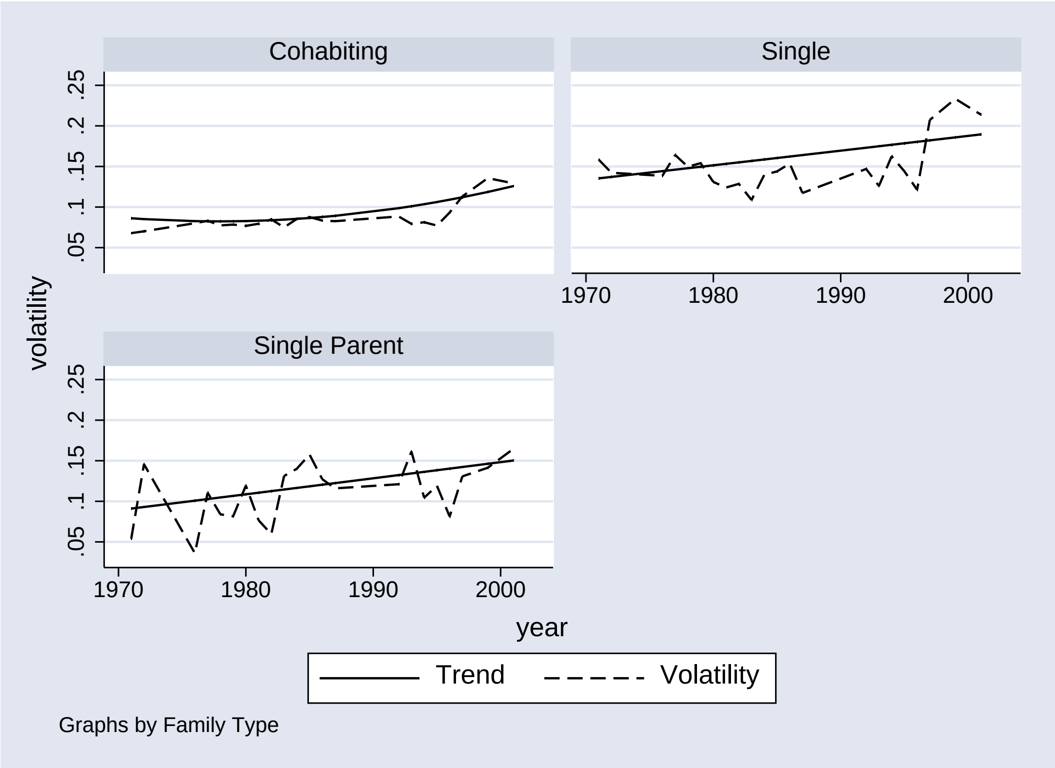
		White Head		Nonwhite Head				single
	Total	$<$ BA	$\geq$ BA	$<$ BA	$\geq$ BA	cohabiting	single	parents
year	-0.001*	-0.299*	-0.001*	-0.902*	-0.004*	-0.320*	-0.002*	-0.002**
	(0.000)	(0.072)	(0.000)	(0.306)	(0.001)	(0.056)	(0.001)	(0.001)
year^2 $\times$ 10^{-3}	0.000*	0.076*	0.001*	0.228*	0.002*	0.081*	0.001*	0.001**
	(0.000)	(0.018)	(0.000)	(0.077)	(0.001)	(0.014)	(0.000)	(0.000)
Obs.	24,012	14,770	6,837	1,985	420	19,212	3,717	1,077
R^2	0.002	0.009	0.007	0.038	0.045	0.002	0.005	0.004

Standard errors in parentheses; ** significant at 5%; * significant at 1%

each household. The presence of this term implies that we cannot analyze volatility levels, but only its change.

From Table 2, we see that for the sample as a whole, as well as for all the disaggregations that we report below, the coefficient of consumption risk on the quadratic trend is statistically significant at a 1 percent significance level. Consumption risk for the entire sample increased by

Figure 6: Consumption Risk by Family Type



6 percentage points between 1970 and 2002, validating our previous observation that volatility of consumption increased for a median household and especially for the disadvantaged groups. We plot the predicted values from this regression as 'trend' in the accompanying graphs.

Several interesting results are apparent from Figure 5. First, volatility increased for all four groups between 1970 and 2002. For white households, consumption risk rose by 7 percentage points if they were poorly educated and by 6 percentage points if they had at least a Bachelor's degree. For the nonwhite households, volatility steadily increased throughout the period, rising by 13 percentage points for the poorly educated.[45] Due to the presence of measurement error, we cannot say anything about the levels of volatility even across groups since it is possible that the variance in the measurement error is higher for the nonwhite than for the white households, or for the poorly educated than for the highly educated households.

Figure 6 demonstrates the evolution of the mean consumption risk for the unconstrained house-

[45] Volatility increased by 17 percentage points for households with at least a Bachelor's degree. Since our sample of highly educated nonwhite households is very small, 420 observations, or on average 15 observations per year, it is likely that the change in volatility for this group is driven by sample selection issues, and we caution the reader against misinterpreting these numbers.

holds disaggregated by their family status. We look at cohabiting (which includes married households and those living with at least another adult), single and single parent households. For cohabiting households volatility increased by 6 percentage points between 1970 and 2002. Consumption risk steadily increased for single households throughout the sample period. It also increased for single parent households, rising by 9 percentage points.

Not all variations in consumption are detrimental to household's welfare, but some negative unpredictable shocks unambiguously are, even to households that are not liquidity constrained. Indeed, an increase in volatility of unexpected shocks indicates that even the unconstrained households were unable to smooth consumption risk by drawing on their savings.

6 Reconciling Aggregate and Household Level Data

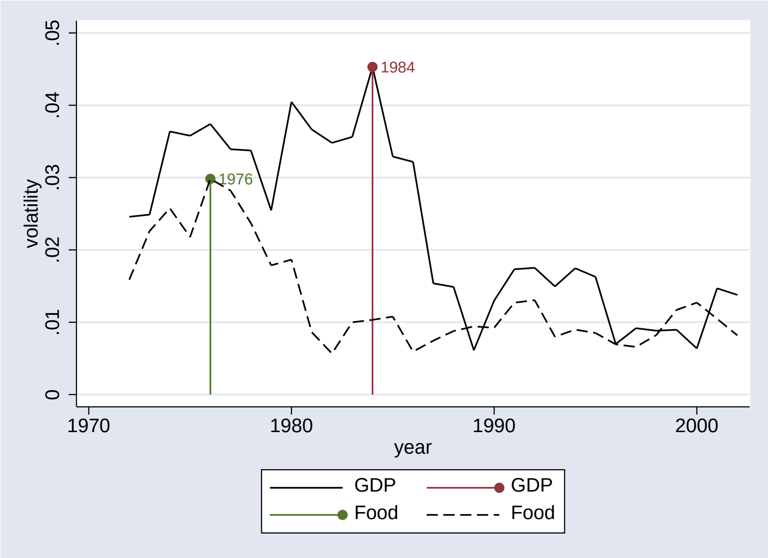
Our results above indicate that mean volatility of household consumption increased by 28 percent between 1970 and 2002. In contrast, as has been mentioned earlier, aggregate volatility of the US economy fell dramatically since 1984. Figure 7 documents that aggregate volatilities of detrended real GDP and food consumption both fell sharply over 1970-2002 period.[46] Volatility of real GDP fell by 60 percent from its peak in 1984. Volatility of aggregate real food consumption fell by 73 percent since its peak in 1976. In this section we propose a way to reconcile these diverging trends by looking at the decomposition of aggregate volatility into two parts: one due to the evolution of the individual shocks and the second due to the evolution of the co-movements of these shocks.

Assuming for simplicity that aggregate consumption growth, ΔlnC_t, can be expressed as a weighted average of household consumption growths,[47] aggregate volatility can be decomposed into the average volatility of individual consumption plus the average covariances of these shocks

[46] McConnell and Perez-Quiros [2000], Stock and Watson [2002], Blanchard and Simon [2001] study aggregate volatility of real GDP growth and find that a structural break occurred in 1984 for this series. We find that the maximum volatility was achieved in 1976 for real food consumption growth series, and since then volatility of food consumption remained stable.

[47] We assume that redistributive weights, w_h, do not change over time and are equal across households.

Figure 7: Aggregate Volatility of Real GDP and Real Food Consumption



Source: National Income and Product Accounts from Bureau of Economic Analysis.
Note: Volatility is computed as a 5-year moving standard deviation of detrended real GDP and real food consumption data.

between different individuals.

$$\begin{aligned}\sigma_t^2 = Var_t(\Delta lnC_{t+1}) &= Var_t\Big[\frac{1}{H}\sum_{h=1}^{H} w_h \Delta lnC_{h,t+1}\Big] \\ &= \frac{1}{H^2}\sum_{h=1}^{H} w_h^2 Var_{h,t}(\Delta lnC_{h,t+1}) + \frac{2}{H^2}\sum_{i\neq j} w_i w_j Cov_t(\Delta lnC_{i,t+1}, \Delta lnC_{j,t+1}) \\ &= \frac{1}{H^2}\sum_{h=1}^{H} w_h^2 \sigma_{h,t}^2 + \frac{2}{H^2}\sum_{i\neq j} \rho_t w_i w_j \sigma_{i,t}\sigma_{j,t}\end{aligned} \tag{16}$$

where $Var_t(\Delta lnC_{t+1})$ is the 5-year variance of the average consumption in the economy as of time t. We assume that redistributive weights, w_h, do not change over time and are equal across households, or that $w_i = w_j = w$. From this simple decomposition, it is easy to see how the current situation, in which aggregate consumption volatility has gone down but mean household volatility has increased, might occur.

Aggregate volatility could go down while the average of individual volatilities goes up, if the average covariances fall enough to compensate for the increase in the average of individual volatilities, or if the correlation coefficients fall significantly. Figure 8 demonstrates how dramatic the fall of the correlation coefficients for both income and food consumption has been over the 1970-2002

Figure 8: Average Correlation Coefficients: Family Income vs. Food Consumption

period.[48] The decline was much steeper for the consumption series, though the average correlation coefficient on food consumption did not fall to the level of income.[49] This situation describes an economy in which aggregate shocks became less important as a source of variation of the individual consumption and income series.

One of the reasons behind the fall in correlation coefficients can be seen from data disaggregated by racial groups. We find that the path of average correlations for white families closely resembles that of the aggregate economy. On the other hand, for nonwhite households, though average correlation coefficients of income growth rates fell as for the white households, average correlations for food consumption increased slightly between 1980 and 2002. Correlation coefficients between white and nonwhite households also fell over this period for both food consumption and income data.[50]

To summarize, the US economy can be characterized by a fall in aggregate shocks but an

[48]For this graph we compute average correlation coefficients on the changes in family income and on changes in food consumption around the trend, and not on the idiosyncratic shocks or unpredictable income and consumption components.

[49]These results are reinforced by the presence of measurement error in consumption. In the early years, it is reasonable to believe that quality of consumption data was worse than in the recent decade, due to for example, the use of computers versus phone surveys. Thus, in the earlier years, the presence of higher measurement error would bias downward our correlation coefficients, while in the later years, it would bias them upward.

[50]It is possible that these differences come from the disparity in the skill composition among households. Thus, in 1970, 87 percent of the nonwhite households were headed by the individual with less than a Bachelor's degree, and 80 percent of the white households were poorly educated. By 2002, 80 percent of the nonwhite and 67 percent of the white households were poorly educated.

increase in individual consumption and income risk over the 1970-2002 period.

7 Conclusions

In the current study, we computed a novel measure of household consumption risk and showed that it increased between 1970 and 2002, particularly for single parents, and households headed by nonwhite or poorly educated persons. Not all variations in consumption are detrimental to households' welfare, but some negative unpredictable shocks unambiguously are, even to households that are not liquidity constrained. Indeed, an increase in the volatility of unexpected shocks for these latter households indicates that even unconstrained households were unable to smooth consumption risk by drawing on their savings. It is thus very likely that liquidity constrained families experienced levels and growth rates of consumption risk on an even greater scale. The increase in volatility, and its concentration among disadvantaged groups, suggests a substantial increase in social cost during this period. A full evaluation of the attendant welfare costs and their policy implications is beyond the scope of this paper.

The increase in household consumption risk stands in sharp contrast to the dramatic fall in aggregate volatility of the US economy. We showed that a spectacular fall in average covariances of consumption growth rates across households during this period accounted for the diverging paths of aggregate and household level volatilities, and that for nonwhite families, average covariances increased slightly.

There have been several significant changes in the patterns of volatility in the US economy over the past several decades. The effects of some of these changes in the context of production and employment were examined in previous joint work with Graciela Chichilnisky (Chichilnisky and Gorbachev [2004, 2005]). The current study highlights how, in the context of consumption, aggregate declines in volatility might mask greater risks borne at the household level. Resolving the reasons underlying the decline in co-movements of consumption growth rates is a key component of the future research agenda on economic volatility and welfare.

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A Appendix: Data

A.1 Panel Study of Income Dynamics

PSID, which began in 1968, is a longitudinal study of a representative sample of U.S. individuals (men, women, and children) and the family units in which they reside, and is conducted by the University of Michigan. The PSID's sample size has grown from 4,800 families in 1968 to more than 7,000 families (and over 60,000 individuals) in 2001. Some families are followed for as much as 36 consecutive years.

The PSID original sample in 1968 consisted of two independent samples: a cross-sectional national sample and a national sample of low-income families. The cross-sectional sample was drawn by the Survey Research Center (SRC), and was an equal probability sample of households from the 48 contiguous states. The second sample came from the Survey of Economic Opportunity (SEO), conducted by the Bureau of the Census for the Office of Economic Opportunity. The PSID selected about 2,000 low-income families with heads under the age of sixty from SEO respondents. In 1990, PSID added 2,000 Latino households, including families originally from Mexico, Puerto Rico, and Cuba. But in 1995 this sample was dropped due to insufficient funding.

The PSID is the only cross-sectional time-series survey that collects data on household consumption. But consumption data are limited to food and shelter. Some studies remedy this by estimating total consumption. Skinner [1987] and Blundell et al. [2004] combine PSID's food expenditure data with data from Consumer Expenditure Survey using synthetic cohorts to construct total consumption measures. Skinner [1987] estimates total consumption using CEX for each cohort by postulating that it depends on food at home, food away from home, rent if a renter, utilities, market value of the home if a homeowner, and the number of vehicles owned. He then uses the predictions from this model to estimate total consumption in PSID. Blundell et al. [2004] improve on this methodology by postulating an economically founded theoretical model of total consumption and allowing for total consumption to vary within cohort by using family, demographic and regional characteristics. Ziliak [1998] proposes to use information from PSID's Wealth Supplement (collected only in 1984, 1989, 1994, and biannually since 1999) and PSID's income data to construct total consumption. He estimates savings using the wealth and income data and then uses these estimated savings to generate total consumption as the difference between family income and estimated savings.

But these estimation strategies have obvious limitations, the introduction of model uncertainty and extra measurement error. Since our study's main focus is on variances rather than means of household level consumption, using imputed consumption measures would distort our results in obscure ways.

Another possibility would be to use Consumer Expenditure Survey (CEX), which collects a more complete inventory of consumption data including expenditure on durables and nondurables. But its structure as a repeated cross-section makes it impossible to construct individual volatility measures that track volatility for the same individual over periods of time longer than one year. Current work on inequality utilizes CEX data by constructing synthetic cohorts. This strategy is inappropriate here as our main concern is to provide a measure of temporal volatility for each household. Synthetic cohort techniques would require aggregation within cohort, which in itself introduces a lot of data smoothing, and is exactly what we want to avoid. Due to this major limitation, we use PSID data in this study. We plan to extend our study, at later date, by combining information from both PSID and CEX surveys. The information obtained from the two surveys will provide a more complete understanding of uncertainty faced by households in the US.

Thus, we compute all our consumption volatility measures using food consumption computed as a sum of food consumed at home plus away from home plus food stamps received. We follow the literature by including food stamps in the definition of food consumed. Food consumption is also the choice variable in other studies of household consumption behavior (see Hall and Mishkin [1982], Zeldes [1989] for earlier studies, and Hurst and Stafford [2004], Cox et al. [2004] for examples of more recent work) and we feel that its use here is also justified on the grounds of complementarity and comparability with these studies.

Another drawback of PSID data is that food consumption was not collected in 1973, in 1988 and in 1989, in addition, the survey became biannual after 1997. We do not impute for the missing years in order to keep measurement error and misidentification to a minimum. We remedy the fact that the survey became biannual by constructing a hypothetical biannual survey, by keeping all the even years of the pre-1997 survey

Table 3: Selected Summary Statistics for Panel Study of Income Dynamics Sample

	1980		1990		2001	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Age of Head	38.9	11.05	39.28	9.66	42.01	9.64
Male Head	0.84	0.36	0.83	0.38	0.81	0.39
White Head	0.89	0.31	0.91	0.28	0.88	0.32
No High School Diploma	0.14	0.35	0.08	0.28	0.09	0.28
High School Diploma	0.34	0.47	0.35	0.48	0.33	0.47
Some College	0.23	0.42	0.24	0.43	0.27	0.44
At Least Bachelor's Degree	0.28	0.45	0.32	0.47	0.31	0.46
Married	0.76	0.42	0.73	0.44	0.68	0.47
Single	0.14	0.34	0.16	0.36	0.18	0.39
Single parent	0.06	0.23	0.06	0.24	0.06	0.24
Number of Kids	1.14	1.18	1.08	1.18	0.93	1.11
Number of Adults	1.98	0.69	1.93	0.65	1.94	0.71
North East	0.20	0.40	0.20	0.40	0.17	0.38
Mid West	0.31	0.46	0.29	0.46	0.31	0.46
South	0.31	0.46	0.33	0.47	0.33	0.47
West	0.18	0.38	0.18	0.38	0.19	0.39
Family Income	33,225	17,805	36,602	21,012	45,048	30,115
Taxable Family Income	29,962	17,396	33,697	20,867	40,681	29,418
Expenditure on Food	4,006	1,810	3,769	1,766	3,764	1,880
Expenditure on Rent	1,179	2,327	1,751	3,456	1,604	3,459
Mortgage Payments	4,229	4,239	6,529	7,482	7,478	7,999
Number of Observations	2195		2540		3054	

Summary Statistics for income and expenditures are converted to real dollars using All-Urban CPI index with base year 1982-84=100. These statistics are for random sample only, i.e. excluding both SEO and Latino samples.

in addition to the data collected post-1997, for the description of the trends in the volatility measure. But the missing data do not constitute a problems for our volatility decomposition exercise since the Euler equation holds true between any two time periods.

Our core sample contains data from 1974 to 2002, and consists of heads of households (both male and female) who are not students and are not retired. We keep households whose head is at least 25 years old but less than 65. We drop all the households that belonged to the Latino sample, and those that were drawn from the Survey of Economic Opportunity (SEO). Households that report negative or zero food consumption levels (that is a sum of food at home plus away from home plus food stamps) are also eliminated. In order to minimize effects of outliers on the results, we follow the literature by dropping households who report more than 300 percent change in family income or food consumption over a one year period as well as those whose

Table 4: U.S. Census Bureau Official Equivalence Scale Computed from Poverty Thresholds by Size of Family and Number of Related Children Under 18 Years

	Related children under 18 years								
Size of family unit	None	One	Two	Three	Four	Five	Six	Seven	Eight+
One person	1.00								
Two persons	1.29	1.32							
Three persons	1.50	1.55	1.55						
Four persons	1.98	2.02	1.95	1.96					
Five persons	2.39	2.43	2.35	2.29	2.26				
Six persons	2.75	2.76	2.70	2.65	2.57	2.52			
Seven persons	3.16	3.18	3.12	3.07	2.98	2.88	2.76		
Eight persons	3.54	3.57	3.51	3.45	3.37	3.27	3.16	3.14	
Nine persons or more	4.26	4.28	4.22	4.17	4.09	3.99	3.89	3.87	3.72

income or consumption fall by more than 33 percent (see for example Zeldes [1989]). Summary statistics for the sample are provided in Table 3.

A.2 Definitions of Variables and Liquidity Constraints

At the time of the interview, the respondent is asked questions about income, transfers, wealth and expenditures on food and shelter. The families are asked to report income and transfers received during the previous year. We use total family income to compute income uncertainty. We adjust income data by one period to correspond to the appropriate demographic characteristics for each household. The timing of consumption data is more ambiguous. We follow Zeldes [1989] and assume that the respondent provided information on food expenditures for the year of the survey rather than for the previous year. We use an annual average of monthly data on 1-year constant maturity Treasury bills.

All the income, expenditure, wealth, and interest rate data are expressed in real terms. Nominal data are converted into real using item specific regional not seasonally adjusted all urban Consumers Consumer Price Index (CPI-U) with base period of 1982-1984=100. Thus, food expenditures are deflated using the Food and Beverages CPI; housing expenditures, using the Housing CPI; and all income, wealth and interest rate series, using All-Items CPI.

Table 4 provides official equivalence adjustments computed from poverty thresholds used by the U.S. Census Bureau. The change in this adjustment factor is used to proxy for change in the family composition, $\Delta N_{h,t+1}$.

We separate our sample into liquidity constrained and unconstrained households combining Zeldes [1989] and Jappelli et al. [1998] findings. We use information on demographics and the amount of savings each household made during the year. We do two different splits. One counts households as unconstrained if they had any amount of positive savings (save=1). The second is more restrictive and includes households if they saved and if those savings equaled at least 2 months worth of family income (2mnths=1). The resolution of problems associated with endogeneity of asset holdings is left for future research.

In 1969-1972, 1975, 1979-1980, households were asked whether they had any savings. If household responded positively to this question, they were counted as unconstrained for the first split, (save=1). Families were also asked if those savings amounted to at least 2 months of family income. If the answer was positive, these households were counted as unconstrained in our second split, (2mnths=1). We utilized data from Wealth Supplements to split the sample for years after 1980. Wealth information was collected in 1984, 1989, 1994, 1999 and biannually after that. We used information from this supplement regarding household's savings in the same manner. For the years when savings information was unavailable we used standard imputation techniques to construct the splits. Specifically, we ran a probit model to project

Table 5: Summary Statistics for Liquidity Constrained versus Unconstrained Households

	1980		1991		2001	
	yes	no	yes	no	yes	no
Do you save?	0.87	0.13	0.89	0.11	0.86	0.14
Age, head	39.09	37.76	39.83	35.72	42.54	40.52
Years of Education, head	13.46	12.05	13.97	11.41	13.86	12.66
Cohabiting	0.78	0.65	0.79	0.69	0.72	0.56
Single Parent	0.05	0.14	0.03	0.15	0.05	0.11
Number of Adults	1.98	1.96	2.00	1.85	1.97	1.85
Number of Kids	1.10	1.37	1.08	2.34	0.93	1.01
Rent	0.23	0.45	0.22	0.45	0.21	0.40
Weeks Unemployed	0.83	2.08	0.69	2.06	0.68	1.42
Family Income	34,566	23,511	39,059	24,256	42,342	25,531
Number of Observations	2200		1932		2833	
	yes	no	yes	no	yes	no
Are your savings at least 2 mths of annual income?	0.49	0.51	0.29	0.71	0.17	0.83
Age, head	41.76	36.25	44.96	37.42	45.37	40.10
Years of Education, head	13.65	12.95	14.90	13.32	14.41	13.42
Cohabiting	0.79	0.74	0.81	0.77	0.71	0.68
Single Parent	0.04	0.08	0.01	0.06	0.04	0.07
Number of Adults	2.01	1.95	2.08	1.96	2.00	1.92
Number of Kids	0.94	1.32	0.68	1.40	0.73	0.99
Rent	0.19	0.32	0.07	0.31	0.14	0.30
Weeks Unemployed	0.70	1.26	0.46	0.89	0.66	0.92
Family Income	37,927	28,655	54,727	31,273	45,654	34,221
Number of Observations	2119		1875		2639	

Summary Statistics for income and expenditures are converted to real dollars using All-Urban CPI index with base year 1982-84=100. These statistics are for random sample only, i.e. excluding both SEO and Latino samples.

backwards the probability of having positive savings or savings equal to 2 months of income, in order to construct the savings dummies for the missing years. These probit regressions have a good predictive power, and results available upon request. The resolution of problems associated with endogeneity of asset holdings is left for future research.

As pointed out by Jappelli et al. [1998], households with zero or negative net worth are not necessarily constrained households, as poor household could still have access to credit cards or other lines of credit. Jappelli et al. [1998] propose to use a direct measure of liquidity constraints that relies on information of whether household was denied loans or was discouraged from borrowing or if it did not have a credit card or other lines of credit. Unfortunately, no such information is available from PSID. Thus, we complement our asset split by excluding household according to some demographic characteristics. Jappelli et al. [1998] find that households with less than college education, unemployed, or younger than 38 are more likely to be turned down for a loan. Lyons [2003] finds that although borrowing constraints relaxed since 1983 and most dramatically between 1992 and 1998, individuals younger than 35, who are black, or poorly educated continued to be constrained, though less than before.

To summarize, we split the sample into two sub-samples: constrained and unconstrained households. *Constrained* households are identified by having zero savings for the first split, and savings of less than 2 months worth of income for the second; and for both splits by having a head of household whose educational attainment is less than a high school diploma, who is under 35 years of age, or who is unemployed.

We allow households to belong to both groups during their sample life depending on the state of their wealth. Thus, if a household with positive savings one year has zero savings the next year, it will be a part of unconstrained and then constrained group. In practice, according to the first split (save=1) only 5 percent of households moved from unconstrained to constrained group, while about 35 percent moved from being constrained to unconstrained in our sample. If we consider the second split, (2mnths=1), these numbers are more pronounced, 24 percent of households transitioned from having savings of at least 2 months of family income to having less than 2 months worth of savings; and only 11 percent transitioned from being constrained to becoming unconstrained. On average, about 13 percent of households are counted as constrained in 1980 and 14 percent in 2001 according to our first measure; and 50 versus 80 percent, respectively, according to the second measure. Summary statistics for constrained and unconstrained households can be found in Table 5.

A.3 Supplementary Tables

Table 6: Between Group Volatility Ratios

	1978		1986		1996		2002†	
	Levels	Growth	Levels	Growth	Levels	Growth	Levels	Growth
White to Nonwhite	0.68	0.79	0.52	0.52	0.59	0.59	0.68	0.57
Single to Single Parent	0.82	1.73	0.94	1.00	0.94	0.92	1.02	1.02
Married to Single	0.47	0.58	0.45	0.45	0.54	0.56	0.74	0.62
Married to Single Parent	0.83	1.01	0.42	0.45	0.51	0.51	0.73	0.63
BA Degree to less	1.12	1.13	1.07	1.00	0.82	1.13	0.95	0.97
House Owner to Renter	0.72	0.77	0.58	0.56	0.73	0.70	0.73	0.70

Notes: Each number in the table corresponds to a ratio of volatilities for group i versus that of group j, such that a ratio of i to j is given by $\frac{median_t(\sigma^2_{h,t}), \forall h \in i}{median_t(\sigma^2_{h,t}), \forall h \in j}$. Columns headed by *Levels* indicate that volatility was computed using the median over the levels of consumption, or as $\sigma^2_{h,t} = median_t(\frac{1}{5}\sum_{\tau=1}^{5}(lnC_{h,t-\tau} - \overline{lnC_h})^2)$. Columns headed by *Growth* indicate that volatility was computed as $\sigma^2_{h,t} = median_t(\frac{1}{5}\sum_{\tau=1}^{5}(\Delta lnC_{h,t-\tau} - \overline{\Delta lnC_h})^2)$.
† indicates that ratios for 2002 were computed using hypothetical biannual survey as described in the main text.

Table 7: Annualized Percentage Change in Volatility of Food Consumption Growth Rates

	1978-2002†	1978-1986	1986-1996	1996-2002†
Median	0.8%	0.2%	0.4%	2.2%
By Race of Head				
White	0.7%	-0.2%	0.6%	2.1%
Nonwhite	1.4%	2.9%	-2.1%	5.2%
By Family Type				
Single	0.0%	0.2%	1.8%	-3.1%
Single Parent	3.4%	16.9%	-6.5%	3.7%
Married/Cohabiting	0.8%	-0.6%	0.0%	4.3%
By Education of Head				
Some College or less	0.8%	1.7%	-0.3%	1.6%
At least BA Degree	0.2%	-2.7%	1.5%	2.0%
By Housing Tenure				
Rent	1.6%	3.0%	-1.4%	4.8%
Own	0.7%	-0.4%	1.0%	1.5%

Notes: By volatility of food consumption *growth rates* we mean volatility computed using the median over the growth rates of consumption, or as $\sigma^2_{h,t} = median_t(\frac{1}{5}\sum_{\tau=1}^{5}(\Delta lnC_{h,t-\tau} - \overline{\Delta lnC_h})^2)$. Each number in this table indicates an average percentage change in volatility observed during the period specified by the column name. † indicates that growth rates between these years is computed using hypothetical biannual survey as described in the main text.