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Measuring Consumption Smoothing in CEX Data

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Abstract

This paper proposes and implements a new method of measuring the degree of consumption smoothing using data from the Consumer Expenditure Survey. The structure of this Survey is such that estimators previously used in the literature are inconsistent, simply because income is measured annually and consumption is measured quarterly. We impose an AR(1) structure on the income process to obtain a proxy for quarterly income through a projection on annual income. By construction, this proxy gives rise to a measurement error which is orthogonal to the proxy itself—as opposed to the unobserved regressor—leading to a consistent estimator. We contrast our estimates with the output of two estimators used in the literature. We show that while the first (OLS) estimator tends to overstate the degree of risk sharing, the second (IV) estimator grossly understates it.

Journal of Economic Literature Classification Numbers: C13; C8; D12; E21

Keywords: Risk Sharing; Consumption Smoothing; Income Risk; Projection

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1 Introduction

In this paper, we propose and implement a new method of measuring the degree of consumption smoothing using data from the U.S. Consumer Expenditure Survey (CEX).

This project is motivated by a large and growing literature on models with heterogeneous agents. In order for this heterogeneity to matter, so that agents are not just scaled versions of one another, these models typically feature some kind of friction that prevents agents from perfectly sharing idiosyncratic risk. The question is what specification is the most realistic one. One useful selection criterion, as suggested in Krueger and Perri (2004), is the extent to which models replicate the degree of risk sharing measured in the data. Properly measuring the degree of risk sharing in the data is therefore important in evaluating models with various kinds of frictions.

The empirically most obvious aspect of risk sharing—indeed it is also the one that Krueger and Perri (2004) focus on—is the extent to which household consumption responds to idiosyncratic earnings shocks. As in Dynarski and Gruber (1997), we operationalize this notion to mean the regression coefficient of the idiosyncratic consumption change on the idiosyncratic change in earnings. Since this is a temporal concept, we may as well call it the degree of *consumption smoothing*. For the purpose of interpretation, it is useful to keep in mind that autarky implies that this coefficient is equal to one. On the other hand, if insurance markets are perfect and consumption and leisure are separable, then this coefficient is zero. Intermediate values can then be interpreted as measuring the *degree* of risk sharing or consumption smoothing.

Mace (1991) was the first to use CEX data to estimate the degree to which households smooth consumption in the presence of variable earnings or employment status. Her OLS estimates lend support to the full consumption insurance or full risk sharing proposition. However, Nelson (1994) points out potential problems with Mace's methodology, which leads Nelson to reject complete risk sharing.[1] Similarly, Dynarski

[1] In particular, Nelson (1994) points out that changes in monthly expenditures, which is the measure of consumption used by Mace (1991), are likely to overstate changes in consumption as they may not reflect changes in service flows. Accordingly, Nelson (1994) uses changes in quarterly instead of monthly consumption.

and Gruber (1997) claim that the OLS estimates used by both Mace (1991) and Nelson (1994) suffer from measurement error and propose an IV method to deal with this problem. Meanwhile, our work shows that the structure of the CEX gives rise to non-classical measurement error that renders this IV approach invalid.

Unlike the papers cited above, our analysis deals with the main problem of the CEX, which is that consumption and income are not observed for coincident periods. Specifically, the structure of the data is as follows. A household reports information regarding 7 quarters (21 months). Consumption expenditure data is available for the last four of these quarters, and income data is available for two 12-month periods, one covering the first 12 months and the other covering the last 12 months. Our main contribution is to develop and implement an estimation strategy that is appropriate given the structure of the CEX.[2]

Our estimator uses a proxy for the true regressor and is based on the following simple result. As pointed out in Wooldridge (2002), if the proxy for true income is such that the implied measurement error is orthogonal to the proxy itself, then the OLS estimator using the proxy as the regressor is consistent.[3] The challenge, of course, is to find a proxy with the required orthogonality property. This is achieved by replacing the unobserved regressor by a linear projection on observable variables. In order to compute the linear projection of income contemporaneous with our consumption measure, we impose an AR(1) structure on monthly income whose parameters are estimated using the generalized method of moments (GMM).

The main result is that we can reject the hypothesis of perfect consumption risk sharing, but that the degree of risk sharing is quite high. In particular, it is much higher than it would appear if measured using the method of Dynarski and Gruber (1997). An additional result of potential practical importance is that it appears that using food as a measure of consumption—the only measure available in PSID data—is not a bad approximation. As one would expect, we find that durable goods purchases

[2]Instead of confronting this inherent problem with the structure of CEX data, Blundell et al. (2004) impute consumption to households in the PSID using information from the demand for food, which is available both in CEX and PSID data. See Blundell et al. (2005) for details on the imputation procedure.

[3]This is in contrast to classical measurement error, where the measurement error is orthogonal to the true regressor.

are more responsive to changes in income than purchases of non-durable goods. More surprisingly, we find that households with a lot of financial assets do not smooth consumption as much as households with less financial assets, consistent with recent findings by Guvenen (2007). By contrast, households with relatively high income smooth consumption to a larger extent than households with relatively low income. Finally, we find that married households consistently smooth consumption less than their non-married counterparts.

The paper is organized as follows. In Section 2 we describe the CEX data and its structure, with details contained in Appendix A. In Section 3 we describe the instrumental variables approach of Dynarski and Gruber (1997) and show why it is invalid in this context. Section 4 describes our solution to the asynchronicity problem. Section 5 presents some simulation results, contrasting the properties of existing estimators with our own. In Section 6 we present some estimation results from the CEX data. Section 7 concludes.

2 Description of the Data

The problem with measuring the degree to which households smooth consumption in the presence of income variability has always been the scarcity of reliable consumption data. It is well known that both the CPS and the PSID contain high quality income data. However, the CPS provides virtually no consumption data and the PSID only has information on food and housing consumption, which is clearly not ideal. CEX is the only survey in the U.S. which collects detailed consumption data.[4] In addition, the CEX collects income data, which essentially makes the CEX the only dataset suitable for our purpose.[5] Another desirable feature of the CEX is that it provides a (short) panel for both consumption and income. However, for the purpose of estimating the

[4] The consumption data used in this paper is from the CEX Interview Survey. Battistin (2003) and Attanasio et al. (2007) document differences between the interview and the diary components of the CEX.

[5] Attanasio and Davis (1996) combine high quality consumption data from the CEX to high quality income data from the CPS. While this strategy is suitable to study risk sharing across groups of households, it masks the degree of risk sharing at the household level as idiosyncratic risk washes out in the aggregation procedure.

response of consumption to income, the structure of the Survey is far from ideal.

Each household or consumer unit (CU) in the Survey is interviewed 5 times.[6] Interviews occur every 3 months, but the interview month varies across CU's: if the first interview occurs in January of a given year, the last interview takes place in January of the following year. The first interview is only used to collect data on various characteristics (such as race and education) of the CU and its members as well as information on some durable goods. Whereas consumption data pertaining to each of the last three months is collected at each subsequent interview, income data is only collected during the second and fifth interviews and pertains to the last 12 months.

Figure 1 illustrates the life of a household in the Survey. In this Figure quarters, labelled Q1 to Q8, do not necessarily refer to calendar quarters: they are calendar quarters only for households whose interview month corresponds to the first month of a calendar quarter. Notice that while the 5 interviews only span 12 months, the data collected span 7 quarters. Since annual income data (y_{a1} and y_{a2}) are collected at the second and fifth interviews, they overlap for 3 months and thus only span 21 months. The $\times$'s in the figure (at months 12 and 21) indicate that information regarding the last paycheck received by members of the household is collected for these months.[7] Since consumption information is collected at each of the last 4 interviews, we have 4 consumption observations, labelled C_4 though C_7. Finally, the Y^p's refer to projected income, which we will explain in detail in section 4.

2.1 Income Data

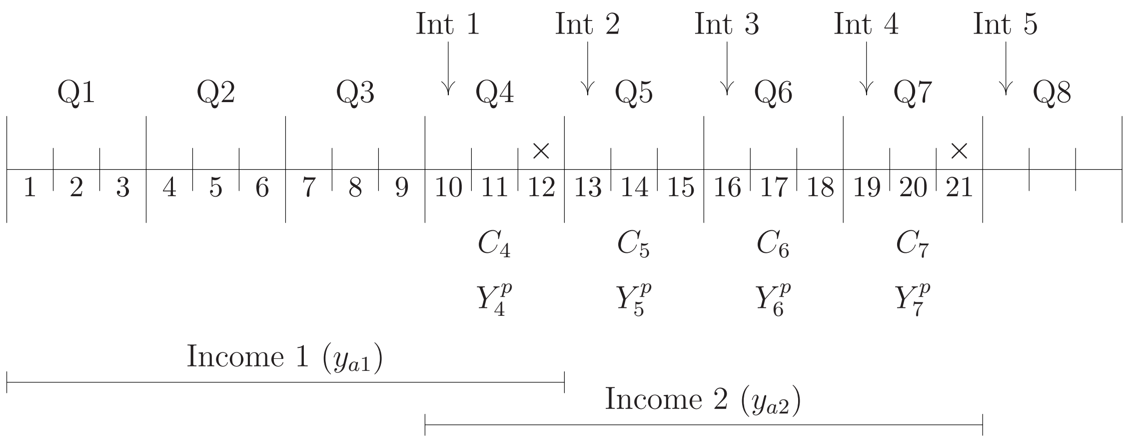
Our definition of income consists of after-tax labor earnings plus government-mandated deductions and benefits.[8] More precisely, for every CU, yearly income is defined as

[6] The primary sampling unit in the CEX is called a consumer unit. A consumer unit consists of individuals who are either related or share their income to make joint expenditures. The CEX makes a subtle distinction between households and consumer units, but we use household and CU interchangeably.

[7] This last paycheck need not refer only to that month, nor does it need to cover the entire month. Fortunately, information on the period of time the pay cheque covers is also collected.

[8] The reason why we include government-mandated contributions and benefits in our concept of income is that we are ultimately interested in how well the private sector is able to share risk, as opposed to society as a whole.

Figure 1: Life of an Interviewee in the CEX



wages and salary (including all compensations from the employer) plus a fraction (0.864) of self-employment (farm and non-farm) income. We also include the following government transfers: social security benefits, unemployment compensation, public assistance and welfare payments, as well as other transfers. From that amount, we then deduct total taxes paid (federal, state and local, including property taxes, all net of refunds), social security contributions, and (government and railroad) retirement contributions. Total income is then deflated by the CPI for the relevant 12 months. See Appendix A for more details.

2.2 Consumption Data

We define quarterly consumption as the expenditure on all items purchased by the household during the quarter (except vehicles and houses) plus imputed consumption flow values for owner-occupied housing and vehicles. Imputed housing services for homeowners is defined as the *rental equivalent*, i.e. the amount that the respondent expects the property to fetch in the rental market. For vehicles, we follow the procedure outlined in Cutler and Katz (1991) in order to impute the purchase price of vehicles owned by the household and then divide by 32 to get the quarterly flow value. To this we add any expenditure on maintaining and repairing the vehicle(s). For all other durables, we do not attempt to impute any service flows from the stocks, and simply add expenditures during the quarter. All observations are deflated by the relevant CPI. The availability of CPI categories thus dictates our choice of consumption categories.[9]

2.3 Idiosyncratic Income and Consumption

To extract the idiosyncratic component of log annual incomes, denoted by y^i_{a1} and y^i_{a2}, we regress log incomes on a constant, a cubic in age, aggregate log GDP per head (not seasonally adjusted), the number of earners in the household, the number of individuals in the household, the number of members below the age of 18, the number of members above the age of 64, and dummies representing marital status, education and race; we then keep the residuals. Since we regress consumption changes on income changes, any individual fixed effects are automatically eliminated.

Idiosyncratic consumption is extracted in the same way as income except that we also introduce a seasonal dummy in order to take care of the possibility that consumption varies systematically with the time of year.

2.4 Sample Selection

Our sample runs from the first quarter of 1980 to the first quarter of 2002. Table 1 summarizes our benchmark sample selection. We exclude CU's whose income in either year is considered incomplete.[10] We also exclude households for whom the characteristics of the reference person are inconsistent over time, either because the reference person grows younger or ages by more than one year from one quarter to the next, gets less or more educated too fast, or undergoes a sex or race change. Because of a coding mistake in the CEX data, all households whose interviews span the years 1981 and 1982 are dropped because of changes in characteristics. We also exclude households with at least one non-positive yearly income observation and those with

[9]Our categories are similar to those of Hobijn and Lagakos (2003). See Appendix A for details.

[10]CU's are considered *complete* income reporters if they list any major source of income, independent of other income responses—see Cutler and Katz (1991) for details.

Table 1: Benchmark Sample Selection

Selection criterion	Observations deleted	Remaining observations
Original dataset		164,507
Incomplete income data	97,554	66,953
Inconsistent race	527	66,426
Inconsistent sex	1,351	65,075
Inconsistent age	2,106	62,969
Inconsistent education	1,078	61,891
Non-positive annual income(s)	1,432	60,459
Zero or missing food consumption	2,310	58,149
Income (y_{a2}) less than total food consumption	1,498	56,651
Negative medical care expenditures	1,537	
Our Benchmark Sample		**55,114**

missing or zero food consumption. Next we drop households whose income in year 2 is insufficient to cover their total food consumption for that year. This criterion is meant to eliminate households whose income is badly measured.[11] Finally, we eliminate households whose consumption of medical care is negative. It should be noted that while these criteria are sufficient to guarantee good consumption data for interviews 2 and 5, they do not guarantee that consumption is available for interviews 3 and 4. There are, however, fewer than 50 households for which consumption in those interviews is missing.

From this benchmark sample, we later explore the sensitivity of our results to many other sample definitions. In particular, we verify that our results are robust to eliminating self-employed households, who may be in a position to manipulate their income in response to consumption expenditures.[12] We also verify that our results are robust to restricting the sample to the working-age population (between 21 and 64), as well

[11]The income of the poor in CEX data is known to be poorly measured (see Meyer and Sullivan (2003)). This criterion is also used by Blundell et al. (2004) for their CEX sample.

[12]We define a household as self-employed if it receives at least 50% of its total income from self-employment in either of our two yearly observations of income. Around 6% of our sample satisfies this definition. Note, however, that only 62 percent of those who are self-employed according to our first observation of income remain self-employed in our second observation of income.

as the elimination of households who live in rural areas.

3 Measurement Error and the IV Solution

The fundamental problem with estimating the degree to which households can smooth consumption in the presence of income risk from CEX data is the fact that we do not observe consumption and income for the same periods of time. Having no observations of income corresponding to consumption, a natural though problematic strategy is to use the change in annual income as a proxy for the income change between quarters Q7 and Q4. Doing so, however, introduces a discrepancy between the true regressor and the proxy, which can be described as measurement error, though it has nothing to do with misreporting.

More explicitly, consider the problem of estimating β in the regression equation

$$C = \beta Y + \varepsilon, \tag{1}$$

where C measures the change in the idiosyncratic component of consumption $(C_7 - C_4)$, Y measures the change in the idiosyncratic component of income $(Y_7 - Y_4)$, and $\mathsf{E}[\varepsilon] = \mathsf{E}[Y\varepsilon] = 0$. Since Y is unobserved, it needs to be replaced by a proxy $\widehat{Y}$. In the existing literature, the proxy is simply the difference between the two yearly observations of income $(y_{a2} - y_{a1})$. We will denote the difference between the true regressor and this proxy by η, defined via $\widehat{Y} = Y + \eta$. The OLS estimator in this case is not likely to be consistent. If we assume that $\mathsf{E}[\eta\varepsilon] = 0$, then

$$\operatorname*{plim}_{N\to\infty} \beta_N^{\text{OLS}} = \beta \frac{\mathsf{E}[Y\widehat{Y}]}{\mathsf{E}[\widehat{Y}^2]}.$$

If the measurement error were "classical," i.e. $\mathsf{E}[Y\eta] = 0$, we would have

$$\frac{\mathsf{E}[Y\widehat{Y}]}{\mathsf{E}[\widehat{Y}^2]} = \frac{\mathsf{E}[Y^2]}{\mathsf{E}[Y^2] + \mathsf{E}[\eta^2]} < 1,$$

so that the OLS estimator would be asymptotically biased towards zero, thereby overstating the degree of risk sharing.

In order to deal with this possible asymptotic bias, Dynarski and Gruber (1997) use an instrumental variable (IV) approach with a second measure of the income change as an instrument. As shown in Figure 1, the CEX provides information about the amount of the CU's last paycheck, as well as its frequency, which we refer to as (log) monthly incomes y_{12}^m and y_{21}^m. This is then used to define the instrument via $Z = y_{21}^m - y_{12}^m$. This instrument is invalid because the measurement error arises from asynchronicity, as opposed to misreporting of income, rendering it non-classical. To see this, notice that

$$\operatorname*{plim}_{N\to\infty} \beta_N^{\mathrm{IV}} = \frac{\mathsf{E}[CZ]}{\mathsf{E}[\widehat{Y}Z]}.$$

Assuming that $\mathsf{E}[\eta\varepsilon] = 0$, we have

$$\operatorname*{plim}_{N\to\infty} \beta_N^{\mathrm{IV}} = \beta\frac{\mathsf{E}[YZ]}{\mathsf{E}[YZ] + \mathsf{E}[Z\eta]}. \tag{2}$$

This instrumental variable strategy will thus be valid if and only if the measurement error in change in annual income is uncorrelated with the instrument, $\mathsf{E}[Z\eta] = 0$.

There are very strong reasons to believe that this condition is violated in this context, simply because of the structure of the CEX as illustrated in Figure 1. For the sake of argument, suppose that income in the second year (y_{a2}) is high relative to what it is trying to measure, i.e. relative to income in the seventh quarter (Y_7). This results in a positive measurement error η. Now if y_{a2} is high relative to Y_7, it is very likely that income during quarters Q4 to Q6 was above average. In particular, income in the third month of Q4, i.e. y_{12}^m, is also likely to be high. But if y_{12}^m is above average, it is also likely to be greater than y_{21}^m. That means that the instrument, $y_{21}^m - y_{12}^m$, is likely to be negative. For such reasons, one would expect measurement error to be negatively correlated with the instrument. Of course the converse assumption—that y_{a2} is low—would lead to the same conclusion. As equation (2) shows, the IV estimator in that case is biased upward (provided of course that the instrument is positively correlated with the true regressor), that is, this estimator tends to understate the degree of risk sharing.

4 Projection-Based Estimation

We have seen that, when the regressor is measured with error, the OLS estimator is asymptotically biased by the factor

$$\frac{\mathsf{E}[Y\widehat{Y}]}{\mathsf{E}[\widehat{Y}^2]}.$$

We have also seen that if measurement error is classical, i.e. $\mathsf{E}[Y\eta] = 0$, then this ratio is strictly less than one. However, if $\mathsf{E}[\widehat{Y}\eta] = 0$, then $\mathsf{E}[\widehat{Y}^2] = \mathsf{E}[\widehat{Y}Y]$ and hence

$$\frac{\mathsf{E}[Y\widehat{Y}]}{\mathsf{E}[\widehat{Y}^2]} = 1.$$

Thus consistency is achieved if the measurement error is orthogonal not to the regressor but to its proxy.[13]

One proxy for the regressor that will certainly have the desired orthogonality property is the linear projection of the unobserved regressor on something we can observe, such as our two observations of annual income. By definition of the projection, the projection error is orthogonal to the projection itself. The only remaining problem is to construct that projection. To do so, we define a vector that we can observe, namely

$$W = \begin{bmatrix} y^i_{a1} \\ y^i_{a2} \end{bmatrix}.$$

Denote the actual (unobserved) idiosyncratic income change by Y and its linear projection on W by Y^p. Then

$$Y^p = \alpha W,$$

where

$$\alpha = \mathsf{E}[YW']\mathsf{E}[WW']^{-1}.$$

Thus in order to compute the projection we need to estimate the covariance matrix of idiosyncratic annual incomes ($\mathsf{E}[WW']$) and the covariance between quarterly income and annual income ($\mathsf{E}[YW']$). For the latter we need to impose some structure on the autocovariance function.

[13] This result is related to the unobserved variable problem discussed in Zellner (1970), Goldberger (1972) and Pagan (1984).

4.1 Constructing the Projection

Our strategy is as follows. First we impose a parameterized structure on the data generating process of income. Then we use GMM to estimate the parameters of that structure. The estimated parameter values can then be used to compute the desired covariance matrix.

Let y_t^i denote (log) monthly income for household i. Assume that the stochastic process governing y_t^i is given by

$$y_t^i = \rho y_{t-1}^i + \varepsilon_t^i, \tag{3}$$

where ε_t^i is the idiosyncratic shock received by household i in period t and ρ measures the persistence of income.[14] Recall that our income data consist of two annual observations of income, denoted y_{a1}^i and y_{a2}^i, which overlap for exactly 3 months. What we want is a measure of quarterly income, which will be constructed from estimates of monthly income y_t^i, $t = 1 \ldots, 21$. First note that given y_1,

$$y_t^i = \rho^{t-1} y_1^i + \sum_{k=2}^{t} \rho^{t-k} \varepsilon_k^i.$$

We can then express our first annual income observation in terms of monthly income;

$$y_{a1}^i = \ln\left(\sum_{t=1}^{12} \exp\left\{\rho^{t-1} y_1^i + \sum_{k=2}^{t} \rho^{t-k} \varepsilon_k^i\right\}\right).$$

Similarly, we can express our second annual income observation in terms of monthly income;

$$y_{a2}^i = \ln\left(\sum_{t=10}^{21} \exp\left\{\rho^{t-1} y_1^i + \sum_{k=2}^{t} \rho^{t-k} \varepsilon_k^i\right\}\right).$$

As moments for GMM we use $\mathsf{E}[y_{a1}^i\, y_{a1}^i]$, $\mathsf{E}[y_{a2}^i\, y_{a2}^i]$ and $\mathsf{E}[y_{a1}^i\, y_{a2}^i]$. Note that these moments are the elements of the covariance matrix of idiosyncratic annual incomes, $\mathsf{E}[WW']$. Denoting the variance of y_1 by $\sigma^2_{y_1^i}$ and the variance of ϵ_t^i by σ^2_ε, we have

[14]It should be emphasized that although this may not be the "true" income process, all that matters from the present point of view is that the implied structure for the autocovariance function is a good approximation of reality.

the following *approximate* results:[15]

$$\mathsf{E}[y^i_{a1}\, y^i_{a1}] \approx \left(\frac{1-\rho^{12}}{1-\rho}\right)^2 \sigma^2_{y_1} + \frac{1}{(1-\rho)^2}\left(11 - 2\rho\frac{1-\rho^{11}}{1-\rho} + \rho^2\frac{1-\rho^{22}}{1-\rho^2}\right)\sigma^2_{\varepsilon}\ ;$$

$$\begin{aligned}\mathsf{E}[y^i_{a2}\, y^i_{a2}] \approx\ & \rho^{18}\left(\frac{1-\rho^{12}}{1-\rho}\right)^2 \sigma^2_{y_1} \\ & + \left[\left(\frac{1-\rho^{18}}{1-\rho^2}\right)\left(\frac{1-\rho^{12}}{1-\rho}\right)^2 + \frac{1}{(1-\rho)^2}\left(11 - 2\rho\frac{1-\rho^{11}}{1-\rho} + \rho^2\frac{1-\rho^{22}}{1-\rho^2}\right)\right]\sigma^2_{\varepsilon}\ ;\end{aligned}$$

$$\begin{aligned}\mathsf{E}[y^i_{a1}\, y^i_{a2}] \approx\ & \frac{\rho^9(1-\rho^{12})^2}{(1-\rho)^2}\sigma^2_{y_1} \\ & + \left[\frac{1-\rho^{12}}{(1-\rho)^2}\left(\frac{1-\rho^9}{1-\rho} + \frac{\rho^{21}-\rho^3}{1-\rho^2}\right) + \frac{(1+\rho)(1-\rho^{11})}{1-\rho} + \frac{(1-\rho^{10})}{1-\rho}\right]\sigma^2_{\varepsilon}\ .\end{aligned}$$

Our estimated process has a persistence parameter $\rho = 0.87$, which is much lower than most estimates from the literature. For example, using PSID data, Storesletten et al. (2004a) find the persistent component of income to be close to a unit root process. Our comparatively low estimate of ρ appears to emanate from the fact that we use a richer set of covariates than is commonly used in the literature. These covariates, which are highly predictable, account for a large fraction (49.5%) of the cross-sectional variation of income. On the other hand, following Deaton and Paxson (1994), Storesletten et al. (2004a) only use age and year of birth as controls, which potentially leaves their income process highly correlated with characteristics (such as marital status and education) which are predominantly deterministic.[16]

The variance of the idiosyncratic shock (σ^2_{ε}) is estimated to equal 0.18, while the variance of first month income ($\sigma^2_{y_1}$), is estimated to be 0.86. Note that stationarity of the income process would imply a variance of first month income equal to 0.69. In a separate estimation, we reject stationarity at any reasonable significance level. Given the values of σ^2_{ε}, σ^2_y and ρ, we can compute the covariance between quarterly and annual income, $\mathsf{E}[YW']$, and hence α, the projection matrix.

[15]The approximation errors emanate from Jensen's inequality and are negligible. A derivation of these approximate results is available upon request.

[16]In Storesletten et al. (2004b), where they use year dummies, a cubic in age and education as controls, they report a R^2 equal to 0.23.

Table 2: Simulation Results

	β^{OLS}	β^{IV}	β^{PRO}
Estimate	0.073	0.415	0.100

4.2 Estimation

Given our projections of quarterly income, we have four observations of both consumption and income for each household. We thus have three equations in log-differences from which to estimate the single regression coefficient β. The orthogonality between the disturbance term and the regressor in each of these equations gives rise to three moment conditions. These moment conditions are then used as the basis for a GMM estimation, where the weighting matrix is chosen optimally.

5 Simulations

To illustrate the properties of our estimator relative to the OLS and IV estimators, we simulate data according to the process for income implied by the estimates from the previous section, that is, we simulate income from month 1 to month 21. We assume that the true value of β is 0.1. The data generating process for consumption is thus given by $C_t^i = \beta Y_t^i + \xi_t^i$, where Y_t^i, which denotes income of household i in quarter t for $t = 4, \ldots, 7$, is the sum of monthly incomes in that quarter. We assume that ξ_t^i is identically and independently distributed (over time and across households) normally with zero mean and variance 0.2.[17] We simulate 100 samples of size 500,000. Our results, shown in Table 2, indicate that the IV estimate is more than 5 times higher than the OLS estimate, as one would expect given our discussion in Section 3. While the estimate from our proposed projection method, labelled β^{PRO}, is equal to the true value of β, the IV estimate understates the degree of risk sharing and the OLS estimate overstates it.

[17]Our results are not sensitive to the variance of ξ_t^i.

6 Estimation Results

Table 3 shows our estimate of the degree of risk sharing together with the OLS and IV estimates. The standard errors in that table were computed using a bootstrap strategy, with 1000 samples of the same number of observations as in the original sample (55,114).[18] As expected, the OLS estimates is low and the IV estimate is high relative to our proposed projection method estimate. Given the size of our sample, all these estimates are fairly precise and thus all statistically different from zero.

Table 3: Estimates

	β^{OLS}	β^{IV}	β^{PRO}
Estimate	0.0630	0.1817	0.1001
	(0.0030)	(0.0216)	(0.0122)
Sample size	55114	34379	55083

Note: Standard errors are in parentheses.

Table 4 shows estimates of the degree of consumption smoothing across broad categories of goods. The sample size for each of these categories (shown in parentheses in Table 4) varies as more households can have non-positive consumption of a particular category and still have positive total consumption. For example, around 32,000 households in the sample report positive expenditures on alcohol and tobacco. As one would expect, all our estimates lie in between the OLS and the IV estimates. It is interesting to note that the estimate for food is not substantially different from that for total consumption. This suggests that using food—the only component of consumption available in PSID data—as a proxy for consumption might not be such a bad idea when answering questions related to risk sharing.[19] This result, however, is somewhat sensitive to the sample. In a very homogeneous sample of non-self-employed, white, married, working-age households living in urban areas, the estimate

[18] Note that some observations still need to be discarded either because consumption in interviews 3 or 4 is non-positive, or, in the IV case, because the instrument (monthly income) is missing.

[19] Limited data on food expenditures are also available in the CPS Food Security Supplement, which was first administered in 1995.

for food consumption is 60% lower than that for total consumption, mainly because the estimate for food at home is lower than in the benchmark sample.

Table 4 also suggests that household durables are used as a buffer stock as suggested in Browning and Crossley (2004). Note also that housing consumption appears very smooth. This should not be surprising given our measure of housing consumption, but also because we lose households with substantial changes in housing consumption since the CEX does not follow households once they have moved. A related result is that consumption less cars and housing is less smooth than total consumption. In Table 8 of Appendix B we verify that these results are robust to alternative sample selections.

Table 5 reports a set of estimates conditional on particular characteristics of the household. First, the CEX reports data on financial assets collected in the last interview.[20] Surprisingly, households with financial wealth below the median seem to smooth consumption more than those whose wealth is above the median. This result, which at first appears counterintuitive, is consistent with recent findings in Guvenen (2007). It is worth emphasizing that these results were obtained through entirely different methods, and using different datasets—Guvenen (2007) uses the PSID and thus food consumption to estimate a structural model of stock market participation. He suggests that this result is due to the higher fraction of entrepreneurs among high wealth households. Table 5 shows that self-employed households indeed do not smooth consumption to the same extent as other households. However, this may be due to the fact that self-employed households can manipulate their income in response to expenditures. Furthermore, the "counterintuitive" result still holds in a sample that excludes self-employed households.

As one would expect, high income households smooth consumption to a larger extent than low income households.[21] However, married households do not smooth

[20] Financial assets consist of savings accounts, checking and brokerage accounts, savings bonds, as well as securities (stocks and bonds). It should be noted that ideally one would like to have access to financial assets at the time of the first interview, as the amount of financial assets at the end of the sample life can be influenced by income shocks received in the previous periods. Unfortunately, the CEX only asks questions related to financial assets during the last interview.

[21] We also find that consumption responds to a much greater extent to a decrease in income than to an increase in income. Indeed, the response of consumption to an increase in income is very close to zero for the benchmark sample.

Table 4: Estimates Across Categories of Goods

	β^{OLS}	β^{IV}	β^{PRO}
Total consumption	0.063	0.182	0.100
	(55114)	(34379)	(55083)
Consumption less cars and housing	0.062	0.188	0.126
	(55114)	(34379)	(55114)
Food	0.052	0.180	0.112
	(55006)	(34346)	(55015)
Food at home	0.039	0.155	0.071
	(54736)	(34184)	(54761)
Food away from home	0.085	0.361	0.172
	(43043)	(29650)	(43306)
Alcohol and tobacco	0.046	0.132	0.103
	(31942)	(22549)	(32236)
Housing[a]	0.029	0.071	0.042
	(55054)	(34346)	(55080)
Household durables[b]	0.119	0.506	0.293
	(50081)	(32611)	(50065)
Transportation[c]	0.131	0.295	0.204
	(52001)	(33842)	(52105)
Education	0.056	0.145	0.072
	(38431)	(25601)	(38810)

Note: Sample sizes are in parentheses.

[a] Housing includes rental and imputed rents.

[b] Household durables consist of furniture, household operations and apparel.

[c] Transportation includes all private and public expenditures on transportation, as well as the imputed service flow of privately owned vehicles.

Table 5: Conditional Estimates

	β^{OLS}	β^{IV}	β^{PRO}
Total Sample	0.063	0.182	0.100
Results by financial asset holdings			
Fin assets < median	0.060	0.187	0.086
Fin assets > median	0.066	0.176	0.118
Results by income			
Income < median	0.053	0.161	0.128
Income > median	0.076	0.197	0.074
Results by type of employment			
Self-employed	0.050	0.150	0.127
Not self-employed	0.065	0.184	0.097
Results by race			
White	0.064	0.183	0.113
Black	0.049	0.193	0.035
Results by marital status			
Married	0.076	0.193	0.119
Not married	0.040	0.127	0.073
Results by education			
Less than high school	0.061	0.242	0.079
High school	0.060	0.179	0.100
Some college	0.066	0.170	0.102
College graduate	0.066	0.161	0.120

consumption as much as singles. Our results by race indicate that whites do not smooth consumption as much as blacks. However, the large difference between the OLS and IV estimates for blacks suggests that their income may be particularly badly measured. While the previous results are robust to alternative sample selections (see Table 9 in Appendix B), such is not the case for education, which *a priori* seem to suggest that more education is associated with less smoothing. In particular, Table 9 shows the estimate for households whose reference person has less than a high school degree increases as the sample becomes more homogeneous. Furthermore, the difference between the estimates for high school and college changes with the sample, and effectively disappears once we restrict the sample to non-self-employed, white, married, working-age households living in urban areas (not shown).

7 Concluding Remarks

In this paper we focused on the structure of the Consumer Expenditure Survey and the problems it raises for obtaining consistent estimates of the extent to which households smooth consumption in the presence of variable earnings. Careful consideration of these problems led us to reject both the OLS and IV approaches previously used in this literature: while the OLS estimator tends to overstate the degree of risk sharing, the IV estimator tends to understate it.

We then proposed an estimation strategy that is appropriate given the structure of the CEX. We used the fact that an OLS estimator is consistent if the proxy variable used in the regression is orthogonal to its measurement error. A proxy variable with that property was constructed by projecting the unobserved regressor on observables.

We used this estimation strategy to estimate the extent to which households smooth consumption across broad categories of goods and for different groups of the population. Our main result was that while full risk sharing can formally be rejected, the degree of risk sharing is nevertheless quite high, lying in between the OLS and IV estimates. We also found that food consumption may be a reasonable proxy for total consumption. Moreover, our results are consistent with the notion that household durables are used as a buffer stock as suggested in Browning and Crossley (2004).

Perhaps more surprisingly, we found that households with a lot of financial assets do not smooth consumption as much as households with less financial assets; this is consistent with recent findings by Guvenen (2007). By contrast, households with relatively high income smooth consumption to a larger extent than households with relatively low income.

Some caveats are in order. First, the structure that we impose on the autocovariance function of idiosyncratic income may be important for the results. However, in an effort to check the robustness of our results, we generated income data according to a process that features a permanent, a persistent, and a transitory component, and computed projections as if income had been generated by an AR(1) process. Our simulation results suggest that the orthogonality property sufficient for our estimator to be consistent holds to a high degree of precision. Second, the validity of our results is vulnerable to reporting error. We tried to deal with this by purging our data of clearly dubious observations as described in Section 2, but the problem may remain.

Appendix A: Consumption and Income Measures

A.1. Consumption

Table 6 reports each of our consumption categories along with their respective CPI deflator(s). Two categories need to be explained in detail. First, within the category of owned primary residence, imputed rents are taken to be the answer to the question "If someone were to rent your home today, how much do you think it would rent for monthly, unfurnished and without utilities?"[22] Second, the value for car consumption is imputed following the procedure outlined in Cutler and Katz (1991). For each year, this procedure first consists of running a regression of the log of car purchases (for households with positive purchases) on the log of total expenditures other than cars and a set of characteristics, which we choose to be: a cubic in age; the size of the household; the number of members under the age of 18; the number of members over the age of 64; the number of earners; and dummy variables for urban/rural area, marital status, race and education.[23] The predicted value from this regression is then our imputation of the value of each vehicle. We then multiply this by the number of vehicles owned by the household to obtain the value of the entire set of vehicles owned by the household. Finally, we divide this number by 32 to obtain the flow of services from vehicles in the given quarter. The number 32 is based on the assumption that a vehicle lasts for 8 years.

[22] In CEX data, the name of this variable is RENTEQVX. Although this variable is not available in the family files for 1993Q3–1994Q4 and is missing for many households, an equivalent variable (UCC910050) can be found in the MTAB files from 1993 and is used when RENTEQVX is unavailable or missing. Unfortunately, neither RENTEQVX nor UCC910050 are available for 1980–81, nor can we replace missing values for RENTEQVX prior to 1993.

[23] In the years 1982 and 1983, all sample households are urban.

Table 6: Consumption Categories and CPI Deflators

Good category	CPI
Food at home	SAF11: Food at home
Food away from home	SEFV: Food away from home
Alcoholic beverages	SAF116: Alcoholic beverages
Rented dwellings	SEHA: Rent of primary residence
Owned primary residence[a]	SAH1: Shelter used for 1980–1982
	SEHC: Owners' equivalent rent of primary residence used for 1982–2002
Other Lodging[b]	SE2102 (old series): Lodging while out of town used for 1980–1997
	SEHB (new series): Lodging away from home used for 1998–2002
Utilities	SAH2: Fuels and utilities
Household furnishings and operations	SAH3: Household furnishings and operations
Apparel	SAA: Apparel
Gas and motor oil	SETB: Motor fuel
Vehicle expenditures[c]	SETC: Motor vehicle parts and equipment
	SETD: Motor vehicle maintenance and repair
Vehicle insurance	SETE: Motor vehicle insurance
Vehicle rental and fees	SE52 (old series): Automobile fees used for 1980–1997
	SETF (new series): Motor vehicle fees used for 1998–2002
Imputed vehicle services[d]	SETA01: New vehicles (exists for the entire sample)
	SETA02: Used cars and trucks (exists for the entire sample)
	SETA: New and used motor vehicles (exists from 1995)
Public transportation	SETG: Public transportation
Medical care	SAM: Medical care
Entertainment	SA6 (old series): Entertainment used for 1980–1992
	SAR (new series): Recreation used for 1993–2002
Personal care	SAG1: Personal care
Reading	SERG: Recreational reading materials
Educational books and supplies	SEEA : Educational books and supplies

continued...

Good category	CPI
Education tuition	SEEB: Tuition, fees and child care
Tobacco	SEGA: Tobacco and smoking products
Miscellaneous	SEGD: Miscellaneous Personal Services

[a] Owned primary residence is defined as the sum of mortgage interest, property taxes and other expenses (including insurance), maintenance and repairs, and imputed rents on owner-occupied houses.

[b] Other Lodging is defined as the sum of mortgage interest, property taxes, other expenses (including insurance) and maintenance and repairs on other lodging.

[c] Vehicle expenditures comprise maintenance and repair as well as parts and equipment. Since we cannot distinguish between these two components in CEX data, we use the weights given in "Relative Importance of Components in the Consumer Price Index" for 1987–2002. We then extrapolates these weights linearly to complete the weights for 1980–1986. We then compute the weighed average CPI of the two components, where the weights are annual, and use the results to deflate this category. Furthermore, we use this CPI to deflate vehicle financing as no CPI exists for this category.

[d] Since we cannot distinguish between new and used vehicles in CEX data, we use the weights given in "Relative Importance of Components in the Consumer Price Index" for 1987–2002. We then extrapolates these wights linearly to complete the weights for 1980–1986. We then compute the weighed average CPI of the two components, where the weights are annual, and use the results to deflate this category.

A.2. Income

Our measure of income corresponds to after-tax (and mandatory deductions) wage and salary income, adding a fraction (0.864) of income from self-employment.[24] We also add benefits from government programs, as well as other income such alimony payments received. Below we define our measure of income using the variable names found in the CEX. The definition of these variables, which unless otherwise specified is the total for all CU members in the past 12 months, can be found in Table 7.

INCOME = FSALARYX + (0.864)*(FNONFRMX+FFRMINCX) + FRRETIRX + FSSIX + (UNEMPLX + UNEMPLBX) + (COMPENSX + COMPNSBX) + (WELFAREX + WELFREBX) + (CHDOTHX + CHDOTHBX) + (ALIOTHX + ALIOTHBX) + (OTHRINCX + OTRINCBX) + (JFDSTMPA + FOODSMPX + FOODSPBX) + (CHDLMPX + CHDLMPBX) + SSOVERPX + (LUMPSUMX + LMPSUMBX) − TOTTXPDX + TAXPROPX − FJSSDEDX − FRRDEDX −

[24]The fraction of self-employment income that is considered labor income is taken from Díaz-Giménez et al. (1997), which is also used by Krueger and Perri (2006).

FGOVRETX

Table 7: Definition of Income Components

Variable name	Definition
FSALARYX	Wage and salary income before deductions
FNONFRMX	Income or loss from nonfarm business, partnership or professional practice
FFRMINCX	Income or loss from own farm
FRRETIRX	Social Security and Railroad Retirement income prior to deductions for medical insurance and Medicare
FSSIX	Supplemental Security Income from all sources
UNEMPLX	Income from unemployment compensation
COMPENSX	Income from workers' compensation or veterans' benefits, including education benefits, but excluding military retirement
WELFAREX	Income from public assistance or welfare
CHDOTHX	Income from child support payments
ALIOTHX	Income from regular contributions from alimony and other sources such as from persons outside the CU
OTHRINCX	Other money income including money received from cash-scholarships and fellowships, stipends not based onworking, or from the care of foster children
JFDSTMPA	Annual value of Food Stamps received
CHDLMPX	Lump sum payments received for child support
LUMPSUMX	Lump sum payments received from estates, trusts, royalties,alimony, prizes, games of chance, or from personsoutside of the CU
TOTTXPDX	Total personal taxes paid (includes annualized Federal, Stateand local taxes paid on the last pay, other Federal, Stateand local taxes paid during the past 12 months, personalproperty taxes, and other taxes, minus Federal, State andlocal tax refunds)
TAXPROPX	Since TAXPROPX is included in TOTTXPDX and is not an income tax, we add it back to income
FJSSDEDX	Social Security deductions

continued...

Variable name	Definition
FRRDEDX	Railroad Retirement deductions
FGOVRETX	Government retirement deductions

Appendix B: Sample selection

Table 1 shows our benchmark sample selection, from which our main results in the text (Tables 3–5) were obtained. We now verify that our results are robust to alternative sample selections. Tables 8 and 9 report estimates under three alternative samples, as well as our original results from the main text. In the third column, we restrict the sample to working age reference persons, that is, between the ages of 21 and 64. This criterion reduces our sample size to 41,604 observations, where the bulk of the observations dropped were retired reference persons. The fourth column reports our results when we also drop households who live in rural areas, further reducing our sample to 37,608 observations. Finally, in column five we further drop self-employed households, leaving us with 35,017 observations.

Table 8: Projection Estimates across Categories of Goods for Different Samples

	Benchmark	Working age	Without rural	Without self-employed
Total consumption	0.100	0.095	0.089	0.089
Total less cars and housing	0.126	0.123	0.112	0.111
Food	0.112	0.093	0.073	0.068
Food at home	0.071	0.048	0.034	0.039
Food away from home	0.172	0.210	0.208	0.198
Alcohol and tobacco	0.103	0.102	0.105	0.125
Housing	0.042	0.035	0.037	0.039
Household durables	0.293	0.319	0.298	0.274
Transportation	0.204	0.186	0.195	0.198
Education	0.072	0.084	0.087	0.096

Table 9: Conditional Projection Estimates for Different Samples

	Benchmark	Working age	Without rural	Without self-employed
Total Sample	0.100	0.095	0.089	0.089
Results by financial asset holdings				
Fin assets < median	0.086	0.078	0.071	0.065
Fin assets > median	0.118	0.116	0.115	0.121
Results by income				
Income < median	0.128	0.118	0.114	0.108
Income > median	0.074	0.066	0.059	0.062
Results by type of employment				
Self-employed	0.127	0.127	0.113	
Not self-employed	0.097	0.097	0.085	
Results by race				
White	0.113	0.107	0.098	0.101
Black	0.035	0.050	0.063	0.055
Results by marital status				
Married	0.119	0.115	0.100	0.106
Not married	0.073	0.059	0.066	0.053
Results by education				
Less than high school	0.079	0.121	0.102	0.124
High school	0.100	0.078	0.082	0.067
Some college	0.102	0.092	0.086	0.088
College graduate	0.120	0.101	0.091	0.091

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