Marginal Propensity to Consume

Zheli He

Penn Wharton Budget Model

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Introduction

Questions:

- What is the marginal propensity to consume (MPC) out of permanent income and income shocks? How does it differ across gender, race, education and age groups?

Why is it important:

- Implications for predicting household responses to tax reforms and other redistributive policies

What has been done:

- In the literature, a common measure of permanent income is the average annual income over some time period

What is new:

- Use a large household dataset which includes measures of both total consumption expenditure and income
- Take into serious consideration the changing individual characteristics when calculating permanent income

This Project

- Provide a regression framework for analyzing the effects of individual attributes on total family after-tax income
  - the Consumer Expenditure Survey
- Construct transition path of these attributes over the life cycle
  - the Panel Study of Income Dynamics
- Use the estimated regression coefficients and the projected demographic profiles to predict family permanent income
- Calculate the MPC by regressing consumption expenditure on permanent income and income shocks

Preview of Findings

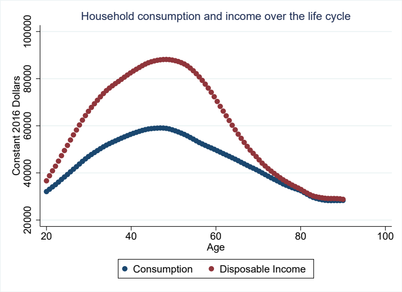
- On average, households spend $\boxed{22.37}$ cents out of each dollar of income shocks
- $1 increase in permanent income drives up current consumption expenditure by $\boxed{2.06}$ cents
- The MPC out of income shocks is not statistically different for people at different permanent income levels

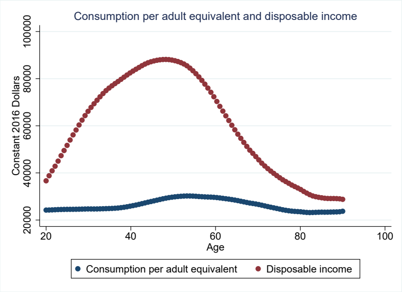
Related Literature

- Predictions about the **level** of consumption in relation to the **level** of the permanent component of income
  - Friedman (1957), Mayer (1966), Evans (1969), Mayer (1972), Dynan et al. (2004), Bozio et al. (2013), Alan et al. (2015) and Straub (2018)
- Predictions about **changes** in consumption in response to predictable or unpredictable, transitory or permanent, income **changes**
  - Shapiro and Slemrod (2009), Parker (1999), Souleles (2002), Johnson et al. (2006), Huntley and Michelangeli (2014), Banks et al. (1998), Hurd and Rohwedder (2006), Aguiar and Hurst (2007), Blundell et al. (2008), Jappelli and Pistaferri (2008)

Consumption Function

- The life cycle and the permanent income models have constituted the main analytical tools to the study of consumption behaviour, both at the micro and at the aggregate level





- Total consumption is much smoother than disposable income, and the consumption profile is flat after accounting for changes in family size and composition
  - use the following equivalence scale: assign weight 1 to the male adult, 0.8 to the female adult, and 0.4 to a kid

Consumer Expenditure Survey

- Data on expenditures, income, assets, and demographic characteristics of consumers in the United States
- The Quarterly Interview Survey is designed to collect data on large and recurring expenditures
- Use the subsample of households that have completed all four quarterly interviews
  - Their annual consumption expenditure chronologically corresponds to the reported income, which is over the last twelve months
- Aggregate expenditures from quarterly to annual frequency using data between 1990 and 2016
- Convert all values into real 2016 dollars based on chained CPI

Imputation of Chained CPI Before 1999

Regression Framework

Apply weighted least squares, minimizing the sum of squared residuals weighted by the inverse probabilities of selection:

$$\ln y_i = \alpha_0 + \alpha_1 age_i + \alpha_2 age_i^2 + \boldsymbol{\beta_0 x_i} + \boldsymbol{\beta_1 x_i} age_i + \boldsymbol{\beta_2 x_i} age_i^2 + \gamma z_i + \eta_i$$

- y_i is total family after-tax income in 2016 dollars
- $\boldsymbol{x}$ includes marital status, number of children, gender, employment status, employment status*$\boldsymbol{I}$(employer pension contributions), employment status*$\boldsymbol{I}$(self-employment), full-time equivalent of weeks worked, educational attainment and race
- z_i is a set of birth-year dummies to control for cohort effects
- η_i is an income shock
- Use robust estimator of variance, which gives heteroskedasticity-consistent standard error

Top-coding

- The CE protects the respondents' identity by changing sensitive data with topcoding
  - Topcoding refers to the replacement of data if the value of the original data exceeds prescribed critical values
- Each observation that falls outside the critical value is replaced with a topcoded value that represents the mean of the subset of all outlying observations
  - Do not correct the top-coding in household expenditures, income and assets
  - Bosworth, et al. (1991): the top coding has only a minimal effect on the surveys conducted after 1981

Income Imputation

- Starting with the publication of the 2004 data, the CE includes income data that have been produced using multiple imputation
  - fill in blanks due to nonresponse, i.e., the respondent does not know or refuses to provide a value for a source of income
  - The process preserves the mean of each source of income, and also yields variance estimates that take into account the uncertainty built into the data from the fact that some observations are imputed, rather than reported.
- Use reported values if available. Otherwise, use imputed values and apply the method of repeated-imputation inference

Repeated-Imputation Inference

The proper estimation uses all five imputations for income by estimating the regression model once with each imputation

- The point estimates, $\bar{b} = \frac{\sum_{i=1}^{m} b_i}{m}$, where m equals the number of imputations
- The variance of the point estimate, $T_m = \bar{U}_m + (1 + m^{-1})B_m$
  - $\bar{U}_m = \frac{\sum_{1=1}^{m} U_i}{m}$ and U_i is the variance of the estimated coefficient for imputation i
  - $B_m = \frac{\sum_{i=1}^{m} (b_i - \bar{b})^2}{m-1}$, which takes into account the uncertainty involving the point estimate Regression Results

Panel Study of Income Dynamics

- Originally designed to study the dynamics of income and poverty
  - an over-sample of 1,872 low income families from the Survey of Economic Opportunity (the "SEO sample")
  - a nationally representative sample of 2,930 families designed by the Survey Research Center at the University of Michigan (the "SRC sample")
- "Sample persons" include all persons living in the PSID families in 1968 plus anyone subsequently born to or adopted by a sample person
  - All sample members are followed even when leaving to establish separate family units (FUs)
- The most common example of "non-sample persons" are those who after 1968 marry sample persons.
  - Information on non-sample persons is collected while they are living in the same family unit as a sample person

Transition Matrix of Attributes

- Use the PSID to construct transition matrix of all attributes for each gender, race, age and education group:

$$
\begin{aligned}
P_{ij}^{g} &= \Pr(X_{t+1}^{g} = j | X_t^{g} = i) \\
&= \frac{n_{ij}^{g}}{\sum_j n_{ij}^{g}}
\end{aligned}
$$

- $\sum_j P_{ij}^{g} = 1$ and $P_{ij}^{g} \geq 0$. n_{ij}^{g} is the weighted sum of the number of observations where individuals in group g transition from state i at age t to state j at age $t+1$ in attribute X
- Impose the restrictions that $Educ_t \leq Educ_{t+1} \leq Educ_t + 1$. In addition, if one's education increases from high school graduates to some college in year t, then there can be no more increase in the next 2 years

Assumptions I

- Include an observation if and only if the individual has a positive sample weight in both last year and the current year, and there is no missing information about their age, gender, race and education as well as the variable in question
- If there is not enough information to calculate the transition probability of a variable for a given group at a given age, then assume that the next state is the same as the initial state with probability 1
- Transition probabilities after age 65 are the same as those at age 65 due to a lack of data

Assumptions II

- Split the PSID sample into three time periods: 1990-1997, 1997-2005 and 2005-2015 to allow transition matrix to vary over time
    - Suppose an individual was 20 in 1996, then apply the 1990-1997 transition matrix to infer the probabilities of their attributes at age 21, and apply the 1997-2005 transition matrix for predications at age 22
- In order to classify an individual as a self-employed or wage worker who claims to be both in the PSID, compare their labor and asset income from business with their wages and salaries
    - If the former is larger, identify the individaul as self-employed
    - If this information is unavailable, assume an individual is a wage worker

One-Year Transition Matrix

PSID was conducted annually until 1996, and biennially since 1997

- Impute 1-year transition matrix by calculating the principal square root of 2-year transition matrix
  - The unique square root for which every eigenvalue has nonnegative real part
- Underlying assumption: transition probabilities are the same from t to $t+1$ and from $t+1$ to $t+2$ between 1997 and 2015
- If $[V, D] = eig(A)$, then the squareroots have the general form $Y = V * S/V$, where $D = S * S$, and the unique principal square root is chosen

Square Root of a Matrix

Transition Path of Attributes

- Assume sequence of all attributes follows a Markov chain, then the conditional probability is:

$$\begin{aligned}
\Pr(X_{i,t+1} = x_{i,t+1} | X_{i,0} = x_{i,0}, X_{i,1} = x_{i,1}, ..., X_{i,t} = x_{i,t}) \\
&= \Pr(X_{i,t+1} = x_{i,t+1} | X_{i,t} = x_{i,t}) \\
&= P^g_{x_{i,t} x_{i,t+1}}
\end{aligned}$$

- The probability of each realization of the random variable $X_{i,t}$ for individual $i \in g$ is:

$$\Pr(X_{i,t+k} = x_{i,t+k}) = \sum_{\{x_{i,t+k}\}} ... \left[\sum_{\{x_{i,\mathbf{2}}\}} (\sum_{\{x_{i,\mathbf{1}}\}} P^g_{x_{i,\mathbf{0}} x_{i,\mathbf{1}}} P^g_{x_{i,\mathbf{1}} x_{i,\mathbf{2}}}) P^g_{x_{i,\mathbf{2}} x_{i,\mathbf{3}}} \right] ... P^g_{x_{i,t+k-\mathbf{1}} x_{i,\mathbf{1}+k}}$$

Permanent Income

- Calculate $PI_i = A_{i,t} + \sum_{k=0}^{T-t} \left(\frac{1}{1+r} \right)^k E_t[Y_{i,t+k}]$, where

$$E_t[Y_{i,t+k}] = \delta_{i,t+k} \sum_l \Pr(Y_{i,t+k} = y_{i,l}) * y_{i,l}$$

$$\Pr(Y_{i,t+k} = y_{i,l}) * y_{i,l} = \Pr(X_{i,t+k} = x_{i,t+k}) *$$

$$[\hat{\alpha}_0 + \hat{\alpha}_1 age_{i,t+k} + \hat{\alpha}_2 age^2_{i,t+k} + \boldsymbol{\hat{\beta}_0 x_{i,t+k}} + \boldsymbol{\hat{\beta}_1 x_{i,t+k}} age_{i,t+k} + \boldsymbol{\hat{\beta}_2 x_{i,t+k}} age^2_{i,t+k} + \hat{\gamma} z_i]$$

- $A_{i,t}$ is a CU's current net worth
- Assume that $r = 0.04$; t corresponds to the age of the individual when interviewed; $T = 94$, the oldest age in the CE
- Mortality rates, $\delta_{i,t}$, is a function of education levels and martial status along with other demographic variables (gender, race, age)
- Use the maximum of the head's and the spouse's predicted permanent income as the family permanent income

Life-Cycle Profiles of Permanent Income

Average Propensity to Consume

Compute the APC by dividing consumption expenditure by permanent income

- more variation across households as they age
- increase monotonically with age, rising from 2% at age 20 to over 10% at age 90
- adjustment using the equivalence scale increases its curvature
- similar results after talking into account the economies of scale of joint living
- not a lot of variation across race nor education groups

Life-Cycle Profiles of APC

Average Propensity to Consume

Table 1: Summary Statistics for the APC

	median	standard deviation
APC	.0380666	.0825273
APC per adult equivalent	.0202603	.0853685
APC joint living	.0248291	.0819932

Marginal Propensity to Consume

- Compute the MPC out of income shocks, θ_1, and out of permanent income, θ_2:

$$\begin{aligned} c_i &= \theta_0 + \theta_1 \hat{\eta}_i + \theta_2 PI_i \\ &\quad + \alpha_1 age_i + \alpha_2 age_i^2 + \boldsymbol{\beta_0 x_i} + \boldsymbol{\beta_1 x_i} age_i + \boldsymbol{\beta_2 x_i} age_i^2 + \gamma z_i + \epsilon_i \end{aligned}$$

- Measure income shocks as:

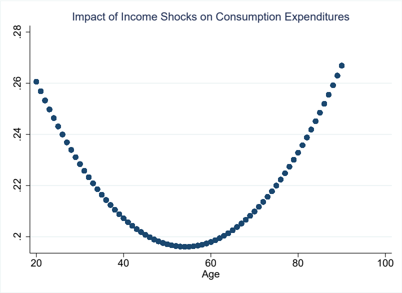
$$\hat{\eta}_i = \ln y_i - (\hat{\alpha_0} + \hat{\alpha_1} age_i + \hat{\alpha_2} age_i^2 + \boldsymbol{\hat{\beta}_0 x_i} + \boldsymbol{\hat{\beta}_1 x_i} age_i + \boldsymbol{\hat{\beta}_2 x_i} age_i^2 + \hat{\gamma} z_i)$$

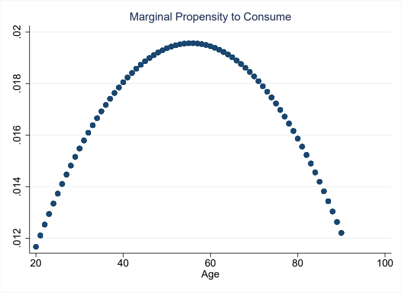
Table 2: Marginal Propensity to Consume

				obs = 109,702
				R-squared = 0.4635
c_i	Coef.	Bootstrapped Std. Err.	t	P>|t|
$\hat{\eta}_i$	0.2237425	0.0048216	46.40	0.000
PI_i	0.0205654	0.0010507	19.57	0.000

- Households spend 22.4 cents out of each dollar of income shocks
- If permanent income goes up by $1, then consumption expenditure goes up by 2.1 cents

Life-Cycle Profiles of MPC

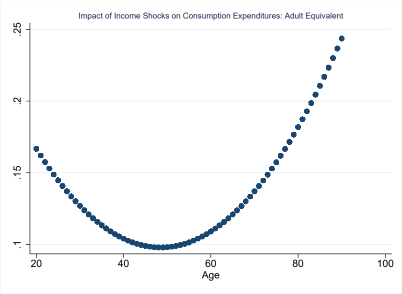


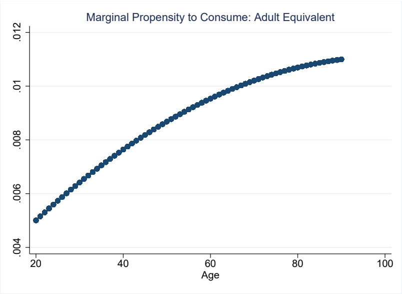


- Before 55, younger households spend more out of each dollar of income shocks; after 55, older households do
- Before 55, older households spend more out of each dollar increase in permanent income; after 55, younger households do

Life-Cycle Profiles of MPC

- To test this hypothesis, examine MPC calculated based on consumption expenditure per adult equivalent





- The shape of MPC out of income shocks does not change much
- MPC out of permanent income monotonically increases with age after change in family size is taken into account

MPC of Income Shocks at Different PI Levels

Table 3: MPC of Income Shocks at Different PI Levels

				obs = 109,702
				R^2 = 0.4453
c_i	Coef.	Bootstrapped Std. Err.	t	P>|t|
$\hat{\eta}_i * PI_i$	1.24e-08	1.20e-08	-1.03	0.303
$\hat{\eta}_i$	0.3871338	0.0615386	6.29	0.000
$\hat{\eta}_i * age$	-0.0054707	0.0023142	-2.36	0.018
$\hat{\eta}_i * age^2$	0.0000491	0.0000243	2.02	0.043
PI_i	0.0178924	0.0055083	3.25	0.001
$PI_i * age$	0.0003511	0.0002047	1.71	0.086
$PI_i * age^2$	-4.81e-06	1.88e-06	-2.56	0.010

- MPC out of income shocks is not statistically different for people at different permanent income levels

Appendix: Imputation of Chained CPI

- Use the series of chained CPI of all items in U.S. city average for all urban consumers from the Bureau of Labor Statistics, which is available from 1999 to 2016
- To impute chained CPI for the missing years:
  - First, compute the difference in average annual growth rate of chained and unchained CPI between 1999 and 2016
  - Second, use that difference to adjust the annual growth rate of unchained CPI between 1990 and 1999
- Use the same deflator for income and expenditures to keep them consistent

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Appendix: Regression Results

Table A1: Mean and Variance of the Estimated Coefficients

Y	Coef.	Robust Std. Err.	*Y*	Coef.	Robust Std. Err.
marital	0.3271049	0.0566488	kid3Xage	0.000208	0.005864
maritalXage	0.0153051	0.002264	kid3Xage2	0.0001387	0 .0000642
maritalXage2	-0.0001664	0.0000209	kid4	-0.098393	0.2316845
kid1	-0.1385342	0.0661254	kid4Xage	-0.005011	0.0106499
kid1Xage	0.0024829	0.0026706	kid4Xage2	0.0002041	0.0001195
kid1Xage2	0.0000598	0.0000257	age	0.0054983	0.0036854
kid2	-0.2628895	0.0877544	age2	0.000048	0.000032
kid2Xage	0.005837	0.0038422	sex	0.0568098	0.0525424
kid2Xage2	0.0000717	0.0000412	sexXage	0.0052125	0.0020828
kid3	-0.1531035	0.1301121	sexXage2	-0.0000892	0.0000193

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Table A1: Mean and Variance of the Estimated Coefficients

Y	Coef.	Robust Std. Err.	*Y*	Coef.	Robust Std. Err.
wk	-0.4799289	0.108972	wksemp2Xage	-0.0130549	0.0041925
wkXage	0.0255648	0.0044286	wksemp2Xage2	0.0000715	0.000043
wkXage2	-0.0002041	0.0000424	wksemp3	0.7996495	0.1193799
wkXemplcont	0.1028728	0.0822613	wksemp3Xage	-0.0077052	0.0052985
wkXemplcontXage	0.0032771	0.0037042	wksemp3Xage2	0.0000136	0.000056
wkXemplcontXage2	-0.0000367	0.0000401	educ2	0.0126893	0.0717158
wkXself_emp	0.4755819	0.1537953	educ2Xage	0.0050793	0.0028126
wkXself_empXage	-0.0250893	0.0062541	educ2Xage2	-0.000038	0.0000255
wkXself_empXage2	0.0002509	0.0000605	educ3	-0.2245933	0.0776458
wksemp2	0.7360999	0.0963762	educ3Xage	0.0203403	0.0030635

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Y	Coef.	Robust Std. Err.	Y	Coef.	Robust Std. Err.
educ3Xage2	-0.0001744	0.0000282	race2Xage	-0.0043084	0.003571
educ4	-0.0304018	0.0876632	race2Xage2	0.0000282	0.0000334
educ4Xage	0.0242336	0.0034926	race3	-0.0147728	0.229137
educ4Xage2	-0.0002314	0.0000326	race3Xage	-0.0065156	0.0095975
educ5	0.0633747	0.1127781	race3Xage2	0.0000704	0.0000927
educ5Xage	0.0244482	0.0044432	race4	0.0593875	0.1540429
educ5Xage2	-0.0002159	0.0000413	race4Xage	0.0017018	0.0063389
race2	-0.1273645	0.0893931	race4Xage2	-0.0000672	0.0000614

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Appendix: Overview of Multiple Imputation

- The method used to derive the multiple imputations is regression-based
  - A regression is run to provide coefficients for use in estimating values for missing data points
  - The coefficients are then "shocked" by adding random noise to each, and missing values are estimated using the shocked coefficients
  - To each of these estimated values, additional random noise is added, to ensure that consumer units (or members) with identical characteristics (e.g., urban service worker aged 25 to 34) will not receive identical estimates for their income
  - The resulting values are used to fill in invalid blanks where they occur, while reported values are retained
  - This process is then repeated four times
- For the small number of cases in which the respondent does not report receipt of any source of income, receipt of each source is imputed using logistic regression.
  - The income value is treated as a missing data point, and is imputed using the method described above

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Appendix: Square Root of a Matrix

- More generally, an n×n matrix with n distinct nonzero eigenvalues has 2n square roots
  - $A = VDV^{-1}$, where V is the matrix whose columns are eigenvectors of A; D is the diagonal matrix whose diagonal elements are the corresponding n eigenvalues λ_i
  - The square roots of A are given by $A = VD^{\frac{1}{2}}V$, where $D^{\frac{1}{2}}$ is any square root matrix of D, which, for distinct eigenvalues, must be diagonal with diagonal elements equal to square roots of the diagonal elements of D
  - Since there are two possible choices for a square root of each diagonal element of D, there are 2n choices for the matrix $D^{\frac{1}{2}}$
- M is called positive semidefinite (or sometimes nonnegative definite) if $x * Mx \geq 0$ for all x in R^n
  - A positive-semidefinite matrix has precisely one positive-semidefinite square root, which can be called its principal square root

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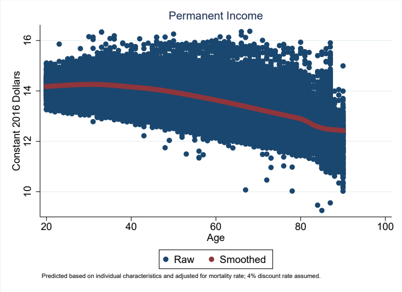
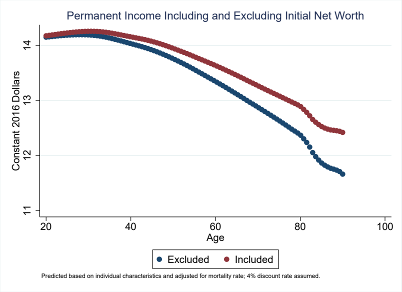
Appendix: Life-Cycle Profiles of Permanent Income





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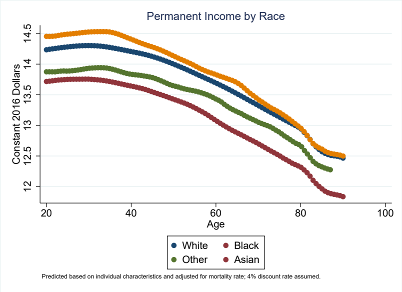

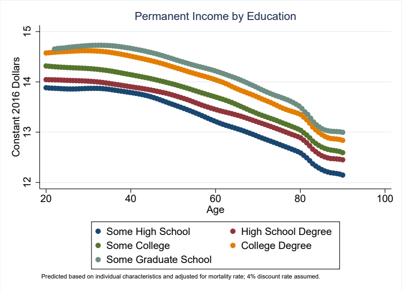

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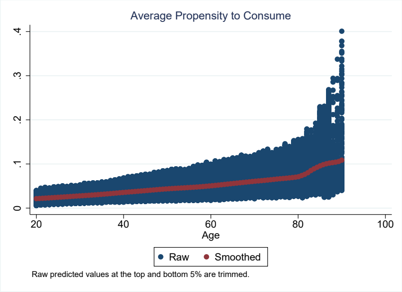
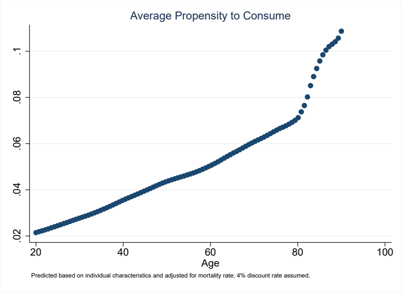
Appendix: Life-Cycle Profiles of APC





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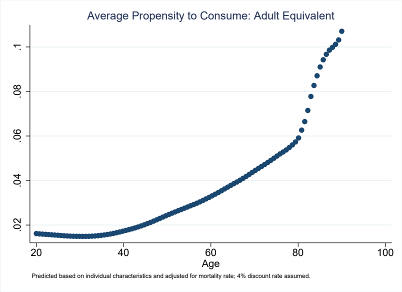

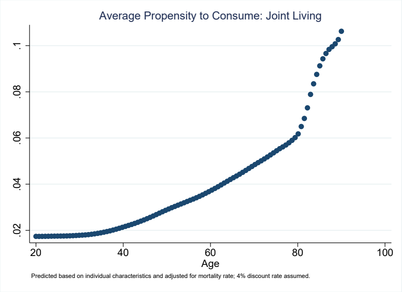

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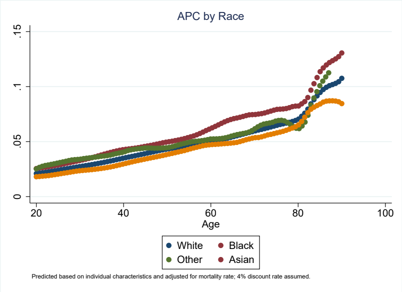

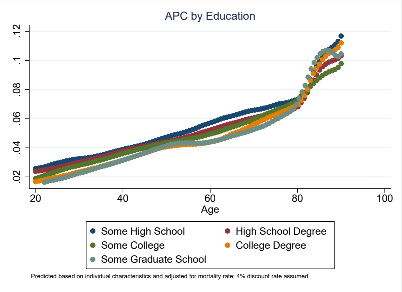

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