# 5329 – Inequality, Household Behaviour and the Macroeconomy

Assignment 1

# Task 2 – Campbell and Mankiw (1989)

- The time-series data on consumption should not be characterized solely by forward-looking consumers, but should also include simple, rule-of-thumb consumers, who live hand to mouth.
- The permanent income hypothesis: consumers ought to smooth their consumption across their lives as an even share of their permanent (lifetime) incomes.
- Though popular in the theory, Campbell and Mankiw argue that this is not borne out empirically.
- The authors see three empirical reasons to use their model.

# Task 2 – Campbell and Mankiw (1989)

1. Expected changes in income are associated with expected changes in consumption. A strong connection between current income and consumption implies hand-to-mouth consumers.
2. Expected real interest rates are not associated with expected changes in consumption and so cannot explain consumption movements.
3. Periods with high consumption (relative to income) are generally followed by income growth. This suggests at least some consumers are forward looking and so justifies keeping some permanent income hypothesis consumers.

# Task 2 – Campbell and Mankiw (1989)

- Conclusions: Two groups of consumers (HTM and PIH), of equal proportions, explain consumption patterns.
- For us: We should find that a significant proportion of the population has consumption which is highly correlated with their current income.

# Task 2: 1. Building Variables

```
psid."labor_inc_family" = psid."labor_inc" .+ coalesce.(psid."labor_inc_spouse",0.0)

psid = psid[psid.rel_head.=="head",:]

psid = psid[psid.year.>=1999 .&& psid.family_comp_change.==0,:]

function lagby2!(df::DataFrame,id::String,time::String,tolag::String)
    sort!(df, [id, order(time, rev = true)])
    df[!,tolag*"_lag_2"] = missings(Float64, size(df,1))
    for i in 1:(size(df,1)-1)
        if df[i,id] == df[i+1,id] && df[i,time] == df[i+1,time] + 2
            df[i,tolag*"_lag_2"] = df[i+1,tolag]
        end
    end
end

lagby2!(psid,"id_ind","year","expenditure_family")
lagby2!(psid,"id_ind","year","labor_inc_family")

psid."expenditure_family_change" = psid."expenditure_family".-psid."expenditure_family_lag_2"

psid."labor_inc_family_change" = psid."labor_inc_family".-psid."labor_inc_family_lag_2"
```

# Task 2: Finding Correlations.

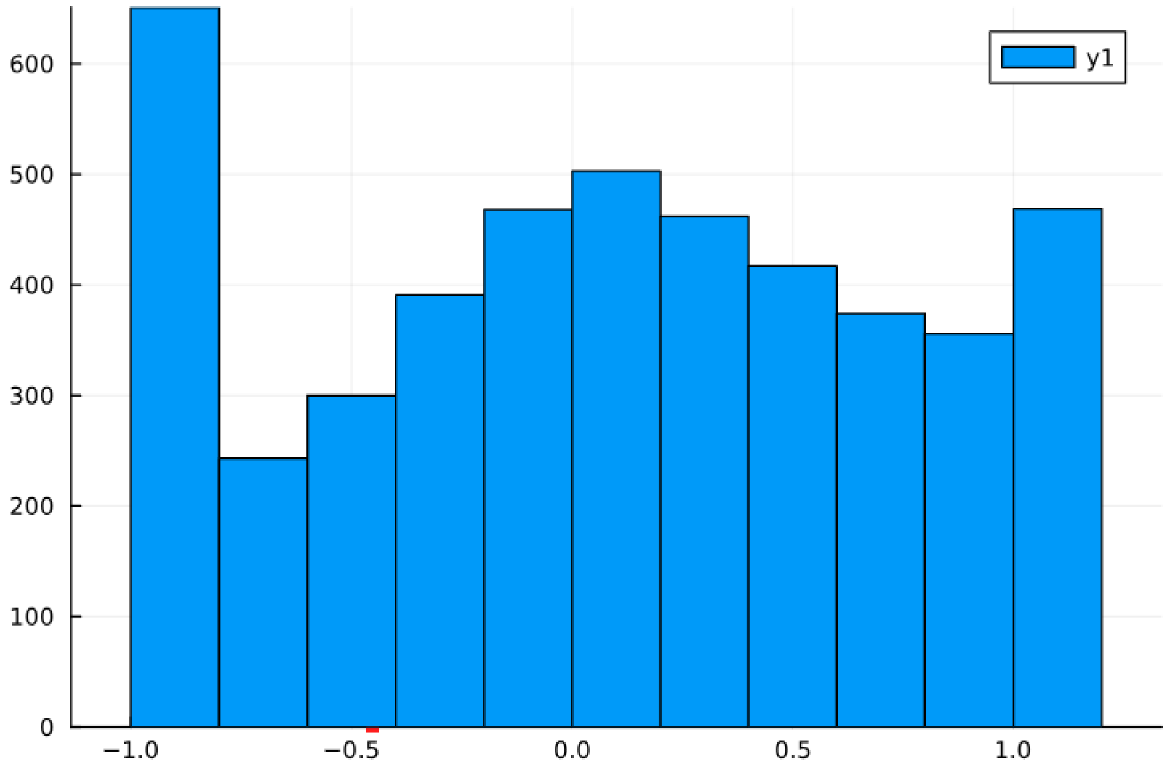
```
ids = unique(psid.id_ind)

cors = fill(0.0,length(ids))

for i in eachindex(ids)
    cors[i] = cor(Array(dropmissing(psid[psid.id_ind .== ids[i],["expenditure_family_change", "labor_inc_family_change"]])); dims = 1)[2,1]
end
```

- We find the correlations, for each Household, between changes in expenditures and labour incomes. Remember that a significant proportion of these ought to be 1 for Campbell and Mankiw (1989) to be correct. These households would be consuming all of the gains to their current income.

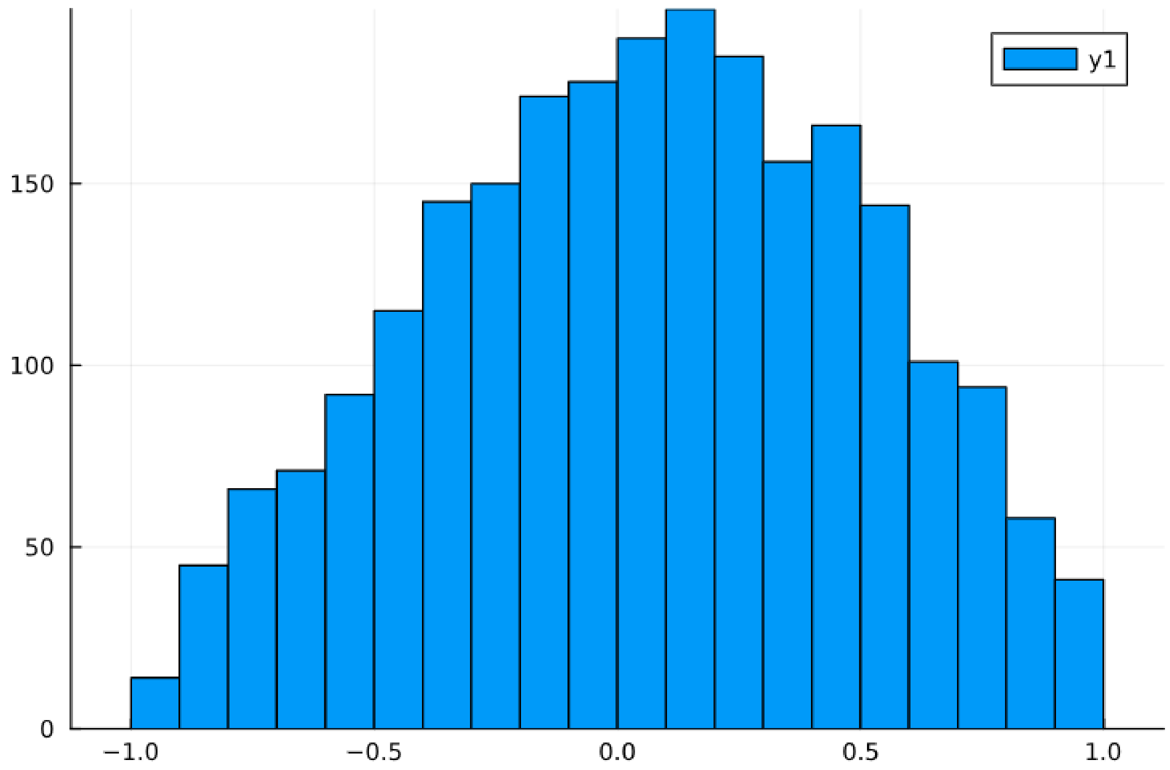
# Task 2: Plotting the Histograms



# Task 2. A sanity check.

```
n_nonmissing = fill(1,length(ids))
for i in eachindex(ids)
    n_nonmissing[i] = size(dropmissing(psid[psid.id_ind .== ids[i],["expenditure_family_change", "labor_inc_family_change"]]),1)
end

histogram(cors[n_nonmissing .> 4])
```



# Task 3. Zeldes and Constrained Agents.

- Recall from lecture notes:

$$\mathcal{L} = \sum_{t=0}^{T} \beta^t \{u(c_t) + \lambda_t [a_{t-1}(1+r) + y_t - c_t - a_t] + \mu_t [-a_t - b_t]\}$$

- And so, we get this Euler-inequality:

$$u'(c_t) - \mu_t = \beta(1+r)u'(c_{t+1})$$

$$u'(c_t) \geq \beta(1+r)u'(c_{t+1})$$

# Task 3. The Lagrange Multiplier.

$$\mu_t[a_t + b_t] = 0$$

- By Complementary Slackness, either this mu is 0 (where the borrowing constraint never binds and is irrelevant), or it is positive, and in this case the consumer simply consumes all they can.
- Zeldes wants to test to see if consumers are optimizing subject to borrowing constraints.

# Task 3. Estimating the Lagrange Multiplier

- Zeldes derives the Euler Equation and rearranges to find:

$$\ln(c_{i,t+1}/c_{i,t}) = \mathbf{X}_{i,t}\beta + \gamma \ln(1 + r_{i,t}) + \underbrace{v_{i,t+1} + \ln(1 + \lambda_{i,t})}_{=x_{i,t+1}}$$

- The Lagrange multiplier is going to be picked up in the error term, if, it exists. It will exist for constrained individuals, and it will be positive.

# Task 3. Zeldes' tests in simulated data

```
ep = EconPars()
np = NumPars()

@time sol = solve(ep,np)

N = 1000

(coh_sim, y_sim) = simulate(ep,sol,N)

cons_sim = hcat([ sol.cp[t].(coh_sim[:,t]) for t in 1:ep.T ]...)
save_sim = hcat([ sol.sp[t].(coh_sim[:,t]) for t in 1:ep.T ]...)
future_cons_sim = hcat(cons_sim[:,2:end],fill(missing,N))
cons_growth_sim = future_cons_sim./cons_sim
ages_sim = [t for i in 1:N, t in 1:ep.T]

data_sim = DataFrame(age = ages_sim[:], consumption_growth = cons_growth_sim[:], income = y_sim[:], wealth = save_sim[:])


low_wealth_limit = -ep.bl + 0.05

constrained_sample = data_sim[data_sim.wealth .< low_wealth_limit,:]

unconstrained_sample = data_sim[data_sim.wealth .> low_wealth_limit,:]
```

# Zeldes Test (i) Theory

- Is the log of income significant in each of these subsamples?
- Current income should not influence consumption growth if the PIH holds (unconstrained).
- Current income would negatively influence consumption growth if borrowing constraints are binding.
- So we would interpret the sign and significance of the estimated parameter on log income as informative about whether constraints are binding.

# Zeldes Test (i) Code

```
# test (i)

test_i_constrained = lm(@formula(log(consumption_growth) ~ age + log(income)), constrained_sample)
println(test_i_constrained)

test_i_unconstrained = lm(@formula(log(consumption_growth) ~ age + log(income)), unconstrained_sample)
println(test_i_unconstrained)
```

# Zeldes Test (i) Results

Coefficients:

| | Coef. | Std. Error | t | Pr(>\|t\|) | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| (Intercept) | -0.0145127 | 0.00716473 | -2.03 | 0.0429 | -0.0285603 | -0.000465152 |
| age | -0.000302104 | 0.000150227 | -2.01 | 0.0444 | -0.000596646 | -7.56136e-6 |
| log(income) | -0.3495 | 0.0141681 | -24.67 | <1e-99 | -0.377278 | -0.321721 |

# Zeldes Test (i) Results

Coefficients:

| | Coef. | Std. Error | t | Pr(>\|t\|) | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| (Intercept) | -0.00379081 | 0.000499383 | -7.59 | <1e-13 | -0.00476961 | -0.00281202 |
| age | 7.1865e-5 | 1.44559e-5 | 4.97 | <1e-06 | 4.35313e-5 | 0.000100199 |
| log(income) | -0.0074451 | 0.00109685 | -6.79 | <1e-10 | -0.00959493 | -0.00529526 |

# Zeldes Test (ii)

- The sum of the true residuals in our estimation should be positive for the constrained agents, as they pick up positive bias from the Lagrange multiplier.
- This bias makes it impossible to estimate the constrained sample.
- If we assume parameters are identical across groups (the consumers differ only by being constrained) then we can estimate for the unconstrained individuals, and use their parameters on the constrained individual data to find if our final term is positive, significant and large (in magnitude).

# Zeldes Test (ii) Code

```
test_ii_unconstrained = lm(@formula(log(consumption_growth) ~ age ), unconstrained_sample)

constrained_sample.resid = constrained_sample.consumption_growth .- coef(test_ii_unconstrained)[1] .+ coef(test_ii_unconstrained)[2] .* constrained_sample.age

resid_test_ii = lm(@formula(resid ~ 1), constrained_sample)

println(resid_test_ii)
```

# Zeldes Test (ii) Results

Coefficients:

| | Coef. | Std. Error | t | Pr(>\|t\|) | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| (Intercept) | 1.14509 | 0.00403023 | 284.13 | <1e-99 | 1.13719 | 1.15299 |

# Zeldes Test (iii)

- When (current) incomes are larger, the borrowing constraints should bite less.
- Regress the final term for the constrained on incomes and test whether the sign is negative. This term is comprised of the error and the multiplier (if the constraint binds).
- The error is uncorrelated with the income, so this regression gives the correlation between the Lagrange multiplier and income.

# Zeldes test (iii) Code

```
resid_test_iii = lm(@formula(resid ~ income), constrained_sample)

println(resid_test_iii)
```

# Zeldes Test (iii) Results

Coefficients:

| | Coef. | Std. Error | t | Pr(>\|t\|) | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| (Intercept) | 1.63493 | 0.0181142 | 90.26 | <1e-99 | 1.59942 | 1.67045 |
| income | -0.698732 | 0.0253097 | -27.61 | <1e-99 | -0.748355 | -0.649108 |

# Zeldes Test. Changing the Borrowing Limit (i)

Coefficients:

| | Coef. | Std. Error | t | Pr(>\|t\|) | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| (Intercept) | -0.0373305 | 0.0351791 | -1.06 | 0.2891 | -0.106433 | 0.0317725 |
| age | 0.000605677 | 0.00100176 | 0.60 | 0.5457 | -0.00136209 | 0.00257345 |
| log(income) | -0.270692 | 0.0362904 | -7.46 | <1e-12 | -0.341978 | -0.199406 |

Coefficients:

| | Coef. | Std. Error | t | Pr(>\|t\|) | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| (Intercept) | -0.00772021 | 0.000421043 | -18.34 | <1e-74 | -0.00854545 | -0.00689496 |
| age | 0.000162213 | 1.21838e-5 | 13.31 | <1e-39 | 0.000138333 | 0.000186093 |
| log(income) | -0.00409227 | 0.000889374 | -4.60 | <1e-05 | -0.00583544 | -0.00234909 |

# Changing the Borrowing Limit (ii) & (iii)

```
resid ~ 1

Coefficients:
──────────────────────────────────────────────────────────────────────────
                 Coef.  Std. Error       t  Pr(>|t|)  Lower 95%  Upper 95%
──────────────────────────────────────────────────────────────────────────
(Intercept)  1.14291   0.0102661  111.33    <1e-99    1.12275    1.16308
──────────────────────────────────────────────────────────────────────────
```

```
resid ~ 1 + income

Coefficients:
──────────────────────────────────────────────────────────────────────────
                 Coef.  Std. Error      t  Pr(>|t|)  Lower 95%  Upper 95%
──────────────────────────────────────────────────────────────────────────
(Intercept)   1.51481   0.0435186  34.81    <1e-99   1.42933    1.6003
income       -0.56339   0.0642947  -8.76    <1e-16  -0.689685  -0.437095
──────────────────────────────────────────────────────────────────────────
```

# Tutorial Questions

- Why could we drop the interest rates (1 + r) that we had in equation (1) in the slides?
- In Zeldes' model return varies over time and is even stochastic, meaning extra trouble for him. In particular, he needs to include return in his regression and even do some IV due to the model implying a correlation between r and consumption growth. We have a much simpler job. In our model, r is constant and hence its effect is simply picked up by the constant. From a more practical standpoint, including r in our regression would result in error due to multicollinearity with the constant.

# Tutorial Questions

- The regression for part (ii) of the Zeldes included age but not income, why is this?
- In tests (ii) and (iii) we are working with the (regression version of the) true Euler equation and that does not contain income. Including income in regression (1) is just one way of testing (namely, test (i)) if the Euler equation seems to fail/hold for the constrained/unconstrained samples. But performing that test doesn't mean that from now on we should include income in the Euler-equation. In fact, the basis of test (i) is exactly that income should not be in the Euler-equation (if people follow the PIH model).

# Tutorial Questions

- In part (iii) of our Zeldes question, why did we use income and not log(income)?
- We should have used log income there. In our simulated data this is of little importance, but in real data (where observations are more dispersed), this could make quite some difference.