14.661 Recitation 4: LCLS under Uncertainty

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[1] I thank Clémence Idoux for sharing her material with me. All remaining errors are my own.

Road map

- Theory of LCLS under uncertainty
- Altonji (1986)

LCLS under uncertainty - Set up

Additively separable utility function:

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Uncertainty: add expectation operator in front of what seen in class:

$$\max_{\{h_t, c_t\}_{s=t}^{T}} E_t \left[\sum_{s=t}^{T} \left(\frac{1}{1+\rho} \right)^{s-t} U(c_s, h_s) \right]$$
$$\text{s.t } A_{t+1} = (1+r_t)A_t + w_t h_t - c_t$$

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- They give the same solution in this context, as the conditions for the "sufficiency theorem" hold (see Alp's 14.661 notes and Daron's book "Introduction to Modern Economic Growth"):

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  - Strict concavity of objective function in the control and state variable;
  - Differentiability (we assume it);
  - The state variable has a lower bound and objective increases in the state.

Bellman equation

By the above conditions, let's solve the problem

$$V_t(A_t|\mathcal{I}_t) = \max_{h_t, c_t} U(c_t, h_t) + \frac{1}{1+\rho} E_t V_{t+1}(A_{t+1}|\mathcal{I}_{t+1})$$

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- $V_t(A_t|\mathcal{I}_t)$ is the optimum value function given available information in t, $\mathcal{I}_t$
  - State variable is accumulated assets at time t, A_t,
  - The constraint is the law of motion of the agent's assets

FOCs

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h_t: \quad U_h(c_t, h_t) + \frac{1}{1+\rho} w_t E_t[V'_{t+1}(A_{t+1})] &= 0 \qquad (2)
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To solve the problem, we also add the *envelope condition*:

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$$

This relates the MU of wealth today to the expected MU of wealth tomorrow

MU of wealth

Define the MU of wealth at time t:

$$\lambda_t \equiv V_t'(A_t | \mathcal{I}_t)$$

Then (3) gives:

$$\lambda_t = \frac{1 + r_t}{1 + \rho} E_t[\lambda_{t+1}]$$

Euler equations

Plugging in we get two Euler equations:

$$U_c(c_t, h_t) = \frac{1}{1+r_t}\lambda_t = E_t\left[\frac{1+r_{t+1}}{1+\rho}U_c(c_{t+1}, h_{t+1})\right] \tag{4}$$

$$U_h(c_t, h_t) = -\frac{w_t}{1+r_t}\lambda_t = E_t\left[\frac{1+r_{t+1}}{1+\rho}\frac{w_t}{w_{t+1}}U_h(c_{t+1}, h_{t+1})\right] \tag{5}$$

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As in class with one difference.

- λ_t is no longer time invariant :

$$\lambda_t = \frac{1+r_t}{1+\rho}E_t\left[\lambda_{t+1}\right] = E_t\left[\Pi_{s=t}^{T-1}\frac{1+r_s}{1+\rho}\lambda_T\right]$$

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- summarizes the expected path of the MU of wealth in all future periods given current information

Deriving the HeckMaC LS Equation

Assuming a HeckMaC separable utility function:

$$U(c_t, h_t) = c_t^{\delta_1} - \gamma_2 h_t^{\delta_2}$$

and taking logarithms of the FOC, we can define the ISE

$$\ln h_t = \left[\frac{\ln \lambda_t - \ln \gamma_2 - \ln \delta_2}{\delta_2 - 1}\right] + \frac{t}{\delta_2 - 1} \ln\left(\frac{1+\rho}{1+r_t}\right) + \underbrace{\frac{1}{\delta_2 - 1}}_{\equiv \delta \text{ (ISE)}} \ln w_t \tag{6}$$

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$$\lambda_{t+1} = E_t[\lambda_{t+1}] + \epsilon_{t+1}$$

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HeckMaC Estimation with Uncertainty

$$\begin{aligned} \frac{1+\rho}{1+r_t}\lambda_t &= E_t[\lambda_{t+1}] \\ &= \lambda_{t+1} - \epsilon_{t+1} \end{aligned}$$

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$$

- $\ln \lambda_t$ obtained taking logs and using Taylor expansion around $\epsilon_{t+1} = 0$

$$
\begin{aligned}
\ln \lambda_t + \ln\left(\frac{1+r_t}{1+\rho}\right) &= \ln\left(\lambda_{t+1} - \epsilon_{t+1}\right) - \ln \lambda_{t+1} + \ln \lambda_{t+1} \\
&\approx \ln \lambda_{t+1} + \underbrace{\frac{1}{\lambda_{t+1}}\left(-\epsilon_{t+1}\right)}_{\equiv u_t}
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BUT we still have the term u_{it} after differencing

To get a consistent estimator of the ISE $\delta = \frac{1}{\delta_2 - 1}$, need $cov(u_{it}, \ln w_{it}) = 0$ for all individuals.

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- Altonji (1986): reasonable if individuals know wages one period in advance and have rational expectation
- ϵ_{t+1} is orthogonal to information in period t, so uncorrelated with time-t variables like $\ln w_{it}$.

Consistency of ISE estimates II

$$
\begin{aligned}
cov(u_{it}, \ln w_t) &= E_t(u_{it} \ln w_t) - E_t(u_{it}) E_t(\ln w_{it}) \\
&= E_t\Big(\frac{(1+r_t)\epsilon_{it+1}}{(1+\rho)\lambda_t} \ln w_{it} \Big) \\
&= \frac{1+r_t}{(1+\rho)\lambda_t} E_t(\epsilon_{it+1} \ln w_{it}) \\
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\end{aligned}
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- First line uses definition of covariance,
- Second line uses definition of u_{it} and the fact that $E_t(u_{it}) = \frac{1+r_t}{(1+\rho)\lambda_t} E_t(\epsilon_{it+1})$,
- Third line uses the fact that λ_t and r_t is a constant in period t
- Last line from RE: orthogonality of error terms

Altonji (1986) - Introduction

- **Aim of the paper:** Estimate the ISE given by the HeckMcCurdy regression

$$\ln h_t = \left[\frac{\ln \lambda_t - \ln \gamma_2 - \ln \delta_2}{\delta_2 - 1}\right] + \frac{t}{\delta_2 - 1} \ln \left(\frac{1+\rho}{1+r_t}\right) + \underbrace{\frac{1}{\delta_2 - 1}}_{\equiv \delta \text{ (ISE)}} \ln w_t \tag{8}$$

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- **Data:** PSID with its March supplement
- **Main identification challenge:**
  - Labor supply depends both on current wages w_{it} and on the all past and future wages through the marginal utility of wealth λ_{it}
  - Can control for it through labor supply in previous periods (i.e using Fixed Effects)
  - But this exacerbates measurement error in wages

Altonji (1986) - Empirical strategy

Approach 1 to control for λ_{it}: Use of past labor as proxy for $\ln \lambda_{it}$

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- Instead, assume rational expectation and knowledge of w_{it} one period in advance which we showed leads to the same estimation equation
- Use a second measure for wage (the direct answer to the march survey question about hourly wage) as an instrument for wage to solve the measurement error problem

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- Note that it works because separability of the utility function implies that consumption depends on current wages w_{it} only through $\ln \lambda_{it}$
- in practice, instruments both wage and consumption with the additional measure of wage and the permanent component of wage

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- Pros: does not require perfect foresight or rational expectation
- Cons: assume no unobserved differences in preferences for labor supply/consumption between individuals
- Cons: requires separability of preferences (whereas FD can be seen as log-linear approximation of true demand system)

Altonji (1986) - Approach 1 results

TABLE 1

First-Difference Equations for Labor Supply (Dependent Variable = Dn_t^*)

Explanatory Variable	Instrumental Variables for Dw_t^*: Dw_t^{**}				Instrumental Variables for Dw_t^*: Dw_{t-1}^{**}, w_{t-1}^{**}			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	−.0087	−.0138	−.0350	−.0309	−.0079	.0092	−.0320	−.0202
	(.0039)	(.0199)	(.0098)	(.0213)	(.0104)	(.0241)	(.0156)	(.0293)
Dw_t^*	.0663	.0673	.0432	.0428	.0556	.0387	.0181	.0142
	(.079)	(.0795)	(.0787)	(.0787)	(.4573)	(.454)	(.450)	(.449)
Age	...	.0001	...	−.0001	...	−.0004	...	−.0002
		(.0004)		(.0005)		(.0005)		(.0005)
Year dummies?	no	no	yes	yes	no	no	yes	yes
F-ratio	.70	.38	4.84	4.44	.01	.31	4.44	4.07
R^2	.0002	.0002	.0132	.0132	.0000	.0002	.013	.014
Observations	4,004	4,004	4,004	4,004	3,269	3,269	3,269	3,269

Note.—Standard errors are in parentheses. The first-stage equations are presented in table A1.

Altonji (1986) - Approach 2 results

TABLE 4

LABOR SUPPLY ESTIMATES USING FOOD CONSUMPTION AS A PROXY FOR λ_t
(See Eq. [14])

	ESTIMATION METHOD			
	OLS (1)	OLS (Reduced Form)* (2)	IV (3)	IV (4)
Intercept	7.528 (.155)	7.416 (.157)	8.386 (.644)	7.995 (.359)
$w_t^{*\dagger}$	−.1126 (.014)	...	.1721 (.119)	.0943 (.057)
$c_t^{*\ddagger}$	.0788 (.015)	...	−.5341 (.386)	−.2972 (.202)
w_t^{**}	...	−.019 (.025)	...	...
w_i^{**}	...	−.031 (.032)	...	...

Altonji (1986) - Conclusions

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- Estimates of ISE between 0.01 and 0.1721 : quite small and similar to MaCurdy.
- **Main concern:** non-separable preferences lead to an upward bias in the ISE from the consumption approach.
- In this case, $\ln w_{it}$ enters in the consumption FOC.