Final Exam Review Session

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Econ 8040: Macroeconomics I
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Today's Session

- **Problem Set 7** grades on eLC
- **Computation Exercise 2** grades on eLC
- **Final Exam**, Thursday, December 4, 3:30–6:30 p.m., MLC 275

Problem Set 7

- Recursive planner's problems (Problems 1 and 2)
- Asset pricing (Problems 3 and 5)
- Infinite horizon economy w/ production (Problem 4)

Problem 1

Infinite-horizon production economy with household and business sector.

(a) Write down social planner's problem

Replacing $n_{Ht} = 1 - N_{Mt}$ and $c_{Ht} = k_{Ht}^{\alpha} n_{Ht}^{1-\alpha}$, the planner's problem is

$$\max_{\{c_{Mt}, N_{Mt}, K_{Mt+1}, k_{Ht+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \log\left(\left[\mu c_{Mt}^{\rho} + (1-\mu)[k_{Ht}^{\alpha}(1-N_{Mt})^{1-\alpha}]^{\rho} \right]^{\frac{1}{\rho}} \right)$$

subject to

$$\begin{aligned} c_{Mt} + K_{Mt+1} + k_{Ht+1} &= K_{Mt}^{\alpha} N_{Mt}^{1-\alpha} + (1-\delta_K)K_{Mt} + (1-\delta_H)k_{Ht} \\ c_{Mt}, K_{Mt+1}, k_{Ht+1} &\geq 0 \\ 0 \leq N_{Mt} &\leq 1 \\ K_{M0}, k_{H0} &\text{ given} \end{aligned}$$

Problem 1 (cont.)

(b) Write it recursively

$$V(K_M, k_H) = \max_{\{c_M, N_M K_M', k_H'\}} \left\{ \log\left(\left[\mu c_M^{\rho} + (1-\mu)[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho} \right]^{\frac{1}{\rho}} \right) + \beta V(K_M', k_H') \right\}$$

subject to

$$c_M = K_M^{\alpha} N_M^{1-\alpha} + (1-\delta_K)K_M + (1-\delta_H)k_H - K_M' - k_H'; \lambda$$
$$0 \leq K_M', k_H', K_M' + k_H' \leq K_M^{\alpha} N_M^{1-\alpha} + (1-\delta_K)K_M + (1-\delta_H)k_H$$
$$0 \leq N_M \leq 1$$
$$K_{M0}, k_{H0} \text{ given}$$

Problem 1 (cont.)

(c) Write FOC and envelope condition for Bellman

We have four choice variables. The first-order conditions are

$$\text{wrt } c_M: \qquad \lambda = \frac{\mu c_M^{\rho-1}}{\mu c_M^{\rho} + (1-\mu)[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}$$

$$\text{wrt } N_M: \qquad \lambda\left(\frac{K_M}{N_M}\right)^{\alpha} = \frac{1}{1-N_M}\cdot\frac{(1-\mu)[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}{\mu c_M^{\rho} + (1-\mu)[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}$$

$$\text{wrt } K_M': \qquad \lambda = \beta\frac{\partial V(K_M', k_H')}{\partial K_M'}$$

$$\text{wrt } k_H': \qquad \lambda = \beta\frac{\partial V(K_M', k_H')}{\partial k_H'}$$

Problem 1 (cont.)

We have two state variables. The envelope conditions are

$$\text{wrt } K_M: \quad \frac{\partial V(K_M, k_H)}{\partial K_M} = \lambda(\alpha K_M^{\alpha-1} N_M^{1-\alpha} + 1 - \delta_K)$$

$$\text{wrt } k_H: \quad \frac{\partial V(K_M, k_H)}{\partial k_H} = \lambda(1-\delta_H) + \frac{1}{k_H} \cdot \frac{(1-\mu)\alpha[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}{\mu c_M^{\rho} + (1-\mu)[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}$$

$$= \lambda\left(1 - \delta_H + \frac{(1-\mu)\alpha[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}{\mu k_H c_M^{\rho-1}}\right)$$

Problem 1 (cont.)

(d) Equations that characterize the steady state
We write four equations in four unknowns that can, in principle, be solved

$$c_M = K_M^{\alpha} N_M^{1-\alpha} - \delta_K K_M - \delta_H k_H$$

$$\mu c_M^{\rho-1} \left(\frac{K_M}{N_M} \right)^{\alpha} = \frac{(1-\mu)[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}{1-N_M}$$

$$\frac{1}{\beta} = \alpha K_M^{\alpha-1} N_M^{1-\alpha} + 1 - \delta_K$$

$$\frac{1}{\beta} = 1 - \delta_H + \frac{(1-\mu)\alpha[k_H^{\alpha}(1-N_M)^{1-\alpha}]^{\rho}}{\mu k_H c_M^{\rho-1}}$$

Problem 2

Endogenous mortality model

(a) Write planning problem

$$\max_{\{N_{t+1},c_t,h_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} N_t u(c_t)$$

subject to

$$N_t(c_t + ph_t) = N_t y \qquad \text{[Feasibility]}$$

$$N_{t+1} = \left(1 - \frac{1}{f(h_t)}\right) N_t \qquad \text{[“Law of Motion”]}$$

$$c_t, h_{t+1}, N_{t+1} \geq 0; \qquad N_0, y \text{ given}$$

Problem 2 (cont.)

(b) Recursive planning problem

$$V(N) = \max_{N'} \left\{ \max_{c,h} \{Nu(c)\} + V(N') \right\}$$

subject to

$$N(c + ph) = Ny$$
$$N' = \left(1 - \frac{1}{f(h)}\right) N$$
$$N', c, h \geq 0; \qquad y \text{ given}$$

- The Bellman operator does not *discount*

Problem 2 (cont.)

(c) Verify $V(N) = vN$ solves Bellman. Write equation that describes v.

- Solve by procedure akin to guess-and-verify

$$v = u(c)f(h)$$

New Bellman is

$$u(c)f(h)N = \max_{N'} \left\{ \max_{c,h} \{Nu(c)\} + u(c)f(h)N' \right\}$$

subject to $N' = \left(1 - \frac{1}{f(h)}\right) N; \lambda_1 \qquad N(c + ph) = Ny; \lambda_2$

Problem 2 (cont.)

(d) Write down FOCs and characterize solution

$$\text{wrt } c: \quad Nu'(c) + u'(c)f(h)N' = \lambda_2 N$$

$$\text{wrt } h: \quad u(c)f'(h)N' + \frac{\lambda_1 N f'(h)}{f(h)^2} = \lambda_2 N p$$

$$\text{wrt } N': \quad u(c)f(h) = \lambda_1$$

Using FOCs, we find that

$$p = \frac{u(c)f'(h)}{u'(c)f(h)}$$

Problem 2 (cont.)

(e) Solve for $s \equiv \frac{ph}{y}$.
We cannot derive closed-form solution of s, so we write equation that implicitly defines s as a function of parameters.

$$0 = \underbrace{by^{\sigma-1} - \frac{s}{\alpha(1-s)^{\sigma}} - \frac{1}{(\sigma-1)(1-s)^{\sigma-1}}}_{R(s,\alpha,b,\sigma,y)}$$

Problem 2 (cont.)

(f) How does s change in y, b, p, A, and α? Is health necessity or luxury?
By the implicit function theorem, for given parameter θ,

$$\frac{\partial s}{\partial \theta} = -\frac{\partial s}{\partial R}\frac{\partial R}{\partial \theta} = -\frac{\partial R/\partial \theta}{\partial R/\partial s}$$

- s is unchanging in A and p. s increases as y, b, and α increase if and only if

$$\alpha = \frac{\partial f(h)}{\partial h}\frac{h}{f(h)} < \frac{(1-s)^{1+\sigma}}{1-(1-s)s\sigma}$$

This condition holds if health $f(h)$ is sufficiently elastic with respect to h. Under this condition, health is *luxury*.

Problem 3

"Lucas Tree" model

(a) SMCE is prices $\{p_t^b, p_t^s\}_{t=0}^{\infty}$ and household allocation $\{c_t, b_{t+1}, s_{t+1}\}_{t=0}^{\infty}$ such that

A. Given prices $\{p_t^b, p_t^s\}_{t=0}^{\infty}$, household allocation $\{c_t, b_{t+1}, s_{t+1}\}_{t=0}^{\infty}$ is optimal. That is household allocation solves

$$\max_{\{c_t, b_{t+1}, s_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

Problem 3 (cont.)

subject to

$$
\begin{aligned}
c_t + p_t^b b_{t+1} + p_t^s(s_{t+1} - s_t) &\leq b_t + s_t d_t \text{ for } t = 0, 1, \ldots, \\
c_t, s_{t+1} &\geq 0 \text{ for } t = 0, 1, \ldots, \\
b_{t+1} &\geq -\bar{A} \text{ for some } \bar{A} > 0, t = 0, 1, \ldots, \\
b_0 &= 0, s_0 = 1
\end{aligned}
$$

B. Markets clear
   i. Consumption good: $c_t = d_t$ for $t = 0, 1, \ldots$ (i.e., all dividends are consumed each period),
   ii. Shares: $s_t = 1$ for $t = 0, 1, \ldots$ (i.e., all share-holdings among households must sum to 1),
   iii. Assets: $b_t = 0$ for $t = 0, 1, \ldots$ (i.e., all borrowers have lenders).

Problem 3 (cont.)

(b) Recursive Competitive Equilibrium is collection of price functions $\{p^s(d), p^b(d)\}$, value function $\{V^*(w,d)\}$, and household policy functions $\{c^*(w,d), b^*(w,d), s^*(w,d)\}$ such that

A. Given price functions and dividends d and d', household policy functions solve its Bellman equation

$$V(w,d) = \max_{c,b',s'} \{u(c) + \beta V(w',d')\}$$

Problem 3 (cont.)

subject to

$$
\begin{aligned}
c + p^b(d)b' + p^s(d)s' &\leq w, \\
c, s' &\geq 0 \\
b' &\geq -\bar{A} \text{ for some } \bar{A} > 0
\end{aligned}
$$

The solution to the Bellman equation is value function $V^*(w, d)$.

B. Price functions are functions of dividends d.

$$
\begin{aligned}
p^s &= p^s(d) \\
p^b &= p^b(d)
\end{aligned}
$$

Problem 3 (cont.)

C. Allocation is feasible. That is, household policies satisfy market clearing conditions in aggregate. For all dividends d,

$$c(d, d) = d$$

$$b(d, d) = 0$$

$$s(d, d) = 1$$

Problem 3 (cont.)

(c) Assume $d_t = 1$ and solve p_t^s and p_t^b.

- Use household's first-order conditions and market-clearing condition to solve bond price

$$p_t^b = \beta$$

- Write asset pricing equation in terms of future price and dividend. Then use "no bubble" assumption to solve:

$$p_t^s = \frac{\beta}{1-\beta}$$

Problem 3 (cont.)

(d) Assume $d_t = 1$ if t is even and $d_t = 2$ if t is odd.

- Write down FOCs like in (c). Use dividend growth in even/odd periods to get bond prices:

$$p_t^b = \begin{cases} \frac{\beta}{2} & t = 0, 2, 4, \ldots \\ 2\beta & t = 1, 3, 5, \ldots \end{cases}$$

Problem 3 (cont.)

- Write asset pricing equation and use fact that $p_t^s = p_{t+2}^s$ and $d_t = d_{t+2}$ to solve for even/odd period asset prices

$$p_t^s = \begin{cases} \frac{\beta}{1-\beta} & t = 0, 2, 4, \ldots \\ \frac{2\beta}{1-\beta} & t = 1, 3, 5, \ldots \end{cases}$$

Problem 4

(Final Exam, Fall 2017) Model with Population Growth and Labor-Augmenting Technology Growth.

This model is consistent with the stylized "Kaldor" facts about growth:

1. GDP per worker and capital per worker have grown at sustained rate
2. Wages grow at sustained rate
3. Real interest rate and capital-output ratio are fairly constant over time
4. Factor shares of income are stable

Problem 4 (cont.)

(a) Aggregate feasibility

$$C_t + K_{t+1} = AK_t^{\alpha} L_t^{1-\alpha} + (1-\delta)K_t$$

where $L_t \equiv (1+\gamma)^t (1+\eta)^t h_t$ is aggregate effective hours worked.

(b) Write down firm's maximization problem and its FOCs.

$$r_t = (1-\tau)\alpha A \left(\frac{K_t}{L_t}\right)^{\alpha-1} \quad w_t = (1-\tau)(1-\alpha)(1+\gamma)^t A \left(\frac{K_t}{L_t}\right)^{\alpha}$$

(c) Nat'l Income $= (1-\tau)Y_t = \underbrace{w_t(1+\eta)^t h_t}_{\text{Labor Income}} + \underbrace{r_t K_t}_{\text{Capital Income}}$

Problem 4 (cont.)

(d) SMCE is policy $\{\tau, Tr_t\}_{t=0}^{\infty}$, prices $\{r_t, w_t\}_{t=0}^{\infty}$, interest rate $\{i_t\}_{t=0}^{\infty}$, household allocation $\{c_t, x_t, k_{t+1}, a_{t+1}, h_t\}_{t=0}^{\infty}$, and firm allocation $\{Y_t, K_t^d, h_t^d\}_{t=0}^{\infty}$ such that

A. Given prices, interest rate, and policy, HH allocation solves

$$\max_{\{c_t,x_t,k_{t+1},a_{t+1},h_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t(1+\eta)^t(\phi\log(c_t)+(1-\phi)\log(1-h_t))$$

$$\text{subject to } c_t + x_t + (1+\eta)\frac{a_{t+1}}{1+i_{t+1}} = w_t h_t + r_t k_t + a_t + Tr_t \text{ for } t = 0,1,\ldots;$$

$$x_t = (1+\eta)k_{t+1} - (1-\delta)k_t \text{ for } t = 0,1,\ldots;$$

$$(1+\eta)a_{t+1} \geq -\bar{A}(1+\gamma)^t \text{ for some } \bar{A} > 0 \text{ for } t = 0,1,\ldots;$$

$$k_0 \text{ given}; c_t, x_t, k_{t+1} \geq 0 \text{ for } t = 0,1,\ldots; 0 \leq h_t \leq 1 \text{ for } t = 0,1,\ldots; a_0 = 0$$

Problem 4 (cont.)

B. Given prices, interest rate, and policy, firm maximizes after-tax profit

$$\max_{\{Y_t, K_t^d, h_t^d\}_{t=0}^{\infty}} (1-\tau)Y_t - w_t(1+\eta)^t h_t^d - r_t K_t^d$$

subject to $Y_t = A(K_t^d)^\alpha[(1+\gamma)^t(1+\eta)^t h_t^d]^{1-\alpha}$.

C. Government budget balances: $\tau Y_t = (1+\eta)^t Tr_t$ for $t = 0, 1, \ldots$

D. Markets clear. In all periods $t = 0, 1, 2, \ldots,$

   i. Consumption good: $C_t + K_{t+1} = Y_t + (1-\delta)K_t$
   ii. Labor: $(1+\eta)^t h_t^d = (1+\eta)^t h_t$
   iii. Capital: $K_t^d = (1+\eta)^t k_t$
   iv. Asset: $(1+\eta)^t a_t = 0$

Problem 4 (cont.)

(e) Write three equations in per person variables that describe equilibrium allocations

$$\text{MRS:} \quad w_t = \frac{(1-\phi)c_t}{\phi(1-h_t)}$$

$$\text{Euler:} \quad \frac{c_{t+1}}{c_t} = \beta(r_{t+1} + 1 - \delta)$$

$$\text{Feasibility:} \quad c_t + (1+\eta)k_{t+1} = Ak_t^{\alpha}[(1+\gamma)^t h_t]^{1-\alpha} + (1-\delta)k_t$$

(f) Find interest rate i_t in terms of allocations and tax rate.

$$i_{t+1} = (1-\tau)\alpha A \left(\frac{k_{t+1}}{(1+\gamma)^{t+1}h_{t+1}}\right)^{\alpha-1} - \delta$$

Problem 4 (cont.)

(g) Write aggregate feasibility in terms of de-trended variables, denoted by $\hat{}$. What is long-run growth rate of per-capita variables?

$$\hat{c}_t + (1+\gamma)(1+\eta)\hat{k}_{t+1} = A\hat{k}_t^{\alpha} h_t^{1-\alpha} + (1-\delta)\hat{k}_t$$

Per-capita output, consumption, capital, and investment all grow at gross rate $1+\gamma$. Hours per capita are constant.

Problem 4 (cont.)

(h) Write 3 equations that describe long-run (i.e., steady state) values of the de-trended variables:

MRS: $$\hat{w}_t = (1-\tau)(1-\alpha)A\left(\frac{\hat{k}}{h}\right)^{\alpha} = \frac{(1-\phi)\hat{c}}{\phi(1-h)}$$

Euler: $$(1-\tau)\alpha A\left(\frac{\hat{k}}{h}\right)^{\alpha-1} + 1 - \delta = \frac{1+\gamma}{\beta}$$

Feasibility: $$\hat{c} + [(1+\gamma)(1+\eta) - 1 + \delta]\hat{k} = A\hat{k}^{\alpha}h^{1-\alpha}$$

Problem 4 (cont.)

(i) What is long-run effect of τ on interest rate?

$$1 + i^* = \frac{1 + \gamma}{\beta}$$

Tax rate τ does *not* affect long-run interest rate!

Problem 4 (cont.)

(j) What is long-run effect of τ on $\frac{\hat{k}}{h}$?

$$\frac{\hat{k}}{h} = \left(\frac{(1-\tau)\alpha A}{\frac{1+\gamma}{\beta} - 1 + \delta} \right)^{\frac{1}{1-\alpha}}$$

Long-run capital-labor ratio is *decreasing* in tax rate τ.

Problem 4 (cont.)

(k) Use national accounting data to calibrate model parameters:

$$\delta = 0.02 \qquad \alpha = 0.33$$
$$\phi = 0.36 \qquad \beta = 0.97$$
$$\tau = 0.1$$

Problem 5

Economy with workers and capitalists (i.e., firm owners)

(a) Define ADCE.

- Worker (type 1) budget constraint: $c_t^1 = (1 - \tau_L) w_t n_t^1 \ \forall t$
- Given prices and policy, firm maxes present value of after-tax dividends:

$$\max_{\{d_t, K_{t+1}, N_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} (1 - \tau_d) p_t d_t$$

  subject to $d_t = K_t^{\alpha} N_t^{1-\alpha} - w_t N_t - (K_{t+1} - (1 - \delta) K_t) \ \forall t$

- Government budget balances: $\tau_L w_t n_t^1 + \tau_d d_t = g K_t^{\alpha} N_t^{1-\alpha}$
- Market clearing conditions
  1. Final good: $c_t^1 + c_t^2 + K_{t+1} = (1 - g) K_t^{\alpha} N_t^{1-\alpha} + (1 - \delta) K_t$
  2. Labor: $n_t^1 = N_t$
  3. Stock: $s_t = 1$

Problem 5 (cont.)

(b) Solve for labor supply of workers; consumption of workers and capitalists.

- Use worker's FOC and budget constraint (which holds with equality in every period), to find labor supply.

$$n_t^1 = 1/2$$

- Workers and capitalists consume post-tax income each period

$$c_t^1 = 1/2(1 - \tau_L)w_t$$
$$c_t^2 = (1 - \tau_d)d_t$$

Problem 5 (cont.)

(c) Write asset pricing equation

$$q_t = \beta \frac{c_t^2}{c_{t+1}^2}(q_{t+1} + (1 - \tau_d)d_{t+1})$$

(d) Firm's first-order conditions

$$w_t = (1 - \alpha)K_t^{\alpha} N_t^{-\alpha}$$
$$p_t = p_{t+1}(\alpha K_{t+1}^{\alpha-1} N_{t+1}^{1-\alpha} + 1 - \delta)$$

Problem 5 (cont.)

(e) Steady state capital stock. Use firm's and capitalist's FOCs (and steady state labor supply N):

$$K = \frac{1}{2}\left(\frac{\alpha}{\frac{1}{\beta} - 1 + \delta}\right)^{\frac{1}{1-\alpha}}$$

(f) Find steady state wage. Use K and N in steady state,

$$w = (1-\alpha)\left(\frac{\alpha}{\frac{1}{\beta} - 1 + \delta}\right)^{\frac{\alpha}{1-\alpha}}$$

Problem 5 (cont.)

(g) Find steady state share price q. Start with equation from (c):

$$q = \frac{\beta}{1-\beta}(1-\tau_d)d$$

Simplify using firm's FOC wrt K_{t+1} and household FOCs wrt c_t, c_{t+1}

$$d = \left(\frac{1}{\beta} - 1\right)K$$

which implies steady-state asset price is

$$q = (1-\tau_d)K$$

Problem 5 (cont.)

(h) Dividend tax cut increases stock price q and increases consumption inequality between capitalists and workers. Taxes do not affect other variables (capital stock, wage, labor supply, output, and aggregate consumption)

(i) Dividend tax cut does not affect output, so it would not "pay for itself." Government must raise labor income tax to maintain expenditure policy gY.

Problem 1

Solve two period model using Newton's method

(a) Jacobian for the 3 x 3 system (i.e., two budget constraints and one Euler equation):

$$\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & -\alpha k_2^{\alpha-1} - (1-\delta) \\ -\sigma c_1^{-\sigma-1} & \sigma c_2^{-\sigma-1}\beta\left(1-\delta+\alpha k_2^{\alpha-1}\right) & -(\alpha-1)c_2^{-\sigma}\beta\alpha k_2^{\alpha-2} \end{bmatrix}$$

Numerical solution (within 0.001 margin of error),

$$c_1 \approx 3.7363;\ c_2 \approx 3.8593;\ k_2 \approx 2.6478$$

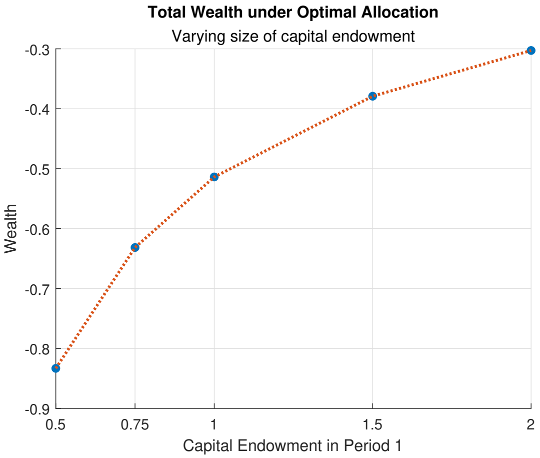
Problem 1 (cont.)

(b) Solve c_1, c_2, k_2, and $w(\bar{k}_1)$ for different values of $\bar{k}_1$

Allocation	$\frac{1}{2}k_{ss}$	$\frac{3}{4}k_{ss}$	k_{ss}	$\frac{3}{2}k_{ss}$	$2k_{ss}$
c_1	2.2576	3.0157	3.7363	5.1142	6.4412
c_2	2.4344	3.1673	3.8593	5.1758	6.4391
k_2	1.4246	2.0411	2.6478	3.8464	5.0336
$w(\bar{k}_1)$	-0.8332	-0.6315	-0.5138	-0.3791	-0.3028

Problem 1 (cont.)

(b) Plot $w(\bar{k}_1)$ for values in $\mathcal{K} = \{\frac{1}{2}k_{ss}, \frac{3}{4}k_{ss}, k_{ss}, \frac{3}{2}k_{ss}, 2k_{ss}\}$



Problem 2

(a) Rewrite planner problem so that it's stationary
- Define $c_t \equiv \frac{C_t}{(1+\gamma)^t N_t}$ and $k_t \equiv \frac{K_t}{(1+\gamma)^t N_t}$

(b) Write problem recursively

$$V(k_t) = \max_{c_t, k_{t+1} \geq 0} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + (1+\gamma)^{1-\sigma} \beta V(k_{t+1}) \right\}$$

subject to

$$c_t + (1+\gamma)(1+\eta)k_{t+1} = Ak_t^{\alpha} + (1-\delta)k_t$$
$$c_t, k_{t+1} \geq 0, k_0 \text{ given}$$

Problem 2 (cont.)

Solve for k_{ss}

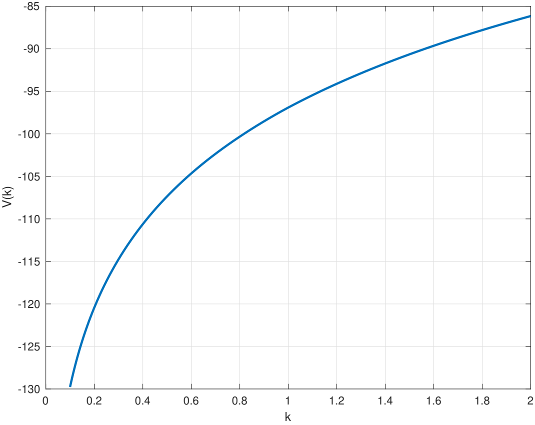
- Derive Euler equation from first-order conditions
- **Per effective worker** variables c_t, k_t are constant in steady state

(c) Calibrate parameters of the model. Given σ, η, and γ,

1. $\alpha = \frac{r_t K_t}{Y_t} = 1/3$
2. Use $\dfrac{K_{t+1} - (1-\delta)K_t}{Y_t} = 0.21$ and $\dfrac{K_t}{Y_t} = 3$ to solve for δ
3. Normalize $k^* = 1$ and use $\alpha \frac{Y_t}{K_t}$ to solve for A
4. Use Euler equation, other parameters, to solve for β

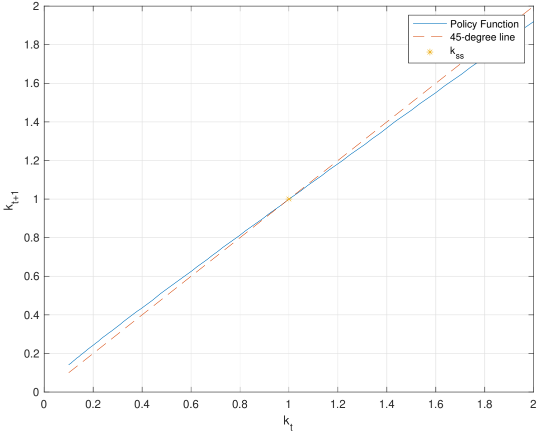
Problem 2 (cont.)

(d) Plot value function . . .



Problem 2 (cont.)

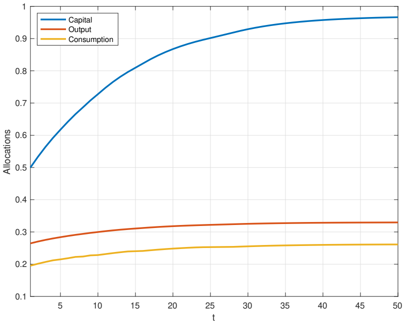
(d) …and the policy function



Problem 2 (cont.)

(e) Set $k_0 = 0.5k_{ss}$. Use your approximation of policy function $g(k)$ from (d) to generate sequence of capital $\{k_1, \dots, k_{50}\}$. Then use production function and feasibility to generate sequence of output and consumption.

Problem 2 (cont.)



- $k_t \rightarrow k^*$
- $\dfrac{k_t}{y_t} = \dfrac{K_t}{Y_t} \rightarrow 3$
- In general, good to check that equations used to calibrate the model are satisfied by results in “long-run” (in this case, $t = 50$)

Second-Half Outline

- Assignments after midterm: PS5, PS6, PS7, CE2
- Past final exams (2017 – 2024) on eLC
- Dynamic CE
  - Arrow-Debreu
  - Sequential Markets
  - Negishi Method
- Growth Models & Steady State
- Search Models
- *Note:* See **TA9** for First-half material review