New Dynamic Public Finance (NDPF)

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GOALS OF THIS LECTURE

(1) New Dynamic Public Finance: A toolbox.

(2) Understand capital taxation from the point of view of NDPF

(3) Application to human capital and how to finance investments in education

SET UP: UNCERTAINTY ON EARNINGS

- So far: representative agents, ex ante heterogeneity, aggregate uncertainty
- We now consider idiosyncratic uncertainty that is not only ex ante, but unfolds over time
- Skill shocks or preference shocks
- Start with finite horizon: $t = 0, 1$
- Preferences $U(c_0, c_1(s), y(s)/s)$
- interpretation: skill shock s realized in period 1. Consumption decision c_0 in period 0 is made before the shock is realized

SET UP: FAILURE OF A-S and RESOURCE CONSTRAINT

- Note difference to time-0 shock (ex ante heterogeneity) as considered so far. Preferences would be $U(c_0(s), c_1(s), y(s)/s)$
- Under separability + homogeneity, the Atkinson-Stiglitz (1976) theorem would rule out the optimality of a capital tax.
- With the period-1 shock, we will find a downward distortion of saving to be optimal (positive capital tax).
- Technology: linear storage with rate of return $R^* = 1/q$, so that the aggregate resource constraint is

$$c_0 + q\sum_s c_1(s)p(s) \le q\sum_s y(s)p(s) \tag{1}$$

FIRST BEST

- $$\max_{c_0, c_1(s), y(s)} \sum_s U(c_0, c_1(s), y(s)/s) p(s)$$

  s.t. (1)

- FOCs for $[c_0]$

  $$\mathbb{E}[U_{c_0}, c_1(s), y(s)/s] = \lambda$$

  and for $[c_1(s)]$

  $$U_{c_1(s)}(c_0, c_1(s), y(s)/s) = \lambda q$$

FIRST BEST – FULL INSURANCE

- Hence,

$$\mathbb{E}[U_{c_0}, c_1(s), y(s)/s] = R^* U_{c_1(s)}(c_0, c_1(s), y(s)/s) \quad \forall s$$

$\Rightarrow$ Full Insurance

- Taking expectations on both sides

$$\mathbb{E}[U_{c_0}, c_1(s), y(s)/s] = R^* \mathbb{E}[U_{c_1(s)}(c_0, c_1(s), y(s)/s)] \tag{2}$$

- For instance, if $U(c_0, c_1(s), y(s)/s) = u(c_0) + \beta u(c_1(s)) - h(y(s)/s)$, then we obtain the usual Euler equation

$$u'(c_0) = \beta R^* \mathbb{E}[u'(c_1(s))]$$

and $c_1(s) = c_1$ for all s.

FREE SAVING GIVEN INCOME TAX

- Free saving with non-linear income tax $T(Y)$:

$$\max_{c_0, c_1(s), y(s)} \sum_s U(c_0, c_1(s), y(s)/s)p(s)$$

s.t.

$$c_0 + k_1 \leq e$$

$$c_1(s) \leq y(s) - T(y(s)) + Rk_1 \quad \forall s$$

- FOCs and $R = R^*$ yields the Euler equation

$$u'(c_0) = \beta R^* \mathbb{E}[u'(c_1(s))]$$

- If agents can freely decide how much to save in a risk-free asset with return $R = R^*$, we obtain the Euler equation as in the first best

PRIVATE INFORMATION AND INCENTIVE CONSTRAINTS

- Suppose s is private information and agents make reports $r = \sigma(s)$, where σ denotes the reporting strategy
- Truth-telling: $\sigma^*(s) = s \quad \forall s$
- Denote

$$c_1^\sigma(s) = c_1(\sigma(s))$$

and

$$y^\sigma(s) = y(\sigma(s))$$

- The set of incentive constraints is

$$\mathbb{E}[U(c_0, c_1(s), y(s)/s)] \geq \mathbb{E}[U(c_0, c_1^\sigma(s), y^\sigma(s)/s] \quad \forall \sigma, s$$

- This is equivalent to

$$U(c_0, c_1(s), y(s)/s) \geq U(c_0, c_1(r), y(r)/s) \quad \forall r, s \tag{3}$$

SECOND BEST DYNAMIC MIRRLEES PROBLEM

- The second best (dynamic Mirrlees) problem is

$$\max_{c_0, c_1(s), y(s)/s} \mathbb{E}[U(c_0, c_1(s), y(s)/s)] \tag{4}$$

s.t.

$$c_0 + q\sum_s c_1(s)p(s) \leq q\sum_s y(s)p(s) \quad \text{(RC)}$$

and

$$U(c_0, c_1(s), y(s)/s) \geq U(c_0, c_1(r), y(r)/s) \quad \forall r, s \quad \text{(IC)}$$

FEASIBLE VARIATIONS

- (RC) and (IC) define the set F of *feasible* allocations, i.e.

$$F \equiv \{(c_0, c_1(s), y(s)) \mid (c_0, c_1(s), y(s)) \quad \text{satisfies (RC) and (IC)}$$

- Key question: Is free saving feasible? Formally, if $(c_0, c_1(s), y(s)) \in F$, does this imply that $(c_0 - \triangle, c_1(s) + R^*\triangle, y(s)) \in F$ as well, for some $\triangle \in \mathbb{R}$?
- In other words, if the agent saves a little in period 0 ($\triangle$) is she stil willing to supply the same output (i.e. not lie about s)?
- Depends on income effects in general
- For instance, suppose

$$U(c_0, c_1(s), y(s)/s) = \hat{U}(c_0, c_1(s) - h(y(s)/s))$$

Then, given c_0, just maximize $c_1(s) - h(y(s)/s)$. There are no income effects due to quasilinearity, and the above variation is feasible.

FEASIBLE VARIATIONS

- Easier to see using (IC):

$$\hat{U}(c_0 - \triangle, c_1(s) + R^* \triangle - h(y(s)/s)) \geq$$

$$\hat{U}(c_0 - \triangle, c_1(r) + R^* \triangle - h(y(r)/s))$$

  if and only if

$$c_1(s) + R^* \triangle - h(y(s)/s) \geq c_1(r) + R^* \triangle - h(y(r)/s)$$

  which is implied by the original allocation being feasible, i.e. $(c_0, c_1(s), y(s)) \in F$
- But in general, saving in period 0 has a negative income effect on labor supply in period 1 (if leisure is a normal good)
- e.g. consider preferences

$$U(c_0, c_1(s), y(s)/s) = u(c_0) + \beta u(c_1(s)) - h(y(s)/s)$$

  Additive separability + concavity of $u(.)$ mean leisure is normal (output is "inferior") and so the variation above is no longer feasible.

CAN WE FIND A FEASIBLE VARIATION?

- Free saving is not feasible with these preferences due to negative income effect on labor supply
- Consider

$$(c_0 - \triangle, c_1(s) + \delta(\triangle, s), y(s)) \tag{5}$$

with $\delta(\triangle, s)$ chosen such that (IC) is satisfied:

$$u(c_0 - \triangle) + \beta u(c_1(s) + \delta(\triangle, s)) = u(c_0) + \beta u(c_1(s)) + A(\triangle) \quad \forall s, \triangle \tag{6}$$

for some $A(\triangle)$, and such that it is resource neutral:

$$-\triangle + q \sum_m \delta(\triangle, s) p(s) = 0 \quad \forall \triangle \tag{7}$$

- With the "free saving" variation, we had $\delta(\triangle, s) = -R^* \triangle$. What is key difference?

VERIFY INCENTIVE COMPATIBILITY OF VARIATION

- Verify that the variation maintains incentive compatibility:

$$u(c_0 - \triangle) + \beta u(c_1(s) + \delta(\triangle, s)) - h(y(s)/s) \geq$$

$$u(c_0 - \triangle) + \beta u(c_1(r) + \delta(\triangle, r)) - h(y(r)/s)$$

  if and only if (6)

$$u(c_0) + \beta u(c_1(s)) + A(\triangle) - h(y(s)/s) \geq$$

$$u(c_0) + \beta u(c_1(r)) + A(\triangle) - h(y(r)/s)$$

  if and only if

$$u(c_0) + \beta u(c_1(s)) - h(y(s)/s) \geq u(c_0) + \beta u(c_1(r)) - h(y(r)/s)$$

- Is this true?
- Key: Given separability, all that matters for incentive compatibility is the total utility from consumption.

INVERSE EULER EQUATION

- Suppose the original allocation $(c_0, c_1(s), y(s))$ solves the second best problem. Then, since the variation $\delta(\triangle, s)$ is feasible as just shown, it cannot improve the objective.
- Formally,

$$0 = argmax_{\triangle} \sum_s p(s)[u(c_0 - \triangle) + \beta u(c_1(s) + \delta(\triangle, s)) - h(y(s)/s)]$$

$$= argmax_{\triangle} \sum_s p(s)[u(c_0) + \beta u(c_1(s) + A(\triangle)) - h(y(s)/s)]$$

$$= argmax_{\triangle} A(\triangle),$$

where we used

$$u(c_0 - \triangle) + \beta u(c_1(s) + \delta(\triangle, s)) = u(c_0) + \beta u(c_1(s)) + A(\triangle) \quad \forall s, \triangle \tag{8}$$

- FOC $A'(0) = 0$

INVERSE EULER EQUATION

- $\delta(\triangle, s)$ satisfies (IC); differentiate w.r.t $\triangle$:

$$-u'(c_0) + \beta u'(c_1(s)) \frac{\partial \delta(\triangle, s)}{\partial \triangle}\Big|_{\triangle=0} = A'(0)$$

rearrange (at optimum):

$$\frac{\partial \delta(\triangle, s)}{\partial \triangle}\Big|_{\triangle=0} = \frac{u'(c_0) + A'(0)}{\beta u'(c_1(s))} = \frac{u'(c_0)}{\beta u'(c_1(s))} \quad \forall s \tag{9}$$

- Condition for resource neutrality of the variation implies:

$$-1 + q \sum_s p(s) \frac{\partial \delta(\triangle, s)}{\partial \triangle}\Big|_{\triangle=0} = 0$$

INVERSE EULER EQUATION (II)

- Using expression for $\left.\frac{\partial\delta(\triangle,s)}{\partial\triangle}\right|_{\triangle=0}$:

$$\frac{1}{u'(c_0)} = \frac{1}{\beta R^*}\sum_s \frac{p(s)}{u'(c_1(s))} \tag{10}$$

- With seperable preferences, optimal allocation has to satisfy this inverse Euler equatoin (Diamond/Mirrlees 1978, Rogerson 1985, Golosov et al. 2003)
- Is this necessary and sufficient? (Think of optimality of $y(s)$).
- Implies that the Euler equation is violated.

$$u'(c_0) = \beta R^* \sum_s p(s)u'(c_1(s)) \tag{11}$$

Is it always violated?

POSITIVE SAVINGS WEDGE

- Inverse Euler implies that, at the optimum,

$$u'(c_0) = \left[\frac{1}{\beta R^*}\sum_s \frac{p(s)}{u'(c_1(s))}\right]^{-1} = \beta R^* \left(\mathbb{E}\left[\frac{1}{u'(c_1(s))}\right]\right)^{-1}$$

  By Jensen's inequality and convexity of the function $f(x) = 1/x$,

$$u'(c_0) < \beta R^* \mathbb{E}[u'(c_1(s))]$$

- The optimal allocation is incompatible with free saving. Is saving is discouraged or encouraged?
- Intuition: saving in period 0 increases income in period 1 across all shocks s → negative income effect on y → is this good or bad for Planner?
- Implications for capital taxation, but study distinction between the wedge derived here and actual implementations later

THE DUAL APPROACH: VARIATIONAL ARGUMENT

- Easier to work with in dynamic problems: Minimize resource cost s.t. reaching given level of utilities.
- Consider allocation in terms of utils

$$u_0 \equiv u(c_0), \quad u_1(s) \equiv u(c_1(s))$$

- Move from original allocation $(u_0, u_1(s))$ to variation $(\tilde{u}_0, \tilde{u}_1(s))$ such that

$$u_0 + \beta u_1(s) = \tilde{u}_0 + \beta \tilde{u}_1(s) \quad \forall s$$

- In particular, set

$$\tilde{u}_0 = u_0 - \beta \triangle$$

and

$$\tilde{u}_1(s) = u_1(s) + \triangle \quad \forall s$$

THE DUAL APPROACH: : VARIATIONAL ARGUMENT (II)

- Are incentive constraints affected?

$$\tilde{u_0} + \beta \tilde{u_1}(s) - h(y(s)/s) \geq \tilde{u_1}(r) + \beta \tilde{u_1}(r) - h(y(r)/s) \quad \forall r, s$$

if and only if

$$u_0 - \beta \triangle + \beta(u_1(s) + \triangle) - h(y(s)/s) \geq$$

$$u_1(r) - \beta \triangle + \beta(u_1(r) + \triangle) - h(y(r)/s) \quad \forall r, s$$

if and only if

$$u_0 + \beta u_1(s) - h(y(s)/s) \geq u_1(r) + \beta u_1(r) - h(y(r)/s) \quad \forall r, s$$

which is this true because original allocation was IC.

- Variation by construction keeps total expected utility unchanged
- Dual problem: minimize total resource cost of allocation

$$min_{\triangle} \left\{ C(u_0 - \beta \triangle) + q \sum_s p(s) C(u_1(s)) + \triangle) \right\}$$

where $C(u)$ is the inverse function of $u(c)$

INVERSE EULER AGAIN

- If the original allocation $(u_0, u_1(s))$ is optimal, $\triangle = 0$ must solve this problem
- The FOC evaluated at $\triangle = 0$ is

$$-C'(u_0)\beta + q\sum_s p(s)C'(u_1(s)) = 0$$

- Use $C'(u) = 1/u'(c)$

$$\frac{1}{u'(c_0)} = \frac{q}{\beta}\sum_s \frac{p(s)}{u'(c_1(s))}$$

  which is the inverse Euler equation again (recall $q = 1/R^*$)
- Alternative interpretation: $1/u'(c)$ is resource cost of providing some given incentives
- IEE requires the equalization of the expected resource cost of providing incentives across both periods

IMPLEMENTATION

- STEP BACK: What is implementation? Why was it not discussed before?!
- Back to 2 period model, 2 shocks $s \in \{H, L\}$
- Suppose have found the optimal allocation with consumption $\{c_0^*, c_1^*(L), c_1^*(H)\}$
- It satisfies the inverse Euler equation

$$\frac{1}{u'(c_0^*)} = \frac{1}{\beta R^*}\Big[\frac{p_L}{u'(c_1^*(L))} + \frac{p_H}{u'(c_1^*(H))}\Big]$$

- Suppose we introduce a linear capital tax τ^k such that the Euler equation is satisfied

$$u'(c_0^*) = \beta R^*(1 - \tau^k)[p_H u'(c_1^*(L)) + p_H u'(c_1^*(H))] \tag{12}$$

IMPLEMENTATION: LINEAR CAPITAL TAX, NONLINEAR INCOME TAX

- Introduce a non-linear income tax system $T_0, T_1(y)$ so that the individuals' budget constraints become

$$c_0 + k_1 \leq e_0 - T_0$$

in period 0 and

$$c_1(s) \leq y(s) - T_1(y(s)) + (1 - \tau^k)R^* k_1$$

in period 1

- Note: Very restrictive tax system where the capital tax is linear and separable from the labor income tax
- Can we find a tax system T_0, T_1, τ^k such that $\{c_0^*, c_1^*(L), c_1^*(H)\}$ is incentive compatible? [What do you think?]
- If we could force the agent to choose c_0^* and thus k_1^*? We'd be back to a standard Mirlees problem in period 1, so we can always find $T_1(y)$ that implements $c_1^*(s), y^*(s)$

PROBLEM WITH LINEAR CAPITAL TAX

- Suppose H's incentive constraint is the binding one at the optimum (which means?)

$$u(c_1^*(H)) - h(y^*(H)/H) = u(c_1^*(L)) - h(y^*(L)/H) \tag{13}$$

  i.e. *if* the agent saves optimally k_1^*, truth-telling is optimum
- Moreover, *given* truth-telling in period 1, Euler equation holds, so the agent finds it optimal to choose optimal savings k_1^*
- But: double-deviation $\sigma_1(s) = L$ for all $s \in \{H, L\}$ *and* $\tilde{k}_1 = k_1^* + \epsilon$
- If $\sigma_1(s)$ for all s and $k_1 = k_1^*$, then

$$u'(c_0^*) < \beta R^*(1 - \tau^k) u'(c_1^*(L)) \tag{14}$$

  Why?
- It is optimal to deviate to $\tilde{k}_1 = k_1^* + \epsilon$ with $\epsilon > 0$
- What is agent tempted to do here? Explain in words.

DOUBLE DEVIATION

- Profitable deviation: save more in period 0 and always claim to be low type in period 1 period

$$\tilde{U} = u(c_0^* - \epsilon) + \beta\Big[u(c_1^*(L) + R^*(1-\tau^k)\epsilon) - p_L h(y^*(L)/L) - p_H h(y^*(L)/H)\Big]$$

$$\approx \epsilon\Big[-u'(c_0^*) + \beta R^*(1-\tau^k)u'(c_1^*(L))\Big]$$

$$+u(c_0^*) + \beta\Big[u(c_1^*(L)) - p_L h(y^*(L)/L) - p_H h(y^*(L)/(H)\Big]$$

$$> u(c_0^*) + \beta\Big[p_H(u(c_1^*(H)) - h(y^*(H)/H)) + p_L(u(c_1^*(L)) - h(y^*(L)/L))\Big]$$

- Where is first approximation coming from? Where did the second equality come from?
- Hence, the double deviation makes the agent better off than truth telling under the optimal allocation that we wanted to implement.

LINEAR CAPITAL TAX DOES NOT WORK – SOLUTIONS?

- State-dependent linear capital tax $\tau^k(s)$ so that

$$u'(c_0^*) = \beta R^*(1 - \tau^k(s))u'(c_1^*(s)) \quad \forall s$$

  state by state (Kocherlakota 2005). Prevents profitable double-deviations.

$$\tau^k(s) = 1 - \frac{u'(c_0^*)}{\beta R^* u'(c_1^*(s))}$$

  is high whenever $c_1^*(s)$ is low.

- What does this mean? Returns to saving are made risky so as to make savings unattractive.
- However: $\tau^k(s)$ is zero in expectation so that the government does not raise revenue with the capital tax.
- In general, capital taxes must be contingent on the entire history of shocks.

ASSET TESTS IN DISABILITY INSURANCE AND MEDICAID

- Asset tests plus income tests are used in social programs in the U.S.
- Disability insurance: have to run down your assets first before applying. Is exactly a "downward distortion" in savings to prevent "shirking" (pretending to be unable to work).
- Medicaid long-term care also has asset test to prevent you from "shirking" (i.e., not using other options) first.

Applications: Every Dynamic Problem with Asymmetric Information

- Many problems in the real world are dynamic.
- R&D and Innovation Policies: Firms produce "quality" products

$$q_t = (1-\delta)q_{t-1} + \lambda_t(\theta_t, e_t, r_{t-1})$$

  where λ_t is called "step size", θ_t is firms' research productivity (unobservable), e_t is research effort (unobservable), r_{t-1} is R&D investments.
- Human Capital investments for people: Income is $y_t = w_t(\theta_t, s_t)l_t$ where the human capital stock is acquired over time $s_t = s_{t-1}(1-\delta) + e_t$ with either a "money cost" $M_t(e_t)$ or a time cost (that naturally will have some interaction with labor supply) $\phi_t(l_t, e_t)$.
- Physician's incentives? Hospital Cost minimization under asymmetric information on hospital's productivity?

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