Econ 277B: Economic Development II
Semester II, 2019-20

Tridip Ray
ISI, Delhi

Final Exam (11 & 12 June 2020)

- There are 2 questions; you have to answer *both* of them. Time allocation: Q1: 1 hour and 15 minutes on 11 June; Q2: 4 hours on 12 June.

1. [33 points]

   Consider a community of a continuum of identical farmers of measure 1. Assume that all uncertainty is idiosyncratic, that is, shocks that affect the state of the harvest on a particular plot. There are two possible outputs, H and L, with $H > L$. For each farmer there are two possible probabilities of producing H; call them p and q, with $p > q$. The idea is that with greater care and better application of inputs, each farmer can produce H with probability p; but if he underapplies inputs, the probability falls to q. Denote the extra cost of diligent effort and input use by $C > 0$ (this is expressed in utility units). The farmers are *risk-averse*, that is, their utility function $u(\cdot)$ is *strictly concave*. Assume that, in isolation, that is, when there is no insurance, each farmer would like to put in the extra effort:

$$p \cdot u(H) + (1-p) \cdot u(L) - C > q \cdot u(H) + (1-q) \cdot u(L).$$

   Mutual insurance at the community level works as follows. Under any insurance scheme suppose that X is a farmer's net consumption when output is H and Y is his net consumption when output is L. That is, when a farmer enjoys a good harvest, he contributes $H - X > 0$ to the community pool, and receives $Y - L > 0$ from the community pool when he suffers a bad harvest. For any insurance scheme to work it must be *feasible*, *individually rational* to join the scheme and *incentive compatible* to put in the extra effort.

(a) [6 points]

   Write down, with brief and clear explanations, the (i) *feasibility*, (ii) *individual rationality* and (iii) *incentive compatibility* constraints.

(b) [7 points]

A *complete insurance* refers to the situation where $X = Y$, that is, regardless of whether the harvest is good or bad a farmer's net consumption is the same.

(i) Is it individually rational to join a feasible complete insurance scheme? Explain clearly.

(ii) Is complete insurance incentive compatible? Explain clearly.

(c) [10 points]

An *incomplete insurance* refers to a situation where $X \neq Y$.

(i) Is it individually rational to join a feasible incomplete insurance scheme? Explain clearly.

(ii) What has to be the relation between X and Y for incomplete insurance to work, that is, to be feasible, individually rational and incentive compatible? Explain clearly.

(d) [10 points]

(i) In view of your answers to parts (b) and (c) what kind of relationship do you expect to see between *individual consumption* and *individual income*?

(ii) In view of your answers to parts (b) and (c) identify the key trade-off that an insurance scheme faces in a risky environment in the presence of moral hazard.

(iii) Give an example of another agricultural contract where you have faced the same trade-off.

2. [67 points]

We study role of *social networks* in reducing agency costs. Most credit contracts in the developing world are not enforced by courts, but instead by social norms of reciprocal and third-party sanctions. Contracts have to be self-enforcing, where repayment of loans rely on the self-interest of borrowers, given the future consequences of a default. Defaults are sought to be deterred solely by the threat of cutting the borrower off from future access to credit.

Consider an infinite-horizon repeated lending-borrowing game. Each period, the producer has access to a production technology which produces output $F(L)$, where L is the value of inputs purchased and applied. The production function satisfies standard conditions: $F'(L) > 0$ and $F''(L) < 0$. Suppose production takes the length of one period, and let ρ be the (gross) bank rate of interest (opportunity cost of funds). Note that there is no production uncertainty in this model. We assume that producers do not accumulate any savings and have to rely on the credit market to finance investment needs every period.

A *debt contract* is a pair (L, R) where L is the loan size and R is the repayment (principal plus interest) the borrower has to make.

(a) **The First Best** [3 points]

(i) Under a debt contract (L, R), express clearly the one-period payoffs of the borrower and the lender, and the social surplus.

(ii) Derive, with a clear explanation, the condition that determines the first-best level of investment, L^*.

- Borrower-producers and lenders are large in number, live for an infinite number of periods and discount the future by a discount factor $0 < \delta < 1$. We focus on a *stationary equilibrium* where the lender offers a debt contract (L, R) every period, and follows the punishment strategy of never offering a loan to a borrower who directly defaults on repayment of a loan from him. Role of the social network becomes relevant in terms of the attitude the other lenders (not directly involved in a particular loan contract) take towards the defaulting borrower. We distinguish between two types of punishment strategies followed by the social network: *Bilateral Punishment Strategy* (*BPS*) and *Multilateral Punishment Strategy* (*MPS*).

- In any period there exists a pool of borrowers who is *not* matched with any lender. There is the possibility that a lender is forced to terminate the credit relationship with his existing borrower due to some *exogenous* reason, an event that can occur in each period with probability $0 < q < 1$. A currently unmatched borrower from the pool of unmatched borrowers gets matched with a lender next period with probability $0 < p < 1$. An unmatched borrower earns $\bar{u}$ for sure for one period.
- Following a default, the existing credit relationship is terminated. The defaulting borrower goes to the pool of unmatched borrowers. The borrower can then approach a new lender.
- *Bilateral Punishment Strategy* (*BPS*): The potential lender does *not* look at the borrower's past record. So the defaulting borrower can get matched with a lender next period with probability p, same as anyone who is currently unmatched.
- *Multilateral Punishment Strategy* (*MPS*): The potential lender does look at the borrower's past record. If a borrower ever defaulted a loan repayment in the past, the lender refuses to give him a loan. (It is a close-knit society so that there is perfect information flow regarding defaults.)

- Note that, under a debt contract (L, R), the borrower's one period payoff from default is $F(L)$ whereas his one period payoff from no default is $F(L) - R$. Let V be the lifetime expected utility of a borrower-producer who is matched with a lender and who does not default. Let U be the lifetime expected utility of a borrower-producer who is not matched with a lender and who is expected not to default if matched.

(b) [5 points]

Provide, with clear explanations, the equations defining V and U.

[Using these two equations we can express U and V in terms of $\bar{u}$, $[F(L) - R]$ and other parameters of the model as follows:

$$U = \frac{\bar{u}(1 - \delta + q\delta) + p\delta[F(L) - R]}{(1 - \delta)(1 - \delta + p\delta + q\delta)},$$

and

$$V = \frac{\bar{u}(q\delta) + (1 - \delta + p\delta)[F(L) - R]}{(1 - \delta)(1 - \delta + p\delta + q\delta)}.$$

You do *not* have to do this derivation.]

(c) **Bilateral Punishment Strategy (BPS)** [14 points: 7 + 7]

(i) Express, with a clear explanation, the *incentive compatibility constraint* of the borrower not to default when the society follows the BPS. Using the expressions for V and U given above show that the incentive compatibility constraint is reduced to the following inequality:

$$R\left(1+p\delta\right) \leq \delta\left(1-q\right)\left[F\left(L\right)-\bar{u}\right].$$

(ii) In deciding the optimal (stationary) debt contract (L, R) the lender maximizes his payoff subject to the incentive compatibility constraint of the borrower not to default.

- Set up the optimization problem that determines the optimal debt contract when the society follows the BPS.
- Derive, with a clear explanation, the condition that determines the investment level of the borrower-producer under the BPS, L_{BPS}. Compare, with a clear explanation, L_{BPS} with the first-best investment level, L^*.

(d) **Multilateral Punishment Strategy (MPS)** [19 points: 6 + 6 + 7]

(i) Express, with a clear explanation, the *incentive compatibility constraint* of the borrower not to default when the society follows the MPS. Using the expressions for V and U given above show that the incentive compatibility constraint is reduced to the following inequality:

$$R\left(1+p\delta-\delta\right) \leq \left[\delta\left(1-q\right)-\delta^2\left(1-p-q\right)\right]\left[F\left(L\right)-\bar{u}\right].$$

(iii) Set up the optimization problem that determines the optimal debt contract when the society follows the MPS.

Derive, with a clear explanation, the condition that determines the investment level of the borrower-producer under the MPS, L_{MPS}. Compare, with a clear explanation, L_{MPS} with the first-best investment level, L^*.

(iv) Which strategy is more efficient, BPS or MPS? Give a clear explanation for your answer. Provide a clear economic intuition for your answer.

(e) **Enforceability of the Multilateral Punishment Strategy (MPS)** [26 points: $4+4+5+6+7$]

A key question for the MPS is how it is enforced. In other words, would not an individual lender have an incentive to deviate from this strategy? (After all, a defaulting and a non-defaulting borrower are equally productive.)

Suppose an individual lender *deviates* to give a *defaulting borrower* a "second chance" and offers him an alternative contract (L', R'). Let us denote the counterpart of V for this alternative contract as V'.

(i) Provide, with a clear explanation, the equation defining V'.

Using this equation express V' in terms of $\bar{u}$, $[F(L') - R']$ and other parameters of the model.

(ii) Express, with a clear explanation, the *incentive compatibility constraint* of the borrower not to default.

Using the expression for V' that you have derived in part (i) show that the incentive compatibility constraint is reduced to the following inequality:

$$R' \leq \delta(1-q)[F(L') - \bar{u}].$$

(iii) Set up the optimization problem that determines the optimal alternative debt contract (L', R').

Derive, with a clear explanation, the condition that determines the investment level of the borrower-producer under this alternative contract, L'. Compare, with a clear explanation, L' with L_{MPS}.

(iv) Is this optimal *deviation* contract (L', R') *feasible* under the MPS (that is, under the scenario described in part (d))? Argue clearly whether this *deviation* by the lender is profitable.

(v) A key element in the model is the *exogenous* termination probability $0 < q < 1$. Argue clearly whether the *deviation* by the lender is profitable when $q = 0$. Provide a clear economic intuition for your answer.