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Problem Sets 6 : Theory of Financial Intermediation

1. Financial Intermediation as Delegated Monitoring in Diamond (1996)

   - Consider an economy in which n identical firms seek to finance projects.
   - Each entrepreneur owns a firm and each firm requires an investment of m = 100 units of capital.
   - The returns of each firm are identically independently distributed.
   - Each entrepreneur does not have any initial funds. They have to borrow from lenders.
   - The total number of lenders is $100n$, each lender owns 1 unit of capital to lend out.
   - The project's realized value is a random variable with realization denoted by Y. Y = 160 with probability 0.9 and 80 with probability 0.1.
   - All entrepreneurs and all lenders know the distribution of Y.
   - The entrepreneur observes the realization of actual Y freely.
   - The other cannot observe the total output of the project without paying a cost.
   - f denotes total loan repayment (principal + interest) promised by each firm for a loan of 100.

   (a) Is an entrepreneur willing to speak the truth about the output of his/her project? Describe the moral hazard problem in this economy.

   Answer. There is moral hazard problem in this economy. After the loans are granted to the entrepreneur, asymmetric information problem causes entrepreneur to be unwilling to speak the truth about the outcome of the project The entrepreneur alone can observe the actual value of the outcome while the others cannot without paying a cost. The entrepreneur has an incentive to underreport the outcome so that the entrepreneur can keep more money, no matter the investment project turns to be successful or failure. No matter what the true value of the output, the best response of the borrower is to report the smallest possible value. The borrower has an incentive to report the outcome of zero, no matter what the true outcome is. If there is no cost to the borrower of understating the amount, the borrower always does. After the loans have been made, the lenders will not be paid unless there is some cost of undereporting the outcome. If the moral hazard problem remains, lenders will be reluctant to grant loans to the borrowers (entrepreneurs). (Note that "Even if the investors knows the true value of the output, the borrower obtain it first and thus controls it, the lenders will not be paid unless the borrowers suffers some consequence of not paying.")

(b) If we impose a punishment system such that the entrepreneur will be forced liquidation if he/she pays equal to or lower than a specified amount, f. Assume that liquidating gives no proceeds to the lenders and the entrepreneurs. Calculate the specified amount, which will lead to payments with an expected value of 108 on a loan of 100. Describe how the punishment system in this question helps solving the moral hazard problem.

Answer. Any f between 80 and 160 forces the borrower into liquidation when the project returns 90. and is paid in full when the project returns 150 .

This gives the lender an expected return of Expected payoff to 100 lenders=$0.1(0)+0.9f$ because nothing is received when liquidation.

As long as $0.1(0) + 0.9f \geq 108$, the lenders are satisfied. They receive at least 1.08 each.

Solving for the minimum value of f ,

$$\begin{aligned} 0.1(0) + 0.9f &= 106 \\ f &= \frac{106}{0.9} \\ &= 117.\dot{7} \approx 117.78 \end{aligned}$$

The value of f equal to 117.78 will lead to payments with an expected value of 108.

With this punishment system, if the entrepreneur can pay $f = 117.78$ (when the project is successful), the entrepreneur will pay 100 lenders 117.78 in order to avoid liquidation and keep the rest of the money (160 - 117.78 = 42.22). If the project fails, the entrepreneur will be unable to pay $f = 117.78$. The entrepreneur will be forced into liquidation. Nobody gets anything. Hence, moral hazard problem will be solved since the true outcome of the entrepreneur's project will be revealed; namely if succeed, pay f and if fail, be liquidated.

(c) From (b) , calculated the expected deadweight loss liquidation cost per one borrower.

Answer. After we impose the punishment system, whenever the borrower has enough money to repay the debt, they will always repay.

Once we impose "the punishment", the truth about their project's outcome will be revealed.

When a borrower is forced into liquidiation, nobody gets anything.

From (b), $f = 117.78$.

The lender would get $f = 117.78$ when $Y = 160$, and get 0 when $Y = 80$.

We have to punish a borrower with probability 0.1 (the probability that project fails)

The remaining value of a failed project is gone by bankruptcy process.

The expected deadweight liquidation cost is equal to $0.1 \times 80 = 8$ (per one borrower).

Without monitoring, the unmonitored debt contract has positive expected deadweight liquidation cost.

(d) Suppose that a lender observe the entrepreneur's output by paying a monitoring cost. Then, in stead of liquidating when less than f is paid, the lender who monitors can use the threat of liquidation and offer to refrain from liquidation as long as the borrower repays as much as possible. Monitoring cost is paid ex ante. Lenders must learn in advance about the borrower's business to properly interpret any data about the project returns. Let K be the cost of monitoring a borrower's project and K= 1.

Calculate total cost of monitoring entrepreneurs in this economy for the two financial system (i) direct finance and (ii) indirect finance. Discuss the benefits of economies of scale and diversification in the banking sector.

Answer. If the lenders monitor, the lenders know the true outcome of the project. Then, instead of liquidating when the borrower fails to repay f, the lender who monitors can use the threat of liquidation and offer to refrain from liquidation as long as the borrower repays as much as possible. Borrower can avoid liquidation by repaying as much as possible. With

monitoring, we do not have to force liquidation when a project fails. There is no deadweight liquidation cost.

- The cost of monitoring under direct finance system : there are so many investors, it is hard to cooperate. If investors do not delegate monitoring job to an agent, all investors have to monitor their own borrower.

Duplicated monitoring costs = $m \times K = 100 \times 1 = 100$ (per one borrower). Duplicated monitoring is prohibitively expensive. Therefore, if there is no way to delegate monitoring, the projects will be financed by unmonitored debt. There will be no monitoring activity if the economy relies on direct financing. The cost of monitoring under indirect finance (intermediated finance) system : Suppose that small lenders can delegate monitoring job to an agent (let's call him or her "the banker"). Then, all investors deposit their money to the bank. The bank is the sole lender to the borrowers. The bank monitors the borrowers on the behalf of the lenders.

The cost of delegated monitoring becomes $K = 1$ (per one borrower). This cost of monitoring the borrower is much lower than cost of duplicated monitoring.

Here, since the bank provide a larger scale on lending, the cost of monitoring per one unit of fund lent is smaller. This is **the benefits of economies of scale** in banking.

- With monitoring, the total expected loan repayment from a borrower is equal to $(1-\pi) \times f + \pi(L)$. The bank lends to n borrowers. If n is large enough, the bank will receive $[(1-\pi) \times f + \pi(L)] \times n$ for sure. The bank's net income from lending = $[(1-\pi) \times f + \pi(L)] \times n$ - monitoring cost = $[(1-\pi) \times f + \pi(L)] \times n$ - 1.n, for certain. If the bank promises ex ante to pay back 100 lenders the amount between 108 and $\{[(1-\pi) \times f + \pi(L)]\, n - 1n\}$, the bank will always be able to pay back all depositors. All depositors are satisfied as long as they receive 1.08 each. If the bank underreports its income and refuse to pay the amount promised to its depositors, the bank will be forced into liquidation. The bank will get nothing. Thus, the bank has no incentive to underreport its income. The bank will never default. There will be no punishment to the bank because the bank will never default. (We never have to force a bank into liquidation.) We never have to pay any delegation cost. This is one **benefit of diversification**. The bank's loan portfolio is better diversified than each lender's loan portfolio. The bank knows its net income from loans ex-ante. All depositors get their deposit repayment in full amount as promised in the deposit contract. Compared with direct finance, not all lenders receive their money back as promised under direct finance system. Only 0.9n of total lenders would get their money back as promised by the borrowers (entrepreneurs). Deposits (claims to the banks) is safer than direct claims to borrowers.
- Possible benefits of indirect finance to lenders are
  - The cost of society to prevent moral hazard problem is lower. Monitoring is prohibitly expensive if we use direct finance. Monitoring is possible only when we use indirect finance because of economies of scale. Monitoring is more cost efficient than punishment. Therefore, lenders may gain benefits from lower cost of preventing moral hazard problem.

  { From (d), punishment (liquidation policy) costs a deadweight loss liquidation cost of $\pi L = 0.1 \times 80 = 8$ million dollars per one borrower. Monitoring costs only 1 million dollars per one borrower.
  With monitoring there is no deadweight loss liquidation cost but we have to pay monitoring cost. Therefore, when the benefit gained from reducing deadweight loss is higher than the cost of monitoring, monitoring is more cost efficient.
  The monitoring cost for indirect finance is lower than that for direct finance. Yet, we may also need to monitor the bank. The bank's performance is its own private

information, the bank has an incentive to underreport its outcome or the bank may not monitor the borrowers. Duplicated monitoring of the bank by each lenders would clearly be inefficient. Imposed a liquidation policy (punishment policy, threat of liquidation). }

- All lenders will certainly receive the amount promised ex ante by the bank. Compared with direct finance, not all lenders will be paid as promised by the entrepreneur. The lenders may gain benefits from risk reduction.

(e) Suppose that the economy choose the intermediated financing. The bank charges their borrowers 10% loan rate. In other words, face value $f = 110$ units per one borrower. What is the maximum amount the bank can repay each depositor?

Answer. With monitoring, the total expected loan repayment from a borrower is equal to $(1-\pi) \times f + \pi(L)$=$(0.9 \times (110))$+$(0.1 \times 80)$=99+8=107. The bank lends to n borrowers. If n is large enough, the bank will receive $[(1-\pi) \times f + \pi(L)] \times n = 107n$ for sure. The bank's net income from lending = $[(1-\pi) \times f + \pi(L)] \times n$ - monitoring cost = $[(1-\pi) \times f + \pi(L)] \times n - 1n = 107n - 1n = 106n$, for certain. If the bank promises ex ante to pay back 100 lenders 106 or 1.06 each, the bank will always be able to pay back all depositors. All depositors are satisfied because they receive 1.06 each. If the bank underreports its income and refuse to pay the amount promised to its depositors, the bank will be forced into liquidation. The bank will get nothing. Thus, the bank has no incentive to underreport its income. The bank will never default. There will be no punishment to the bank because the bank will never default. (Note that 10% is the minimum loan rate the bank can charge the borrowers. With 10% loan rate, depositors will recieve 6% deposit rate, which is the minimum requirement.)

(f) Explain why one loan bank (a bank lend to one borrower) is not more cost efficient than direct financing.

Answer. One loan bank will fail as often as the borrowers. We will not get any benefit from monitoring. We still have to pay deadweight loss liquidation cost since we have to punish some banks. From the example, if one bank lend to one borrowers, there must be n banks. The number of banks must be equal to the number of borrowers. Applying the law of large number, 0.1n banks will fail to pay the depositors back as promised. We have to punish 0.1n banks. Each failed banks will have $80-1 = 79$. Liquidation process destroys this value. The cost of punishing 0.1n banks is then equal to $(80-1) \times 0.1n$. This deadweight loss liquidation cost is even more than direct financing. Hence, one loan bank is not more cost efficient than direct financing.