Market Power in Agricultural Markets: *Rice Supply Chain in India*

Gourika Khanna

Background

- Farmers in developing countries are poor
  - Small farmers make up to 80% of the farming population
- The reasons for their low income are:
  - Low productivity
  - High input costs
  - Lack of formal credit institutions
  - Low prices for their produce

Why farmers get low prices?

- Farmers sell their produce via intermediaries who have market power

Why farmers get low prices?

- Farmers sell their produce via intermediaries who have market power
- Potential source of market power for intermediaries
  - Heterogeneous capacity to buy
  - Intermediaries with large capacity have more power

Why farmers get low prices?

- Farmers sell their produce via intermediaries who have market power
- Potential source of market power for intermediaries
  - Heterogeneous capacity to buy
  - Intermediaries with large capacity have more power

Question -

- Quantitative importance of intermediaries' heterogeneity in determining their market power
- Implications on farmer's welfare

Driving Question

- Competition among intermediary traders -
  * How, and by how much ...
  * traders are exerting market power matters for policy making

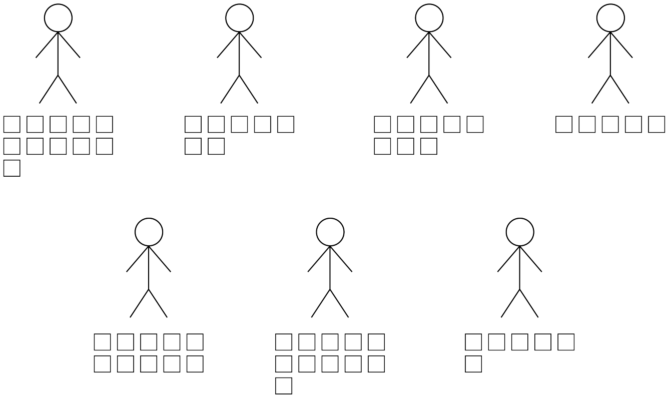
Driving Question

- Competition among intermediary traders -
  * How, and by how much ...
  * traders are exerting market power matters for policy making

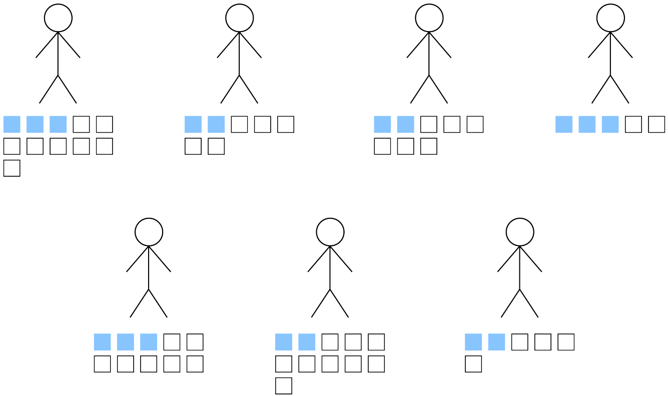
Context: Regulated intermediary market in India

- Intermediaries are capacity constraint
- ...and vary in capacity
- Intermediary gets license to trade in one market

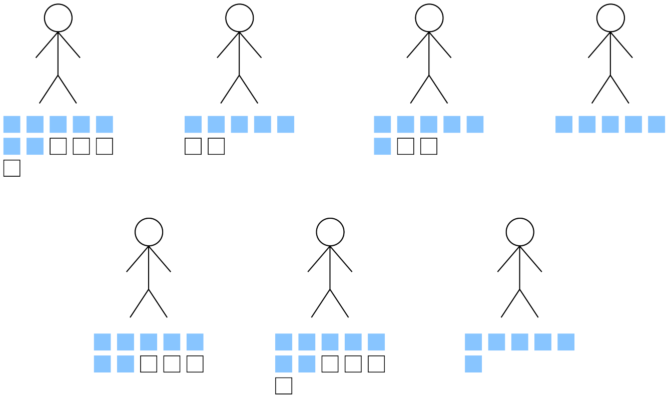
Core Mechanism



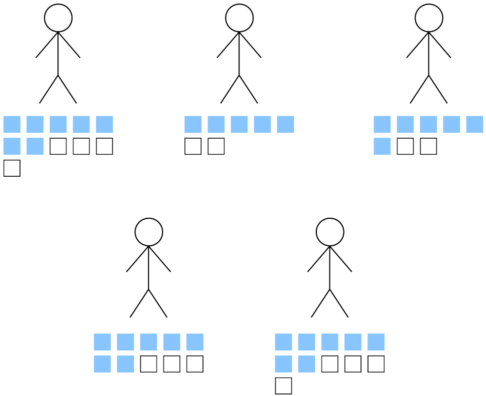
Core Mechanism



Core Mechanism



Core Mechanism



Preview of What I Do

Part I

- Empirical patterns to motivate the source of market power
- Impact of heterogeneity on the prices paid to farmers

Preview of What I Do

Part I

- Empirical patterns to motivate the source of market power
- Impact of heterogeneity on the prices paid to farmers

Part II

- Dynamic Model with bargaining which captures the market structure

Yet to do:

- Quantify the importance of competition on farmer's income
- Relationship between intermediaries' heterogeneity and prices

Rice Supply Chain in India

Farmers → Marketplace → Rice Millers → Rice → Consumer

Rice Supply Chain in India

Farmers → **Marketplace** → **Rice Millers** → **Rice** → **Consumer**

- Farmer sows paddy in July-Aug
- Harvested in Oct-Nov

Rice Supply Chain in India

Farmers $\longrightarrow$ **Marketplace** $\longrightarrow$ **Rice Millers** $\rightarrow$ **Rice** $\longrightarrow$ **Consumer**

- Government-licensed local market places
- Government laws dictate that farmers sell their produce only in the local markets

Rice Supply Chain in India

Farmers ⟶ **Marketplace** ⟶ **Rice Millers** → **Rice** ⟶ **Consumer**

Intermediaries

- Role is to convert paddy into rice ▸ Miller

Rice Supply Chain in India

Farmers → **Marketplace** → **Rice Millers** → **Rice** → **Consumer**

Seller (Farmers) *Buyer* (Rice Millers)

Data

- Time Period: 2013 - 2016
- Five rice miller's transaction-level data ▸ Data ▸ Map
  - Market share is $\sim 40\%$ in the *local market*
- Variables : Date of transaction, quantity and price transacted and the order of transactions
- Miller's daily total purchases - 2014
- Administrative Data: Daily paddy supply in *marketplace*
- *District:* 80% of the farmers are small
  - median size of the land holding is 1.08 hectares ▸ Land Holdings
- Data on rainfall

▸ No of Transactions

Typical Day in the Market

6.00am Farmers come to the marketplace

- place their produce around the marketplace ▸ Local Market

8.00am Millers come to the marketplace

- Go to farmers - negotiate and buy the produce ▸ Negotiation
- Farmers sell their produce to a single miller

9.30am Market ends

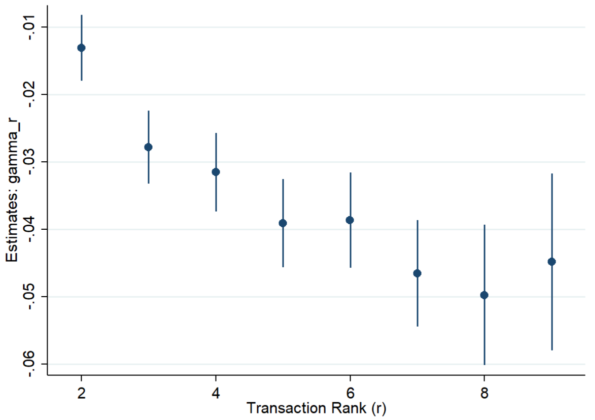
Fact 1: For each miller, later transactions get lower price

$$\text{logPrice}_{tmd} = \gamma_r + \gamma_m + \gamma_d + \epsilon_{tmd}$$

- *Transaction Rank* (r) is the order of transaction
    - Bunched together in groups of 10
    - $r = 1$ is the first 10 transactions of a miller on a day, $r = 2$ is the next 10 transactions, and so on
- Omitted Category is $r = 1$

Fact 1: For each miller, later transactions get lower price

$$\text{logPrice}_{tmd} = \gamma_r + \gamma_m + \gamma_d + \epsilon_{tmd}$$



I observe the downward trend after controlling for quantity transacted and number of days for payment delay.

Variation in price is not due to quality - 1

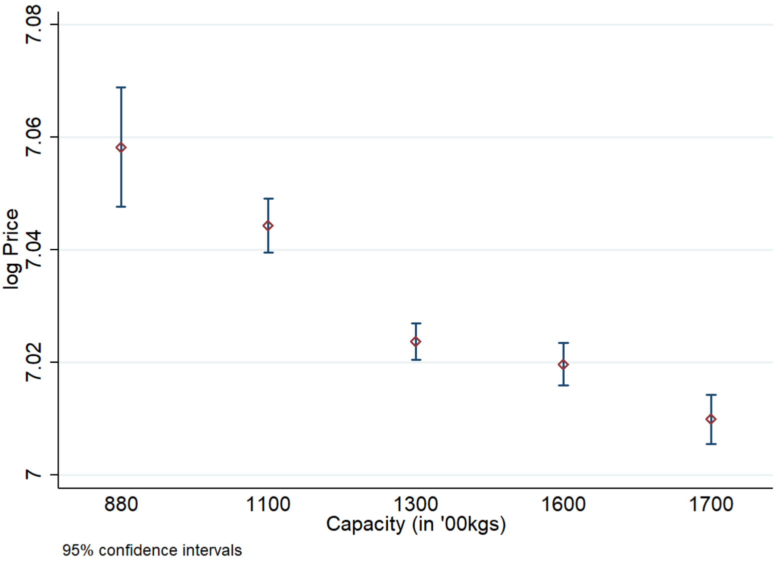
- Farmers cannot signal their quality to the miller
- Millers do not know paddy's quality without sampling it.

Variation in price is not due to quality - 2

- Main driver of quality for paddy is **moisture content**
- Lu, R., et al. (1995) - state that moisture content in paddy on a day can be predicted by the daily weather
  - Conditioning on the day, the quality of paddy should not vary a lot

Fact 2: Given the transaction, millers pay the same

Fact 3: Large capacity millers pay less



Fact 4: Millers buy relatively

$$\log \text{Quantity}_{dm} = \beta_w \text{Weeks from Harvest}_{dm} + \text{Rainfall}_{\text{mon}} + \gamma_m + \gamma_{\text{Year}} + \epsilon_{dm}$$

- Weeks from Harvest - Week from the first day that paddy comes to market

Fact 4: Millers buy relatively

$$\log \text{Quantity}_{dm} = \beta_w \text{Weeks from Harvest}_{dm} + \text{Rainfall}_{\text{mon}} + \gamma_m + \gamma_{\text{Year}} + \epsilon_{dm}$$

	log(Quantity Bought)		log(Quantity Bought)
Week - 1	0.293	Week - 5	-0.278
Week - 2	0.147	Week - 6	-0.636*
Week - 3	0.0669	Week - 7	0.124
Week - 4	-0.133	Week - 8	0.439
Constant	5.534***		
Rainfall	×		
Miller	×		
Year	×		
N	753		
R^2	0.294		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Other Facts

- Large millers buy more and do more transactions daily ▸ Fact 5

Farmers

- Farmers are fairly homogeneous in the quantity that they bring to the market ▸ Fact 6
- There is excessive supply in the market ▸ Fact 7

Forces at Play

- Beginning of the day, market is more competitive
  - More millers in the market

Forces at Play

- Beginning of the day, market is more competitive
  - More millers in the market
- For the millers -
  - costly to be in the market
  - they want to fill up to their capacity
- Small millers leave the market sooner
- Large millers are left in the market - giving them monopsony power

Forces at Play

- Beginning of the day, market is more competitive
  - More millers in the market
- For the millers -
  - costly to be in the market
  - they want to fill up to their capacity
- Small millers leave the market sooner
- Large millers are left in the market - giving them monopsony power
- High transportation and storage costs prevent farmers from delaying their sales

Outline - Environment

- Finite and discrete transactions t in a day
- Maximum number of transactions in a day - T
- On Day d millers and farmers enter the market
    - Each miller has fixed number of units that he buys
    - Fixed demand and supply for a given day

Outline - Environment

- Finite and discrete transactions t in a day
- Maximum number of transactions in a day - T
- On Day d millers and farmers enter the market
  - Each miller has fixed number of units that he buys
  - Fixed demand and supply for a given day
- Farmers are homogeneous and each sells 1 unit
- Millers
  - homogeneous in their value of unit v_d (retail price)
  - heterogeneous in their capacity (they buy different units)
- Farmers and miller match randomly to negotiate
- Price is negotiated via Nash Bargaining

Outline - Environment

- Finite and discrete transactions t in a day
- Maximum number of transactions in a day - T
- On Day d millers and farmers enter the market
  - Each miller has fixed number of units that he buys
  - Fixed demand and supply for a given day
- Farmers are homogeneous and each sells 1 unit
- Millers
  - homogeneous in their value of unit v_d (retail price)
  - heterogeneous in their capacity (they buy different units)
- Farmers and miller match randomly to negotiate
- Price is negotiated via Nash Bargaining
- Cost that a miller considers
  - of staying in the market - paid per transaction

Timeline: on any day

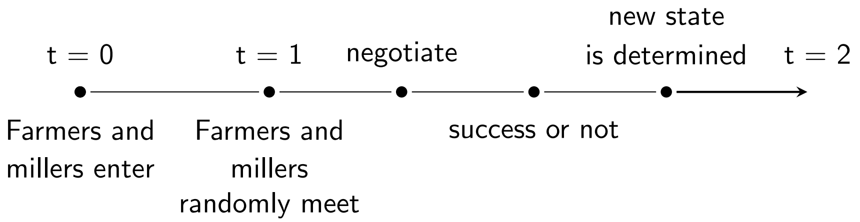
$t = 0$

•

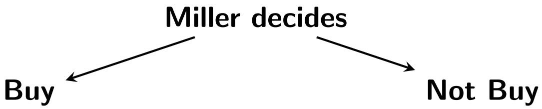
Farmers and millers enter

- Determines the initial state of the day
  - * Number of Farmers
  - * Number of Millers
  - * Distribution of Millers' capacity

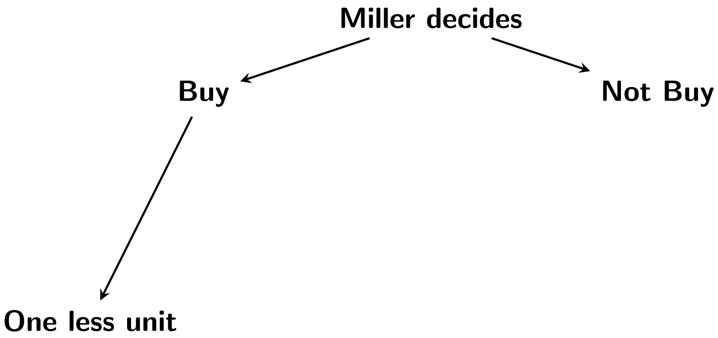
Timeline: on any day



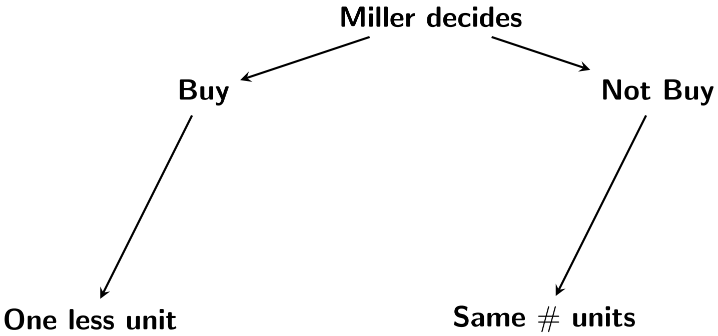
Optimization - Miller



Optimization - Miller



Optimization - Miller



Miller's Decision

- State of market for round t and day d

$$s_{td} = (M_{td}, F_{td}, C_{td})$$

  - M_{td} - Number of miller in round t and day d
  - F_{td} - Number of farmers
  - C_{td} - Vector of miller's leftover capacity in round t and day d

Miller's Decision

- Drop d subscript
- State of market for round t

$$s_t = (M_t, F_t, C_t)$$

Miller m in round t

$$K^m(s_t) = \max\{\overbrace{v - p_m(s_t) + \mathbb{E}[K^m(s_{t+1})|s_t, D_t]}^{\text{if he buys}}, \overbrace{\mathbb{E}[K^m(s'_{t+1})|s_t, D_t]}^{\text{if he does not buys}}\} - c_{mt}$$

Miller's Decision

- State of market for round t

$$s_t = (M_t, F_t, C_t)$$

Miller m in round t

$$K^m(s_t) = \max\{ \underbrace{v - p_m(s_t)}_{\text{Net value of a good}} + \underbrace{\mathbb{E}[K^m(s_{t+1})|s_t, D_t]}_{\text{Continuation Value}}, \mathbb{E}[K^m(s'_{t+1})|s_t, D_t]\} - c_{mt}$$

- v is the retail value of each unit
- D_t is the decision vector of all the millers in round t.
- c_{mt} is the transaction cost paid by miller
- Terminal Value, $K_{T+1} = 0$

Miller's Decision

- State of market for round t

$$s_t = (M_t, F_t, C_t)$$

Miller m in round t

$$K^m(s_t) = \max\{v - p_m(s_t) + \mathbb{E}[K^m(s_{t+1})|s_t, D_t], \mathbb{E}[K^m(s'_{t+1})|s_t, D_t]\} - c_{mt}$$

- Miller buys if his payoff from buying is higher than from not buying.
- A transaction is successful when the surplus is positive, i.e. $\mathbb{1}\{S_{mt} > 0\}$.

Optimization - Miller

Trade-off - 1

- Waiting to buy produce in the next transaction
- Cost of waiting

Trade-off - 2

- Delay purchasing decision
- Not filling upto his capacity

Farmer's Decision

Every time he matches with a miller, he decides based on

- Whether he will later match with a miller or not
- Type of miller that he matches with

Farmer's Problem

Value function of a farmer for round t is

$$V(s_t) = \theta_t^F \sum_m Prob(M_t = m)\mathbb{1}\{S_{mt} > 0\}p_m(s_t) +$$
$$(1 - \theta_t^F + \theta_t^F \sum_m Prob(M_t = m)(1 - \mathbb{1}\{S_{mt} > 0\})V(s_{t+1})$$

- $\theta_t^F = \frac{M_t}{F_t}$ is the probability of matching with a miller
- Terminal Value $V_{T+1} > 0$
  - * As a farmer has high transportation costs, he prefers to sell his produce on the same day.

Bargaining

Surplus from matching with miller m in round t is,

$$S_{mt} = v + A - B - V(s_{t+1})$$

where,

$$A = \mathbb{E}[K^m(s_{t+1})|s_t, D_t]$$
$$B = \mathbb{E}[K^m(s'_{t+1})|s_t, D_t]$$

Surplus is the sum of grain's value and his gain from transacting in period t, net of the farmer's continuation value.

Bargaining

Surplus from matching with miller m in round t is,

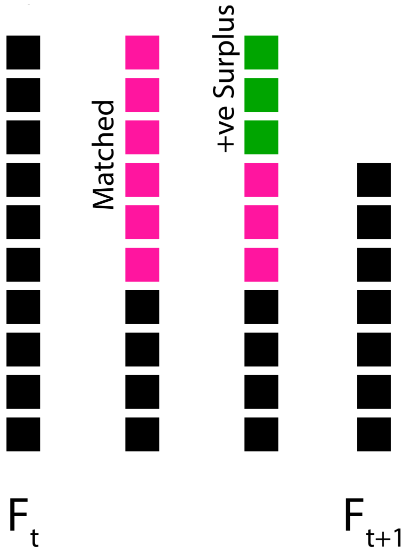
$$S_{mt} = v + A - B - V(s_{t+1})$$

where,

$$A = \mathbb{E}[K^m(s_{t+1})|s_t, D_t]$$
$$B = \mathbb{E}[K^m(s'_{t+1})|s_t, D_t]$$

- A positive surplus gets divided between miller and farmer proportional to their bargaining weight.
- Miller's payoff from buying is ρS_{mt} and farmer's payoff is $(1 - \rho)S_{mt}$.
- ρ is the bargaining weight for the miller.

Transitions: Farmers



Transitions: Millers and their capacity

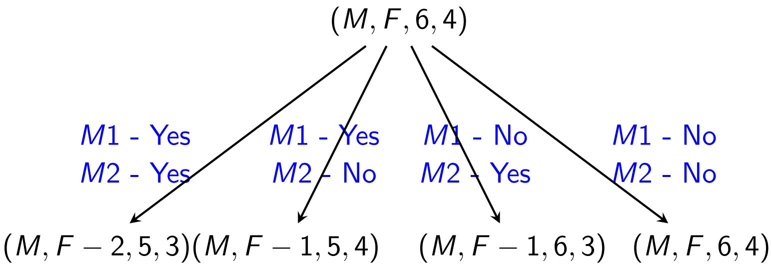
- Millers leave the market once the fill their capacity
- **Capacity** changes:
  - Decreases by 1 if they buy
  - Stays the same if they do not buy

Estimation: State Transitions

initial state: $(M, F, 6, 4)$

- $M = 2$
- $F > 10$
- $T = 2$: maximum number of transactions in a day

Estimation: State Transitions



Dimensionality Concerns

- As T - maximum number of transactions in a day increase
- As M - number of millers increase

Dimensionality Concerns

- As T - maximum number of transactions in a day increase
- As M - number of millers increase

Conjecture

- There are some states that never happen in the data
- What if I can remove such states from the model

Algorithm

- Start with limiting $T = 3$.
- List all the state transitions
- Solve the model for each parameter value
- I note the states that are not reached for all the parameter values - calling them *dominated*

Algorithm

- Start with limiting $T = 3$.
- List all the state transitions
- Solve the model for each parameter value
- I note the states that are not reached for all the parameter values - calling them *dominated*
- Increase T to 4
- When listing all the state transitions, I do not extend the states that were dominated for $T = 3$.

Algorithm

- Start with limiting $T = 3$.
- List all the state transitions
- Solve the model for each parameter value
- I note the states that are not reached for all the parameter values - calling them *dominated*
- Increase T to 4
- When listing all the state transitions, I do not extend the states that were dominated for $T = 3$.
- Keep doing this till $T = 50$.