Cluster-based Agricultural Transformation

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Outline

• Since the conference theme is “Agro-Allied Industrialization for Inclusive Growth,” I will use two case studies to highlight some Chinese experiences related to:
  – Mechanization
  – Specialization
Conditions of China’s Agricultural Production

• Extreme small farm size: about 0.5 hectare ≈ a football field (150 hectares in the US; 1.6 in Ghana; 2.25 in Nigeria).
Conditions of China’s Agricultural Production

- High degree of land fragmentation: 6 plots (often not adjacent) per farm.

- Real wages have grown at an annual rate of more than 10% since 2004.
China: some facts

• Water availability: \( \approx 5\% \) of world total

• Arable land: \( \approx 8\% \) of world total

• Population: 1.375 billion
  \( \approx 20\% \) world population
Economists’ Thinking

• Treating farm household as a production unit:
  – Output is a function of land, labor, and other input. Given constant (or even decreasing) returns to scale, the small farm size will be extremely inefficient.

• The conventional thinking is to increase farm size (therefore the scale of production).
  – Developing land rental markets;
  – Increasing mechanization
Ruttan on Mechanization

• “The seasonal characteristic of agricultural production requires a series of specialized machines --- for land preparation, planting, pest and pathogen control, and harvesting --- specially designed for sequential operations, each of which is carried out only for a few days or weeks in each season. This also means that it is no more feasible for workers to specialize in one operation in mechanized agriculture than in premechanized agriculture.” (page 190, Ruttan, 2001).
Pinglai’s View

• Prof. Pingali has written a very thoughtful and widely cited review article in the *Handbook of Agricultural Economics* (2007).

• He holds a similar pessimistic view on rice mechanization in Southeast Asian countries (page 2790):
  – “In the absence of land consolidation and the re-design of the rice land to form large contiguous fields, the prospects for large-scale adoption of the harvester-combines are limited.”
Will China Follow Japan’s Agricultural Development Model? (Otsuka)

- Japan: overly protected agricultural/rural sector.
- Due to small farm size, agricultural productivity is much lower than the US and domestic food price is several times of the international level.
- Given China’s similar natural endowment and rising wages, China’s agricultural production is likely to repeat Japan’s path.
Changes in the Grain Self-Sufficiency Ratio in Japan, Korea, and Taiwan
China’s problem could be potentially more serious

• Due to the absence of private ownership rights on land, land transactions cannot be made and land rental transactions are not as active as they should be.

• Due to the extremely small farm size, an average farmer has to rent in land from at least 16 other farmers to accumulate 10 hectares. It will be prohibitively costly to do so and, even if successful, a “large farm” may not be very efficient to support mechanization due to the dispersion of plots.

• The Chinese government began supporting agriculture massively, which reduces the pace of outmigration.

----Kejiro Otsuka (President Address in ICAE, 2012)
Yet, China’s Agriculture has performed quite well

• Yields (tons per hectare) went up from about 2.5 in 1978 to 4.3 in 2000 to 5.3 in 2012 (China Statistical Yearbook 2013, NBS).

• According to Jin, Huang and Rozelle (2009), the TFP for staples has grown at an annual rate of more than 2% since 1978; the annual growth rate of TFP for horticulture and livestock lies between 3% and 5%.

• Food self-sufficiency: \(\approx 96\%\) in 2014
Agricultural Total Factor Productivity (TFP) in China, India and Indonesia, 1961-2009

Base Year 1961=100

Data Source: Fuglie’s Worksheet 2011
Rural population under poverty in China

Rural population under poverty (million)

- National Poverty line 1: 100 Y/yr
- National Poverty line 2: 1196 Y/yr
- National Poverty line 3: 2300 Y/yr

Rural population under poverty (%)

- National Poverty line 1 (%)
- National Poverty line 2 (%)
- National Poverty line 3 (%)
How to Reconcile the Conundrum?
May, 2009, Sichuan Province
Distance from Peixian to Zizhong County: 1,079 miles (twice the distance between Accra and Abuja)
A Rice Harvesting Route

From the mid July to the end of November:
Hunan → Hubei → Sichuan → Shannxi → Jiangsu → Shanghai → Inner Mongolia → Northeastern provinces → Jiangsu → Guangdong → Guangxi
A Wheat Harvesting Route

Early April to early July:
Sichuan → Shanxi → Hunan → Hubei → Jiangsu → Shandong → Tianjin
Answers to the Conundrum

• Agricultural production is divisible.
• Some steps of production, such as ploughing and harvesting, can be outsourced to others.
• Even in the US, migratory harvesting and pollination service are popular.
  – Steven Chang “The Fable of Bees: An Economics Investigation” JLE (1973)
  – Nordhaus “The Beekeeper’s Lament”
Conditions for Outsourcing

- Market size: The division of labor is limited by the extent of the market (Stigler, JPE 1951).

- Machinery cost: combines are much more expensive than attached disc ploughs.

- Asset specificity: tractors have multi-functionality, while combines don’t have.

- High labor cost.
Rice Production Steps

**Economics text book:** Cobb-Douglas or CES production function
Labor+capital+land+other inputs → Rice

**Traditional rice production:**
Land preparation → planting → weeding → irrigation
(draft animals or labor) (labor) (labor) (pumps or rain-fed)

→ harvesting → threshing → drying
(labor) (labor, animal, or threshers) (labor)

**Current practice in China:**
Land preparation → planting → weeding → irrigation
→ harvesting+threshing
(Tractors) (most by hand) (herbside+labor) (pumps) (combine harvester)
Rice Harvesting: National Market

• Rice is planted in many parts of China, mostly in flat areas. Thereby migratory labor-cum-machine service providers can travel up to 8 months to recoup the high cost of combines, which have no other uses.

• In a small country, such as Japan, migratory harvesting is not feasible because of low regional variations in seasons.
Division of Labor in Agricultural Production

C2: Average cost of non-harvesting steps
C1: Average cost of harvesting

Adapted from Stilger (1951 JPE paper)
### Use of Mechanization in Rice Production

<table>
<thead>
<tr>
<th></th>
<th>Using machinery</th>
<th>Hiring mechanization service</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plough</td>
<td>0.94</td>
<td>0.77</td>
</tr>
<tr>
<td>Plant</td>
<td>0.11</td>
<td>0.82</td>
</tr>
<tr>
<td>Harvest</td>
<td>0.77</td>
<td>0.97</td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plough</td>
<td>0.91</td>
<td>0.75</td>
</tr>
<tr>
<td>Plant</td>
<td>0.08</td>
<td>0.76</td>
</tr>
<tr>
<td>Harvest</td>
<td>0.60</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Based on authors’ complementary survey attached to RCRE survey in 2013.
Ploughing market is mostly local because the ploughs attached to tractors are much cheaper and tractors can be used for other purposes in the slack seasons.
## Agricultural Output and Input

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Growth rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain output value per household ($)</td>
<td>455.34</td>
<td>423.73</td>
<td>435.88</td>
<td>501.73</td>
<td>531.94</td>
<td><strong>16.82</strong></td>
</tr>
<tr>
<td>Land size (hectares)</td>
<td>0.53</td>
<td>0.53</td>
<td>0.51</td>
<td>0.53</td>
<td>0.54</td>
<td>0.92</td>
</tr>
<tr>
<td>Labor input per hectare (days)</td>
<td>213.45</td>
<td>210.00</td>
<td>206.40</td>
<td>201.30</td>
<td>189.45</td>
<td><strong>-11.24</strong></td>
</tr>
<tr>
<td>Machinery fee per hectare ($)</td>
<td>45.69</td>
<td>52.40</td>
<td>58.51</td>
<td>68.43</td>
<td>75.79</td>
<td><strong>65.89</strong></td>
</tr>
<tr>
<td>Seed fee per hectare ($)</td>
<td>32.18</td>
<td>34.45</td>
<td>36.18</td>
<td>38.67</td>
<td>41.22</td>
<td>28.11</td>
</tr>
<tr>
<td>Fertilizer fee per hectare ($)</td>
<td>109.68</td>
<td>119.59</td>
<td>122.67</td>
<td>131.13</td>
<td>154.44</td>
<td><strong>40.81</strong></td>
</tr>
<tr>
<td>Pesticide fee per hectare ($)</td>
<td>22.47</td>
<td>26.24</td>
<td>26.52</td>
<td>29.75</td>
<td>31.00</td>
<td>37.94</td>
</tr>
<tr>
<td>Irrigation fee per hectare ($)</td>
<td>31.18</td>
<td>30.91</td>
<td>34.81</td>
<td>35.22</td>
<td>34.19</td>
<td>9.64</td>
</tr>
</tbody>
</table>

Data: RCRE 2004-2008  
Constant US dollars in 2004 price
Machinery Power and Draft Animal

![Graph showing the comparison of machinery power and draft animals over time.](image-url)
China passed the Lewis turning point in 2003/2014: Real wages have increased by more than 10% per year since then.
Small and Big Tractors

Lewis turning point
Cross-Regional Mechanization Harvest Service

- Often clustered;
- 3-4 operators per team; Traveling in flocks (average 10 trucks) with combines on the top;
- Chasing production seasons for up to 8 months (average half year);
- Charging fee only half of the cost of hiring labors (about US$200 per hectare).
Peixian Harvesting Service Cluster

• 36 rural mechanization cooperatives;
• 2,100 combine harvesters (mainly for wheat and rice);
• 1,100 are engaged in cross-province harvest service.
• Cross-regional harvest service started in 1998 with 50 combines largely supported by the county agricultural mechanization bureau.
The Scale Economy of Cross-Regional Mechanization Service
Advantage of Traveling in Groups

• Better coping with harassment and extortions from local gangs;
• Greater bargaining power with local agents thanks to large scale of harvesting;
• Pooling spare parts for repairing (even bringing a service truck);
• Sharing the search cost (like scout bees)
### Income and Cost Per Team

<table>
<thead>
<tr>
<th>Variable</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Net income ($)</td>
<td>14,285.71</td>
</tr>
<tr>
<td>2. Total costs ($)</td>
<td>22,539.68</td>
</tr>
<tr>
<td>a) Repair and maintenance</td>
<td>3,174.60</td>
</tr>
<tr>
<td>b) Employee wages</td>
<td>7,936.51</td>
</tr>
<tr>
<td>c) Telephone</td>
<td>317.46</td>
</tr>
<tr>
<td>d) Food/lodging while traveling</td>
<td>4,761.90</td>
</tr>
<tr>
<td>e) Gasoline/diesel</td>
<td>6,349.21</td>
</tr>
<tr>
<td>3. Area served (hectares)</td>
<td>133.33</td>
</tr>
<tr>
<td>4. Days working away from home</td>
<td>179.00</td>
</tr>
</tbody>
</table>

About six times of rural per capita income in Jiangsu Province.
Role of Government

• Central level:
  – Machinery purchase subsidy;
  – Waive highway tolls.

• Local level:
  – Distributing harvest calendars;
  – Training, inspection;
  – Conflict resolution for those on the road;
  – Setting up cell phone group message platform
Conclusions and Implications

• Lack of production scale has been regarded as a major constraints of smallholder farmers in developing countries.

• We show that agricultural production is divisible and some steps of production can be sourced to specialized service providers which run at a much larger scale.
Implications

• Collier and Dercon (2009) argue that African agriculture's future lies in large farms because smallholder farmers lack sale of production.

• Peter Hazell holds an opposite view: Smallholders are more efficient due to advantage in incentive and information.

• Is there a future for smallholder farmers in Africa?
Teff threshing in Ethiopia
Migratory plowing service: The driver drives tractors for three months and combines for three months.
Second ploughing after mechanized ploughing in Ethiopia

Increase the sown area, which in turn drives up demand for agricultural labor

Remedy the absence problem during harvest time in the manufacturing sector
Ghana, 2011
60 Cides (0.3 US dollars per bag) * 100 = $30 per day for 15 days.
Due to labor shortage, seeds are broadcasted
winnowing rice in Myanmar
Rice harvesting in Myanmar, March 2015
Daily wage has increased from $3/day in 2014 to $4 in 2015
Specialization: Anding Potato Cluster

• Anding of Gansu Province used to be one of the poorest places in China (poverty rate 78% in 1980) and didn’t produce potato until 1960s.

• Now it has become one of the three largest potato production centers in China.

• Potato accounts for two-thirds of the cropping area; Anding provides every Chinese with one kg potato per year. Farmers generate about 60% of their income from potatoes.
Major Potato Production Centers in China

Anding potato cluster

Zhang and Hu, 2015, *World Development*
Improve Land Quality

From the 1950s to 1990s, the government made great efforts to build terrace fields and irrigation facilities at the river basin level. Of the land compatible to terracing, 93.7% of it has been converted into terrace.
Adopt Potato Production

• Potato is more suitable to the dry environment than wheat. Anding receives only 380mm rainfall per year, compared to 1389mm in Abuja, 809mm in Accra, and 980mm in Kano (capital of Niger).

• Potato was introduced in the 1960s as a secondary crop for coping with food shortage. However, wheat is much more appealing than potato in the Chinese diet. In addition, government had guaranteed procurement price for wheat but not potato.

• The local government first asked village cadres to set up demonstration fields on their own land. It took years to scale up potato production as seen below.
Breed Better Varieties

• Gansu Academy of Agricultural Science bred a high yield variety for starch processing (high starch and low sugar contents).

• County agricultural extension station and a farmer accidently bred Xiadaping, the most popular vegetable potato; the “Atlantic” was imported from the US for chips and French fries.

• The county set up a breeding center to produce toxin-free potato seeds. Anding is one of the largest potato breeding centers in China.
Price Shocks and Shift in Government Policy

Shift in government policies from stimulating supply to expanding market
Market Equilibrium in the Supply/Demand Expansion Phases

Source: Drawn by authors.

Note: Policy interventions that shift the supply curve $SS'$ include improving land quality, breeding better varieties, and so on. Local policies that move the demand curve $DD'$ up include lobbying for more freight car quotas, building storage capacity, and developing processing industries.
Expand the Market

- Establish trader and producer associations.
- Update market information systems.
- Set up a new system of local wholesale markets.
- Apply for more freight car quotas.
- Subsidize farmers to build storages.
Acquire and Spread Market Information

• The potato association sends informants to live in major wholesale markets nationwide to collect market information.

• The county broadcasts the information in local media (radio, TV, and newspapers) and on large monitors in major gathering places (central squares, railway and bus stations).

• Greater market transparency makes it harder for traders to cheat farmers.
The Spatial Distribution of Markets Over Time

☆: Wholesale market
○: Village collection point
Blue: Built 1996-2000
Red: Built 2001-2005
Yellow: Built 2006-2010
Overcome Transportation Bottleneck

- Lobby for more freight car quotas (up from 1507 in 2003, to 3605 in 2004, and 6145 in 2009).

Transportation cost to Shanghai:
By car: 450 yuan/ton
By train: 225 yuan/ton

Anding to Guangzhou:
Anding, China: potato train
Build More Storages (55% of annual output)

Centrally air conditioned: 10000 ton each

Natural ventilation storages: Medium size

Small natural ventilation storages: 0.185 million tons

Farmer’s storage: 0.36 million tons

More than 2 storages per household

200 Yuan Subsidy/storage

Farmer’s storage: 0.36 million tons

More than 2 storages per household
Develop the Processing Sector

• Local government intensified their effort to attract investors:
  – Provide free land
  – Help secure subsidized bank loans
  – Guarantee stable potato supply

• The number of processing plants increased from 0 in 2003, 2 in 2004, to 12 in 2009. Now it can process about 1/3 of total output.
Develop the Processing Sector

• In 2004, the first two plants produced only starch.
• Quickly, the product lines have become more diversified:
  – Modified starch for industry use
  – Frozen French fries for fast food chains
  – Potato chips
  – Potato flour
  – Even export to the Middle East and Southeast Asia.
Role of Local Government

• Developing clusters is a continuous process with constantly involving in overcoming constraints.

• The one-size-fits-all type interventions may work for once, but not all the time.

• After a policy helps remove one binding constraint, another emerges, that in turn, requires a new set of local policies.

• Continuous tinkering is often required.
Role of Local Government

• Most clusters are at the local level. Their development involves constantly tinkering with various bottlenecks.

• It is important to put local governments on the driver’s seat considering their informational advantage.

• A question arises: how to align local governments’ interest with local economic development?
Role of Local Government

• In China, local governments have strong embedded interests in promoting cluster/industrial park development:
  – Fiscal competition among local governments
  – Career competition among local officials

• More research is needed to understand the incentive structures of local governments in other developing countries.
My presentation is mainly based on the following two publications:
