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Research Case Study:
The Organization of Contracting and Quality Control
in Dairy Supply Chains in Kyrgyzstan

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Kyrgyz dairy sector

- Dairy is an important sector
 - 90% of households consume milk
 - accounts for almost 50% of food and beverage exports
 - important source of income for smallholder farmers
- Transformation after the end of the Soviet period
 - initial contraction
 - raw milk from large operations to households
- Dairy processing is now relatively well developed
- Most of raw milk is supplied by households

Sources: FAO, WB, Cattle Site

Survey of participants in dairy supply chains in Kyrgyzstan

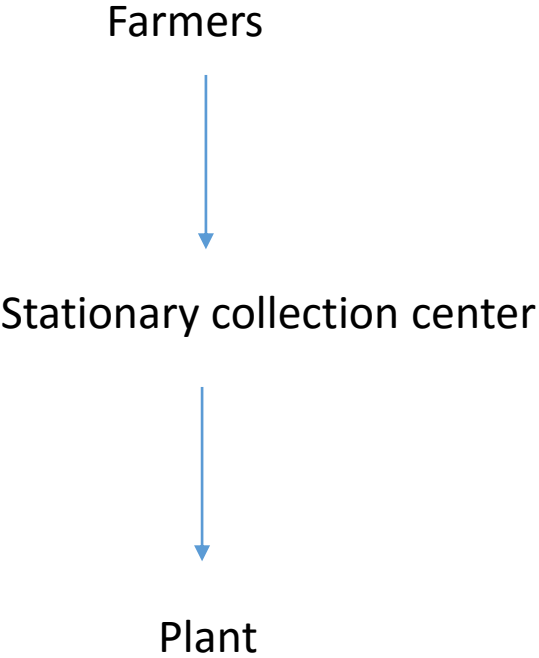
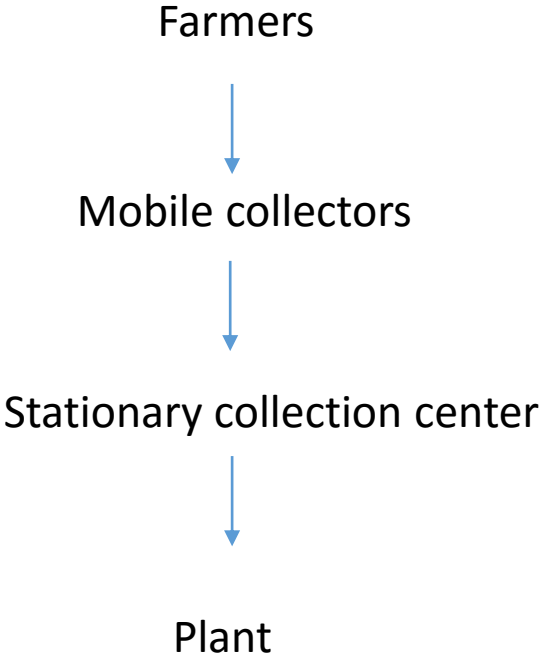
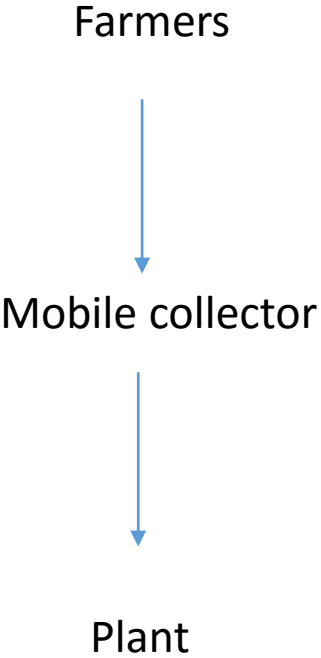
(by IFPRI and Kyrgyz National Academy of Sciences, September – October 2014)

- Dairy farmers (520), collectors (12 stationary and 53 mobile), and 26 (out of 31) plants in Chui, Issuk-Kul, Narun and Talas oblasts
- **Farms**
 - small cow herd: 2 dairy cows per household
 - farm-gate price of raw milk is 30% of retail price
 - low quantity and quality: yield is 20 - 30% of potential, fat content is substandard
 - low investment in milk production: local breeds, expenditure on animal health is 3%
- **Collectors**
 - mobile collectors: aggregate milk, visual and smell inspection of individual quality
 - stationary collection centers: fat content and level of bacteria can be measured
- **Processing plants**
 - private companies (limited liability corporations, joint stock, other)
 - no direct relationships with farmers
 - no external certification of quality of milk/dairy products
 - capacity underutilization: shortage of raw milk in terms of both quantity and quality

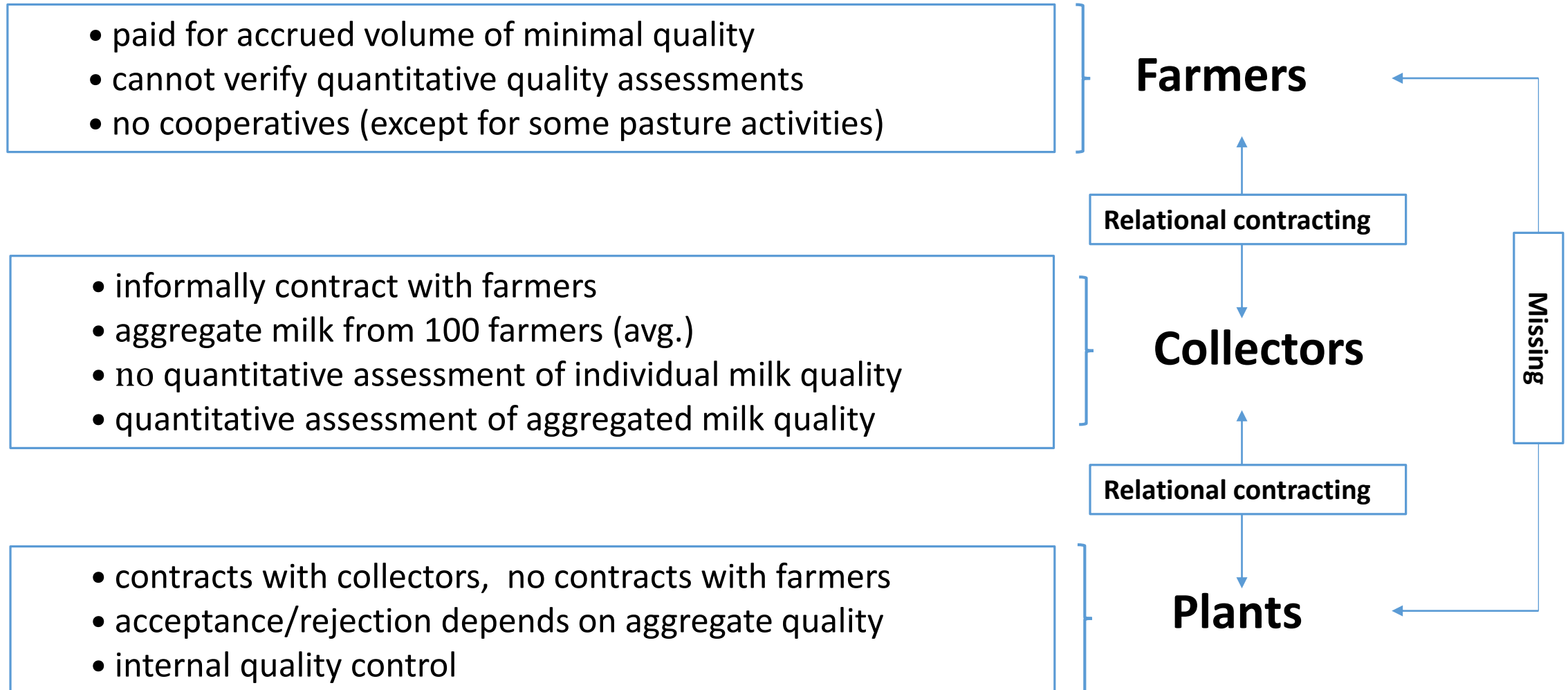
Milk collection is based on informal contracts

- **mobile collectors** (85%, 11.6 liters per farmer)
- **stationary collection centers** (15%, 8.6 liters per farmer)
- neighbors (9 liters per farmer)
- local markets (24 liters)
- milk plant (8 liters)

Typical milk collection system



Contractual arrangements and quality control in the value chain



Research questions

1. Why do plants not assess individual milk quality through testing?

- testing costs can be controlled through random testing
- observability of test outcomes may play an important role

2. Why do plants not contract with and pay farmers?

- local information about milk quality: (farmer, collector), (collector, plant)
- non-verifiable milk quantity and quality
- private relational contracts

3. Why do plants not engage in external quality control and product certification?

- convincing consumers of their quality through third-party certifiers

Survey of dairy farmers

- 520 respondents in four oblasts
- list of farmers from various sources:
 - government offices
 - plants' catchment areas
 - randomization across towns

General dairy business characteristics

Experience with domestic dairy	19 years (since 1991-1992)
Experience with supplying raw milk	9 years
Income from selling raw milk	\$100/month
Main income source	50%
Consistently profitable	46%
Member of a cooperative/ farmer organization	0%

Long-run inputs

Number of cattle and composition

Herd size	
average	2 heads of cattle
less than 10	95%
30 – 60 head of cattle	1% (5 farms)
Number of dairy cows	
less than 3	92%
less than 10	98%
Landrace (Ala Tau)	97%
Dairy cattle value	
Ala Tau	\$758/cow
Holstein	\$1092/cow

Housing, milking equipment, and transportation

Cow sheds	
ownership	100%
capacity	2-10 cows
Milking machine	3%
Transportation	
by tanker truck	84%
independent collector	48%
affiliated with a collection center	19%
affiliated with a milk plant	17%
by own means to a collection center	15%
on foot	14%
own transport	<1%
Selling to neighbors	<1%

Short-run inputs

Feed sources

Pasture (distant)	10%
selling to outside buyers while on pasture	2.5%
Own feed crops (hay, barley, beet, corn)	84%
Cropland for feed	3 ha
Purchased feed	70%
Purchased feed not from neighbors	43%
Purchased from a long-term feed supplier	16%

Feed supplements

Feed supplements	
salt	54%
bran	49%
alfalfa	31%
food waste	22%
corn	18%
feedstuffs	17%
potatoes	14%
bean stalks	12%
beets	3%
glycerin, monohydrate crystallized glucose, sugar, vitamins, and branded supplements	<1%

Water sources and cleaning supplies

Water	
for cows (drinking)	
pump (piped)	65%
river	83%
stream	18%
well/groundwater	4%
for washing cows and udders	
pump (piped)	91%
river	6%
well	3%
Cow shed	
drainage	55%
slanted flooring	65%
rubber/cement flooring	<1%
daily cleaning	96%
Special brush for hide cleaning	58%
Near milking station	
sink with running water	83%
sink with running hot water	16%
soap and towels	86%
Washing hands with soap after cleaning cows	85%
Special robe when milking	53%

Farming practices

Animal care and health

Cows are in a fenced-off area	100%
Contact with wild animals	33%
Disaggregation of sick and healthy cows	14%
Medicated cows	
by themselves	52%
using uncertified drugs	20%
Consulted a veterinarian	92%
Satisfied with their veterinarian	93%
Government veterinarian vaccinated cows	100%
twice a year	81%

After-milking on-farm storage practices

Cooling after milking in the morning	none
Cooling after milking in the evening	64%
no need for cooling in the evening	34%
refrigerator cooling	56%
water	9%
Boiling for home consumption	30%

“Out-of-pocket” cost of animal health care: less than 5% of income

Total expenditures on medical treatment	\$8 - \$16 / year
less than \$33	93%
Cow shed	
sanitation	\$8 / year (<\$33 for 97%)
wooden flooring and insulation	\$49 / year (<\$326 for 93%)
Outbreaks of infectious animal diseases	2%
Sold milk from sick cows	3%
Feed contaminated with	
unapproved chemicals	1%
mold	2%

Milk quantity and quality

	Survey	Developed countries
Total milk production	12 (liters/day)	30 per cow/day
Fat content (120 responses, avg)	2.98% (2.5 - 3.42)	3.5 – 5.5%
Milk density (49 responses, avg)	1.0268 g/m ³ (1.0257 – 1.0278)	1.026 – 1.032
Acidity, protein, solids, somatic cell count, bacterial count	unknown	

Marketing channels

Mobile collector (delivering to stationary center or milk plant)	83%
Stationary collector	15%
Neighbors	2%
Marketplace	<1%
Milk plant	<1%

Monitoring of quality: mixed evidence

Individual assessments

	Mobile	Stationary
Cleanness	80% (60%)	80% (11%)
Smell	50% (37%)	63% (8%)
Fat content	50% (72%)	94% (12%)
Density measurement	83% (68%)	88% (13%)
Acidity measurement	80% (59%)	74% (9%)
Solids, protein levels, bacterial count, and somatic cell count	0%	0%

Frequency of evaluations

Frequency	Mobile	Stationary
each time	20%	40%
once a week	54%	45%
less frequently than once a week	25%	12%
never	1%	3%
Collector returned milk at least once	2%	

Relational contracts with farmers

Agreements specify	
price	66%
minimum quantity (>10 liters)	none or not consistent
minimum quality	none
financing or input provision	none
Duration (avg)	6.8 years
Trust (degree of trust >90%)	100%
Delayed payments	<2%

Among farmers selling to	Stationary collector	Mobile collector
selling more than 5 years	85%	70%
never delivered to others buyers within last 5 years	77%	70%

Reasons for switching to a different buyer (out of those who switched)	10%
personal relationships	33%
low price	25%
changes in transporting arrangements	20%
delays in compensation	13%
more convenient location	10%
Alternative buyers (collectors, schools, local markets) are easy to find	80%

Survey of milk collectors

	Stationary	Mobile
Number	9 large stations 3 small stations (in stores)	53 tank trucks
Representation across milk plants		
number of collectors per plant	1 – 3	1-8
number of different milk plants	8	16
Ownership and status		
independent firms	67%	100% (?)
owned by the milk plant	33%	
Business history	6 years (1 – 18)	6 years (1 – 22)

Transport, cooling and storage equipment

	Stationary	Mobile
Value of cooling and storage facilities	\$5327 (\$40 - \$24,424)	none
Number of supplying farmers regular occasional	343 (18 – 1400)	118 (13- 1500) 113 31 (<10% of total)
Milk volume (liters/day) per farmer	6990 (200 – 25000)	1111 (100 – 5500) 13 (5 – 70)
Method of inbound delivery		
own trucks	all large centers	
farmers deliver themselves on foot	42%	
farmers deliver by truck	8%	
Truck fleet at large collection centers	8 trucks (up to 21 trucks)	
Accepted milk from not own trucks	66%	
Milk delivered by own trucks	4500 liters (2/3 of total volume)	

Quality assessment equipment

Measurement technologies	Stationary	Mobile
fat	75% (all large)	20%
density	75% (all large)	90%
acidity	92%	53%
bacteria count	8% (1 collector)	none
temperature	none	43%
cost of equipment (estimated)	<\$100	<\$30
time per test (estimated)	5 minutes	5 minutes

Farmer price discounts

Discounts for	stationary	mobile
fat content	75%	49%
acidity	75%	36%
density	58%	57%
taste	33%	8%
smell	25%	15%
temperature	25%	none
alcohol test	16%	<1%
bacterial contamination	8%	none

Farmer premiums for quality

Premium for quality	stationary	mobile
monetary	25%	<1%
other (holiday gifts or unspecified)	33%	26%
none	42%	70%
Farmers were told about quality discounts/premiums	75%	66%

Monitoring by collectors

Daily visual inspection (with testing if needed for stationary collectors)	75%	100% not fewer than 3 farmers 50% fewer than 35 farmers
Daily sample collection	16% (4 – 11 samples)	
none	8%	<1%
Frequency (for mobile collectors)		
each pick-up		60%
once a month		15%
only if suspicious		23%

Rejections by collectors

Rejection criteria	stationary collectors	mobile collectors
bad smell, taste or high acidity	100%	100%
fat content less than 2.5 - 3.5%	100%	
fat content less than 2.8 - 3%		73%
fat content less than 2.2 - 2.5%		10%
minimum density 1024-1026 (kg/m ³)	100%	69%
minimum density 1020 - 1022 (kg/m ³)		8%
minimum density 1032 (kg/m ³)		11%
positive alcohol test		6%
milk turned sour		8%
Rejection rates		
none	75%	30%
more than once in the past	25%	70% (up to 100)

Collector price, rejection rates, and quality assessments by milk plants

	Stationary	Mobile
Standard price formula:	none	none
Price depends on		
fat	60%	94%
density	42%	80%
acidity	42%	80%
smell	33%	
cleanness	33%	40%
taste	25%	
protein	25%	17%
temperature	17%	5%
bacteria	17%	8%
somatic cell count	(?)	
Daily monitoring and performance feedback by the plant	100%	100%
Rejection by milk plant		
total 1 - 15 occurrences	up to 15 occurrences: 58%	up to 40 occurrences: 2%
never	42%	85%
Trust in milk quality assessments by the plant	75%	93%

Contracts and agreements between collectors and plants

Formal contracts	Stationary	Mobile
with farmers	none	none
formal with milk plant	75% (all large collectors)	80%
informal with milk plant	25% (small collectors)	17%
no contract with milk plant	none	3%
Farmers provide certificates of cow health	100%	100%

Trust that farmers and truck operators exert efforts to ensure quality

Trust		
high degree	33%	40%
low degree	33%	30%
somewhat	33%	30%

Mobile collectors (additional certificates)

Permits/licenses	
from milk plants	68%
from government health authorities	6%
none	25%
Certificate of driver's health	25%
Certificate of compliance with safety norms for their truck	17%

Survey of dairy plants

Business history	12 years (2- 50)
Milk quantity processed	40,000 (80 – 600,000) liters/day
Underutilized capacity	56% (25% – 93%)
Output (kg/liters)	
packaged milk	15,500
ice cream	16,500
kefir	6,750
dry milk	3,466
yogurt	900
sour cream	812
butter	751
cheese	590
cottage cheese	313
Country of destination	
domestically	100%
Kazakhstan	67%
Russia	4% (1 plant)

Number of farmers and collectors

Farmers (12 responses)	1189 (10 – 3500)
Stationary collectors	
owned (10 responses)	8 (1 – 50)
independent (2 responses)	10 - 20
Mobile collectors	
owned (12 responses)	7 (1 – 26)
independent (20 responses)	10 (1 – 31)
Own laboratories for quality testing	100%

Contracts with collectors

Contract/agreement with independent stationary collectors	
written contract	23%
none	77%
Contract/agreement with independent mobile collectors	
written contract	73%
none	27%
If signed, contract specifies	
payments	100%
acceptance according to the delivery schedule	78%
minimum quality	100%
delivery according to schedule	68%
veterinary certificates from farmers	58%
Turnover among stationary collectors	
infrequent	100%

Contracts with farmers

Who sets the farm-gate price	
plant	27%
collectors	11%
market	62%
Formal contracts with farmers	26% (?)

Question 1. Why is there so little quantitative assessment of individual quality?

Hypothesis 1: *When quality is non-verifiable, contracting with a small team of suppliers rather than with each supplier individually is optimal because it allows the buyer to commit to buy or not buy the aggregated output*

=> **farmers rationally reduce quality until it is just marginally acceptable to the buyer**

=> **free-riding in team production alleviates shirking on non-contractible quality**

This happens if

- contractual payments are contingent **on quantity but not on quality**
- farmers are subject to cost shocks and cannot collude against the buyer
- small uncertainty about the buyer's willingness to pay for quality

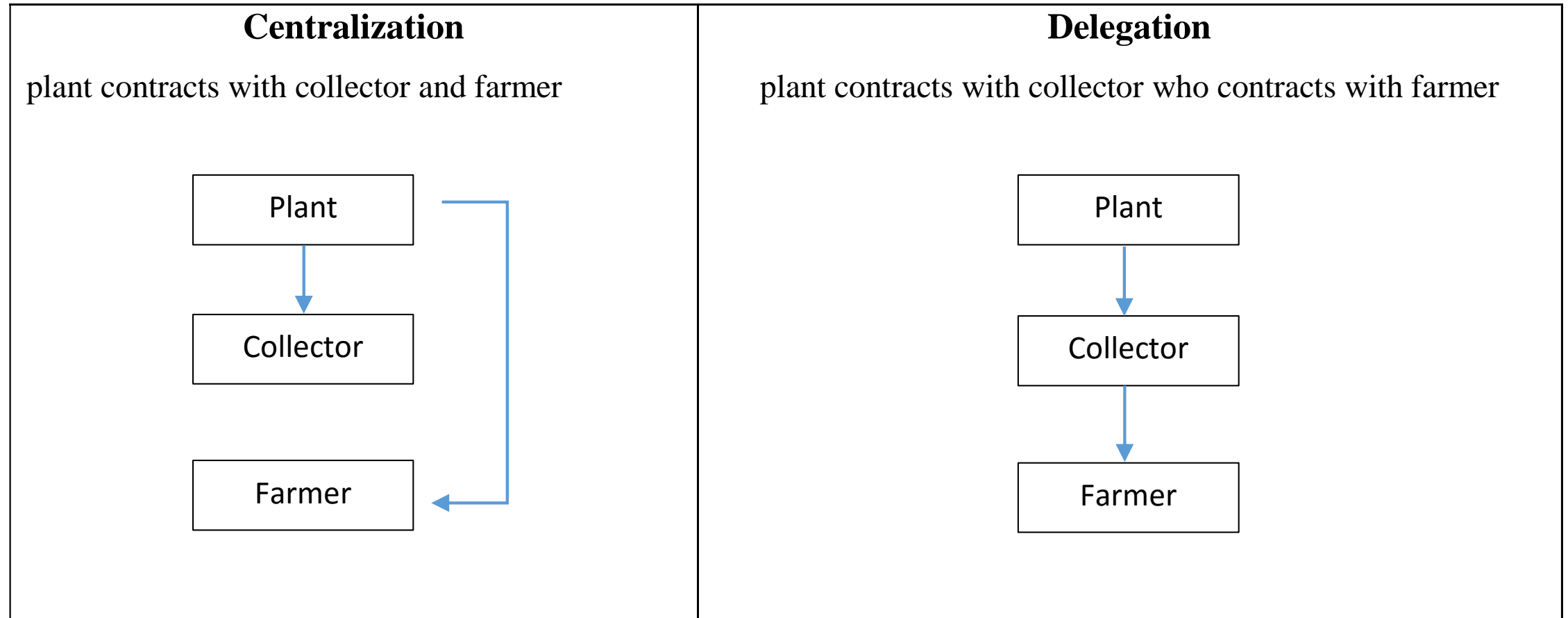
Policy implication

Third-party assessment of milk quality can improve farm practices and farmer incomes

Question 2. Why do plants delegate paying farmers to milk collectors?

- **Diversity of contractual arrangements** between farmers and buyers
 - **centralized model:** plant contracts and pays farmers
 - **intermediary model:** plant contracts/pays middlemen who contract/pay farmers
 - **relational incentives** to enforce the terms of the contract:
reneging on promises may result in future retaliation

Centralized versus decentralized contracting arrangements



Economic forces and incentives

- **Centralized model of contracting:**

- (+) plant controls payments to farmers
- (-) farmers are tempted to corrupt collector to maximize payments total payments

- **Intermediary model of contracting:**

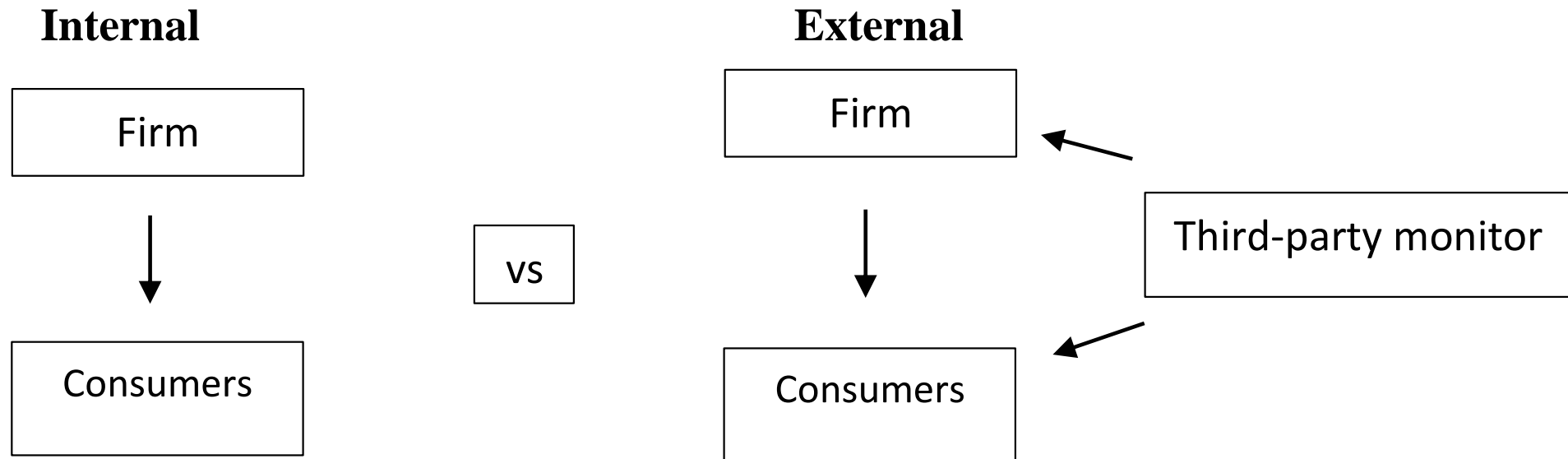
- (+) collector internalizes the cost of procurement
- (-) collector controls payments to farmers
- (-) collector is tempted to corrupt farmers to maximize his net payments

Hypothesis 2: *Intermediary model is more profitable if intermediary's information about quality is imprecise*

Intuition:

- if information is precise => farmer's **rent is small** =>
 collector easily corrupts farmer under delegation => centralization of contracting is optimal
- if information is imprecise => farmer's **rent is large** =>
 farmer easily corrupts collector under centralization => decentralization of contracting is optimal
- delegation can cause inefficiencies in monitoring and quality provision
- Policy implications
 - contracting arrangement **interacts** with incentives to invest in productivity, quality, and monitoring
 - improving **quality assessment** at farmer level can lead to centralized contracting

Question 3. When is external quality control more profitable?



Incentives to engage in quality control

- Moral hazard concerns in quality control
 - obtain information about quality
 - react to this information

Internal monitoring

advantage: no third-party rents

disadvantage: both concerns are present

External monitoring

advantage: concern with allocation is gone,
if reports are observable to consumers

disadvantage: incentives through fixed fee are costly

- **Hypothesis 3:** *Internal quality control is more profitable if trades are sufficiently frequent and consumer information is sufficiently precise*
- **Policy** of mandatory third-party certification of food safety
 - too little voluntary certification, if trades are infrequent and consumer information is noisy
 - mandatory certification decreases welfare, if otherwise

Discussion

- **Different problems at different points in the value chain**
 - **aggregation** of raw milk from multiple farmers: free-riding problem among upstream suppliers
 - **intermediary model of contracting**: intermediated links between farmers and final buyers
 - **internal quality control**: good or bad for consumers' trust in local industry?

Methodology

- **Detailed survey of farmers, collectors, and plant managers**
 - pilot survey to test questions and responses
 - length and detail
 - identifying potential respondents
 - drawing a sample: plants - catchment areas – farmers
- **Contract theory**
 - non-verifiable quality characteristics
 - private information
- **Institutional design**
 - team production and size
 - delegation of contracting
 - delegation of quality control

Teaching notes

- survey design and cross-checking
- real-world examples of contractual frictions
- study of the organization of supply chains through the lens of incentive theory
- randomized control trials:
 - smaller farmer teams
 - the plant pays farmers
 - third-party certification of final products
- policies and regulation to improve quality control and profitability
 - individual milk testing
 - formal contracting
 - certification institutions

Additional Slides: Dairy Farmers

Demographic characteristics

Household	
size	5
age of head	45% are younger than 50 years old
male head	83%
Education	
college degree	15%
associate degree	20%
finished high school	64%

Land ownership and pasture access

Land ownership	3 ha (0.03 – 40)
Pasture	
access	8%
area	183 ha (estimated)
number of users	more than 40
number of cattle	more than 100 (adjusted)
distance	3.7 km (for accessible and not accessible)

Self-monitoring of quality

Self-monitoring	36%
fat content	26%
density	10%
acidity	2%
cleanness	31%
smell	14%
taste	2%
Interested in more precise self-monitoring	62%
Quality measurement devices are available for purchase	5%

Price and quality relationship

Price does not depend on any characteristics	100%
Buyers refused to accept at least once	27%
fat content below threshold	8%
too dirty	<1%
sour	5%

Farmers' perceptions of buyers' concerns about quality

Staff at stationary collecting centers	
very concerned about quality	12%
not concerned	<1%
Mobile collectors	
very strongly concerned	72%
not concerned	<2%

Reputational concerns

Farmers know which milk plant buys their milk	54%
Concern with the milk plant's profits	
some	18%
none	67%
Customer loss due to low quality milk	
some	7%
none	81%

Peer monitoring of milk quality

Peer monitoring	
some (<1% visited their neighbors' facilities)	2%
none	85%
Believed that neighbors do not sell low quality milk	
most of the time	20%
none of the time	67%
Concerned that neighbors sell low quality milk	
some	1%
none	86%
Concerned with opinions of neighbors about one's own milk quality and cow health	
some	2%
none	85%

Certificates of animal health and on-site inspections

Certificates and record-keeping

Vaccination certificate	36%
Certificate of cow health issued by a veterinarian	38% (conflated)
Requests to demonstrate a health certificate	
none	53%
buyers of milk	4%
buyers of cattle	30%
ownership certificate	14%
Buyers required some animal health inspections/certifications	9%
Farmers required certificates for cow feed from suppliers	2%

On-site inspections

Visited by government inspector (other than veterinarian)	1%
Visited by veterinarian last year and outcomes:	28%
non-compliance	<1%
in-compliance	3%
Bribe paid or demanded	none

Sources of information about sanitary norms

Information about animal health and sanitary norms	
from buyers	4%
government	none
New requirements (associated with regional trade agreements)	
milk plant and visitors	10% (conflated)

Additional slides: Collector survey

Milk price and payments to farmers

Price paid to farmers	Stationary	Mobile
summer	16 soms/liter	same
winter	19 soms/liter	same
Price is determined by		
milk plant	75%	83%
market (themselves, etc)	25%	15%
Milk payments are administered		
every two weeks	50%	50%
every week	50%	40%
daily (at each pick-up)		10%