



INITIATIVE ON  
Rethinking  
Food Markets

Science, Innovation and Policy Symposium  
December 10 & 11, Washington DC

# Impacts of Bundled Innovations for Cold Chain Development, Food Quality, and Food Loss Reduction in Nigeria's Horticulture Value Chain WP2 Nigeria

Futoshi Yamauchi (IFPRI)

Bawa Dauda (Univ Jos), Bedru Balana, Hyacinth Edeh, Weilun Shi (IFPRI)



# Horticulture in Nigeria

---

- Extremely heterogeneous
- Micronutrient rich
- Growing consumption and demand especially in urban area in **south**, while production hubs remain in **north**
- Significant employment potential along the VC
- Low **productivity** on farm
- Large **seasonal + spatial variations of supply**
- Significant **loss and waste at post harvest stage** (due to insufficient cold storage, packing methods and materials, cool transportation, varieties used, and poor infrastructure)
- Limited use of modern **processing** methods (due to insufficient and unreliable supply; imported high quality processed products)
- **Weak/poor market linkages** (coordination failure)

# Innovation Types

---

## Process innovation (new tech) → loss reduction

- Off grid cooling that reduces loss
- Cool transportation
- Plastic crates

## Product innovation (new product) → quality enhancement

- Processing that adds values and reduces loss
- Improved seeds

## Improved information and coordination

- Market information and linkages
- Certification and labels
- Logistics

## Partnership – IFPRI, IITA and

---

Wageningen  
University & Research  
[WUR] (seeds,  
research)

East-West Seed [EWS]  
(seeds)

World Vegetable  
Center (solar dryer,  
scoping work)

ColdHubs (cool  
transportation, solar  
powered cold storage,  
plastic crates)

University of Jos (cool  
transportation, solar  
powered cold storage,  
research)

Nigerian Stored  
Products Research  
Institute [NSPRI] (solar  
dryer)

Bunkasa (plastic  
crates, market  
linkages)

Farmer groups and  
market unions  
(various, esp Jos,  
Bauchi, Gombe)

Plant Health Initiative  
[PHI] (sola dryer)

Government of  
Nigeria

Government of Japan

# RCT/Interventions

---



## **Intervention 1 – Improved seeds (WUR, EWS, IFPRI)**

Innovations: (a) improved varieties and (b) signaling



## **Intervention 2 – Off-grid cooling: Cold storage (ColdHubs, Univ of Jos, IFPRI)**

Innovations: (a) solar panels/battery + refrigeration, and (b) plastic crates



## **Intervention 3 – Off-grid cooling: Cool transportation (ColdHubs, Univ of Jos, Market Unions, IFPRI)**

Innovations: (a) refrigeration + transportation, (b) plastic crates, and (c) labelling



## **Intervention 4 – Solar dryer (processing) (WorldVeg, NSPRI, IITA, IFPRI, and PHI)**

Innovations: (a) solar dryer, (b) labeling, and (c) marketing/contract



## **Intervention 5 – Plastic crates (Bunkasa, IITA, IFPRI)**

Innovations: (a) plastic crates and (b) market information/linkage

# Cool Transportation (Intervention 3)

---

- Refrigeration/plastic crate to reduce loss/preserve quality - **process innovation**
- Transportation/truck to spatially connect - **process innovation**
- Labels to improve information - **information innovation**
- Tomato



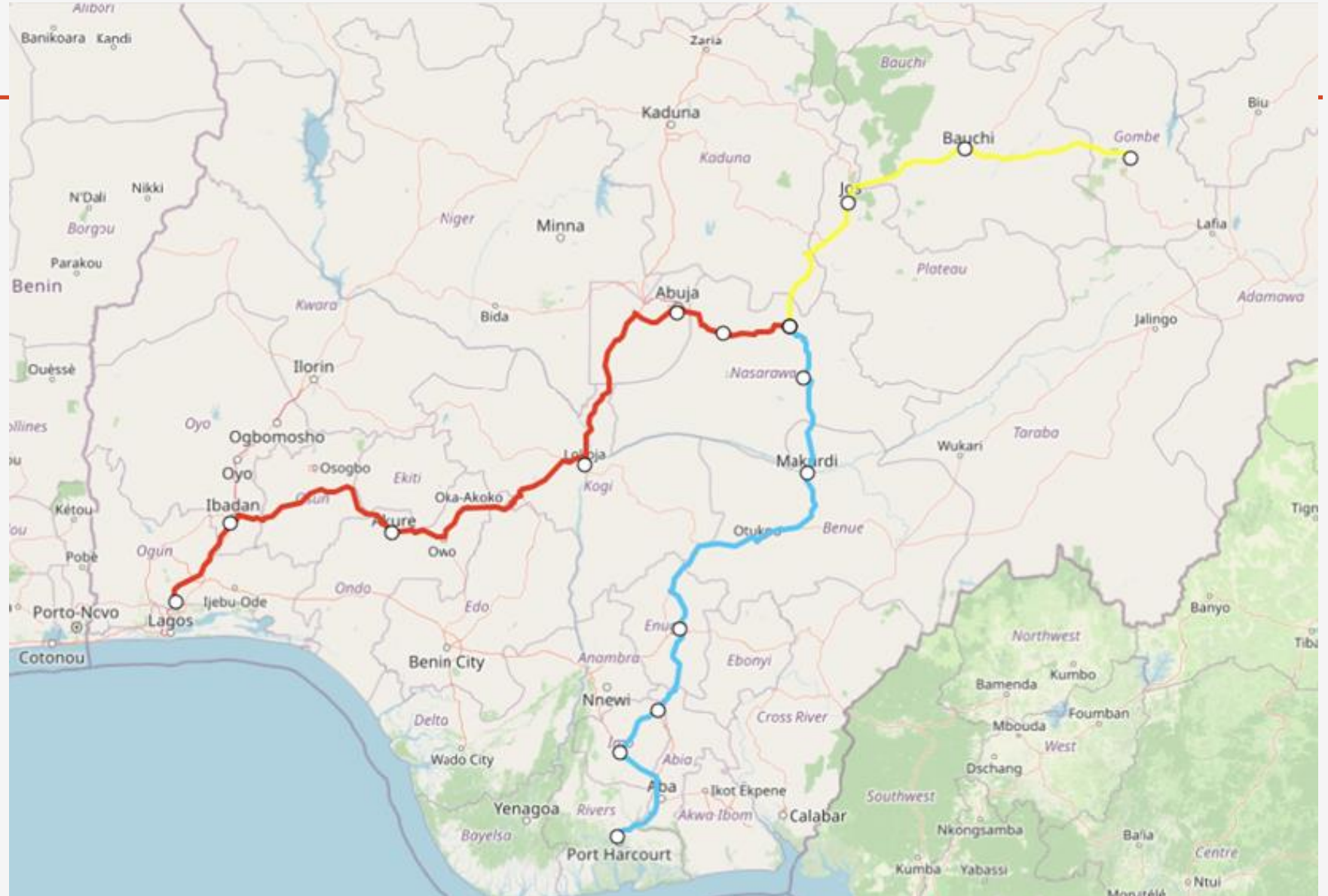
# Routes

## Origin markets

- Jos
- Bauchi
- Gombe

## Destination markets

- Lagos
- Port Harcourt



# Experiment

## Design

- Baseline sample: marketers at Jos, Bauchi, Gombe markets (**n = 600**)
- RCT participants: those who are interested (**n = 331**)
- Randomly assign treatment: a group of **8 marketers** per round to use truck
- 5 groups: **A, B, C, D, E**
- Rotating over rounds
- A round = 5 to 7 days
- Total 15 rounds
- Follow up data collection at the end of each round

Round	DATE	Destination	Treatmet	Control				Pure Control
1st	2/21/2024	Lagos	D	A	B	C	E	
2nd	3/3/2024	Lagos	A	D	B	C	E	
3rd	3/10/2024	Lagos	C	A	B	D	E	
4th	3/21/2024	Lagos	E	A	B	D	C	
5th	10/12/2024	Lagos	B	A	C	D	E	
6th	10/19/2024	PortHarcourt	C	A	B	D	E	
7th	10/29/2024	PortHarcourt	D	A	B	C	E	
8th	11/2/2024	PortHarcourt	A	D	B	C	E	
9th	11/9/2024	PortHarcourt	B	A	C	D	E	
10th	11/16/2024	PortHarcourt	E	A	B	D	C	



# Experiment

---

## **Operational arrangement**

### **Phase 1** February - March

- Private business partner, ColdHubs Inc, operated for the pilot experiment
- *The project borrowed their trucks*
- *Rent (implicit)*

### **Phase 2** October - December

- IFPRI/Univ Jos/Market Unions operate for ourselves
- *The project bought and owns new trucks*
- *No rent*

# Baseline

---

## **Almost no marketers use cool transportation or cold storage**

- Only 2% of the sample marketers cool transport products; 0% in Jos, 4.5% in Bauchi, 1.5% in Gombe.
- Only 0.5% of the marketers store products in cold storage; 1% in Jos, 0% in Bauchi, 1.5% in Gombe.

## **Many marketers use non-cool transportation in Jos and Gombe**

- In Jos and Gombe, nearly 70% and 64%, respectively; only 15% in Bauchi.

## **In Bauchi, many marketers own storage**

- More than 80% of the marketers in Bauchi own storage; only 14.5% and 27.5% in Jos and Gombe, respectively.

**Participants, those who want to participate in the experiment, are self selected.**

**Treatment and control groups are statistically comparable.**

# Three markets

Variable	All markets	Jos	Bauchi	Gombe
Position (owner)	99.17	97.5	100	100
Used cold storage	27.67	11.5	51.5	20
<b>Using cold storage now</b>	<b>4.67</b>	<b>3.5</b>	<b>7</b>	<b>3.5</b>
Is commission agent	67.83	93.5	50	60
Is Wholesaler	91.33	82	93	99
Grow crops by self	32.83	45.5	23.5	29.5
Sell in other markets	62.17	58	78	50.5
Crop sole ownership(%)	93.67	96.5	85.5	99
Selling experience (years)	16.79	16.44	15.99	17.94
Producing experience (years)	3.24	4.68	1.76	3.29
Is member of trade association	91.5	79.5	99	96
Sell tomatoes	60.33	86	19.5	75.5
Quantity of tomatoes sold (kg)	7910.58	12215.01	3647.69	4108.52
Purchase from someone	53.5	67	19.5	74
Cool transport	2	0	4.5	1.5
Cold storage	0.5	1	0	0.5
<b>Non-cool transport</b>	<b>49.5</b>	<b>70</b>	<b>15</b>	<b>63.5</b>
<b>Own storage space</b>	<b>41.17</b>	<b>14.5</b>	<b>81.5</b>	<b>27.5</b>
Storage space (tons)	24.09	5.66	34.96	1.56
WTP for cool transport	1592.14	1884.64	1341.9	1549.9
Estimated current price (per crate)	9025.5	7824	10767.5	8485
Estimated transportation capacity (crates)	129.32	146.32	91.42	150.22
Expected price (per crate)	26206.67	26030	28410	24180
Concerned about transportation loss	99.83	100	99.5	100
Willingness to participate	55.17	64	46.5	55
Number of observations	600	200	200	200

# Balance

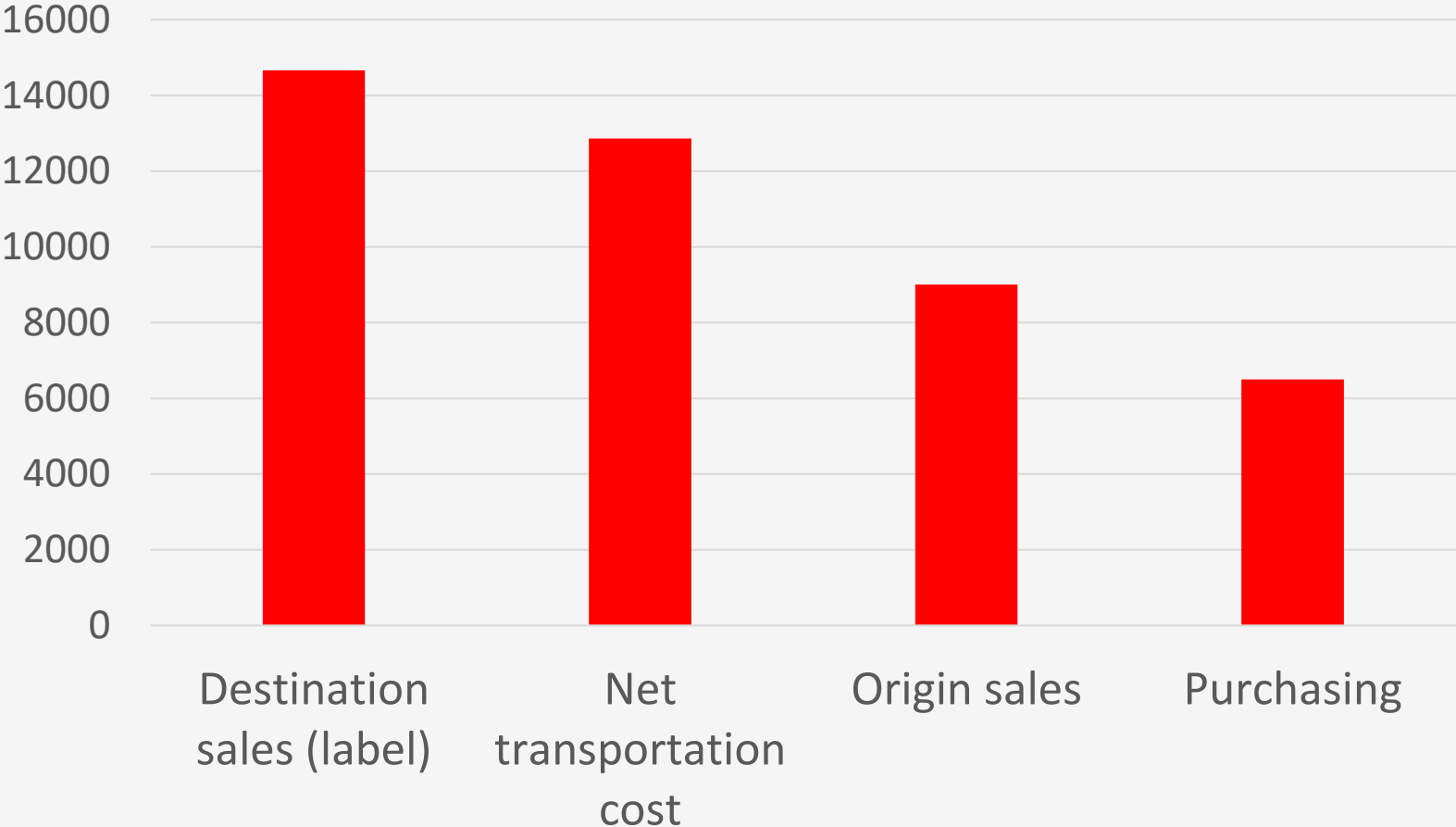
	Mean	Treatment	Control	Participants	Non participants
<b>Variable</b>					
<b>Position (owner)</b>	99.17	97.5	99.05	98.49	100**
<b>Used cold storage</b>	27.67	36.67	27.49*	30.82	23.79*
<b>Using cold storage now</b>	4.67	5.83	5.69	5.74	3.35
<b>Is commission agent</b>	67.83	69.17	71.09	70.39	64.68
<b>Is Wholesaler</b>	91.33	85	86.26	85.8	98.14***
<b>Grow crops by self</b>	32.83	26.67	28.91	28.1	38.66***
<b>Sell in other markets</b>	62.17	57.5	55.92	56.5	69.14***
<b>Crop sole ownership (%)</b>	93.67	99.17	97.63	98.19	88.1***
<b>Selling experience (years)</b>	16.79	17.48	18.22	17.95	15.36***
<b>Producing experience (years)</b>	3.24	2.55	2.94	2.8	3.8**
<b>Is member of trade association</b>	91.5	86.67	88.63	87.92	95.91***
<b>Sell tomatoes</b>	60.33	55.83	63.98	61.03	59.48
<b>Quantity of tomatoes sold (kg)</b>	7910.58	7701.19	8749.84	8402.02	7290.12
<b>Purchase from someone</b>	53.5	49.17	56.4	53.78	53.16
<b>Cool transport</b>	2	0.83	1.9	1.51	2.6
<b>Cold storage</b>	0.5	2.5	0*	0.91	0*
<b>Non-cool transport</b>	49.5	42.5	51.66	48.34	50.93
<b>Own storage space</b>	41.17	34.17	31.75	32.63	51.67***
<b>Storage space (tons)</b>	24.09	20.55	25.43	23.57	24.48
<b>WTP for cool transport</b>	1592.14	1454.17	1584.49*	1537.24	1659.7**
<b>Estimated current price (per crate)</b>	9025.5	8795.83	8317.54	8490.94	9683.27***
<b>Estimated transportation capacity (crates)</b>	129.32	161.17	167.89	165.45	84.86***
<b>Expected price (per crate)</b>	26206.67	25570.83	23741.71*	24404.83	28423.79***
<b>Concerned about transportation loss</b>	99.83	99.17	100	99.7	100
<b>Willingness to participate</b>	55.17	100	100	100	0
<b>Number of observations</b>	600	120	211	331	269

# Rounds

	<b>Jos</b>	<b>Destination</b>		<b>Bauchi</b>	<b>Destination</b>		<b>Gombe</b>	<b>Destination</b>	
<b>1<sup>st</sup></b>	<b>03/16</b>	<b>Lagos</b>	<b>D</b>	<b>11/15</b>	<b>Port Harcourt</b>	<b>D</b>	<b>02/21</b>	<b>Lagos</b>	<b>D</b>
<b>2<sup>nd</sup></b>	<b>10/10</b>	<b>Lagos</b>	<b>A</b>	<b>11/22</b>	<b>Port Harcourt</b>	<b>A</b>	<b>03/03</b>	<b>Lagos</b>	<b>A</b>
<b>3<sup>rd</sup></b>	<b>10/17</b>	<b>Port Harcourt</b>	<b>C</b>	<b>11/29</b>	<b>Port Harcourt</b>	<b>C</b>	<b>03/10</b>	<b>Lagos</b>	<b>C</b>
<b>4<sup>th</sup></b>	<b>10/24</b>	<b>Port Harcourt</b>	<b>E</b>	<b>12/06</b>	<b>Port Harcourt</b>	<b>E</b>	<b>03/21</b>	<b>Lagos</b>	<b>E</b>
<b>5<sup>th</sup></b>	<b>10/31</b>	<b>Port Harcourt</b>	<b>B</b>	<b>12/13</b>	<b>Port Harcourt</b>	<b>B</b>	<b>10/12</b>	<b>Lagos</b>	<b>B</b>
<b>6<sup>th</sup></b>	<b>11/07</b>	<b>Port Harcourt</b>	<b>C</b>	<b>12/20</b>	<b>Port Harcourt</b>	<b>C</b>	<b>10/19</b>	<b>Port Harcourt</b>	<b>C</b>
<b>7<sup>th</sup></b>	<b>11/14</b>	<b>Port Harcourt</b>	<b>D</b>			<b>D</b>	<b>10/26</b>	<b>Port Harcourt</b>	<b>D</b>
<b>8<sup>th</sup></b>	<b>11/21</b>	<b>Port Harcourt</b>	<b>A</b>			<b>A</b>	<b>11/02</b>	<b>Port Harcourt</b>	<b>A</b>
<b>9<sup>th</sup></b>	<b>11/28</b>	<b>Port Harcourt</b>	<b>B</b>			<b>B</b>	<b>11/09</b>	<b>Port Harcourt</b>	<b>B</b>
<b>10<sup>th</sup></b>	<b>12/05</b>	<b>Port Harcourt</b>	<b>E</b>			<b>E</b>	<b>11/16</b>	<b>Port Harcourt</b>	<b>E</b>
<b>11<sup>th</sup></b>	<b>12/12</b>	<b>Port Harcourt</b>	<b>E</b>			<b>E</b>	<b>11/23</b>	<b>Port Harcourt</b>	<b>E</b>
<b>12<sup>th</sup></b>	<b>12/19</b>	<b>Port Harcourt</b>	<b>C</b>			<b>C</b>	<b>11/30</b>	<b>Port Harcourt</b>	<b>C</b>
<b>13<sup>th</sup></b>			<b>D</b>			<b>D</b>	<b>12/07</b>	<b>Port Harcourt</b>	<b>D</b>
<b>14<sup>th</sup></b>			<b>B</b>			<b>B</b>	<b>12/14</b>	<b>Port Harcourt</b>	<b>B</b>
<b>15<sup>th</sup></b>			<b>A</b>			<b>A</b>	<b>12/21</b>	<b>Port Harcourt</b>	<b>A</b>

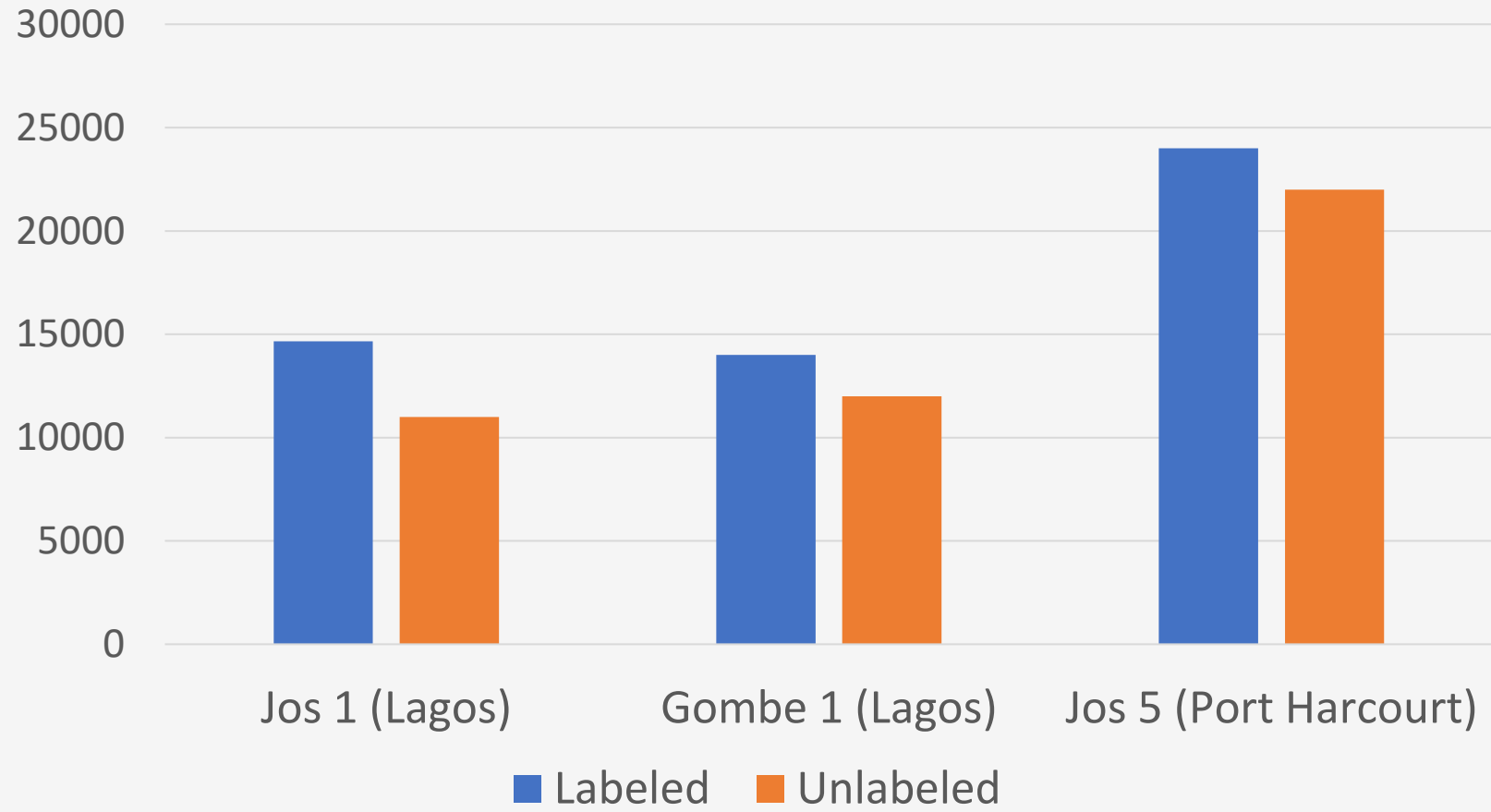
# Returns to Cool Transportation (Jos - Lagos, 1st Round)

---



# Labeling - Better information creates premium

---



## Impacts (preliminary midpoint analysis)

Variables	Sales price (control: non-cool)	Sales price (control: origin market)	Revenue (cool & non-cool)	Profit (cool & non-cool)
	Coefficient (std.err)	Coefficient (std.err)	Coefficient (std.err)	Coefficient (std.err)
<b>Cool transportation</b>	7757.65*** (294.42)	11023.45*** (374.77)	757206.8*** (75500.6)	445495.1*** (42156.9)
<b>Market Agent Fixed Effects</b>	Yes	Yes	Yes	Yes
<b>Market Round Fixed Effects</b>	Yes	Yes	Yes	Yes
<b>Constant</b>	Yes	Yes	Yes	Yes
<b>Sample-size</b>	822	457	622	689
<b>% Increase</b>	53.72	111.81	81.59	255.82
<b>Difference in sales price</b>	<b>29.6% - Reallocation, i.e., origin to destination markets</b> <b>70.4% - Quality preservation, i.e., cooling to keep fresh (no loss)</b>			



# Economics of Cool Transportation

---

## **Marketers and business partner are both middlemen in the value chain**

### **Imperfect information**

- Market prices: destination markets, near perfect though dynamically changing
- Product/quality: asymmetry between origin and destination markets

### **Incentives**

- Profit maximization: both business partner and marketers
- Moral hazard: hidden actions - mainly, truck operation

### **Contract/Sequential game**

- Principal-agent: which player is principal, marketers or business partner
- Alternatives (reservation):
  - Business partner (truck) - many locations/users
  - Marketers - not many options other than non-cool transportation
- Internalization: marketers want to integrate vertically; business partner may contract farmers
- Discount factor: marketer  $\ll$  business partner

### **Credit constraint**

- Large fixed cost - who can invest in truck?

# What was seen

---

Perfect information: marketers know market prices at potential destinations

- Business partner has no informational advantage

Moral hazard: business partner tends to, for example

- Overcharge, e.g., fuel cost (money loss)
- Divert trucks to different routes for other purposes (time loss)
- Mismanage temperature (can cause total loss of tomatoes)
- Lack proper maintenance (can cause total loss of tomatoes)

Contract/MOU is enforceable or not: business partner can easily go away with truck

**A credible threat from marketers to us - get out of the project if business partner stays**

**Game changer**

- **IFPRI bought/owns 3 new trucks (Phase 2)**

**Marketers, if technically supported, can take over and manage cool transportation**

- Efficiency gain (more efficient logistics and more reduction of food loss)
- Redistribution (more profits to marketers and potentially more jobs)

**What was missing was not another player in the middle, but just trucks**