Making an Impact?

A Tale of Two Projects

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Market Design

- One of my key methodological "hammers" is **market design**

- Markets are a great way to allocate **scarce resources** when
  - agents are self-interested
  - information about values is not available centrally
  - the designer cares about good social outcomes ("efficiency")

- **Computer science and AI** have transformed market design
  - distributed, electronic markets
  - rich bidding languages
  - managing computational complexity
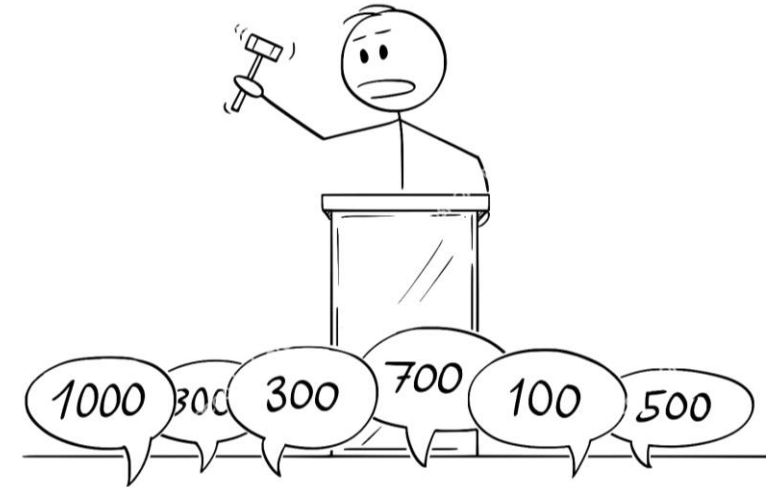
Project #1:

Allocating Donated Food

Allocation for Social Good: Auditing Mechanisms for Utility Maximization. T. Lundy, A. Wei, H. Fu, S. Kominers, K. Leyton-Brown. Twentieth ACM Conference on Economics and Computation (ACM-EC), pp. 785–803, 2019.

Allocating Donated Food

- Large donations of food are given to a **centralized food bank**

- This food must be redistributed to local subsidiaries called **food pantries**

- To do this the food bank must ask the food pantries to **report demand**
    - they have an incentive to over-report
    - inappropriate to take the standard econ approach of incentivizing via payments

Food Bank

Shipments of Food

Food Pantries
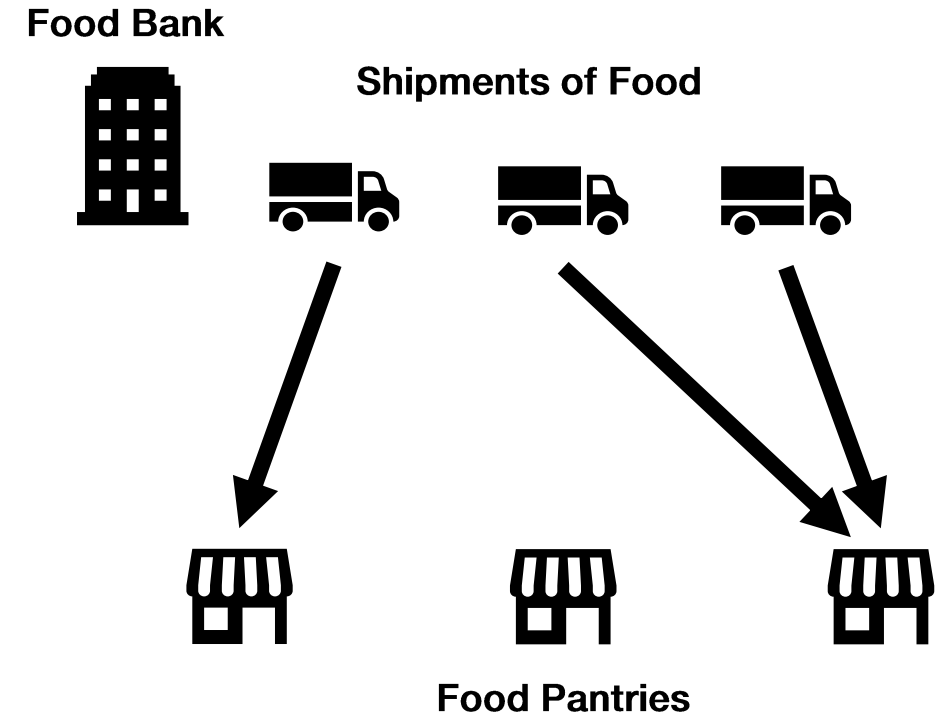
# Abstracted as a mechanism design problem

- Through the market design lens
  - **stochastic demand**
    - agents know their **probability of needing food today** (their type)
    - then this demand is realized
    - the center only knows the setting (type distributions)
  - food banks want food to be **used efficiently**
  - food pantries are (at least somewhat) **strategic**
    - prefer to receive needed food than to see someone else get it

✓ Yup, looks like a market design problem

- Idea #1: Model as a **utility maximization problem**
  - maximize efficiency **minus dollars collected**
  - most market literature instead ignores (or only focuses on) payments
- Idea #2: Incentivize agents via **auditing**
  - if you demand food and don't use it, you can be punished
 - charities are already audited anyway

Key Result: Unit Demand

- Agents either need a food allocation or they don't
  - they get no utility for consuming an allocation they don't need
  - there's no way of specifying quantity: **all-or-nothing allocation**

- **Waste-not-Pay-not mechanisms:** audit; only charge when agents were allocated and didn't need the allocation

- Second-price auction with auditing is **still efficient, lowers payments**
  - payments scaled by a factor <1 (depending on second-highest type, expected price)
  - derived using a classic mechanism design tool (Myerson)
  - upshot: same allocation, smaller payment (no "revenue equivalence")

- This same idea applies to **any mechanism with payments**
  - we can thereby construct a provably optimal auditing mechanism
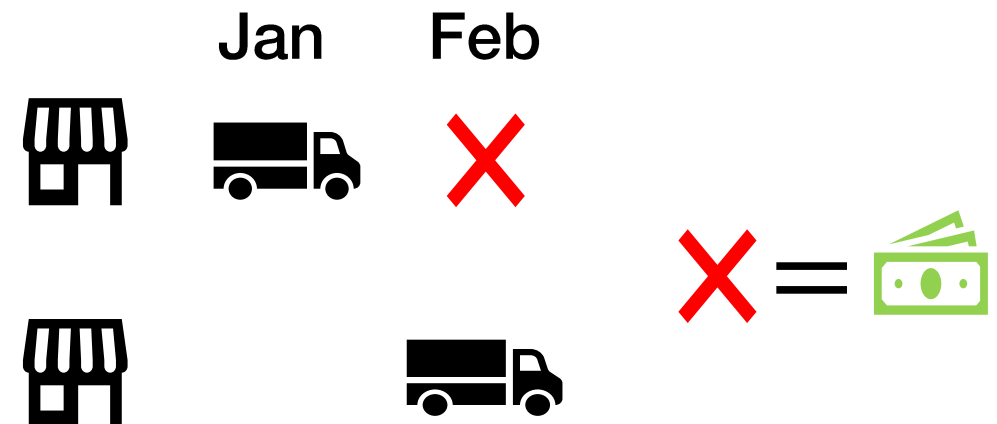   - intuitively, combines second pricing and lotteries
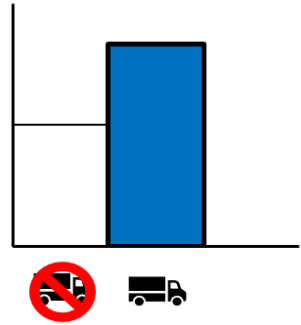
Generalizations

Multi-Unit Demand
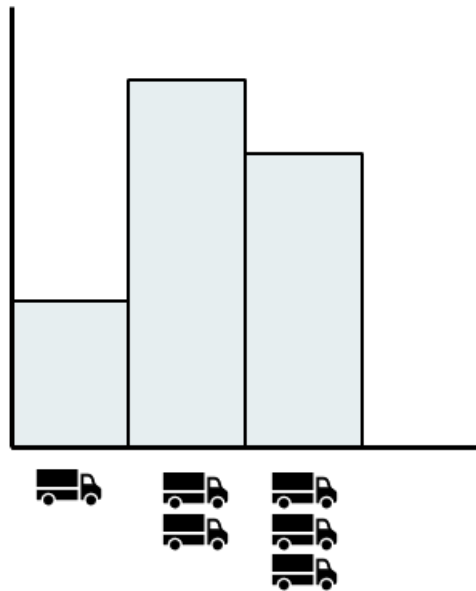
Auditing + VCG = Higher Utility
But, no proof of optimality here

Repeated Interactions

Dynamic Mechanism Design
Replace payments with punishments

Analysis: pros and cons

- We **modeled some core issues** that arise in the interaction between food banks and food pantries
  - stochastic demand
  - desire to maximize utility (i.e., to minimize payments)
  - ability to audit consumption

- In response, came up with some **meaningful new theory**

- But, food banks **aren't yet beating down our door**
  - they sell more than one kind of food
  - preferences are combinatorial (substitutes and complements)
  - concerns about fairness and limiting waste may trump incentives

Project #2:

Agricultural Market Inefficiency in Uganda

A Mobile Market for Agricultural Trade in Uganda. *R. Ssekibuule, J. Quinn,*
K. Leyton-Brown. ACM Symposium on Computing for Development (ACM-DEV), 2013.
Designing and Evolving an Electronic Agricultural Marketplace in Uganda. *N. Newman,*
K. Leyton-Brown, N. Immorlica, L. Bergquist, B. Lucier, J. Quinn, C. McIntosh, R. Ssekibuule.
ACM SIGCAS Conference on Computing and Sustainable Societies (ACM-COMPASS), 2018.

Market Inefficiency in Uganda

- **Subsistence agriculture** is a main occupation in Uganda

- Buyers and sellers have trouble **finding each other**

- Farmers **waste a lot of time** transporting produce; waiting by the road

- Robust **arbitrage** opportunities

The Goal

Link farmers in the villages with markets in the cities
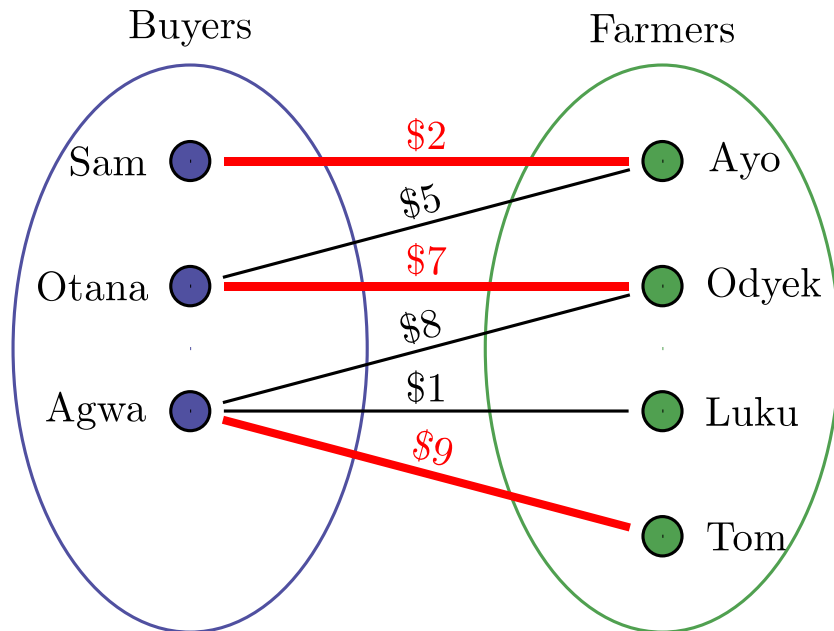
Solution: Electronic Marketplace

**Kudu:** a feature phone based market for agricultural commodities

- **bids** consider price, quantity, geographic location

- **matching**; **price alerts** via SMS

Automated Matching, First-Pricing Sellers

- Obtain matches automatically
  - original iteration: greedy algorithm (!)
  - eventually: find a **maximum weighted bipartite matching**

- Ran a limited trial
  - small scale **radio ads**
  - a student helping to respond to **malformed** SMS messages
  - limited outreach to **buyers**
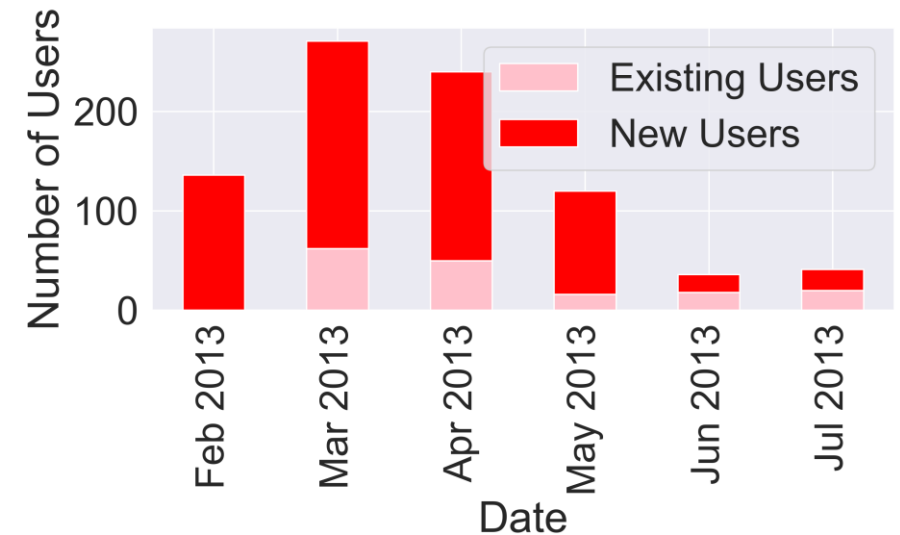
2015–2018 Reboot

2015–2018 Reboot

AgriNet
Your Bridge to the Market
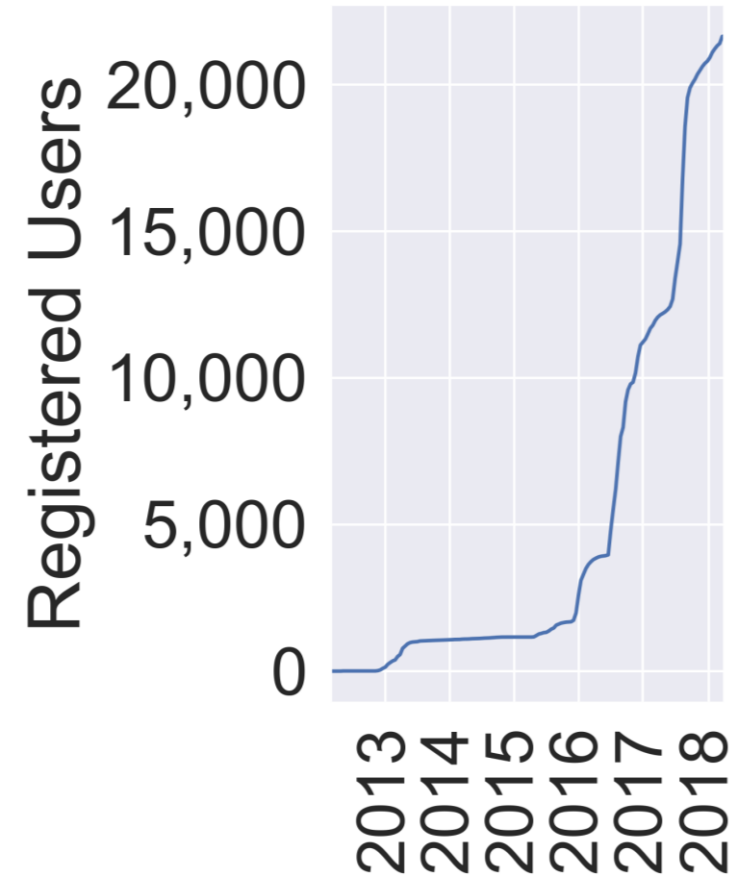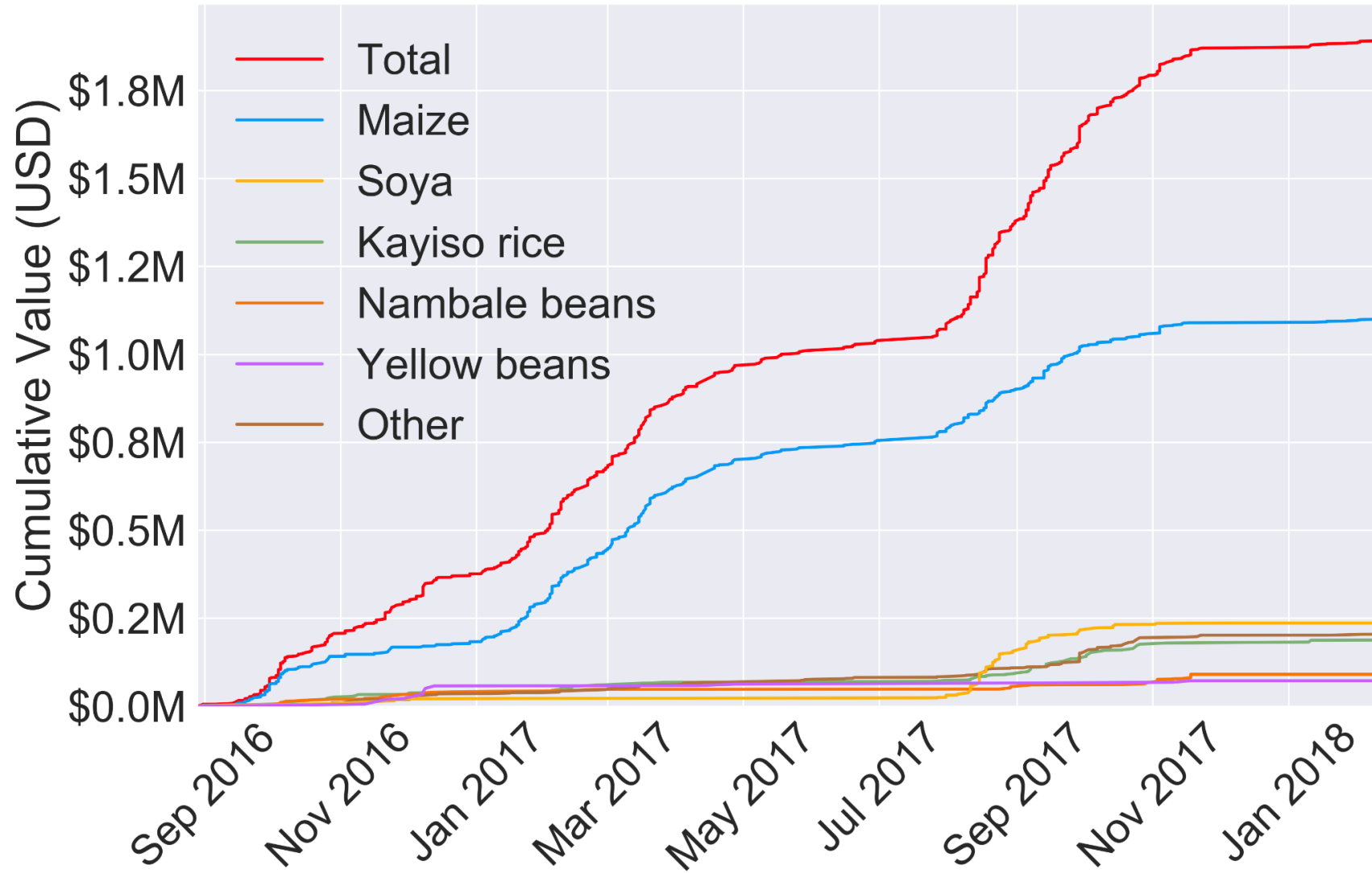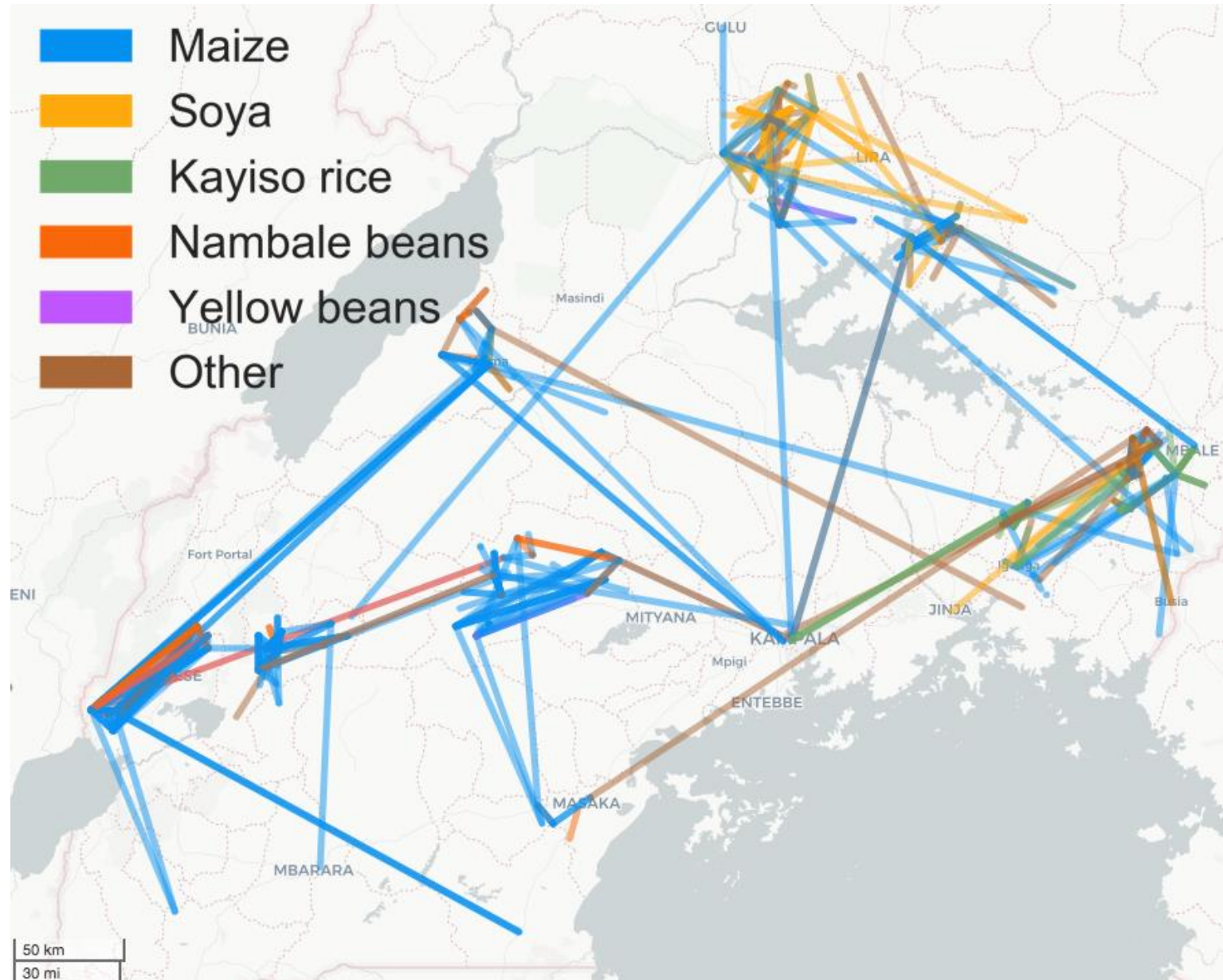
IPA Uganda

Uptake
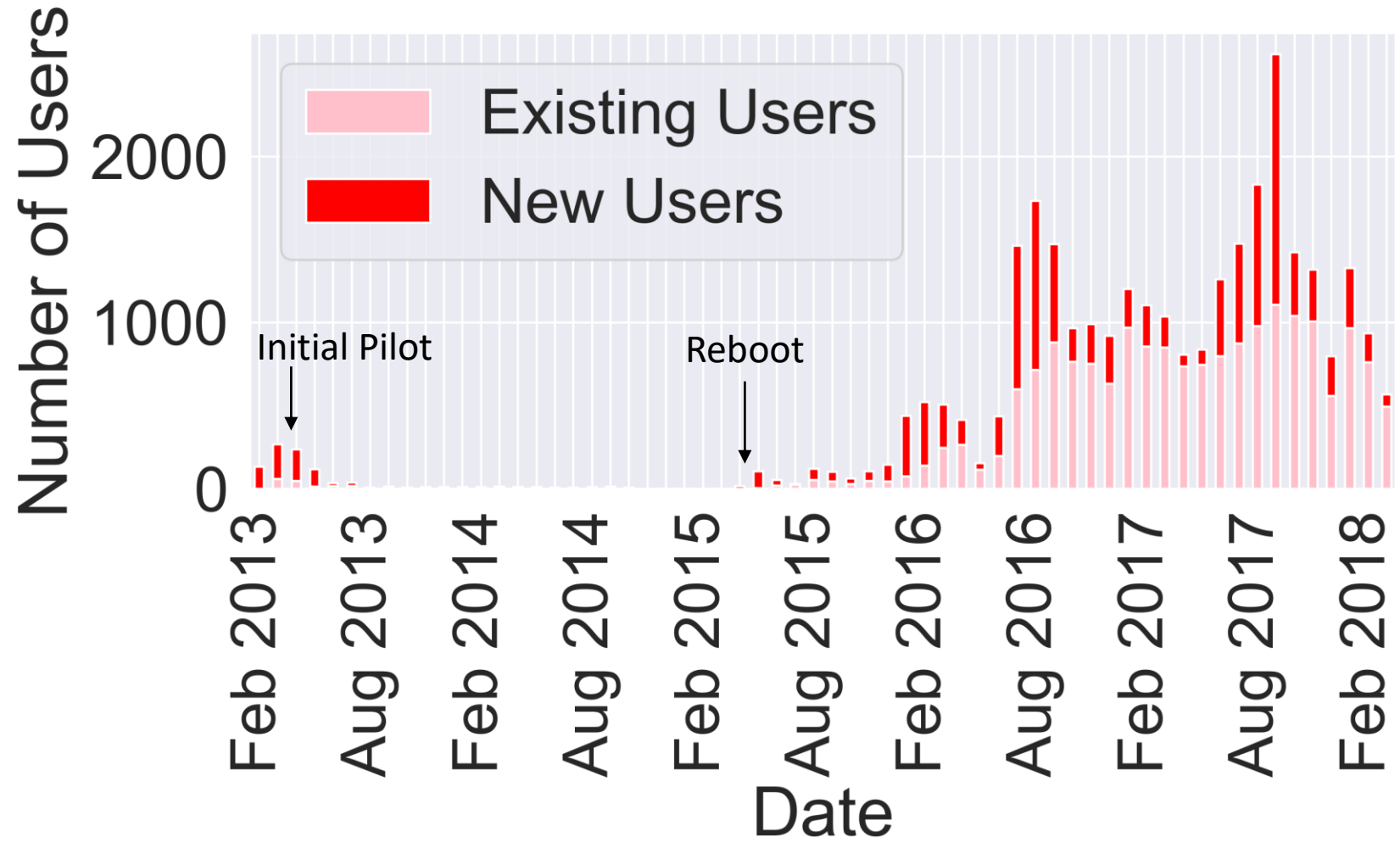
Verified Trades

Cumulative Trade Value ($) vs Time

Lots of Activity All Over Uganda

Manual Matching by Deal Coordinators

Search for potential matches

Asks

Show 100 entries   Search: _____

Ask	Ask Date	Seller Name	Seller District	Seller Subcounty	Seller Parish	Ask Quantity	Ask Price	Ask Matched Times	Seller Category	Bulk
26540	Oct. 18, 2017		Butaleja	Nazimasa	Kachonga	10,000	1,200	0		☐ Yes ☑ No
26537	Oct. 18, 2017		Kasese	Munkunyu	Kicucu	3,000	1,000	1		☐ Yes ☑ No
26536	Oct. 18, 2017		Budaka	Lyama	Lyama	500	1,200	0		☐ Yes ☑ No
26531	Oct. 18, 2017		Mubende	Kasambya	Kigando	6,000	1,100	0		☐ Yes ☑ No
26530	Oct. 18, 2017		Kasese	Kitswamba	Rugendabara	5,000	1,000	1		☐ Yes ☑ No
26528	Oct. 18, 2017		Kasese	Kitswamba	Rugendabara	16,000	1,000	1		☐ Yes ☑ No
26526	Oct. 18, 2017		Mubende	Bagezza	Gayaza	2,000	800	3		☐ Yes ☑ No
26523	Oct. 17, 2017		Oyam	Aber	Wirao	2,000	900	1		☐ Yes ☑ No
26520	Oct. 17, 2017		Mubende	Madudu	Kabulamuliro	5,000	820	1		☐ Yes ☑ No
26519	Oct. 17, 2017		Mubende	Kiganda	Kayunga	3,500	850	0		☐ Yes ☑ No
26518	Oct. 17, 2017		Mubende	Kasambya	Kigando	30,000	850	1		☐ Yes ☑ No
26513	Oct. 17, 2017		Oyam	Iceme	Aungu	1,500	800	1		☐ Yes ☑ No
26504	Oct. 17, 2017		Kasese	Kisinga	Kagando	2,000	2,500	0		☐ Yes ☑ No
26503	Oct. 17, 2017		Mubende	Kassanda	Kikandwa	15,000	750	2		☐ Yes ☑ No
26498	Oct. 17, 2017		Kamwenge	Bwiizi	Bwiizi	4,000	1,300	0		☐ Yes ☑ No
26497	Oct. 17, 2017		Kasese	Kitswamba	Kihyo	1,500	920	1		☐ Yes ☑ No
26495	Oct. 17, 2017		Kamwenge	Kahunge	Kyakanyemera	8,000	1,100	0		☐ Yes ☑ No
26491	Oct. 17, 2017		Hoima	Hoima TC	Central Ward	10,000	780	3		☐ Yes ☑ No

Bids

Show 100 entries   Search: _____

Bid	Bid Date	Buyer Name	Buyer District	Buyer Subcounty	Buyer Parish	Bid Quantity	Bid Price	Bid Matched Times	Buyer Category
27734	Oct. 18, 2017		Kamwenge	Kahunge	Kiyagara	500	1,200	0	
27727	Oct. 18, 2017		Mubende	Bagezza	Gayaza	5,000	780	2	
27726	Oct. 17, 2017		Budaka	Kamonkoli	Kadimukoli	4,000	900	0	
27725	Oct. 17, 2017		Kasese	Kisinga	Kagando	10,000	850	2	
27718	Oct. 17, 2017		Budaka	Kameruka	Kameruka	500	800	0	
27715	Oct. 17, 2017		Dokolo	Dokolo	Adagmon	20,000	700	0	
27711	Oct. 17, 2017		Dokolo	Kwera	Apyen-Nyang	8,000	600	0	
27707	Oct. 17, 2017		Apac	Cegere	Cegere	3,000	800	2	
27702	Oct. 17, 2017		Hoima	Kigorobya	Kapaapi	2,000	600	0	
27698	Oct. 17, 2017		Mubende	Bukuya	Kizibawo	12,000	750	1	
27697	Oct. 17, 2017		Oyam	Acaba	Atekober	2,000	900	4	
27693	Oct. 17, 2017		Hoima	Kigorobya	Bwikya	12,000	700	0	
27686	Oct. 17, 2017		Dokolo	Kwera	Apenyoweo	1,000	700	0	

Manual Matching by Deal Coordinators

Contact the Seller of a Potential Match

Matches - Call Seller

Show [5] entries   Search: [   ]

Match	Follow Up	Match Date	Produce	Seller Name	Seller Number	Seller Comments	Buyer Name	Buyer Number	Buyer Comments	Ask Quantity	Bid Quantity	Ask Price	Bid Price	Matched By	Interested?	Next Follow-Up
15417	Add	02/11/2018 11:57 a.m.	Kanyebwa beans	Mbabazi Aswankwire	256555555555	—	Jorum Godfrey	256555555555	—	50	3,000	1,500	1,600	Deal Coordinator #1	Yes No	02/13/2018 10 a.m. confirm crop
17027	Add	02/15/2018 12:02 p.m.	Kayiso rice	Ashiraf Bendicto	256555555555	—	Mujuni Onesmus	256555555555	—	2,000	10,000	2,500	2,300	Deal Coordinator #2	Yes No	
17572	Add	02/07/2018 11:44 a.m.	Millet	Okello Siraji	256555555555	—	Omara Costanziya	256555555555	—	200	1,000	1,000	1,700	Deal Coordinator #1	Yes No	
17575	Add	02/13/2018 11:45 a.m.	Millet	Olwi Budala	256555555555	—	Nabwomya Oyo	256555555555	—	200	1,000	1,000	1,800	Deal Coordinator #1 (Kudu AI)	Yes No	02/15/2018 3 p.m. Call back confirm crop
17576	Add	02/13/2018 11:46 a.m.	Millet	Mesulamu Davidson	256555555555	—	Glacia Kinemata	256555555555	—	200	1,000	1,000	1,700	Deal Coordinator #3 (Kudu AI)	Yes No	

Showing 1 to 5 of 20 entries

Previous 1 2 3 4 Next

Challenges: Usability; Training

Most Trades Fail

- **< 10%** of proposed trades complete

- Modelling issues
  - transport cost
  - road quality
  - reliability of buyer, seller

- Timing: selling **off-platform**
  - farmers are highly liquidity constrained

- Hard to repair solutions
 - buyer may plan to visit several sellers to fill truck

2020 Reboot

- Our most recent pilot was very **labour intensive**
  - we provided in-village support services
  - ran a call center
  - verified transactions over the phone

- The pilot had to end when **funding was exhausted** in early 2018

- What would a **leaner version** of Kudu look like?
  - **Replace deal coordinators**
    - offload the search problem to the buyer side via a smartphone application
  - Let buyers express **richer preferences** over location, quantity, price, …
  - Accept asks from sellers via **multiple channels**
    - structured SMS, unstructured SMS/WhatsApp, and/or via a small call center

Virtual Call Center via Smartphone App
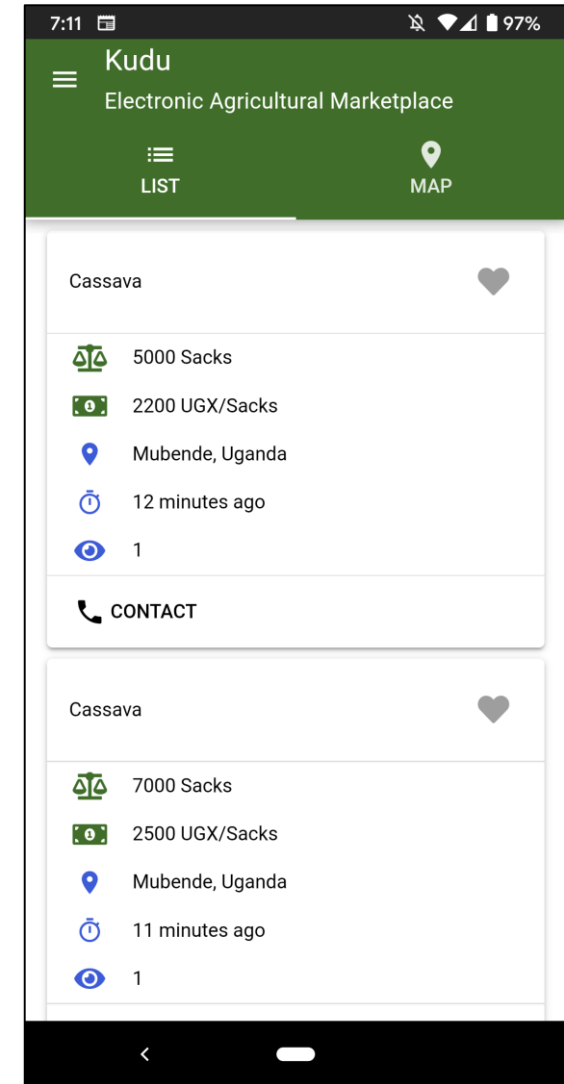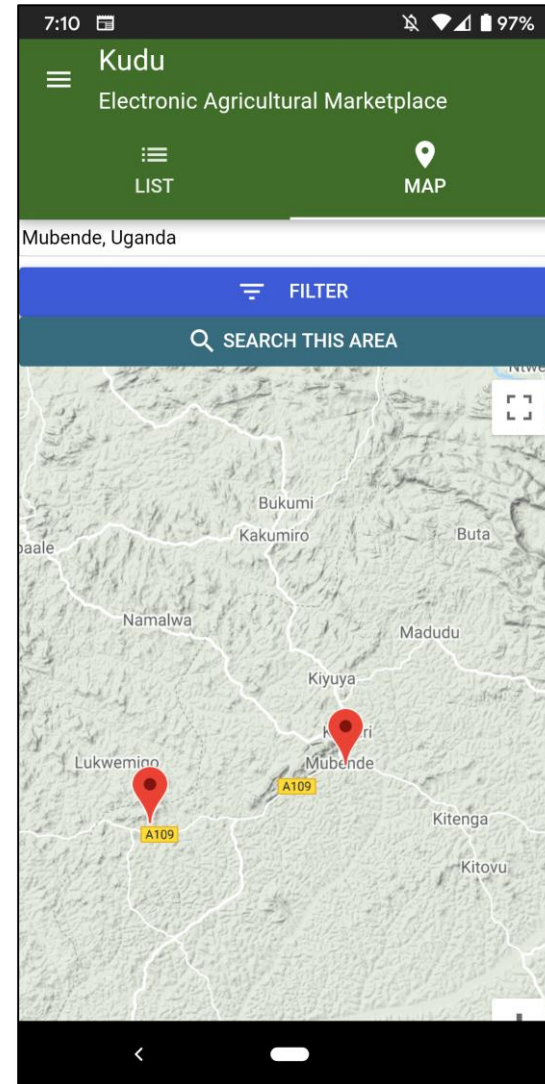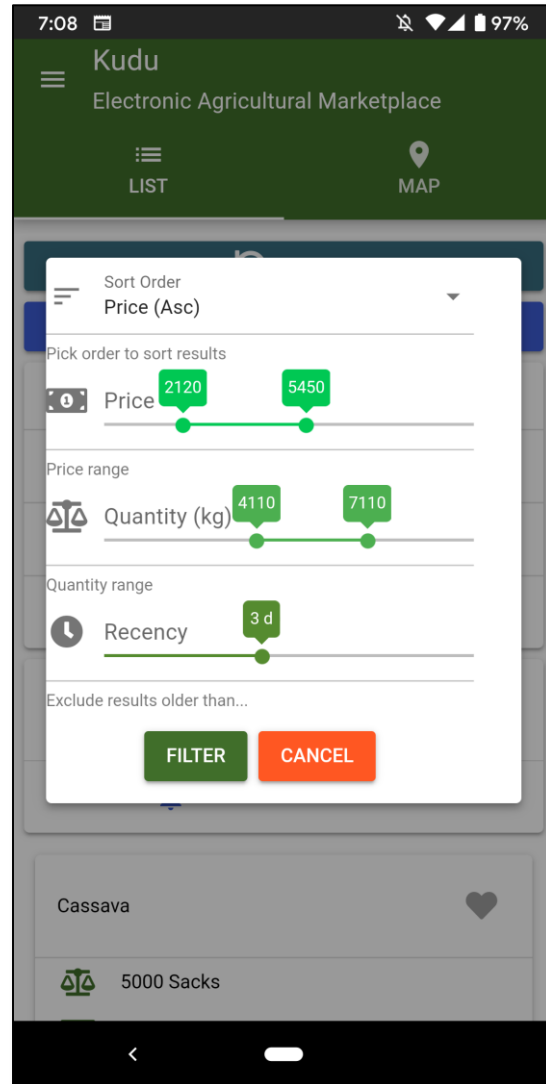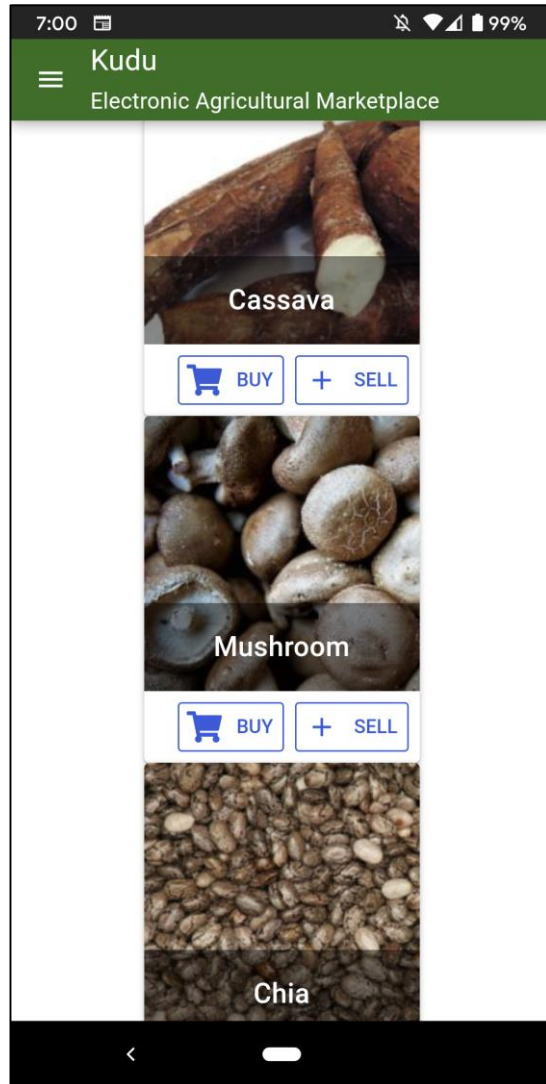
Analysis: Pros and Cons

- Compelling problem: **agricultural markets in Uganda** are highly inefficient

- Solution: an **electronic market** that connects farmers and traders across the country
  - Matching and price advisory services

- **Long and twisting road** to the current point
  - reasonable traction but no explosion
  - real technical challenges but no big theoretical result
  - some of the most appealing approaches didn't work

- Lots of **work still to be done**
  - market design; usability; profitability; marketing; …
  - we hope that success is around the corner!

What can we learn from this "**tale of two projects**"?

Based on ongoing work with S. Kominers.

Overall, AI technologies are really hard to develop!

- Solving **straightforwardly stated problems** is often really hard, computationally intractable, or even provably impossible

- So we are trained to do **lots of very clever work** to
  - approximate
  - reformulate or relax to a problem that we *can* solve
  - find heuristics that work in a limited domain

- Our literature focuses on **conveying these clever ideas** so that others don't have to reinvent the wheel

- What happens when researchers trained this way seek to **address social problems**?

AI4SI Project Model #1: Write a Paper

- Get approached by a stakeholder with a good idea for **how your research expertise aligns** with a social problem
  - you probably don't initiate a project with them unless you see the kernel of an idea: some way that technology you understand deeply might move the needle
- Abstract a **clean statement** of the problem
- Try to **solve it**, iterating on the problem definition
  - elaborate the problem if it seems trivial or addressed by existing work
  - simplify/scope down if you get stuck
- Once you get a **positive result**
  - "at this point, I'm sure we have a paper"!
  - See how much you can generalize, elaborate, understand the model more deeply
- **Write it up** in time for the next deadline. Move on.

AI4SI Project Model #2: Be an Entrepreneur

- The "lean startup" recipe:
  - **understand the market** as well as you can before committing to an approach
  - **prototype** rapidly
  - get lots of **user feedback**
  - **pivot** if you're not getting traction
  - repeat

- 90% of even non-technology startups fail
  - It's hard to guess right about what approaches will meet people's needs!

- Focusing on addressing under-resourced communities via developing new AI technologies **doesn't make the problem easier**!
  - if we lock into a solution right at the beginning, less likely to be impactful in practice
  - if we focus on making a difference, more likely to drift away from our core expertise

Project Model #3: All of the Above?

- **Unsatisfying approach:** do #1 and #2 in parallel, with loose causal connections between technical innovations and impact

- Some of our field's most celebrated projects do #1 and #2 in parallel with **real causal connections** between theory and impact

- Key question: did these projects get lucky, or is there a secret sauce?
  - novelty in **problem formulation** at least as much as in technical solution
    - not just applying an existing "recipe"
  - ability to **communicate with (and understand!) stakeholders** is key
  - it helps to have a partner who **identifies practical problems** that really are technical ones
    - hard to come in from the outside and truly understand a problem domain
    - how do we identify/support/grow such people?

Teaching and Growing the Community

- How to teach CS students to do good AI4SI work?
  - Business school **cases** that describe the way enterprises reason about some concrete challenge that they face
  - **Experiential** (project-based) learning
  - **Scaffolded learning experiences** that involve the teacher in the problem reformulation part
  - Maybe we need **our own cases**: reason about the way previous social impact projects replanned in response to a roadblock

- How can we encourage great work in our research community?
  - Seek out/develop **partners** at least as much as projects
  - Look for **innovation in business model/application strategy** at least as much as in methodology (conferences already have a main technical track for the latter)
  - Share best practices regarding **process** at least as much as outcomes

- …We get better at what we **focus explicitly on**

How Can AI Researchers Impact Society?

- Project Model #1: **Write a Paper**
    - food banks can be incentivized to better report their demands by auditing

- Project Model #2: **Be an Entrepreneur**
    - Ugandan farmers can sell crops online and via SMS

- Project Model 1+2: **Have it All**
    - Sometimes misses the mark
    - Occasional shining successes
    - Hard work to understand what separates the two

We have a moral obligation to do everything we can: new technologies + novel ideas about applying them can **transform people's lives**!