Price Discrimination and Food Waste

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Introduction

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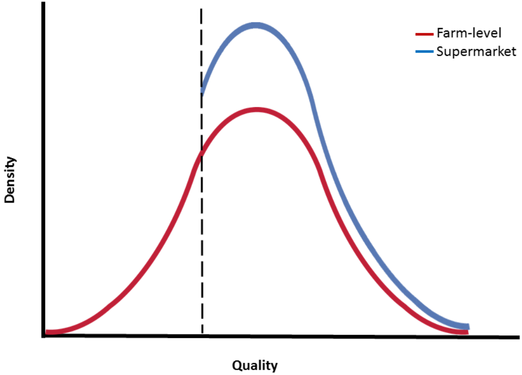
- Scale of food waste problem is well-understood:
  - \$165 billion in value (Buzby et al. 2014)
  - 25% of fresh water (Hall et al. 2009)
  - 18% of volume in landfills (EPA 2016)
  - 300 million bbls of oil (Hall et al. 2009)
- Waste at retail level alone is substantial:
  - 19.5 million tonnes of edible food
- Sources of pre-consumer food waste
  - Farmers: Harvesting all food not optimal
  - Retailers: Price discriminate by quality-grading
    - Minimum quality standards
    - Maintain reputation for high-quality produce
    - Results in excess supply of graded products
- Substantial loss in farm value
- Evidence that consumers will buy: Imperfect Produce

Distribution of Food Quality / WTP



Objective

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- To explain how quality-based price discrimation leads to retail loss
- To empirically test price-discrimination hypothesis
- To determine the degee of loss in a fresh supply chain
- To demonstrate new loss-identification strategy
- To show impact of price-discrimination on retail and farm revenue

Contribution

Contribution

- Explain retail loss as consequence of optimizing behavior
- Devise identification strategy for supply-chain loss
- Estimate of retail loss due to quality-based price discrimination
- Estimate impact on value lost in supply chain due to WTP for quality

Economic Model

Economic Model

- Consumers demand produce with higher quality
- Retailers maximize profit subject to grading standard
- Grading standard is costly to maintain
- We derive an equilibrium quality standard
- Two cases:
    - Case 1: Farmers do not produce enough to meet standard
        - No food waste when grading cost are sufficiently low
    - Case 2: Farmers produce more than enough
        - Graded food sent to retail channel priced out of consumer's reach
- Simulate potential for loss in retail channel
- Scale of retail food waste problem:
    - Retail price discrimination potential driver of food waste
    - For reasonable parameters, retail loss = 37.5%

Data

Retail Scanner Data

- Nielsen Scantrack data for bagged fresh apples
- Every store of major US retail supermarket chain
- 52 weeks from Oct. 2014 - Oct. 2015
- Six varieties of apples:
  - Ambrosia
  - Fuji
  - Gala
  - Honeycrisp
  - Jazz
  - Pink Lady
- 14 different UPCs over bagged items
- Quality data from agronomic literature
  - Miller, et al. (2004, 2007)
  - Henroid et al. (2008)
- Wholesale prices from Washington Tree Fruit Assn.

Retail Data

Table 1. Distribution of Retail Data by UPC

Item	Description	Measure	Units	Value	Std. Dev.
Item 1	Ambrosia, 4 lb.	Retail Price	$ / lb	1.7894	0.1667
Item 2	Fuji, 5 lb.	Retail Price	$ / lb	1.2133	0.2095
Item 3	Fuji, 6 lb.	Retail Price	$ / lb	1.2366	0.0984
Item 4	Fuji, 7 lb.	Retail Price	$ / lb	1.0241	0.0954
Item 5	Gala, 5 lb.	Retail Price	$ / lb	1.2059	0.2415
Item 6	Gala, 6 lb.	Retail Price	$ / lb	1.1973	0.1408
Item 7	Gala, 7 lb.	Retail Price	$ / lb	0.9899	0.1032
Item 8	Gala, 8 lb.	Retail Price	$ / lb	0.8614	0.1225
Item 9	Honeycrisp, 4 lb.	Retail Price	$ / lb	2.3584	0.4606
Item 10	Jazz, 4 lb.	Retail Price	$ / lb	1.6063	0.1942
Item 11	Jazz, 4 lb.	Retail Price	$ / lb	1.3948	0.0383
Item 12	Pink Lady, 2 lb.	Retail Price	$ / lb	3.4389	0.1603
Item 13	Pink Lady, 4 lb.	Retail Price	$ / lb	1.4132	0.1810
Item 14	Pink Lady, 5 lb.	Retail Price	$ / lb	1.3632	0.0950

Empirical Model

Empirical Model

- Estimate random utility model of demand
  - Standard, mixed-logit form
  - Allow for non-linear preference for quality
  - Consistent with empirical IO literature (McManus 2007)
- Preference for quality randomly distributed over consumers
- Recover shape of WTP for quality:
  - Non-parametric, kernel-density estimator
  - Epanechnikov (1969) weighting function
  - Allows for non-normal empirical distributions
- Compare to distribution of quality grown on farm:
  - Log-normal distribution
  - Shifts according to variety
  - Henroid, et al. (2008)

Results

Results

Table 2. Empirical Model of Price Discrimination: Non-Linear

	Model 1: Fixed		Model 2: Random	
Variable	Estimate	Std. Err.	Estimate	Std. Err.
Random Parameter Means				
Quality	0.0538	0.0007	0.5832	0.0636
Price	-0.3597	0.0084	-0.3408	0.0059
Random Parameter Std. Devs.				
Quality			0.0207	0.0023
Price			0.0770	0.0003
Random Parameter Function				
Qual (Variety 2)			0.0132	0.0197
Qual (Variety 3)			0.0513	0.0199
Qual (Variety 4)			0.0119	0.0110
Qual (Variety 5)			0.0419	0.0483
Qual (Variety 6)			0.0495	0.0315
LLF	-3851.23		-235.974	

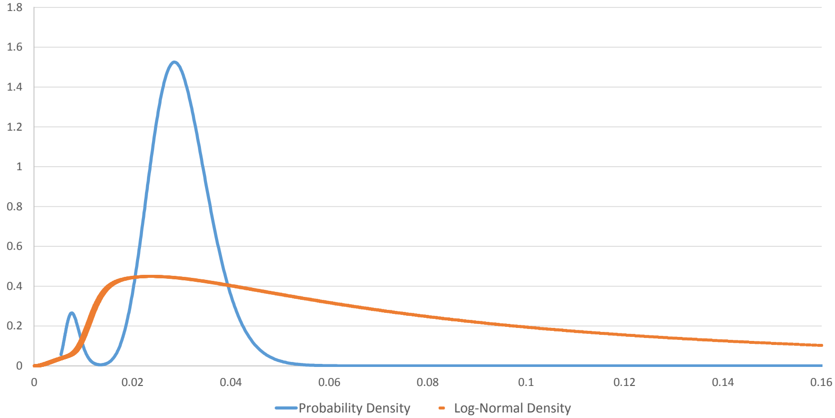
Results

Table 3. Non-Parametric Kernel Density Estimates

	Linear Model		Non-Linear Model	
	Empirical	Log-Normal	Empirical	Log-Normal
Bandwidth	0.0354	0.0353	0.1853	0.1850
Mean	1.6011	1.6011	0.2379	0.2379
Standard	0.2089	0.2086	1.0947	1.0929
Skewness	0.2918	0.0000	1.5326	0.0000
Kurtosis-3	-1.3139	-0.0380	2.8910	-0.0380
χ^2	6.5485	0.0047	52.7325	0.0047
Minimum	1.2844	0.8705	0.0066	0.0005
Maximum	1.9373	2.3317	0.6137	1.0934
Points	1062		1062	
% Food Loss	10.0814		12.0732	

Note: Kernel densities estimated with Epanechnikov function.

Density of WTP for Quality



Results

Table 4. Estimates of Farm Value Loss ($ mil.)

WTP Quality	Loss (%)	Retail Value	Farm Value
Baseline	10%	$350	$109
1%	21%	$746	$231
2%	31%	$1,099	$341
5%	44%	$1,551	$481
10%	49%	$1,722	$534

Note: Farm share from ERS-USDA (2018)

General Equilibrium Considerations

- Farm value lost due to retail quality discrimination
- Value can be recovered by:
  - Secondary markets: eg. sharing economy
  - Direct markets: eg. farmers markets
  - Donation markets: eg. food banks
- What if we used the whole distribution of quality?
  - Average price falls
  - Quantity demanded increases
  - Returns per acre may rise
  - Long run increase in acreage possible
  - Lower imports for tradable produce
- More complete use of planted acreage
- Small "rebound" effect possible

Conclusions

Conclusions

- Quality-based price discrimination can generate surplus food
  - Farmers produce a continuous distribution of quality
  - Retailers have an incentive to truncate that distribution
- We test this hypothesis using store-level scanner data
- Fresh produce sold through retailers is:
  - Horizontally differentiated
  - Vertically differentiated
- We use variety-, package-,market-variation to identify WTP for quality
- Distribution of quality preference is recovered via kernel density
- We find that retailer behavior is responsible for 10% loss in apples
- Retail loss represents $100.0 m opportunity to gain farm-revenue
- Loss due to retail intermediation likely similar for other products

Thank you! Questions?