Revised October 21, 2025

14.03/003 Micro Theory & Public Policy, Fall 2025

Lecture slides 13. The power of general equilibrium: Fish markets in Kerala, India

David Autor (Prof), MIT Economics and NBER

Salome Aguilar Llanes (TA), Nagisa Tadjfar (TA), Emma Zhu (TA)

Reminder: The First and Second Welfare Theorems

1. First Welfare Theorem
    - A free market in competitive equilibrium is Pareto efficient
2. Second Welfare Theorem
    - Any Pareto efficient allocation can be maintained as a competitive equilibrium

When do welfare theorems hold?

1. **No transaction costs**
2. **No market power**
3. **No externalities**
4. **Full information**
5. **Plus consumer axioms A1-A5**

The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector

Robert Jensen, *QJE*, 2007

Indian States and Territories

Kerala

The Case of Kerala

- 590 km coastline (+rivers/backwaters)
- Hundreds of fishing villages, 1million+ fishermen
- 600 K tons annual fish production
- 70+% eat fish daily. Primary source protein.
- Sardines (small, cheap), mackerel, prawns, seer

Rob Jensen '07 (slides)

The Case of Kerala

Fishing

- Wooden canoes, plywood or fiber glass boats
- Mostly outboard motors, 9-40HP.
- Gill net fishing, ring seine units
- 1-30 person crew, most 5 - 15. Joint ownership.

Marketing

- ~100-150 beach landings where sell fish, ~10km apart.
- Markets run largely from 5-8AM.
- Pre, Most fish sold via beach auction (English).
- Said to be competitive (buyers not collude (TN)).
- Little in way of interlinked transactions

Ring Seine Fishing in Kerala

Beach Market

This Project

- In Kerala, state in south India, fishing is:
  - A huge industry (1 million+ directly employed)
  - Important component of diet (70+% consume *daily*)

- 1997, cell phones available--big take-up by fishermen, traders. Market information.

- What is the impact on market functioning, LOP, profits and consumer prices/welfare.

Characteristics of Kerala fishing markets before 1997

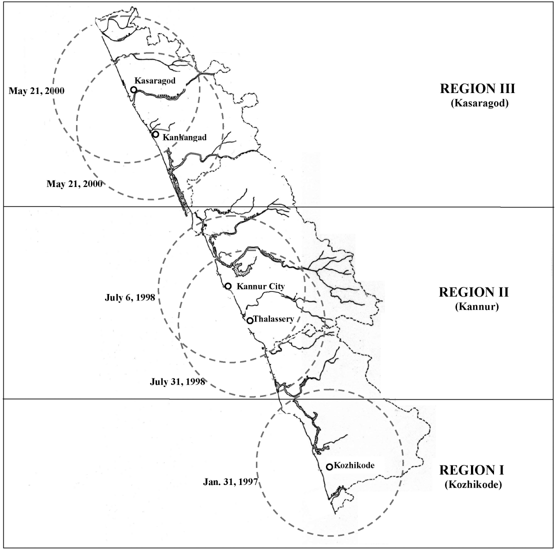
1. Isolated beach markets along the coast, far apart
2. Large price variation across beaches each morning
3. Some beaches have buyers but no sellers
4. Some beaches have sellers but no buyers – resulting in wastage

Why is there waste and price variation in Kerala's fish markets?

- Why not go to other markets when have high catch?
- High transport costs and uncertainty.
- Plus, constraints:
  - Market open only a few hours (supply chain)
  - Can visit 1 market per day (distance)
  - fish can't be resold on land (distance, roads, cost)
  - can't store overnight
  - no contracting or futures market

The mobile phone rollout —
One of the world's great quasi-experiments

Spread of mobile coverage: Kasaragod, Kannur, and Kozhikode districts



A mobile phone tower

Rob Jensen '07 (slides)

Large Changes in Fish Marketing

1996

2001

Spread of mobile coverage by date

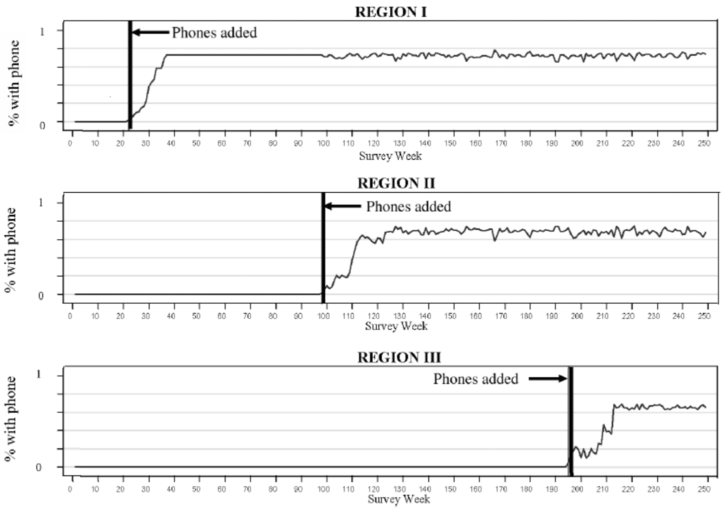
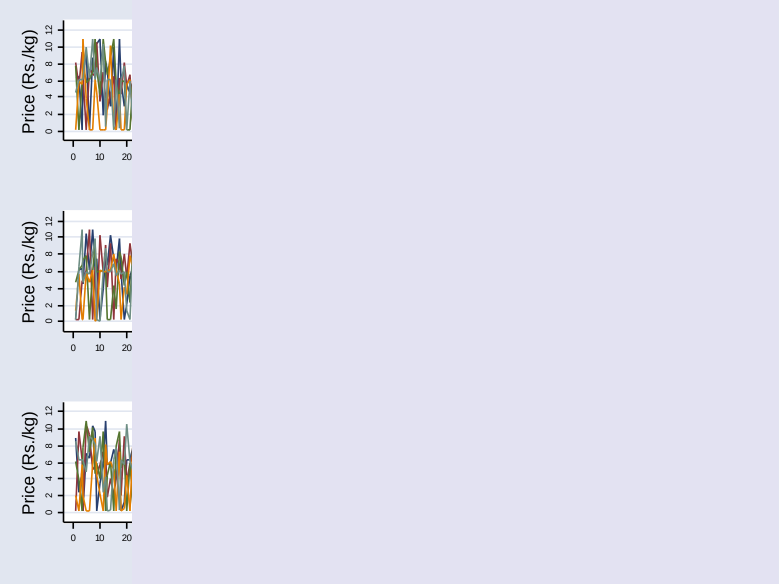


FIGURE III
Mobile Phone Adoption by Fishermen
Data from the Kerala Fisherman Survey conducted by the author.

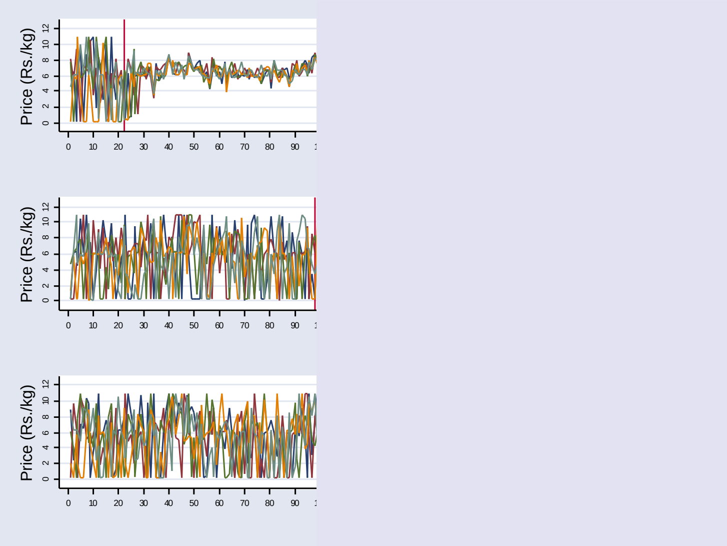
Plicker #1

Fish price dispersion across beaches by date

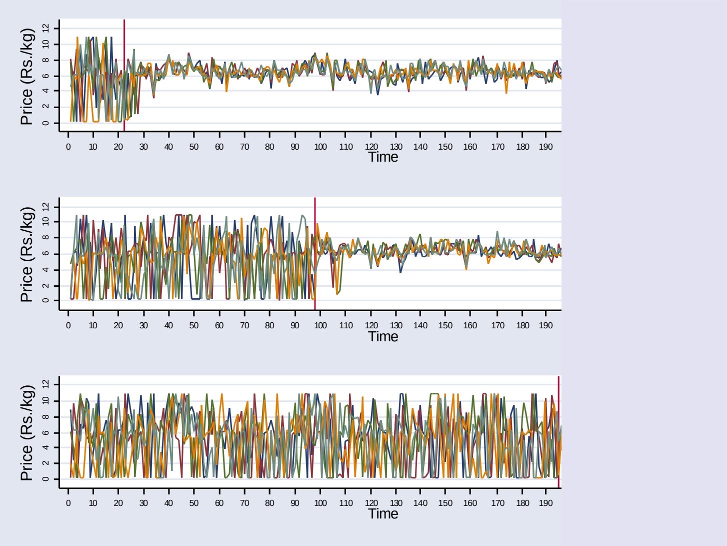


Rob Jensen '07 (slides)

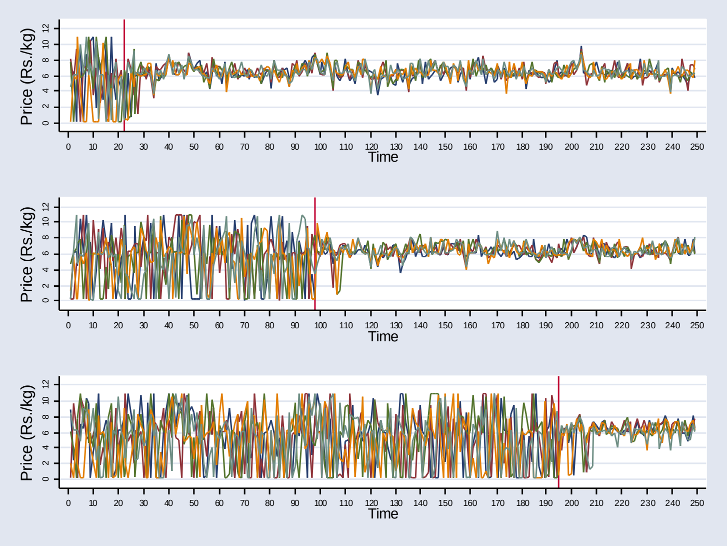
Fish price dispersion across beaches by date



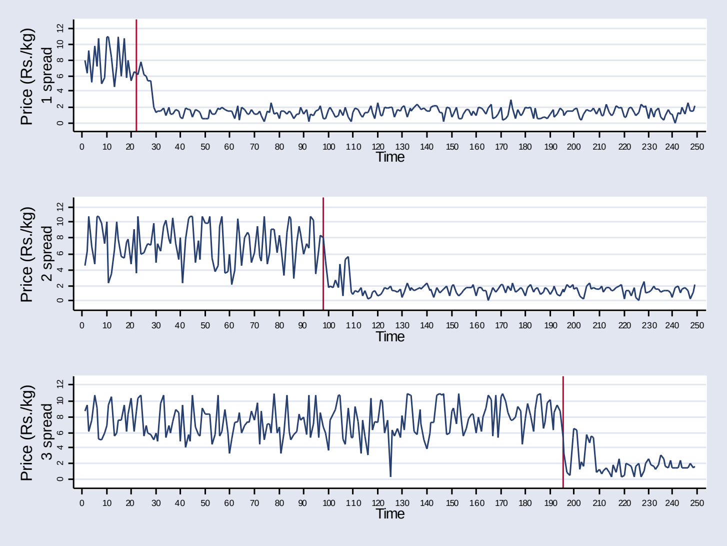
Fish price dispersion across beaches by date



Fish price dispersion across beaches by date



Decline in price spread across beaches



Decline in wastage across beaches

Price dispersion and waste in Kerala sardine markets

TABLE III
PRICE DISPERSION AND WASTE IN KERALA SARDINE MARKETS

	Period 0 (pre-phone)	Period 1 (region I adds phones)	Period 2 (region II adds phones)	Period 3 (region III adds phones)
Max–min spread (Rs/kg)				
Region I	7.60	1.86	1.32	1.22
	(0.50)	(0.22)	(0.10)	(0.44)
Region II	8.19	7.30	1.79	1.57
	(0.44)	(0.29)	(0.19)	(0.16)
Region III	8.24	7.27	7.60	2.56
	(0.47)	(0.27)	(0.25)	(0.34)
Waste (percent)				
Region I	0.08	0.00	0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)
Region II	0.05	0.04	0.00	0.00
	(0.01)	(0.01)	(0.00)	(0.00)
Region III	0.07	0.06	0.06	0.00
	(0.01)	(0.01)	(0.01)	(0.00)

Causal effects of mobile phone rollout on price dispersion

Estimated Effects of Mobile Phones on Market Outcomes: Separate Treatments

	Max–min spread	Coefficient of variation	Waste
Estimated effects of adding phones to region I			
(a) Using region II as the control group $(Y_{I,1} - Y_{I,0}) - (Y_{II,1} - Y_{II,0}) = \beta_{RI\_P1} - \beta_{RII\_P1}$	−4.8 (0.68)	−.46 (0.07)	−0.064 (0.005)
(b) Using region III as the control group $(Y_{I,1} - Y_{I,0}) - (Y_{III,1} - Y_{III,0}) = \beta_{RI\_P1}$	−4.8 (0.68)	−.42 (0.07)	−0.060 (0.005)
Estimated effects of adding phones to region II			
(c) Using region I as the control group $(Y_{II,2} - Y_{I,1}) - (Y_{I,2} - Y_{I,1}) = \beta_{RII\_P2} - \beta_{RII\_P1} - \beta_{RI\_P2} + \beta_{RI\_P1}$	−5.8 (0.43)	−.39 (0.05)	−0.039 (0.003)
(d) Using region III as the control group $(Y_{II,2} - Y_{II,1}) - (Y_{III,2} - Y_{III,1}) = \beta_{RII\_P2} - \beta_{RII\_P1}$	−4.9 (0.43)	−.36 (0.05)	−0.038 (0.003)
Estimated effects of adding phones to region III			
(e) Using region I as the control group $(Y_{III,3} - Y_{III,2}) - (Y_{I,3} - Y_{I,2}) = \beta_{RI\_P2} - \beta_{RI\_P3}$	−4.9 (0.48)	−.38 (0.05)	−0.055 (0.004)
(f) Using region II as the control group $(Y_{III,3} - Y_{III,2}) - (Y_{II,3} - Y_{II,2}) = \beta_{RII\_P2} - \beta_{RII\_P3}$	−4.7 (0.48)	−.35 (0.05)	−0.054 (0.004)

Plicker #2

Arbitrage and price convergence

Definition: arbitrage

1. Taking advantage of a price difference between two or more markets
2. Striking a combination of matching deals that capitalize upon the imbalance between prices

Mobile phone rollout and market arbitrage

TABLE II
Mobile Phone Introduction and Changes in Fish Marketing Behavior

	Period 0 (pre-phone)	Period 1 (region I adds phones)	Period 2 (region II adds phones)	Period 3 (region III adds phones)
Percent of fishermen who fish in local catchment zone				
Region I	0.98	0.99	0.98	0.98
	(0.003)	(0.001)	(0.001)	(0.002)
Region II	0.99	0.98	0.99	0.99
	(0.002)	(0.001)	(0.01)	(0.001)
Region III	0.98	0.98	0.98	0.99
	(0.002)	(0.001)	(0.001)	(0.001)
Percent of fishermen who sell in local catchment zone				
Region I	1.00	0.66	0.63	0.62
	(0.00)	(0.005)	(0.005)	(0.006)
Region II	1.00	1.00	0.64	0.58
	(0.00)	(0.00)	(0.004)	(0.006)
Region III	1.00	1.00	1.00	0.70
	(0.00)	(0.00)	(0.00)	(0.005)

Testing law of one price: Is price difference between markets greater than transport cost?

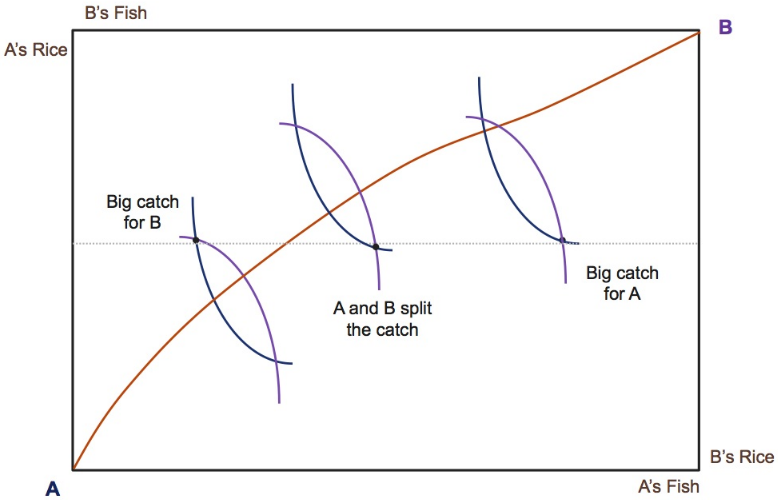
TABLE VII
VIOLATIONS OF THE LAW OF ONE PRICE

	Period 0 (pre-phone)	Period 1 (region I has phones)	Period 2 (region II has phones)	Period 3 (region III has phones)
Overall				
Region I	0.54	0.03	0.04	0.03
Region II	0.57	0.55	0.06	0.05
Region III	0.60	0.58	0.58	0.08
With time + depreciation				
Region I	0.50	0.01	0.02	0.02
Region II	0.53	0.52	0.03	0.03
Region III	0.57	0.55	0.54	0.05
All markets combined				
Without time + depreciation	0.47	0.35	0.20	0.05
With time + depreciation	0.44	0.31	0.16	0.03

Data from the Kerala Fisherman Survey conducted by the author. In the top two panels, the figures represent the average percent of unique market-pairs among the five markets in a given region for which the 7:30–8:00 A.M. average price differences differ by more than the estimated transportation costs between the two markets on a given day. For the bottom panel, the figures are for the unique market pairs among all fifteen markets in the sample.

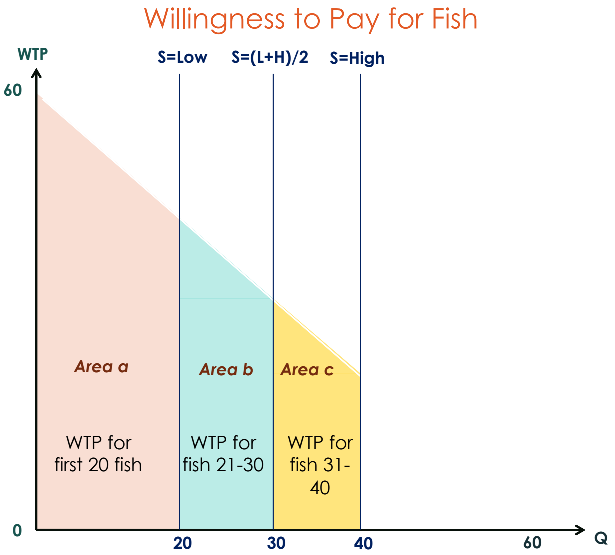
Consumer benefits from trade

Bundle adjustment

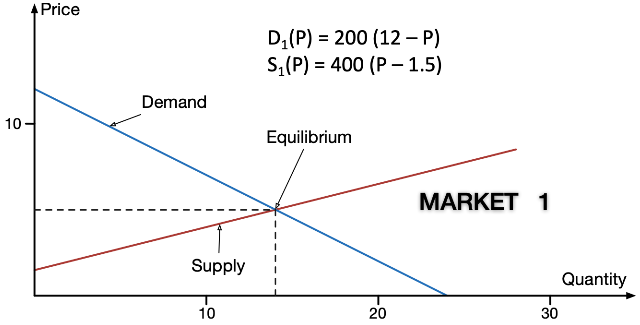


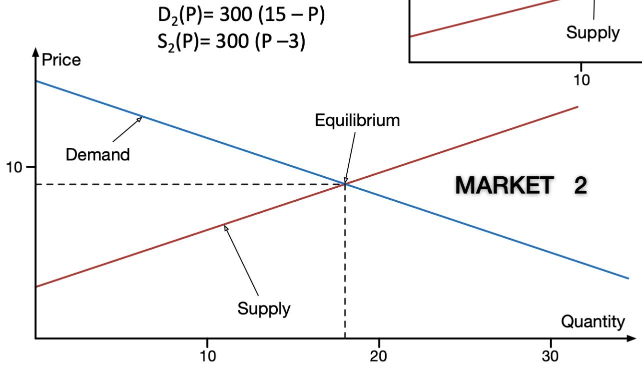
Consumer benefits from trade

Consumption smoothing



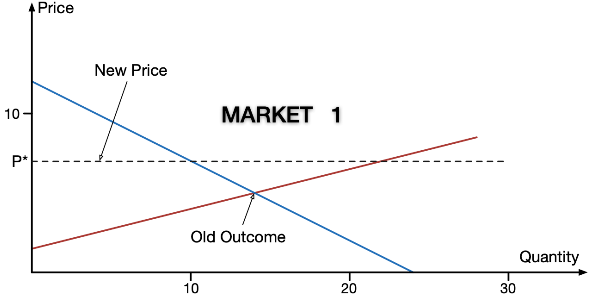
Effects of market integration on welfare





How does market integration affect prices, buyers & seller surplus, welfare?

After combining the market, we get a single equilibrium price of P* = 7.
How does total surplus change?



Equilibrium in market 1

Market-clearing price and quantity

- $D_1(P_1) = 200 \times (12 - P_1)$, $S_1(P_1) = 400 \times (P_1 - 1.5)$
- $P_1^* = 5$, $Q_1^* = 1,400$

Equilibrium in market 1

Market-clearing price and quantity

- $D_1(P_1) = 200 \times (12 - P_1)$, $S_1(P_1) = 400 \times (P_1 - 1.5)$
- $P_1^* = 5$, $Q_1^* = 1,400$

Consumer + producer surplus [note: area = (base $\times$ height)/2]

Equilibrium in market 1

Market-clearing price and quantity

- $D_1(P_1) = 200 \times (12 - P_1)$, $S_1(P_1) = 400 \times (P_1 - 1.5)$
- $P_1^* = 5$, $Q_1^* = 1,400$

Consumer + producer surplus [note: area = (base × height)/2]

- $D_1(P_1 = 12) = 0$, $S_1(P_1 = 1.5) = 0$
- Surplus $= (12 - 1.5) \times 1,400 \times 0.5 = 7,350$

Equilibrium in market 2

Market-clearing price and quantity

- $D_2(P_2) = 300 \times (15 - P_2)$, $S_2(P_2) = 300 \times (P_2 - 3)$
- $P_2^* = 9$, $Q_2^* = 1,800$

Equilibrium in market 2

Market-clearing price and quantity

- $D_2(P_2) = 300 \times (15 - P_2)$, $S_2(P_2) = 300 \times (P_2 - 3)$
- $P_2^* = 9$, $Q_2^* = 1,800$

Consumer + producer surplus [note: area = (base × height)/2]

- $D_2(P_2 = 15) = 0$, $S_2(P_2 = 3) = 0$
- Surplus $= (15 - 3) \times 1,800 \times 0.5 = 10,800$

Equilibrium in the integrated market

Market-clearing price and quantity

- $D_0(P_0) = 200 \times (12 - P_0) + 300 \times (15 - P_0) = 6,900 - 500P$
- $S_0(P_0) = 400 \times (P_0 - 1.5) + 300 \times (P_0 - 3) = 700P - 1,400$

Equilibrium in the integrated market

Market-clearing price and quantity

- $D_0(P_0) = 200 \times (12 - P_0) + 300 \times (15 - P_0) = 6,900 - 500P$
- $S_0(P_0) = 400 \times (P_0 - 1.5) + 300 \times (P_0 - 3) = 700P - 1,400$
- $P_0^* = 7$, $Q_0^* = 3,400$

Equilibrium in the integrated market

Market-clearing price and quantity

- $D_0(P_0) = 200 \times (12 - P_0) + 300 \times (15 - P_0) = 6,900 - 500P$
- $S_0(P_0) = 400 \times (P_0 - 1.5) + 300 \times (P_0 - 3) = 700P - 1,400$
- $P_0^* = 7$, $Q_0^* = 3,400$

Consumer + producer surplus

Equilibrium in the integrated market

Market-clearing price and quantity

- $D_0(P_0) = 200 \times (12 - P_0) + 300 \times (15 - P_0) = 6,900 - 500P$
- $S_0(P_0) = 400 \times (P_0 - 1.5) + 300 \times (P_0 - 3) = 700P - 1,400$
- $P_0^* = 7$, $Q_0^* = 3,400$

Consumer + producer surplus

- $D_0(P_0 = 13.8) = 0$, $S_0(P_0 = 2.14) = 0$
- Surplus $= (13.8 - 2.14) \times 3,400 \times 0.5 = 19,822$

Effects of market integration on welfare

	P*	Q*	Consumer + Producer Surplus
Market 1	5	1,400	7,350
Market 2	9	1,800	10,800
Sum of (1) and (2)		**3,200**	**18,150**
Integrated market	7	**3,400**	**19,822**

Plicker #3

Plicker #4