05a. Mechanization

Econ 373: US Economic History

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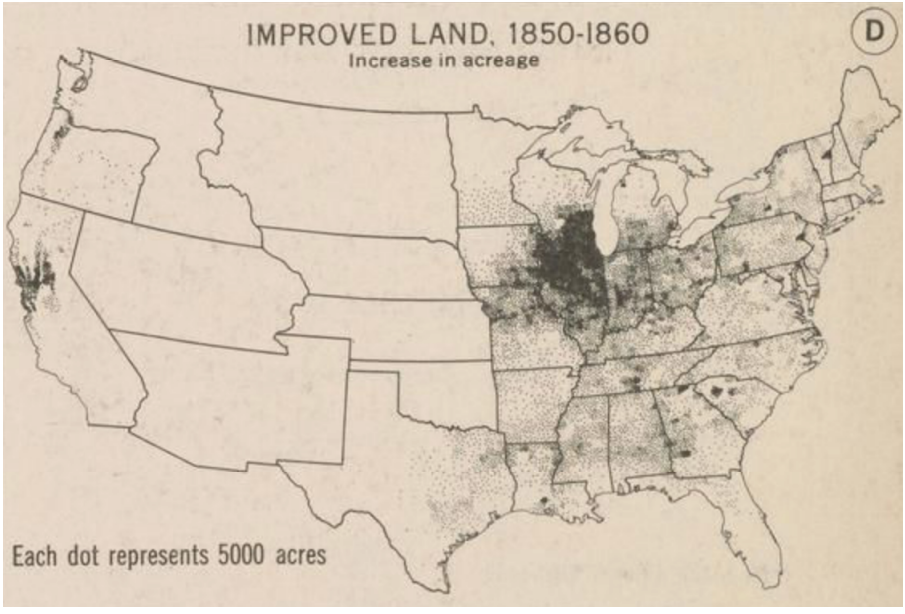
Agricultural development in the North and South

- In 19thC, American farmers rapidly moved frontier of settlement westward
- In two main regions of United States agricultural development preceded along different lines
  - North: "yeoman democracy" organized around family-owned and family-operated farms that produced a mix of crops for own and local consumption as well as international markets
  - South: plantations organized around planter autarky producing staple crops (especially cotton) for world markets using slave labor
- Aim to understand economic aspects of agricultural development

A "typical" farm in the North

- Usual progression of development was for family to clear 5-10 acres per year and plant crops as land became available
  - Took 5-10 years to complete farm during which family was drawing down savings
  - Family could also hire outside labor as an alternative
- What is economic calculus governing these choices?
  - Savings on hand, availability of outside labor, time preference
- Cost was $10-$12 per acre for woodland and $2-$5 per acre for prairie


IMPROVED LAND, 1850-1860
Increase in acreage
D
Each dot represents 5000 acres

A "typical" farm in the North

- To "self-finance" cost of homestead with family labor required:
  - Mortgaging land, e.g., for $200
  - Repaying balance in cash in 3-5 years, e.g., $595
- Family farm required savings, difficult work at subsistence living standards
- Suggests farmer's wealth could not fall below $800-$1,700
- Structure could also give rise to individuals or families with different "stakes" in farming, e.g., tenancy for cash or shares

Table 1: Capital Costs of Tenant and Owner-Occupied Farms

	Owner-Occupied	Tenant	Owner-Occupied	Tenant	Owner-Occupied	Tenant
Midwest						
Farm Value	738	969	1,363	1,460	2,490	2,151
Implement Value	46	38	67	57	96	87
Livestock Value	197	219	285	268	426	335
Total cost to						
O/T-occupier	981	257	1,715	325	3,002	422
Northeast						
Farm Value	1,599	2,967	2,621	2,772	3,966	3,636
Implement Value	65	58	116	80	162	124
Livestock Value	256	256	401	277	615	501
Total cost to						
O/T-occupier	1,920	314	3,138	357	4,743	625

The process of growing wheat and other small grains

- Soil had to be loosened to bury seeds, provide drainage and space
  - Done with wooden or metal-sheathed wooden plow pulled by animals
- Seeds scattered by hand, buried under shallow soil by animal-drawn plow
- Mature plants cut with hand-swung scythe and bound together in shocks
- Shocks stored until grain separated from straw, chaff, dirt by screening

Farming practices and productivity growth

- Labor productivity limited by:
  - Number of acres that could be plowed and harvested
  - Number of bushels of grain each acre could yield
  - Number of bushels each worker could thresh (or otherwise prepare for consumption)
- William Parker and Judith Klein estimated it took worker:
  - 1.45, 3.17, and 3.50 hours for oats, wheat, and corn in 1840-60
  - 0.40, 0.76, and 0.96 hours for oats, wheat, and corn in 1900-10
- Calculate change in labor productivity by crop

Farming practices and productivity growth

- To understand "why" we use decomposition methodology
  - Mechanization: change in time spent plowing, planting, harvesting, preparing crop
    e.g., use of seeders, harrows, cultivators, reapers, and mechanical threshers
  - Westward movement: change in regional shares
  - Scientific farming: change in yields
- Can ask: if only one of these had changes how much of total gains in productivity would have been achieved?
  - Fixing "regional shares" and "yields" in 1840-60, changing only "mechanization" would have led to 186-246 percent increase in productivity
  - Represents 1/2 to 2/3 of the total increase, depending on crop

Mechanization

- According to Parker and Klein labor productivity growth would have been less than half actual rate in absence of mechanization
- What factors determined adoption of mechanization?
- Many improvements came easily, e.g.,
  - 1820s wooden plows were displaced by cast-iron plows
  - 1840s spread of John Deere's 1837 invention (using steel)
  - Mechanical threshers cut time by 90 percent and cost by 50 percent
- Although threshing was hard it could be completed in winter, planting and harvesting had to be done at specific time and within certain period

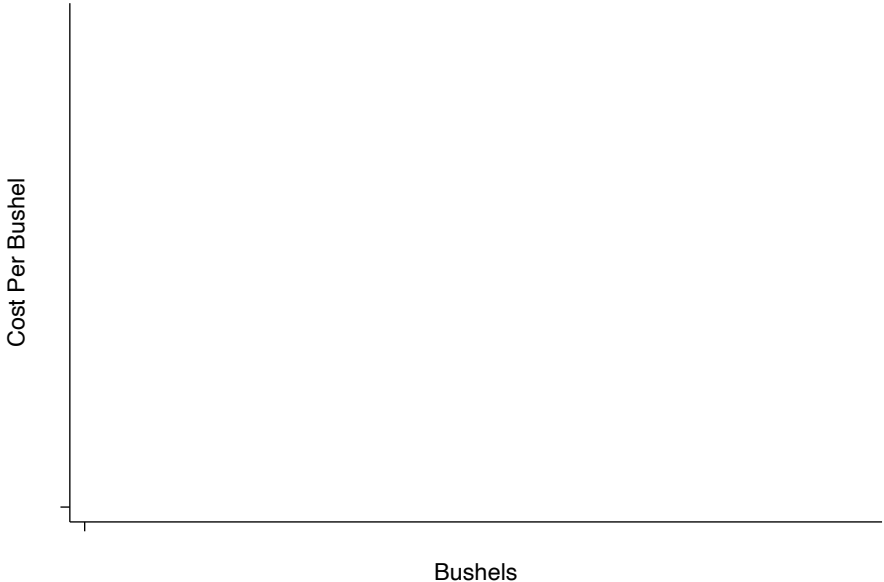
Mechanization

- Small grain had two-week window of opportunity in which ripe grain could be harvested, imposing a binding labor constraint on farm output
- Individual farmers could use labor-for-hire to break constraint, but this was not solution for entire region for which labor supply was fixed
- What is solution to this problem?
- Obed Hussey (1833) and Cyrus McCormick (1834) patented first mechanical harvesters, but substantial adoption only occurred in 1850s

The adoption of the reaper

- Why did widespread adoption of the reaper take so long?
- Conventional explanation is high price of wheat in 1850s raised wheat profitability, encouraged additional planting, and forced adoption
- What is economic model that describes this situation (and other instances of technological innovation in agriculture and industry)?
  - A model of supply (costs)
  - Relates costs (per bushel) to total quantity
  - Predicts the "threshold" (quantity) for adoption of the reaper

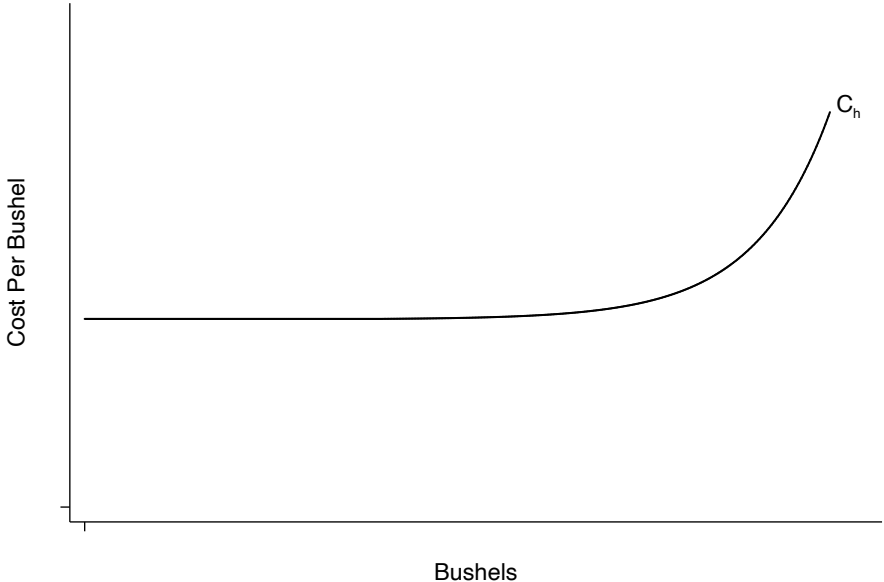
The Threshold of Reaper Adoption

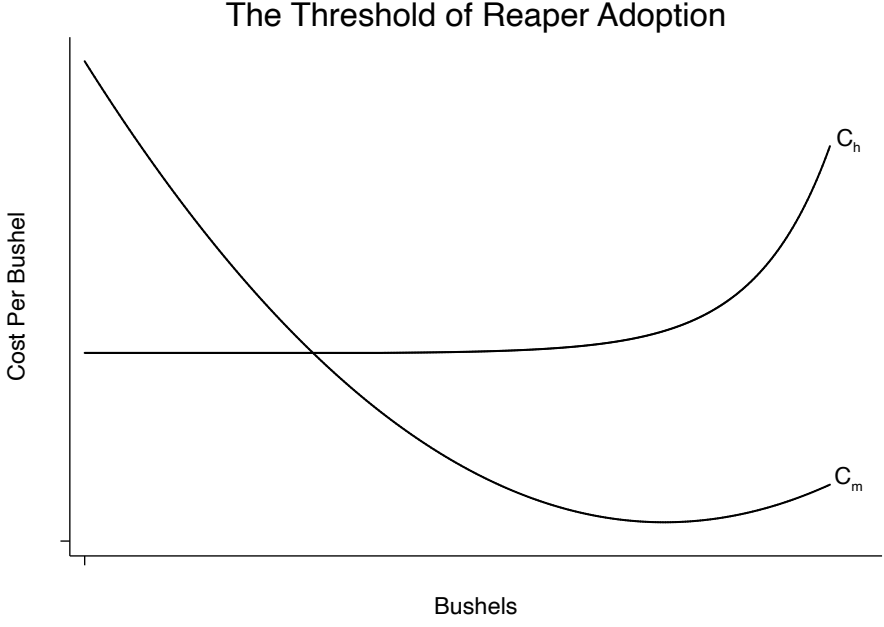


The adoption of the reaper

- Represent relationship between cost per bushel, quantity
  - C_h: cost curve for harvesting by hand, C_m: cost curve for mechanized harvesting

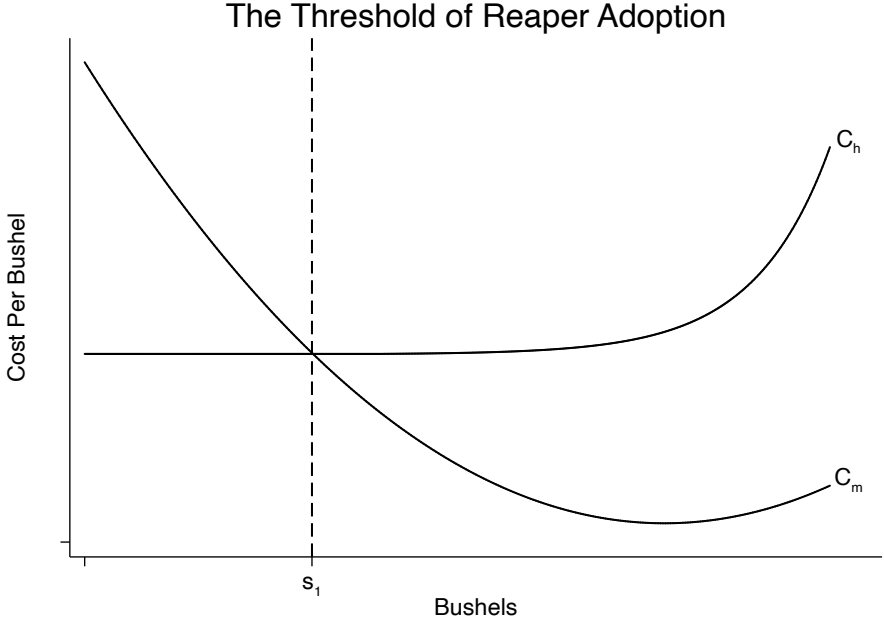
The Threshold of Reaper Adoption




The Threshold of Reaper Adoption
Cost Per Bushel
Bushels
C_h
C_m

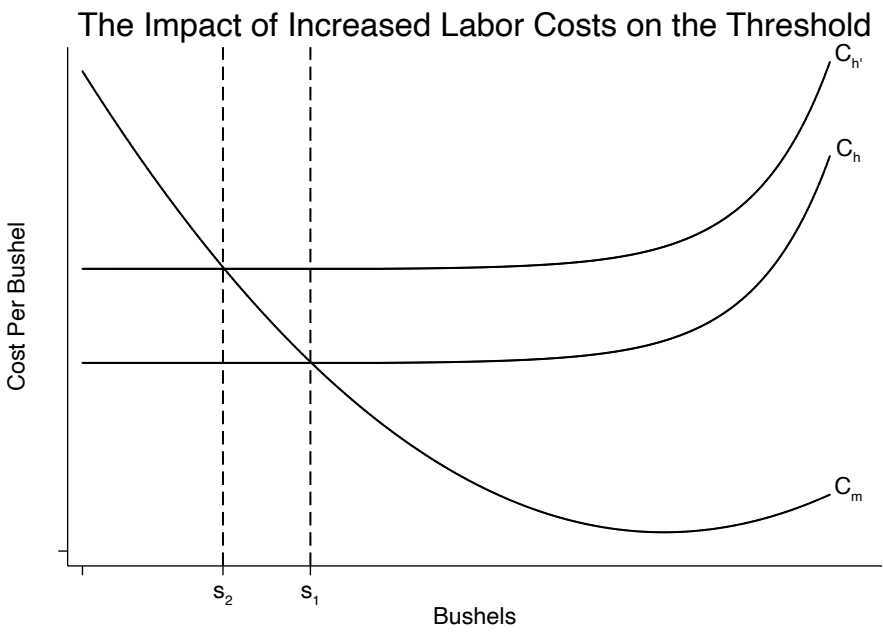
The adoption of the reaper

- Represent relationship between cost per bushel, quantity
  - C_h: cost curve for harvesting by hand, C_m: cost curve for mechanized harvesting
- To left of s_1 costs of hand harvesting are less than mechanized harvesting, to right of s_1 costs are greater (s_1 is "threshold of adoption")


The Threshold of Reaper Adoption
Cost Per Bushel
C_h
C_m
s_1
Bushels

The adoption of the reaper

- Represent relationship between cost per bushel, quantity
  - C_h: cost curve for harvesting by hand, C_m: cost curve for mechanized harvesting
- To left of s_1 costs of hand harvesting are less than mechanized harvesting, to right of s_1 costs are greater (s_1 is "threshold of adoption")
- What economic factors explain shape of cost curves?
  - Labor constraint $\rightarrow C_h$, Fixed costs $\rightarrow C_m$
- Finally, what happens if there is region-wide increase in labor demand?

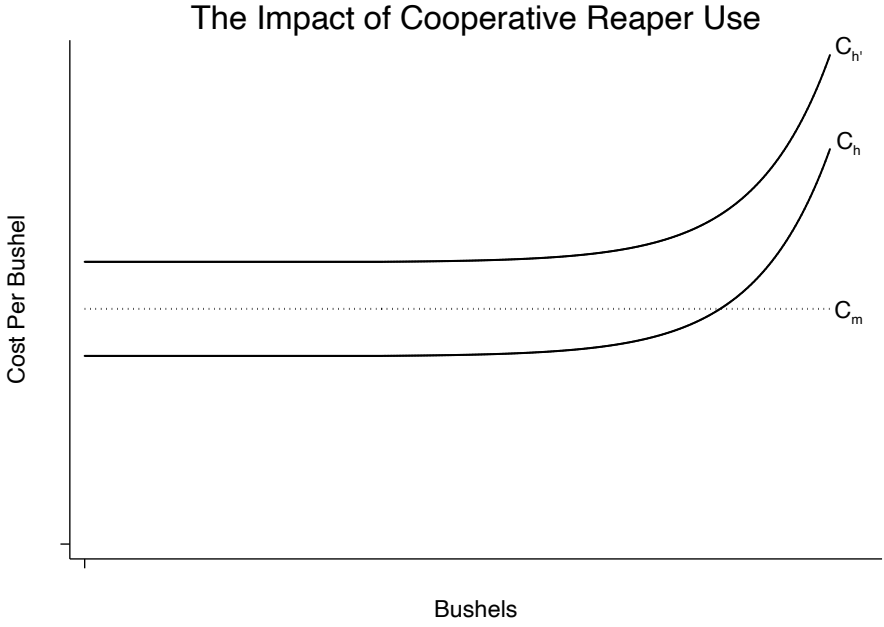

The Impact of Increased Labor Costs on the Threshold
Cost Per Bushel
$C_{h'}$
C_h
C_m
s_2
s_1
Bushels

The adoption of the reaper

- So explanations of reaper adoption here are twofold:
  - Increase in planting induced by higher prices
  - Increase in labor costs across the entire region
- What does evidence suggest about plausibility of these explanations?
  - 1849-53: McCormick reaper was 97.6 laborer-day wages $\rightarrow$ threshold $= 46.5$
  - Typical farm in Illinois between 15-40 acres
  - By 1859-60, threshold decreased and average farm size increased
- Note: changes reflect changing conditions at home *and* change conditions abroad, e.g., interruption of European wheat trade by Crimean War

The adoption of the reaper

- So far, discussion assumed reapers are "indivisible," i.e., to gain services of reaper farmer must purchase a whole reaper
  - How does adding rental market change shape of cost curve?


The Impact of Cooperative Reaper Use
Cost Per Bushel
Bushels
$C_{h'}$
C_h
C_m

The adoption of the reaper

- So far, discussion assumed reapers are "indivisible," i.e., to gain services of reaper farmer must purchase whole reaper
  - How does adding rental market change shape of cost curve?
- Indeed, Olmstead found evidence of cooperative ownership with neighboring farmers and related farmers pooled resources to buy reapers jointly
- How have technology choices (reaper and other forms of mechanization) shaped subsequent history of American agriculture?
  - Once farmer adopted expensive equipment reluctant to make changes even if incentives changed
  - Called "lock-in" and arises because of complementarity of technology, inputs