



OVERVIEW

This episode discusses the sugarcane industry, examining how regulation can shift the costs of production and have unintended consequences for the environment. The cost of production in the sugar industry is influenced by the prices of inputs such as capital (machinery) and labor. In addition, there are different environmental challenges posed by using either the mechanical or manual method of sugarcane harvesting. Using the manual method of harvesting, fields are cleared by fire, causing heavy smoke and particulate matter. Using the mechanical harvest method, processing occurs in fossil-fuel powered mills, leading to sulfur dioxide emissions. Mexico's attempt to regulate the mechanical harvest process has resulted in a shift toward more manual harvest methods and unintended impacts on areas surrounding the fields. Clearing fields with fire in Florida has negatively impacted surrounding regions.

Key Microeconomics Links

- **Cost of Production:** The cost of producing sugar is influenced by the prices of capital (i.e. machinery) and labor. This affects the overall economic efficiency and profitability of the industry.
- **Externalities:** The environmental impact of sugarcane production, particularly pollution from harvesting methods, represents a negative externality that affects third parties not directly involved in the production process.
- **Regulation and Market Failure:** Government interventions, such as regulations aimed at reducing pollution, are attempts to correct market failures associated with negative externalities. However, regulations can lead to changes in input choices and unintended shifts in pollution.
- **Marginal Rate of Technical Substitution (optional/more advanced topic):** The rate at which one input (like capital) can be substituted for another (like labor) in production, while maintaining the same level of output. If the price of input changes the concept of the marginal rate of technical substitution (MRTS) shows the shift of inputs, keeping output constant along an isoquant.

Preview Question

What happens in the sugar cane industry when pollution is regulated?

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Discussion Questions

1. How did the regulation of sugar mills in Mexico change the cost structure of sugar production?
2. How did the regulation of sugar mills in Mexico change the use of labor and capital in sugar production?
3. Why did producers switch from mechanical to manual harvesting after the regulation? What does this tell us about how firms respond to changes in relative input costs?
4. Why is it important to understand the production process and costs when designing regulations?
5. Why might a firm continue producing the same level of output despite an increase in costs? Under what conditions would we expect firms to reduce output instead?
6. In what ways did the regulation increase production costs for sugar mills, even though total output stayed the same?
7. What challenges do governments face in regulating pollution in the sugar industry?
8. How do production costs in the sugar industry influence the choice between mechanical and manual harvesting methods, and what are the implications for environmental impact?
9. How does this story of sugarcane production illustrate unintended consequences in economics?
10. Discuss how the regulation changed impacted the firm's marginal cost of production and production functions.

Multiple Choice Questions

1. Which of the following are inputs in the production of sugar?
A) Labor
B) Mills and machinery
C) Sugarcane
D) All of these

Answer: D) All of these

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2. What is one major environmental concern associated with manual sugarcane harvesting?
- A) Excessive water use
 - B) Air pollution from fires
 - C) Soil erosion
 - D) Noise pollution

Answer: B) Air pollution from fires

3. How did sugarcane producers respond to the regulation of mill emissions in Mexico?
- A) Increased mechanical harvesting
 - B) Decreased sugar production
 - C) Shift to more manual harvesting
 - D) Improved air quality

Answer: C) Shift to more manual harvesting

4. How does the marginal cost of manual harvesting compare to mechanical harvesting?
- A) Higher due to increased labor costs
 - B) Lower due to decreased equipment costs
 - C) Equal in both methods
 - D) Variable depending on weather conditions

Answer: A) Higher due to increased labor costs

5. Which factor primarily influences the choice between mechanical and manual harvesting?
- A) Government regulations
 - B) The marginal cost of inputs
 - C) Consumer preferences
 - D) Availability of raw materials

Answer: B) Marginal cost of inputs

6. What is the impact of shifting production methods on socioeconomically vulnerable communities?
- A) Decreased economic burden
 - B) Worse health outcomes due to pollution
 - C) No impact on communities
 - D) Improved living conditions

Answer: B) Worse health outcomes due to pollution

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7. Environmental regulation on the mills used to process sugarcane resulted in
- A) An increase in the marginal cost of production
 - B) A shift to using more of the manual method of harvesting
 - C) An increase in pollution from fires clearing the field
 - D) All of these

Answer: D) All of these

8. What was a significant consequence of producers shifting inputs from mechanical to more manual methods in the sugar industry?
- A) Increased sugar prices
 - B) Pollution shifting to other production stages
 - C) Reduced sugar demand
 - D) Enhanced sugar quality

Answer: B) Pollution shifting to other production stages

9. Producers in the sugarcane industry are displaying what type of behavior?
- A) Profit maximizing
 - B) Cost maximizing
 - C) Labor minimizing
 - D) None of these

Answer: A) Profit maximizing

10. The environmental impacts from the sugarcane production process is known as a
- A) Negative commonality
 - B) Economic incident
 - C) Positive externality
 - D) Negative externality

Answer: D) Negative externality

True / False Questions

1. True/False: The cost of production in the sugar industry is primarily driven by the prices of capital (i.e. machinery) and labor.

Answer: True

2. True/False: Regulatory measures in Mexico targeted the mills emitting sulfur dioxide, leaving manual harvesting methods unregulated.

Answer: True

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3. True/False: The cost of production in the sugar industry is driven solely by consumer demand.
Answer: False
4. True/False: The marginal cost of manual harvesting is higher due to increased labor costs.
Answer: True
5. True/False: Mechanical harvesting involves higher equipment costs but lower labor costs compared to manual harvesting.
Answer: True
6. True/False: The marginal rate of technical substitution refers to the rate at which sugar can be substituted for other crops.
Answer: False
7. True/False: The use of manual labor in sugarcane harvesting typically results in less pollution compared to mechanical methods.
Answer: False
8. True/False: When regulation increased in the cost of mechanical harvesting (capital) producers responded by decreasing the amount of sugar produced.
Answer: False
9. True/False: Regulations in Florida designed to improve health outcomes actually increased the pollution burden on socioeconomically vulnerable communities.
Answer: True
10. True/False: Regulation targeting only the mills in Mexico successfully eliminated all pollution from the sugar industry.
Answer: False

Application Questions

Consider the table below, which provides the firm Sugary Surgarcane's production information in a week. Sugar is produced using labor hours and capital.

Questions

1. Suppose in the sugarcane industry, labor costs (wages) are \$15 per hour and mill hours cost \$40 per hour. Production using capital and labor before regulation is found in Table 1. Calculate the total cost and marginal cost before regulation.
2. After the environmental regulation, production shifted to more labor (manual) and less capital (mechanical in mills) after regulation. Labor costs remain the same. Calculate total cost and marginal cost after regulation.

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3. Suppose wages become more expensive after regulation (due to increasing demand for labor). How will this impact total cost and marginal cost?
4. Suppose we hold mill hours constant and only examine the changes of labor on output. Graph the production function with output on the x-axis and labor on the y-axis. Similarly, suppose that we hold labor constant and only example the changes of mill hours on output. Graph the production function with output on the x-axis and capital (mill hours) on the y-axis.

Table 1: Before Regulation

Output, Q (metric tons)	Labor, L (labor hours per week)	Capital, K (mill hours per week)	Total Cost (\$)	Marginal Cost (\$/metric tons)
1	5	0		
2	10	10		
3	15	20		
4	20	30		
5	25	40		
6	30	50		
7	35	60		

Table 2: After Regulation

Output, Q (metric tons)	Labor, L (labor hours per week)	Capital, K (mill hours per week)	Total Cost (\$)	Marginal Cost (\$/metric tons)
1	50	0		
2	60	2		
3	75	4		
4	100	6		
5	140	8		
6	200	10		
7	300	12		

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Answers

1. Total costs are calculated with the following formula.

Total Costs = (Wage rate x Number of Labor hours) + (Mill rate x Number of Mill hours)

Total Costs = $(15 \times \text{Number of Labor hours}) + (40 \times \text{Number of Mill hours})$

Example of Output =2 before regulation:

Total Costs = $(15 \times 10) + (4 \times 90) = 150 + 360 = 510$

Marginal costs are calculated with the following formula.

Marginal costs = Change in Total cost ÷ Change in Output

Example at Output =2 before regulation:

Marginal Costs = $(510 - 315) / (2 - 1) = 195$

Table 1: Before Regulation

Output, Q (metric tons)	Labor, L (labor hours per week)	Capital, K (mill hours per week)	Total Cost (\$)	Marginal Cost (\$/metric tons)
1	5	6	$75 + 240 = 315$	---
2	10	9	$150 + 360 = 510$	$(510 - 315) / (2 - 1) = 195$
3	15	13	$225 + 520 = 745$	$(745 - 510) / (3 - 2) = 235$
4	20	18	$300 + 720 = 1020$	$(1020 - 745) / (4 - 3) = 275$
5	25	25	$375 + 1000 = 1375$	$(1375 - 1020) / (5 - 4) = 355$
6	30	34	$450 + 1360 = 1810$	$(1810 - 1375) / (6 - 5) = 435$
7	35	44	$525 + 1760 = 2285$	$(2285 - 1810) / (7 - 6) = 475$

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2. The impact of regulation in this example shows increasing labor (manual harvesting) and decreasing mill hours (mechanical harvesting), overall this increases total cost and marginal costs. See for example an output of 3 metric tons. Before regulation, total costs are \$745, with marginal costs of \$235. When regulation takes place, production shifts such that more labor is used with fewer mill hours (capital). The result is an increase in total costs to \$1285 and marginal costs to \$305.

Table 2: After Regulation

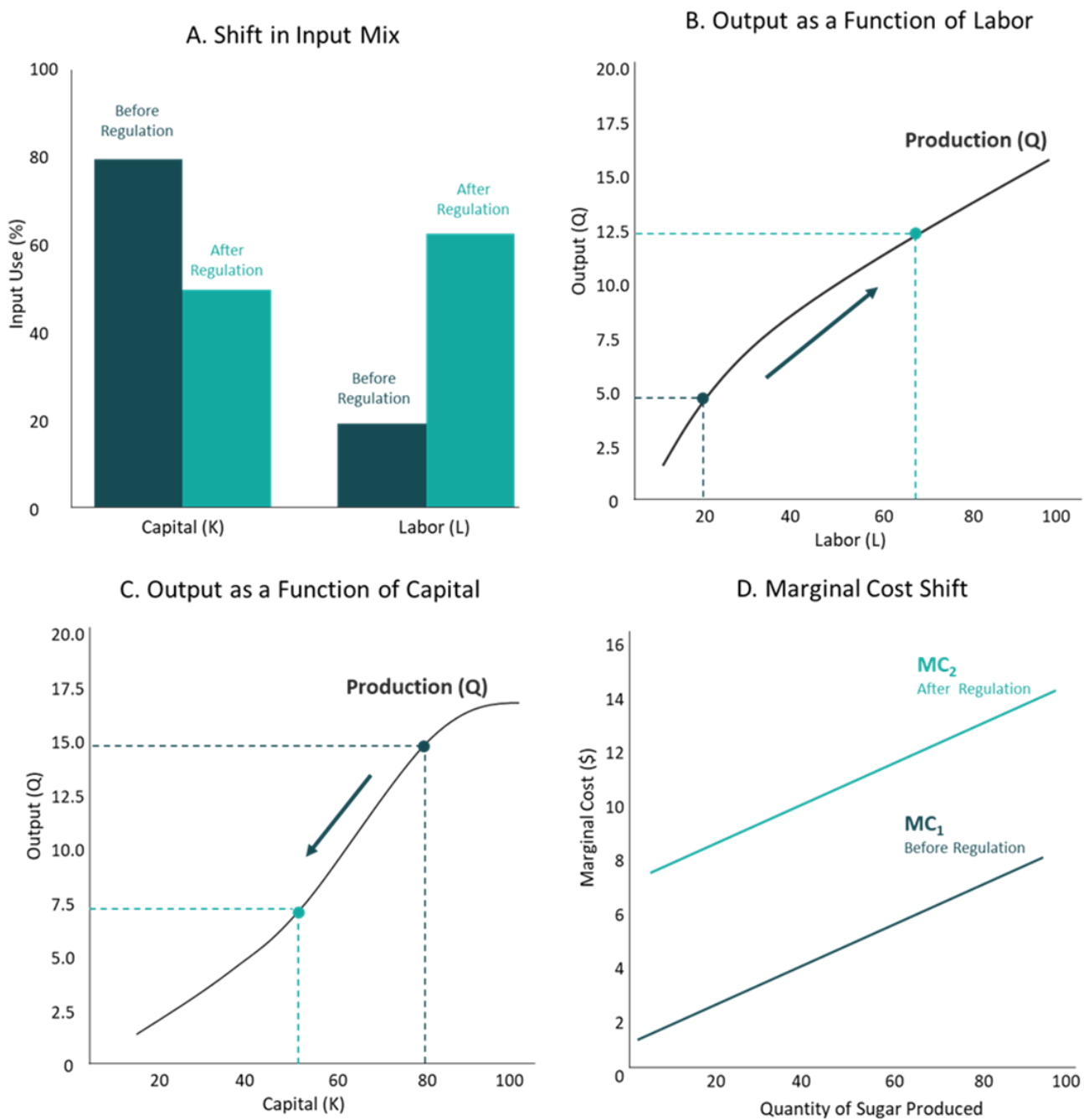
Output, Q (metric tons)	Labor, L (labor hours per week)	Capital, K (mill hours per week)	Total Cost (\$)	Marginal Cost (\$/metric tons)
1	50	0	$750+0=750$	--
2	60	2	$900+80=980$	$(980-750)/(2-1)=230$
3	75	4	$1125+160=1285$	$(1285-980)/(3-2)=305$
4	100	6	$1500+240=1740$	$(1740-1285)/(4-3)=455$
5	140	8	$2100+320=2420$	$(2420-1740)/(5-4)=680$
6	200	10	$3000+400=3400$	$(3400-2420)/(6-5)=980$
7	300	12	$4500+480=4980$	$(4980-3400)/(7-6)=1580$

3. Increases in wages result in an increase in total cost and marginal cost for all output levels. For example from Table 2, suppose that wages are now \$20/hour (higher than the previous \$15/hour). At an output level of 6, our total cost now increases to $4000+400=4400$. Total cost at output of 5 is $2800+320=3120$ (both higher than before). At output of 6, marginal cost is $(4400-3120)/(6-5)=1280$ (higher than before).
4. See the graphs section, specifically graphs b and c provide an illustration of these production functions. In graph b, since you are holding capital constant, if capital changes, you will see a shift in the production function. Similarly, for graph c, since you are holding labor constant, when labor changes, you will see a shift in the production function.

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Episode in a Graph



UE Figure S1 Ep2: Effects of Regulation on Sugarcane Production.

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Description: This figure illustrates the impact of an environmental regulation on production decisions and costs in the sugarcane industry. Panel A shows a shift in the input mix: regulation targeting mill emissions led producers to substitute away from capital-intensive mechanical harvesting and toward labor-intensive manual harvesting. Panel B depicts a movement along the labor production function, as reduced use of capital increased reliance on labor to maintain output. Panel C illustrates movement along the capital production function. Since labor input increased while output remained constant, a corresponding reduction in capital use would be expected in. Finally, Panel D shows that these input shifts—combined with additional regulatory costs—caused the marginal cost curve to shift upward, increasing the overall cost of sugar production.

Innovative Ways to Extend the Lessons

1. Listen to our podcast! Student Assignment:

- Listen to the episode podcast and have students reflect: *What is lost or gained when research is translated into casual language? What did I hear that I missed in the video? What concepts does the video clarify that the podcast does not?*

2. Case Study Analysis:

- Provide students with detailed case studies of sugarcane production in different countries, focusing on regulatory approaches and outcomes. Students can analyze and compare these cases, identifying key factors that lead to successful or unsuccessful regulation and propose improvements.

3. Research and Presentation Project:

- Assign students to research the sugar industry in a specific country or region, focusing on its economic, environmental, and social impacts. Students then present their findings and recommendations for sustainable practices and policies to the class, fostering public speaking and critical analysis skills.