Household Water and Energy Use: An Experimental Analysis of Decision-making under Uncertainty and Penalty Rate Structures

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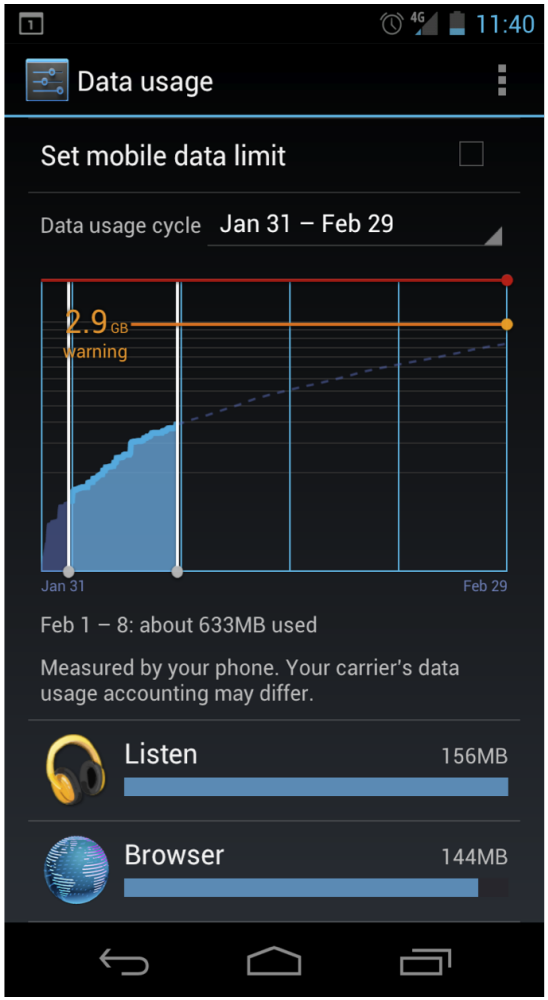
11:40
Data usage
Set mobile data limit
Data usage cycle
Jan 31 – Feb 29
2.9 GB
warning
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Feb 1 – 8: about 633MB used
Measured by your phone. Your carrier's data usage accounting may differ.
Listen
156MB
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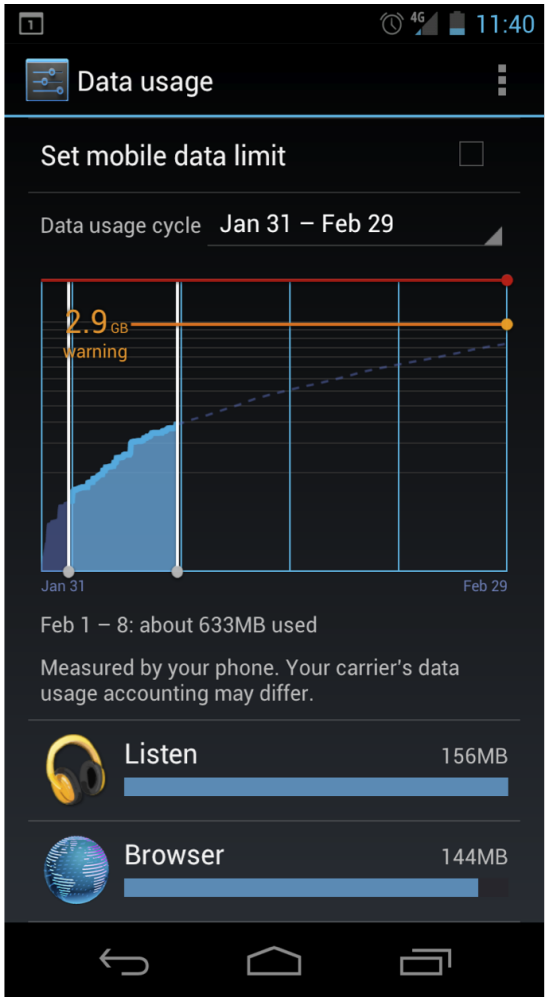
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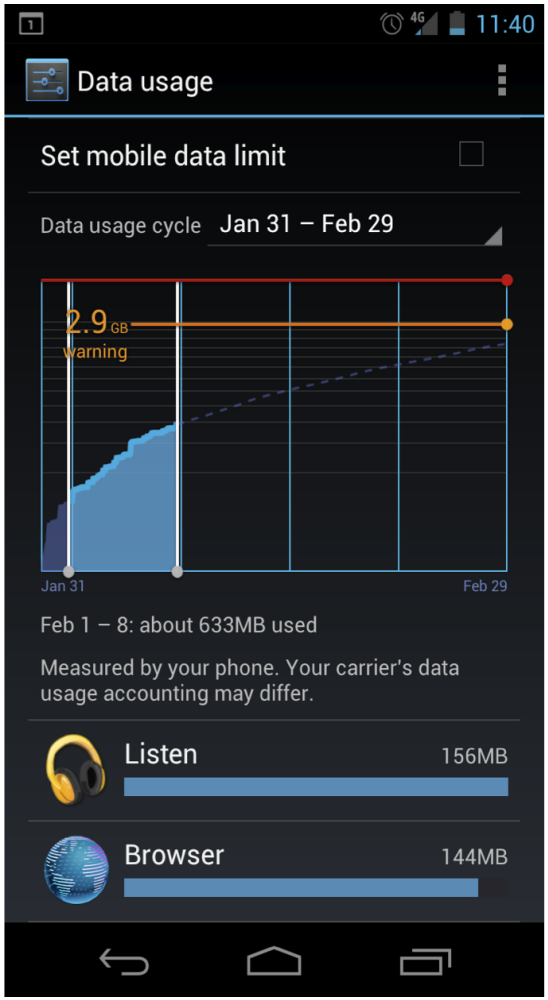

- Bill Shock
- "It can be difficult to know when you're running up a surprising high wireless bill, especially if you don't monitor your usage or receive automatic usage alerts" – fcc.gov

Water and Energy

Utilities are anticipating gaps between supply and demand

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"For the United States to realize its full demand response potential, customers must have access to, and a better understanding of, information about real-time or near-real-time price"

– Energy Independence and Security Act of 2007

OUTLINE

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- Multiple decisions within a billing period: $x_1, x_2, ...x_S$

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A. Backward Uncertainty
and Forward Uncertainty :

$$...r_{s-2}, r_{s-1}, r_s, r_{s+1}...$$

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B. Forward Uncertainty only:

$$r_s, r_{s+1}...$$

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   - Quantity Uncertainty $\implies$ Marginal Price Uncertainty

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$$\underset{\{x_1, x_2 \ldots x_S\}}{\text{Max}} \; U(x_1, x_2 \ldots x_S) + E\left[V(z)\right]$$

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Theoretical Predictions:

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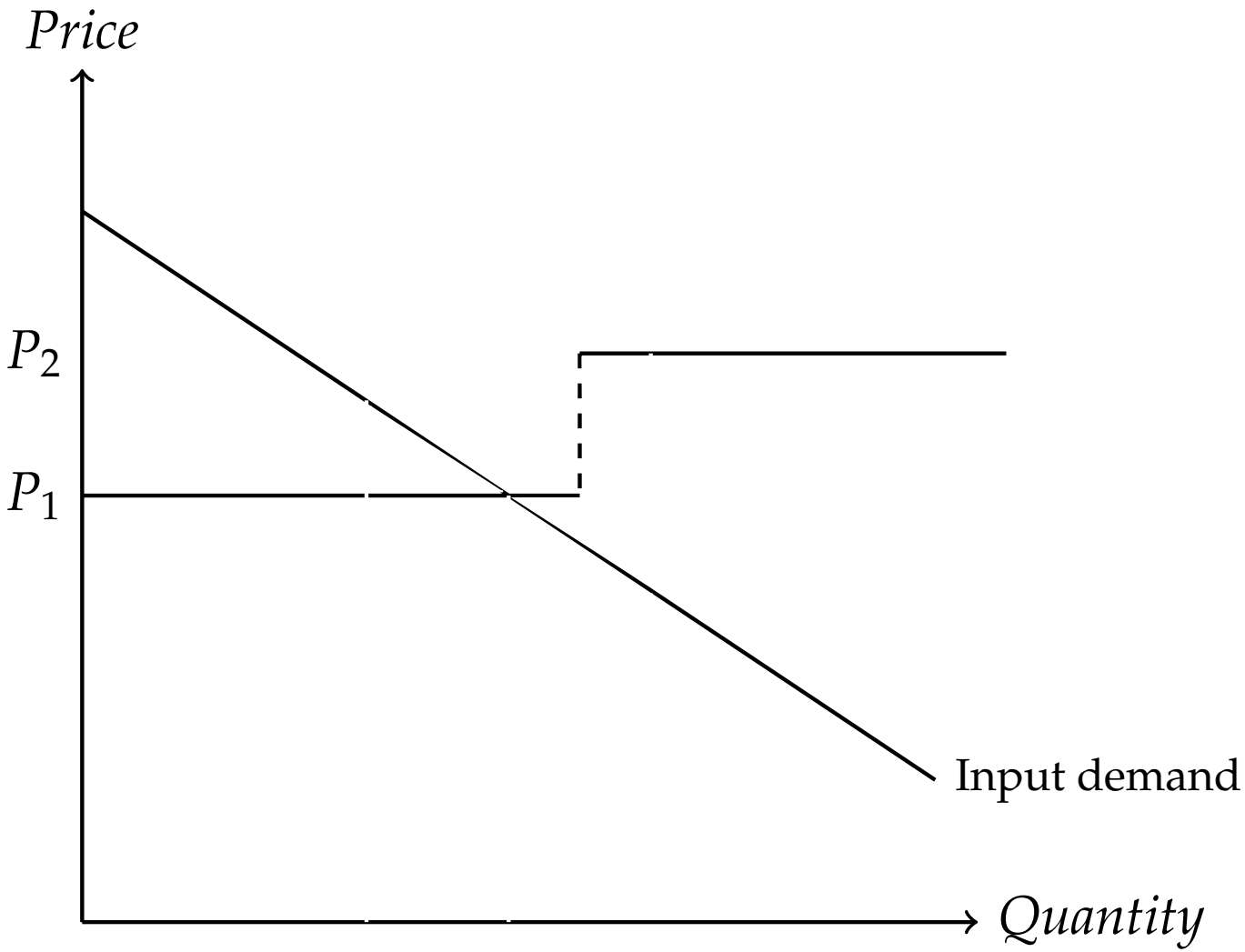
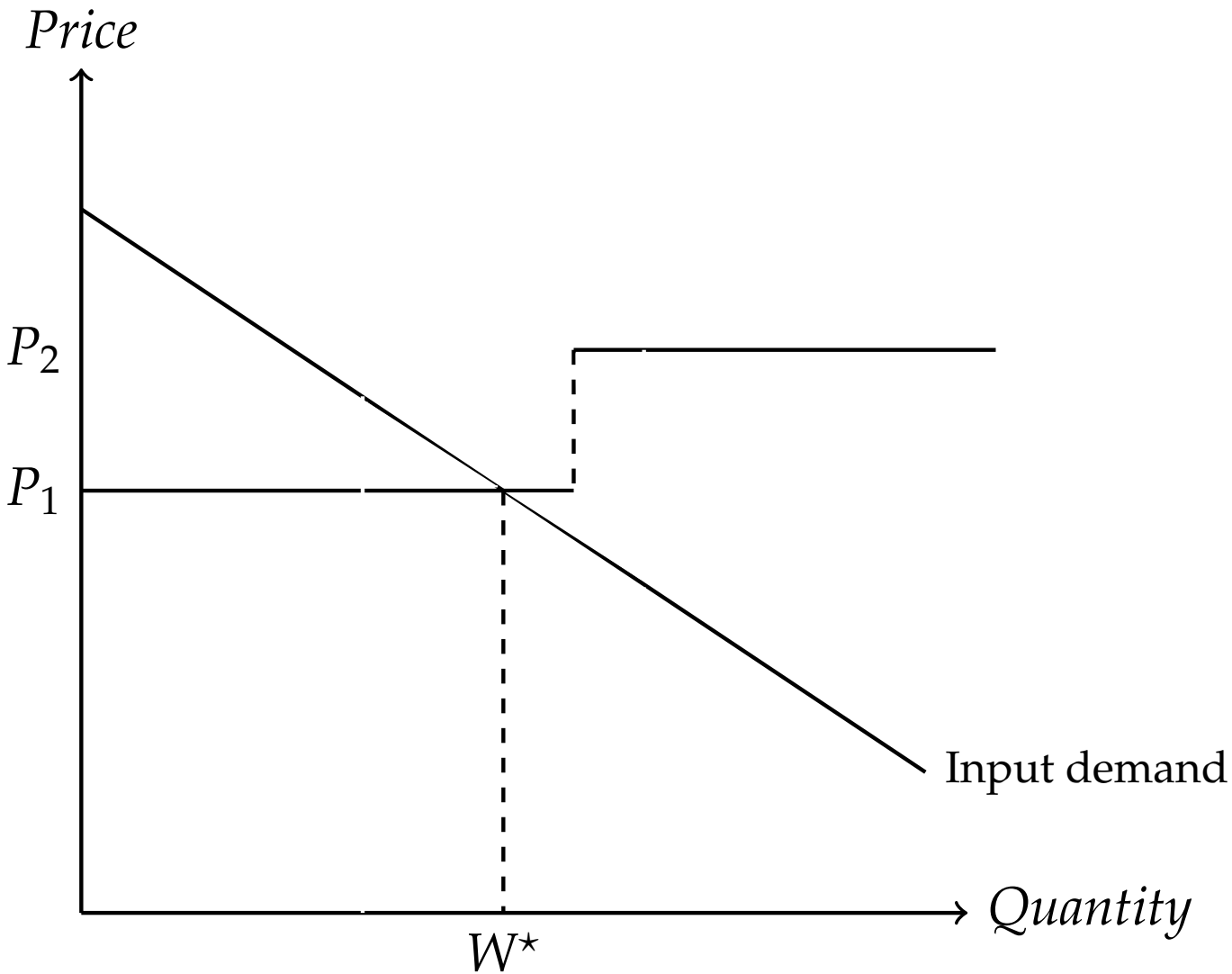
  + Rate structure induces behavior consistent with risk preference behavior


Price
P_2
P_1
Input demand
Quantity


Price
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Input demand
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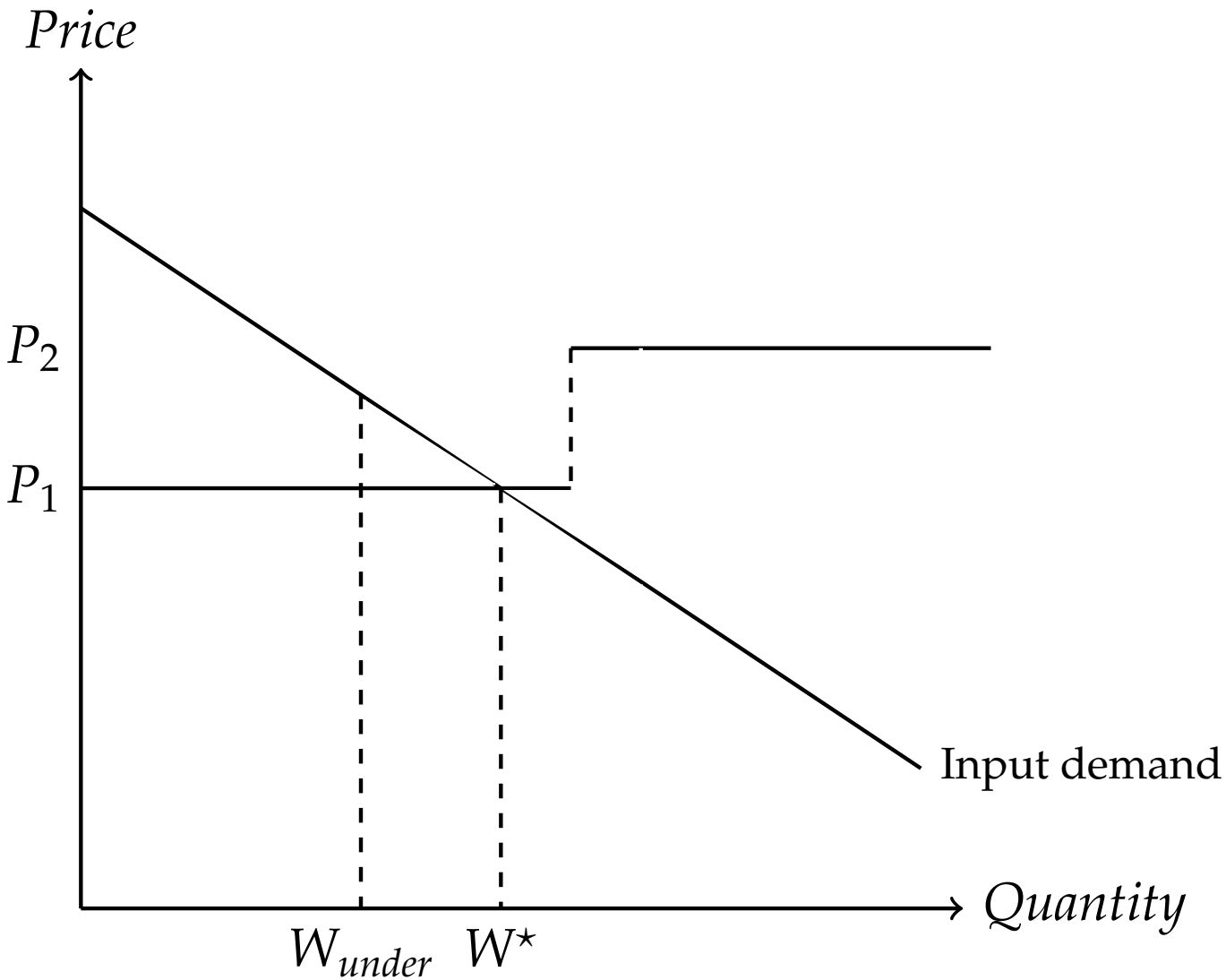
$W^\star$


Price
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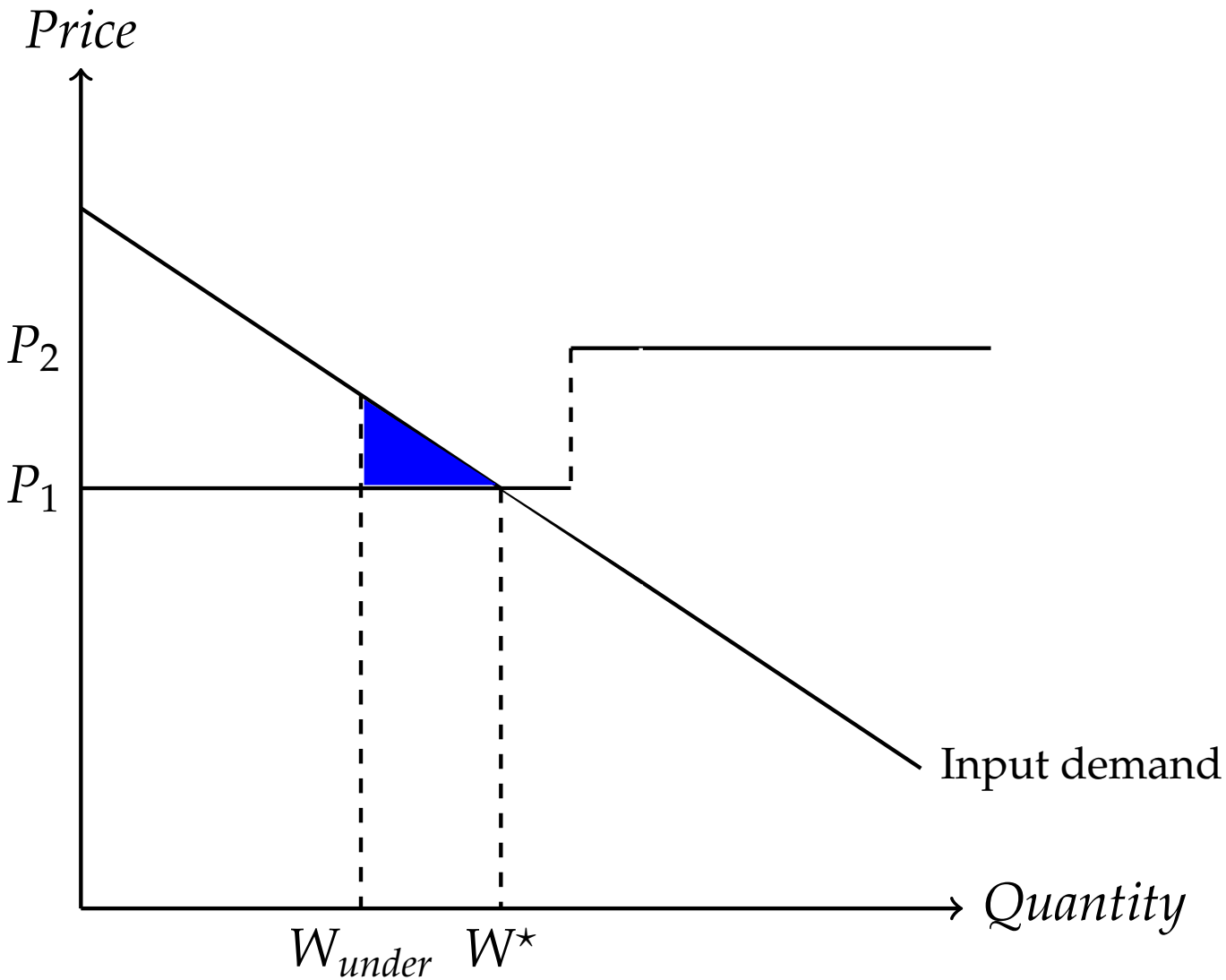
W_{under}
$W^\star$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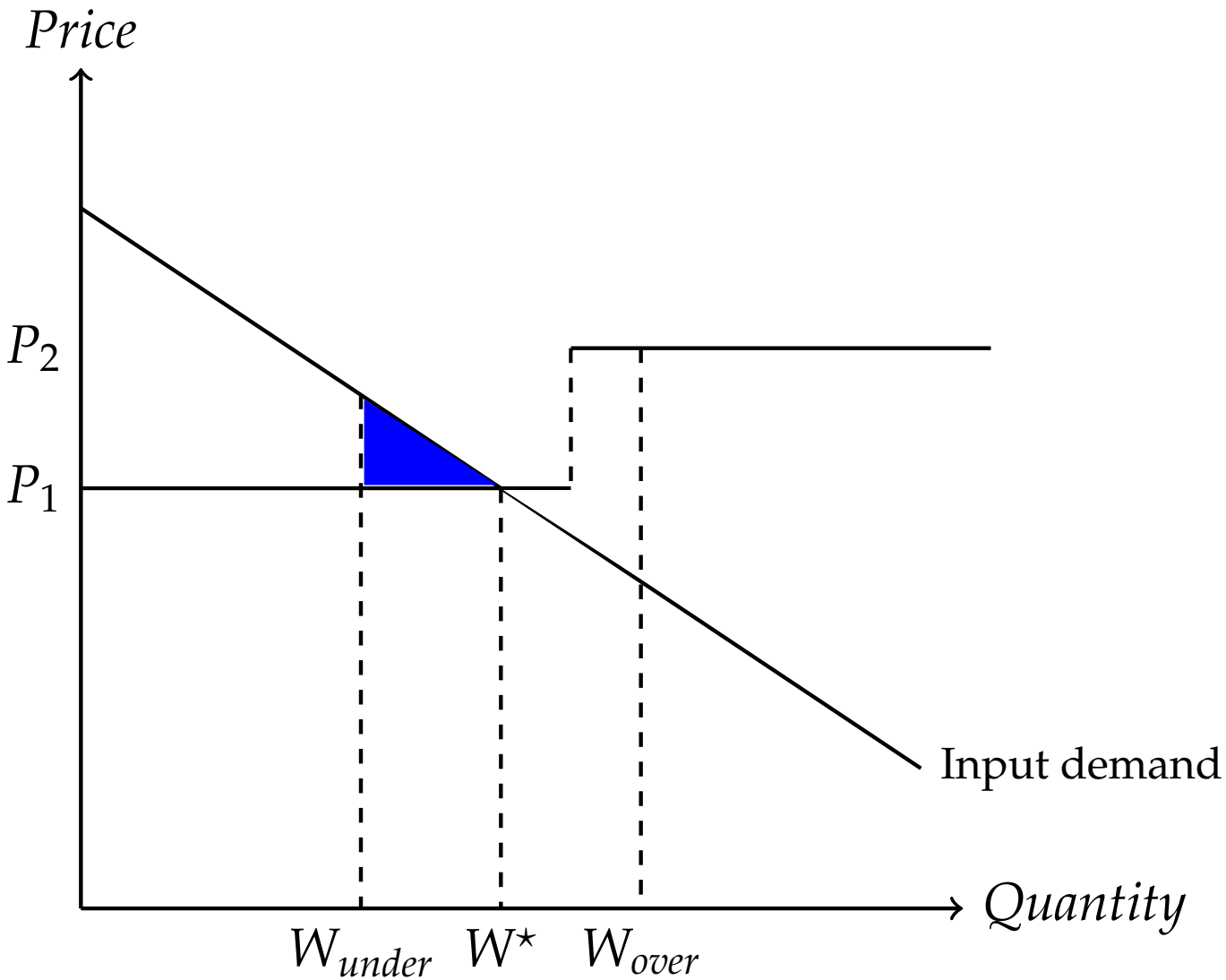
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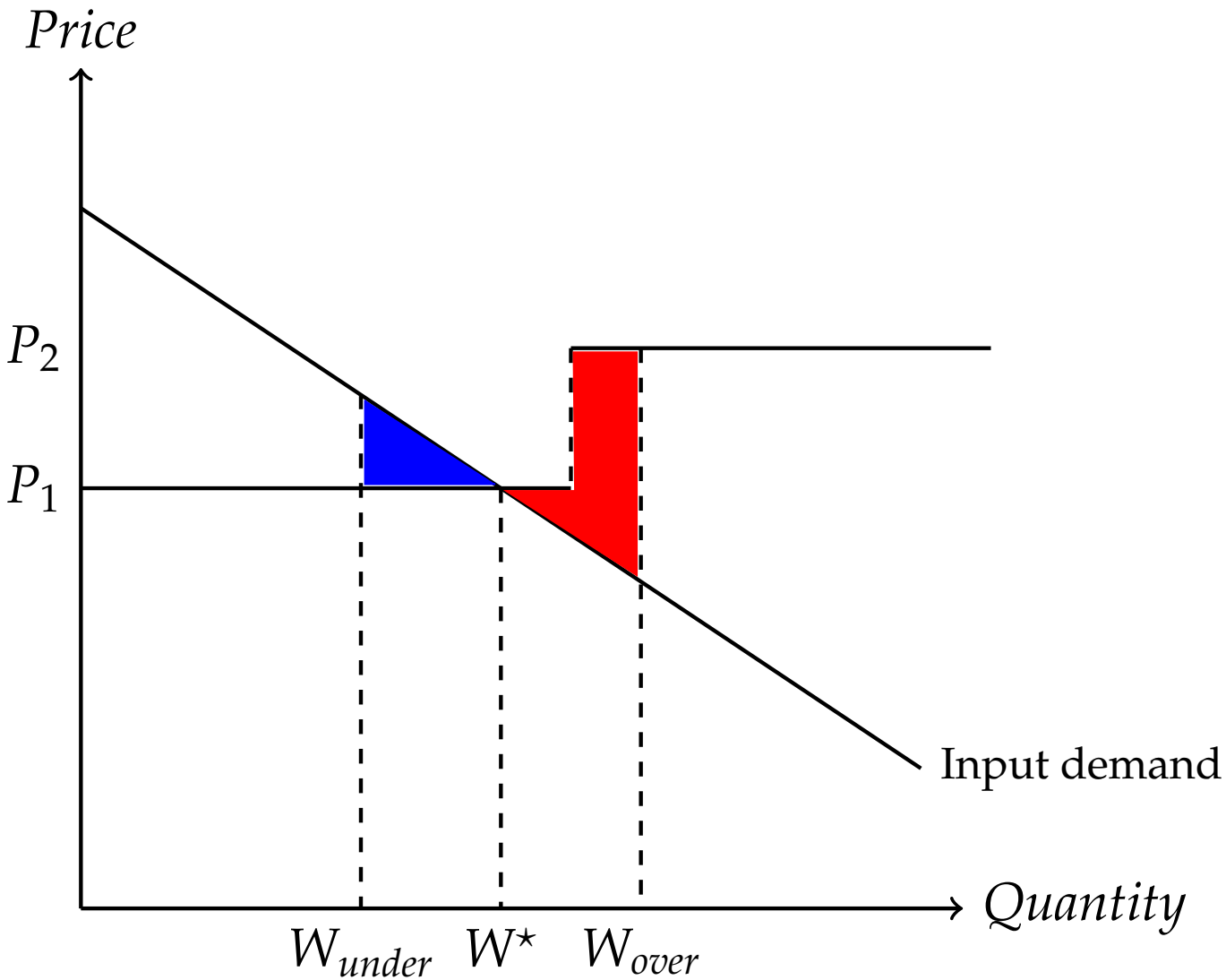
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5. Does feedback improve decision-making?
   - More information $\not\Longrightarrow$ Better decisions

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  - Week 1 $\Rightarrow$ x_1 $\Rightarrow$ *Feedback Treatment*
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- Paid based on cumulative profit
- To elicit risk preferences: Holt-Laury lottery game

This is Week 2 of Month 2

Summary of Week 2 Results

Revenue Summary	
You chose to produce the following number of outputs	**6**
Your revenue from this week's production is	**72** lab dollars

Input Use Summary	
This week's input requirements were	**Low**
This week, to produce one ouput, the following number of inputs were required	**2**
This week, in producing **6** units of output, you used	**12** total inputs

So far this month...	
As of right now, the combined total number of inputs used this week and the previous week(s) in this month are	**24**

This is Week 2 of Month 1

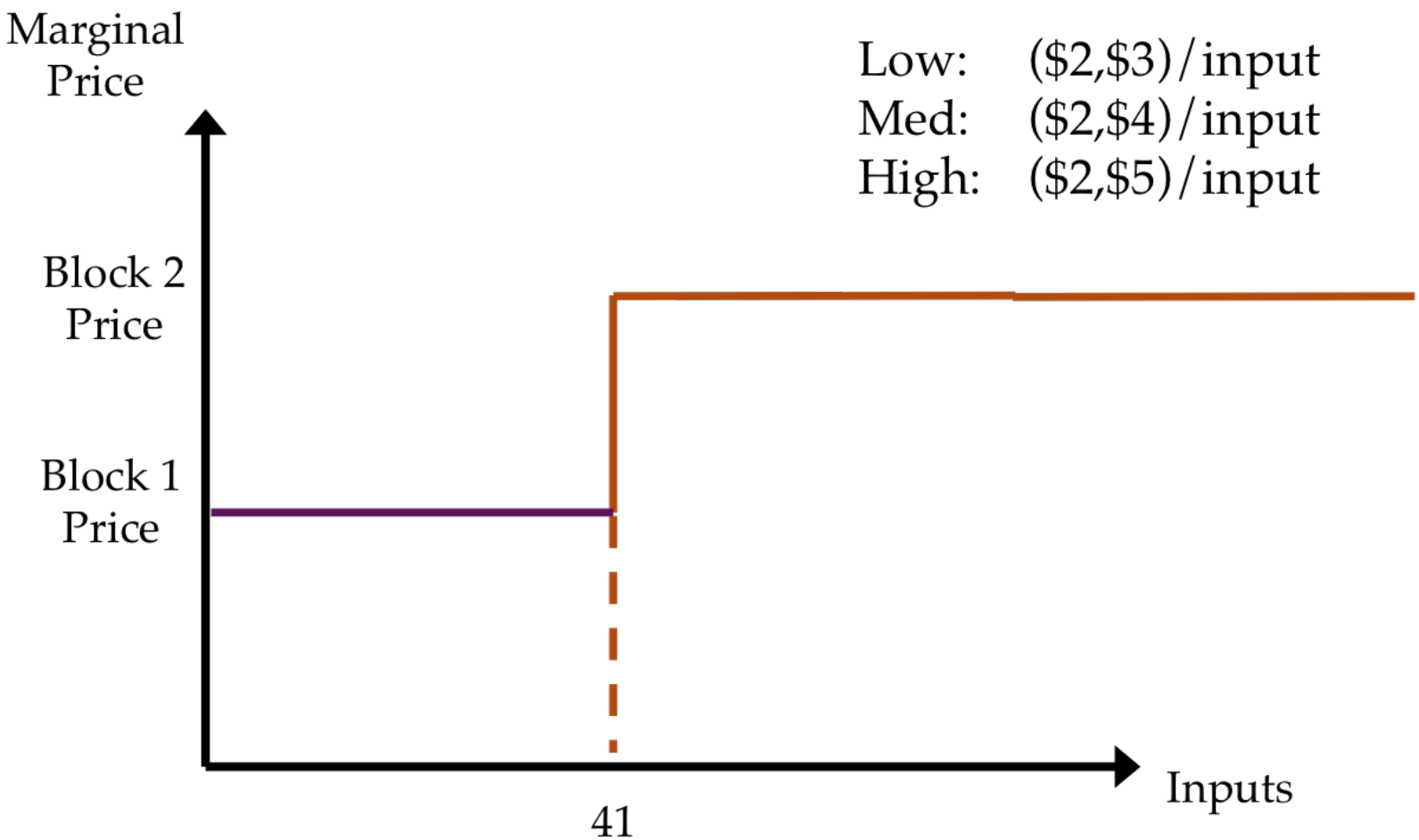
Summary of Week 2 Results

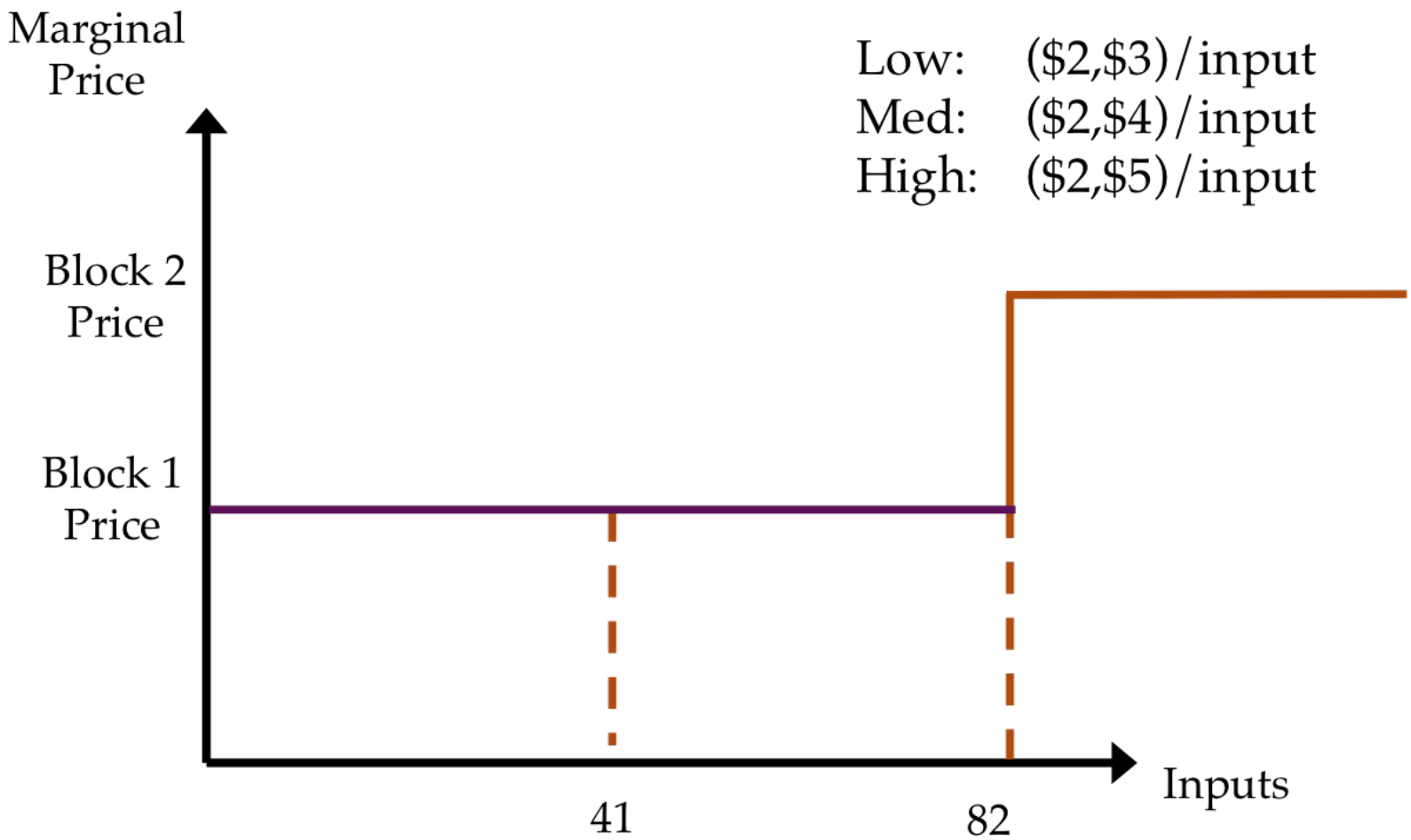
Revenue Summary	
You chose to produce the following number of outputs	**6**
Your revenue from this week's production is	**72** lab dollars

Input Use Summary	
This week's input requirements were	Information not available this week.
This week, to produce one ouput, the following number of inputs were required	Information not available this week
This week, in producing **6** units of output, you used	Information not available this week

So far this month...	
As of right now, the combined total number of inputs used this week and the previous week(s) in this month are	Information not available this week


Marginal Price
Low: $2/input
Med: $3/input
High: $4/input
Block 1 Price
Inputs


Marginal Price
Low: ($2,$3)/input
Med: ($2,$4)/input
High: ($2,$5)/input
Block 2 Price
Block 1 Price
Inputs
41


Marginal Price
Low: ($2,$3)/input
Med: ($2,$4)/input
High: ($2,$5)/input
Block 2 Price
Block 1 Price
41
82
Inputs

Did they understand the experiment?

Did they understand the experiment?

- High value participants produced 35.7% more than low-value participants

Did they understand the experiment?

- High value participants produced 35.7% more than low-value participants
- Produced less (and used fewer inputs) in higher-priced months

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- Feedback increases consumption

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- Feedback reduces price responsiveness:

Effect on D_{inputs}	No Feedback	Feedback
P_{med}	-8.70***	-4.28**
P_{high}	-14.56***	-9.57***

Estimates are relative to the lowest price level.

*, **, *** denotes p-values of 0.10, 0.05 and 0.01 respectively.

Full RE model

- Rate structure influences price responsiveness

Effect on D_{inputs}	CMP	IBR41	IBR82
P_{med}	-6.43**	-10.24***	-2.19
P_{high}	-14.24***	-14.62***	-7.82***

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P_{high}	-14.24***	-14.62***	-7.82***
Feedback	4.41**	3.17**	1.38

Price estimates are relative to the lowest price level.

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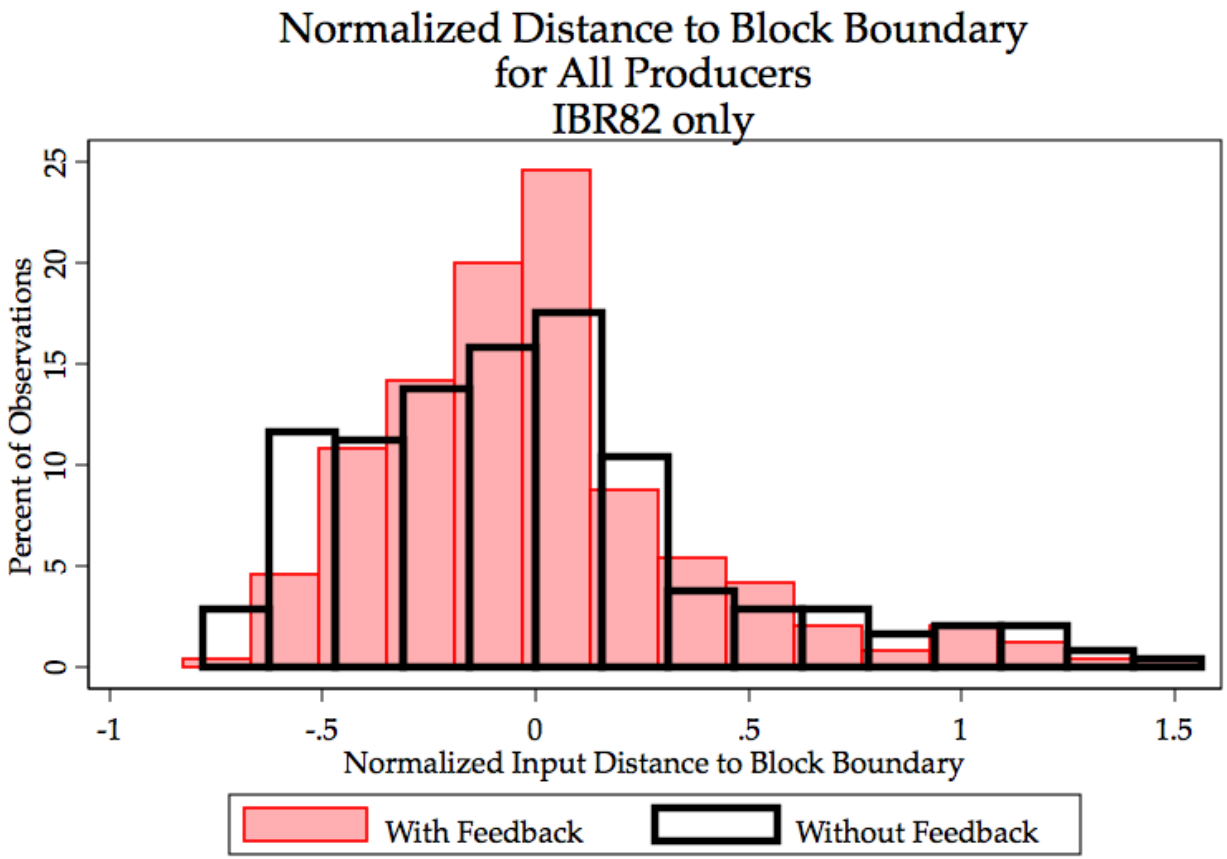
Targeting Behavior

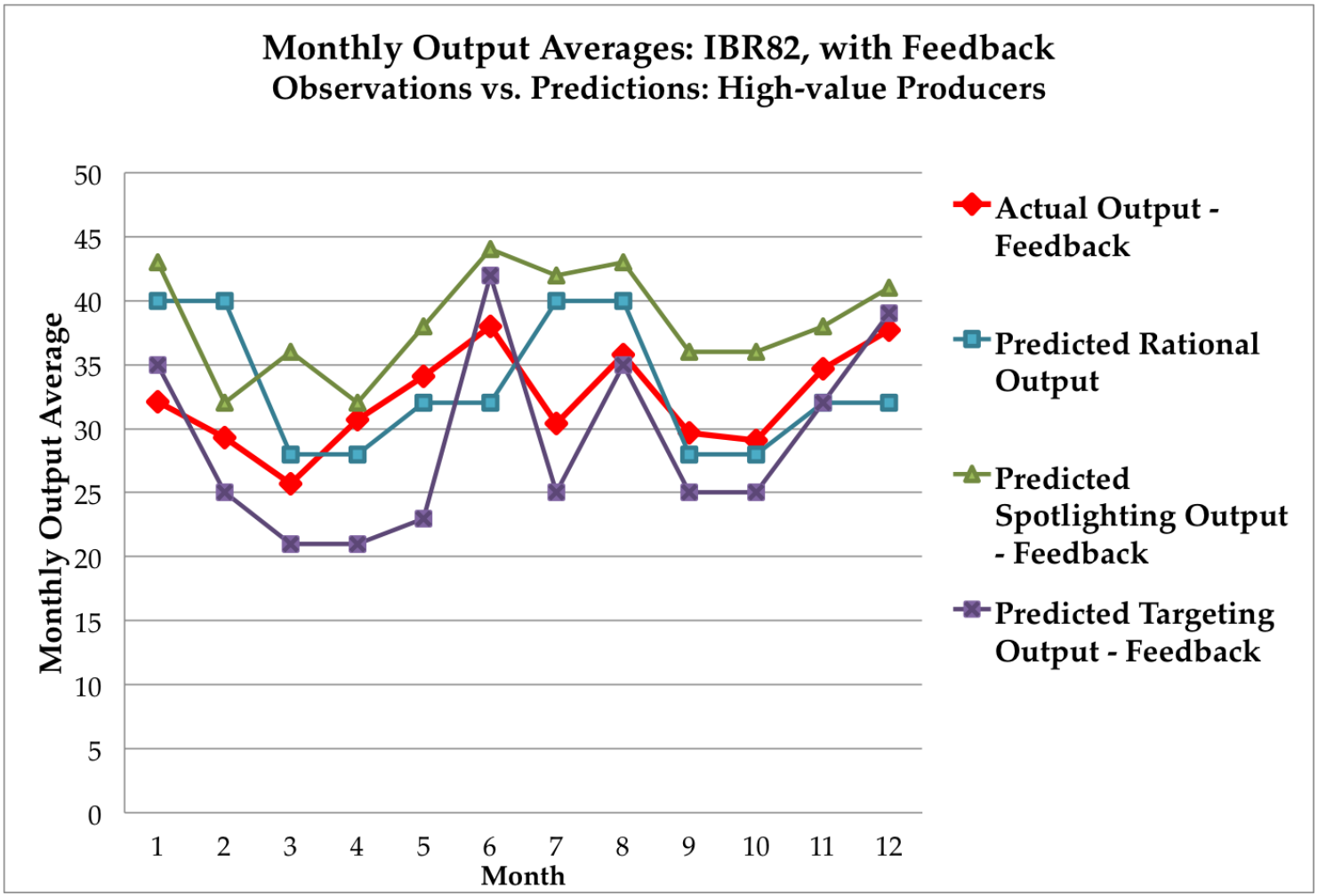


Rate-structured Induced "Risk" Behavior

	Input Totals by Feedback Treatment, Producer Assignment and Risk Preferences (IBR sessions only)					
	Low-value Producer			High-value Producer		
	Seeking	Neutral	Averse	Seeking	Neutral	Averse
% Diff with Feedback	-2.6	+2.9	+5.2	-3.6	+0.9	+9.1

Expected below boundary above boundary

Types of Behavioral Models



Gender:

Gender:

- Women are more responsive to feedback than men

Gender:

- Women are more responsive to feedback than men
- With feedback, output increases by $\approx 7.7\%$

Gender:

- Women are more responsive to feedback than men
- With feedback, output increases by $\approx 7.7\%$
  - Men's output only increases by $\approx 1.9\%$... and not stat. sign.

Conclusions

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Conclusions

- Feedback, itself, may not enhance conservation or pricing programs
- Feedback may increase variability in demand
- Rate structure design: block boundary has to matter, block prices have to matter
- Next: further characterize types of decision-makers

Questions?

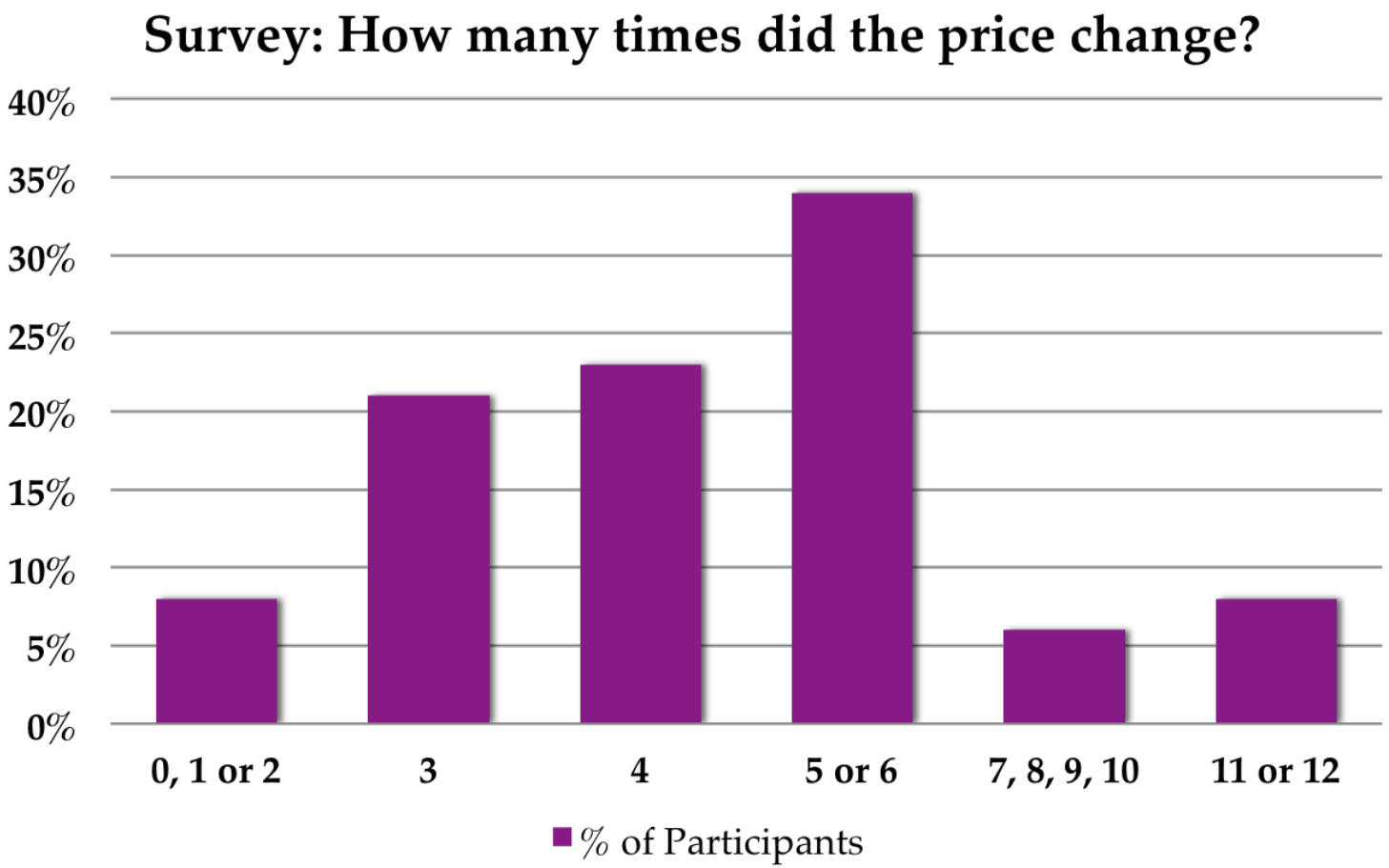
Thanks!

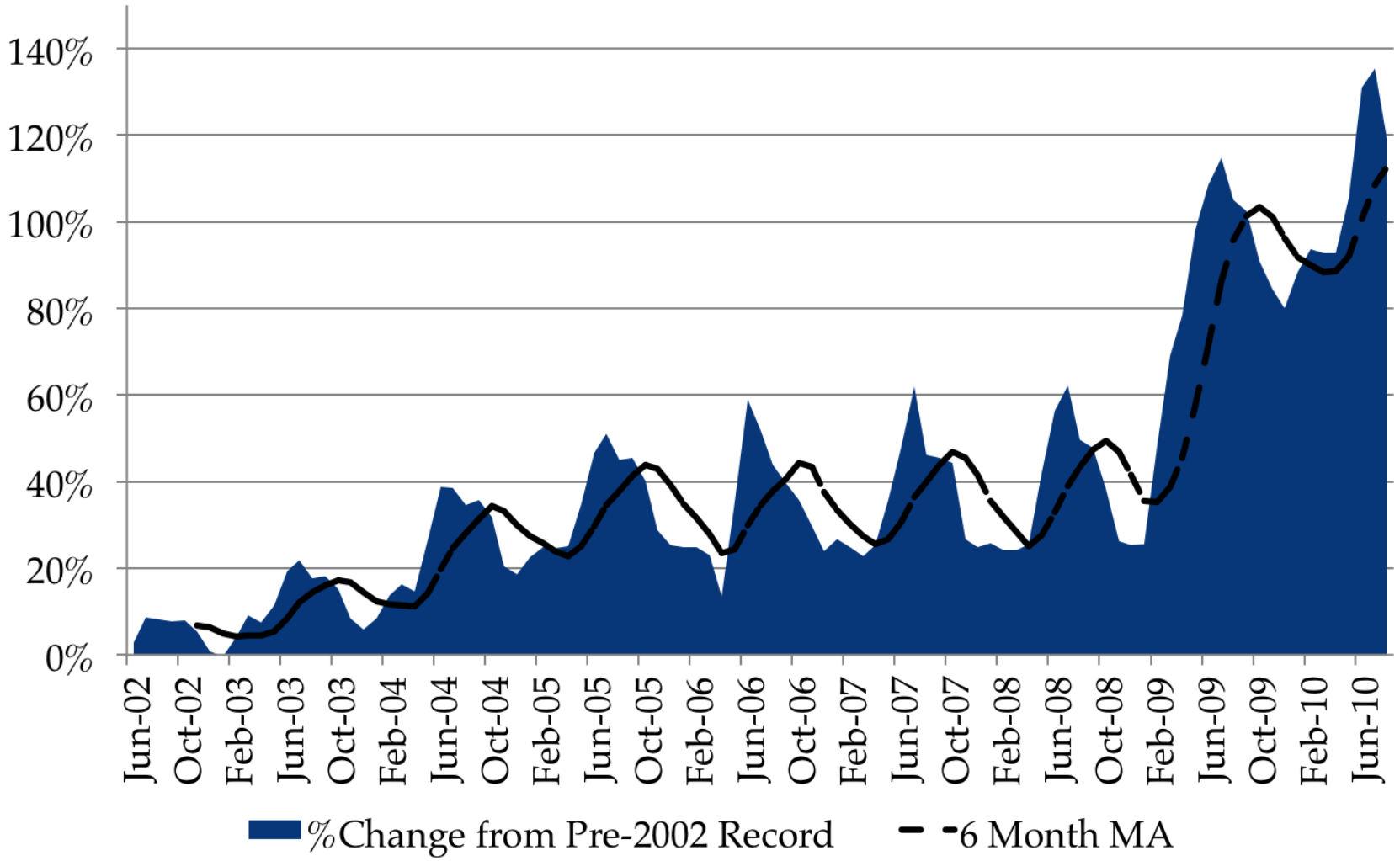
Contact ▷ Liesel.Hans @ Colostate.edu

Does feedback improve decision-making?

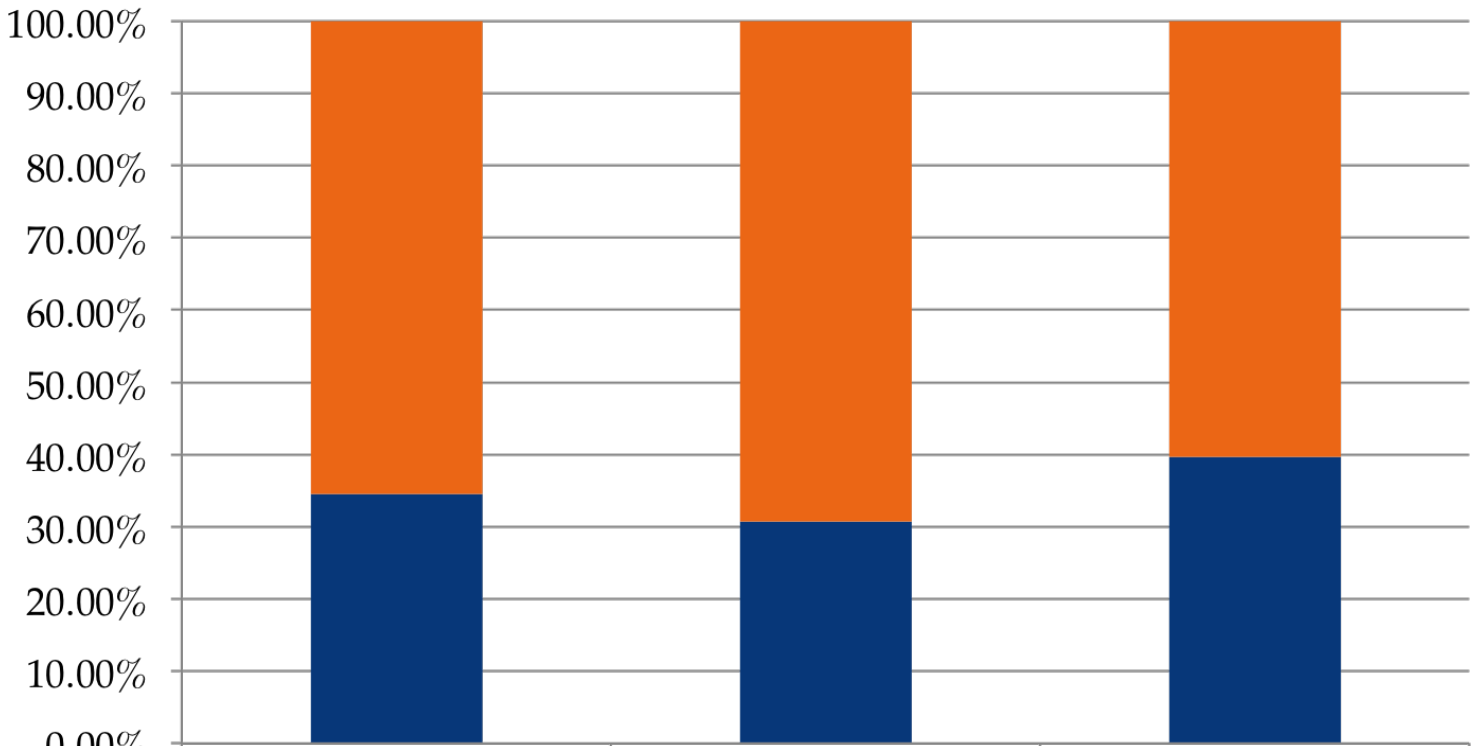
- Sometimes
  - From the survey:
    $\Rightarrow$ Some said it was harder to make choices with weekly feedback
    $\Rightarrow$ These participants did worse with weekly feedback

Real world connections

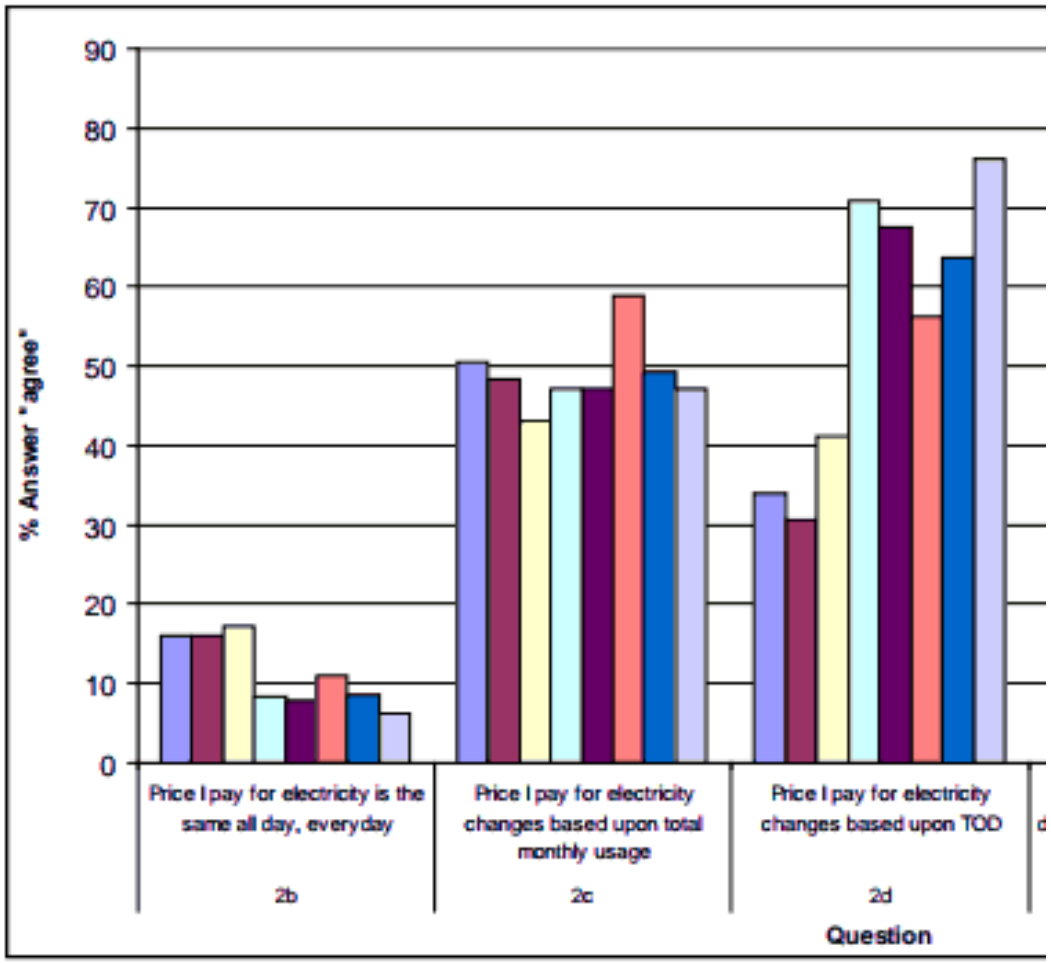

Survey: How many times did the price change?
40%
35%
30%
25%
20%
15%
10%
5%
0%
0, 1 or 2
3
4
5 or 6
7, 8, 9, 10
11 or 12
% of Participants


140%
120%
100%
80%
60%
40%
20%
0%
Jun-02
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Oct-04
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
%Change from Pre-2002 Record
6 Month MA

Are you aware of any recent changes in your water service or water price?



	All Years	2009	2010
No	65.43%	69.25%	60.33%
Yes	34.57%	30.75%	39.67%



Back to results

Participant characteristics:

Table : Summary Statistics

Participant Characteristics

	Average	Min	Max
Gender (1=female)	0.38	0	1
Age (years)	19.26	18	33
Year in College (1=Freshman)	1.61	1	4
Semesters of Econ Courses	1.27	0	15

Table : Treatment Effects: Random Effects Model

Partial Effects on Monthly Input Demand	
Independent Variable	Coefficient$^{\diamond}$
Feedback	2.972***
	(0.993)
Producer Type	22.529***
	(3.188)
Medium Price Level	-6.289***
	(1.404)
High Price Level	-12.208***
	(1.310)
IBR82	12.192***
	(3.913)
IBR41	6.816***
	(3.913)
Average Input Requirements	25.568***
	(0.863)
constant	-11.501***
	(4.198)
Overall R^2	0.4717

$^{\diamond}$Standard errors are in parentheses.
*, **, *** denotes p-values of 0.10, 0.05 and 0.01 respectively.

Organization of Sessions

Table : Experiment Timeline

Timing of Prices and Feedback

Month	Price Level	Session A	Session B
1	Low		Weekly Feedback
2	Low	Weekly Feedback	
3	High	Weekly Feedback	
4	High		Weekly Feedback
5	Medium		Weekly Feedback
6	Medium	Weekly Feedback	
7	Low	Weekly Feedback	
8	Low		Weekly Feedback
9	High		Weekly Feedback
10	High	Weekly Feedback	
11	Medium	Weekly Feedback	
12	Medium		Weekly Feedback

Back