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### **Robotic Harvesters or Migrant Workers? A Mechanization Adoption Model**

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# **Robotic Harvesters or Migrant Workers? A Mechanization Adoption Model**

## Background

Labor shortages have been threatening the sustainability of U.S. agriculture, particularly the labor intensive fruit and vegetable industry.





• The urgency of developing robotic harvesters has been increasing due to labor shortages.

• An understanding of robotic harvester adoption decision is important for policymakers and relevant stakeholders.

# Objectives

• This study aims to model farmers' robotic harvester adoption decisions and identify a series of conditions for adoption.

# Method

• The decision of hiring robotic harvester and/or using manual labor is modeled using a framework of farm profit maximization. • Two scenarios when robotic harvesting profit is higher or lower than labor harvesting profit are considered.



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# Model Framework

A representative grower is to make adoption decisions in a two-period setup to maximize the expected "harvesting profit"

- Harvesting profit = revenue harvesting costs.
- Yield  $Y_t = g_t + e$ ,  $e \sim \text{Uniform} [-b, b]$

harvestable) in the second period, either. by solving the problem

$$\pi = \max_{M_{tm}} \left\{ E \sum_{t=1}^{2} [p_t(Y_{tl} + Y_{tm}) - w * S - r * M_{tm}] \right\}$$

- robotic harvesters.
- by their working time (S and  $H_{tm}$ ), respectively.

•  $H_{tm}$  is bounded by a maximum contracting time M.

volumes harvested by labor and robotic harvesters.

$$K = \int_{-b}^{u_1} 0 * f(e) \, de + \int_{u_1}^{b} (Y_t - Y_{tl} - Y_{tm}) f(e) \, de$$

yield, harvesting time and efficiency.

•The unharvested acreage in the first period will not be harvested (not

•The grower chooses the optimal contracting amount of times of robotic harvesters  $(M_{tm})$  to maximize the cumulative expected profit

where p is product price; w is wage; and r is the rent of hiring

The volume harvested by labor  $(Y_{tl})$  and robotic harvesters  $(Y_{tm})$ are determined by harvesting efficiency ( $\theta_l$  and  $\theta_m$ ) multiplied

• Crop abandonment may occur if the total yield is more than the total

The expected amount of abandoned crops in the first period is

where *e* is the yield shock, f(.) is the error distribution; and u1 is the cutoff point where abandonment occurs, which a function of

### **Scenario A: Robotic harvesting profit > labor harvesting profit**

 $E[pY_t]$ 

The condition for adopting robotic harvester is

$$\theta_m > \frac{(g_t)}{(g_t)^2}$$

### **Scenario B: Robotic harvesting profit < labor harvesting profit**

The optimal contracting time of robotic harvesters in the first and second periods are :

$$M_t^* =$$

Analysis shows that:

$$\frac{\partial M_t^*}{\partial p_1} > 0, \frac{\partial M_t^*}{\partial p_2} > 0, \frac{\partial M_t^*}{\partial r} < 0, \frac{\partial M_t^*}{\partial S} < 0, \text{ and } \frac{\partial M_t^*}{\partial \theta_m} < 0$$

• A grower's decision to replace labor with robotic harvesters is determined by the relative profits of machine and labor harvest. • The adoption of robotic harvesters is affected by crop yield, crop price, labor supply, wage, labor efficiency, machinery efficiency, and machine rental price. • The use of robotic harvester increases with crop prices, but decreases with labor supply, machine efficiency, and rental

price.



## Results

$$Y_{tm} - rM_{tm}] > E[pY_{tl} - wS]$$

 $\left(\frac{g_t - S}{2mS + mS}\right)$  and  $\mathbf{r} < \frac{(g_t p - 2pS + wS)\theta_m}{2mS + mS}$ -2pS+wS) $(g_t - S)r$ 

$$f(g, b, p_1, p_2, w, r, S, \theta_l, \theta_m)$$

## Conclusions