ASSESSING THE IMPACT OF A LABOR SHORTAGE ON POST-HARVEST ACTIVITIES AND MARKETS

By Andrew J. Cassey, Associate Professor, School of Economic Sciences, Community and Economic Development Extension, Washington State University. Kwanyoung Lee, Ph.D. student, School of Economic Sciences, Washington State University. Jeremy Sage, Assistant Research Professor and Assistant Director, Freight Policy Transportation Institute, School of Economic Sciences, Washington State University. Peter Tozer, formerly Research Associate and Director of IMPACT Center, School of Economic Sciences, Washington State University.
Assessing the Impact of a Labor Shortage on Post-Harvest Activities and Markets

Abstract

Labor is an important input into the production and distribution of US horticultural commodities and products. Labor shortages are often thought of as a pre-harvest problem, and the economic impacts of labor shortages are estimated with respect to production. We find a pre-harvest labor shortage creates a post-harvest labor shortage as well, and leads to increased prices of more than 15%. The apple industry is able to adjust to the labor shortages better than the peach industry because consumers are more sensitive to price increases of peaches than apples.

Introduction

For horticultural commodities, labor is necessary not only for pre-harvest and harvest activities but also for post-harvest activities such as management, marketing, packing, and distribution. Labor shortages can lead to sizeable losses for producers of all sizes as well as lack of choice for consumers. Historically, labor shortages are usually thought of as a pre-harvest problem, and the economic impacts of labor shortages are estimated with respect to the impact on production. (We use the term pre-harvest throughout to account for both pre-harvest and harvest activity.) Such an approach does not consider that a labor shortage for pre-harvest activities may have impacts on the post-harvest labor market, which would be realized in terms of impacts to the timely transportation and delivery of harvested produce to market. Thus the size and economic consequences of post-harvest labor shortages are unknown. This is an important problem because post-harvest labor shortages undermine the best methods for processing, packing, handling, transporting, storing, distributing, and delivering agricultural products.

A labor shortage is the difference between the number of workers willing and available to work and the number of workers needed by producers at a particular wage rate. Post-harvest is the time from the instant the bulk of the crop is separated from the tree until delivery for purchase by a consumer. It is the stage of the process covering the cooling, cleaning, sorting, packing, transportation, and delivery of products to consumers. Because fruit deterioration begins with harvest, post-harvest labor shortages causing delayed crop processing and delivery can greatly affect quality and the price paid by the consumer.

Despite advances in the environmental and biological control of post-harvest loss, spoilage of fresh produce before reaching market remains an issue. The interaction between the skill, location, and availability of labor post-harvest plays a significant role for all producers regardless of size. Thus the direct beneficiaries of our work will be producers in the apple and peach industries. The lessons from our work, however, extend much more broadly. Thus, indirect beneficiaries include the small fruit industry. Knowing the size and extent of the problem allows producers to develop more efficient and effective mitigation strategies to reduce overall economic impacts. Indirect benefits extend to other agricultural industries that face similar post-harvest labor shortages because though our results are specific to the apple and peach industries, labor shortages apply to other agricultural industries as well. Consumers may experience a benefit too. They may gain from increases in efficiency obtained by better management of labor shortages resulting in a lower price.

We focus on the US apple and peach industries because of their large total value of production and their wide geographic spread. Therefore, our findings apply to multiple states, producers, and agribusinesses as well as illustrate the problem to the greater agricultural sector. We also study apples and peaches because, though they are similar in terms of production techniques, they have differences in demand characteristics and spoilage rates that allow us to see how a post-harvest labor shortage would have differential outcomes on different commodities.

The results in this report are from Cassey et al. (2015). That report contains the details of the method employed as well as a detailed discussion of the effects of post-harvest labor shortage on economic welfare for consumers, labor, and producers.

Method and Data

To estimate the effects of how a pre-harvest labor shortage affects the post-harvest labor market, we develop an economic model that has two goods: apples and peaches. That model has also two labor markets: labor for pre-harvest activities and labor for post-harvest activities. Pre-harvest occupations include production workers, production managers, and irrigators. Post-harvest occupations include transportation activities, management, sales and financial operations, and jobs related to cleaning, washing, cooling, packaging, and freezing produce.
We use employment and wage data available from the US Department of Labor. From the labor statistics, we choose occupation information from the “Support Activities for Crop Production” category. We then partition tasks into those that are pre-harvest and production focused and those that are post-harvest or full-time focused, such as management. This sorting of tasks into pre-harvest and post-harvest activities are done using the description of each occupation. We do not use education level as there is unskilled and skilled labor involved in both pre-harvest and post-harvest activities. We average employment and wages over the years 2002–2013 to prevent the data from one year to unduly affect our results.

We use price and output data from the US Department of Agriculture and wage and employment data from the US Department of Labor. We adjust the price and wage data to account for inflation and then average over the years 2002–2013 to arrive at an initial benchmark economy. Those data may be seen in Table 1. As Table 1 shows, there are three times more pre-harvest employees than post-harvest. However, the post-harvest workers get paid about a third more. The apple industry is more than six times larger than the peach industry in terms of output, but peach prices are 33% higher than the price for apples (Cassey et al. 2015).

In addition to the data for the initial state of the economy in Table 1, we also need a measure of how much consumers change their purchasing when the price of apples and peaches changes. We use the values in Henneberry et al. (1999). According to Henneberry et al., consumers are more sensitive to a change in the price of peaches than apples. Thus if the price of apples and peaches increase the same amount, more consumers reduce their amount of peaches purchased than apples purchased.

### Shocking the Model

In order to see what happens when there is a labor shortage, we first need to “shock” the model to move it from its initial benchmark to a new outcome.

Figure 1 shows an illustration of the model. There are four markets illustrated. The apple and peach output markets are on the top of Figure 1. These are the markets where firms supply fresh fruit and consumers demand and buy fresh fruit. The price is what people pay and the amount firms receive from the sale.

The two markets in the bottom of the figure are the labor markets for pre-harvest and post-harvest employment. In each labor market, labor supplies workers and firms demand workers for production. The market wage is denoted on the y-axis and the employment is on the x-axis.

In each of the four markets, the benchmark demand curve is denoted by D and the benchmark supply curve is labeled S. The single intersection between D and S in each market is the so-called competitive equilibrium. At this intersection, the supply of labor and the demand for labor is equal and there is not a labor shortage.

The benchmark prices, outputs, wages, and employments are marked by E1. As can be seen in Figure 1, E1 matches the data in Table 1.

We shock the model by using the predictions in Gallardo et al. (2014). Gallardo et al. predict that in five years, demand for apples and peaches will increase by 5.4% each.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-harvest employment (thousands)</td>
<td>36.07</td>
<td>4.84</td>
<td>30.01</td>
<td>43.74</td>
</tr>
<tr>
<td>Post-harvest employment (thousands)</td>
<td>11.75</td>
<td>1.59</td>
<td>9.87</td>
<td>15.07</td>
</tr>
<tr>
<td>Pre-harvest wage ($/hr)</td>
<td>11.64</td>
<td>0.62</td>
<td>10.55</td>
<td>12.64</td>
</tr>
<tr>
<td>Post-harvest wage ($/hr)</td>
<td>15.71</td>
<td>1.13</td>
<td>13.78</td>
<td>17.37</td>
</tr>
<tr>
<td>Apple production (million lb)</td>
<td>6126.45</td>
<td>1075.44</td>
<td>5366.00</td>
<td>6886.90</td>
</tr>
<tr>
<td>Peach production (million lb)</td>
<td>932.15</td>
<td>201.31</td>
<td>789.80</td>
<td>1074.5</td>
</tr>
<tr>
<td>Apple real retail price ($/lb)</td>
<td>1.24</td>
<td>0.12</td>
<td>1.16</td>
<td>1.33</td>
</tr>
<tr>
<td>Peach real retail price ($/lb)</td>
<td>1.69</td>
<td>0.17</td>
<td>1.57</td>
<td>1.82</td>
</tr>
</tbody>
</table>

Source: Cassey et al. (2015).
This is seen in Figure 1 by the demand curve in the apple and peach market shifting out to $D'$. When there is more demand for apples and peaches by consumers, there is more demand for pre-harvest and post-harvest labor by firms in order to meet the increased demand. Thus there is a shift out of the demand curve in the labor markets too, to $D'$.

Gallardo et al. (2014) also predict that in five years there will be 7% fewer available pre-harvest workers from migration. That shock is seen in Figure 1 as $S'$ in the pre-harvest labor market. Because there is a reduction in pre-harvest labor, firms want to replace the lost pre-harvest labor with post-harvest labor.

However, because pre-harvest labor tasks and post-harvest labor tasks are different and require different skills, firms cannot easily move labor from one task to another. Thus firms do increase demand for post-harvest labor to $D''$, but they cannot fully replace the lost pre-harvest workers. The result in the labor markets is denoted as $E3$ in Figure 1: wages for pre-harvest labor increase and employment falls. The increase in wage means the cost to firms from production increases and that is realized as a shift of supply in the apple and peach markets. This is seen in Figure 1 as $S'$.

The new post-shock economic outcome is denoted by $E3$ in all four markets. The increase in output demand and the decrease in pre-harvest labor have the net result of increased prices for apples and peaches and a decrease in output.
Wages for both pre-harvest labor and post-harvest labor increase, by 6.7% for pre-harvest workers and 3.5% for post-harvest workers. Because wages increase, labor supplied and labor demanded equate at a new level, and there is no labor shortage.

**Fixed Wage Results**

Suppose that wages do not increase as a result of the two shocks, but rather wages remain fixed at their initial level. This is seen in Figure 1 with the horizontal line through the pre-harvest and post-harvest labor markets. If the wage in the pre-harvest markets remains at $11.64 as before, then firms wish to employ 37,500 pre-harvest workers, but only 26,800 pre-harvest workers are willing to work at that wage. Thus, there is a labor shortage of 10,700 workers, or 30% of the pre-shock employment of 36,100.

As before, firms wish to employ more post-harvest labor in response to the pre-harvest labor shortfall, but the fixed wage means though they demand 12,300 workers, only 11,800 are willing to work at $15.71. The labor shortage in the post-harvest labor market is 500 workers or 4.4% of the pre-shock employment.

Firms thus experience a large labor shortage in pre-harvest workers and a smaller, but still impactful, shortage of post-harvest workers. Employment in both markets is well below that indicated by E3, which means there are not enough workers to produce the output of apples and peaches indicated by E3. Thus output is constrained by the lack of workers to the level indicated by the vertical bar in the apple and peach markets.

Though output has decreased in the apple and peach markets in the fixed wage scenario compared to E3, firms are able to get a price premium as the reduction in output means consumers are willing to pay more. Apple firms can charge 16% more, to $1.54 up from $1.33. Peach firms are also able to charge 16% more, to $2.10 up from $1.81.

This price premium harms consumers as they have to pay more as well as the fact that consumers purchase fewer apples and peaches. Firms, though, largely benefit. Though sales are lost, firms make up for that from both the price premium as well as the benefit of paying workers at the lower fixed wage.

Table 2 shows the percent change and level for the fixed wage outcome compared to the flexible wage outcome denoted by E3 in Figure 1. Though the price for apple and peach increases by 16% each, output for peach is much more severely reduced than for apple. This is because consumers are more sensitive to price increases of peaches than apples. Thus, consumers reduce their purchases of peaches by almost 19% whereas it is only about 8% for apples. Since the apple industry is six times larger than the peach industry, apple sales decrease by 493 million lb whereas peach sales decrease by about 172 million lb.

**Transportation and Spoilage**

Fresh fruit spoils. According to the USDA, when conditions are normal, 4% of the value of fresh apples is lost from spoilage in route to market and 6% of the value of fresh peaches is lost. Those rates of loss will increase if there is a post-harvest labor shortage because the shortage of drivers and other workers along the transportation route will delay delivery time. In such a case, the amount of fresh fruit firms sell decreases beyond the output constraint indicated by the vertical line in Figure 1.

Though we do not know how much delay a 4.4% post-harvest labor shortage will cause, and thus how much additional spoilage will occur, we do know that the peach industry will suffer more harm than the apple industry. This is for two reasons. First, peaches spoil 33% faster than apples (USDA-ERS). Thus, any delay because of a shortfall of truck drivers will more seriously affect the peach industry. Secondly, because consumers are more price sensitive to peaches than apples, peach firms are less able to pass the additional costs from spoilage on to consumers in the form of higher prices.
Because of these two facts, we calculate that the peach industry suffers harm from a post-harvest labor shortage for any amount of delay in the timeliness of produce delivery. The apple industry, on the other hand, is not harmed by small delays in produce delivery because it can pass the cost on to consumers in the form of higher prices as long as the industry parameters remain those reported in Henneberry et al. (1999). If delays become large, however, then the apple industry too suffers sizeable losses from spoilage that cannot be made up from an increased price.

### Summary

Agricultural labor shortages may cause economically significant impacts to producers and consumers. To better assess its impact, we partition labor markets to focus on the economic impacts of a pre-harvest labor shortage spilling over onto the post-harvest labor market. We use data from the U.S. apple and peach industries because their large value and wide geographic spread make them representatives for the overall agricultural sector, as well as being industries with a sizeable presence in Washington State.

We estimate that given a plausible increase in final demand and a decrease in unskilled labor supply, wages of pre-harvest labor would need to increase by 6.7% and wages of post-harvest labor would need to increase by 3.5% in order for labor supply to equal labor demand and thus avoid a labor shortage. If wages remain fixed at the previous level, it creates a labor shortage of 30.0% of the pre-shock total for pre-harvest labor and 4.4% shortage for post-harvest labor. These shortages result in the price of apples and peaches increasing by about 16% over the price when wages adjust. Because consumers are more sensitive to price increases for peaches than apples, the impact of a labor shortage is larger in the peach industry. Output decreases by 19% for peaches, whereas output only decreases by 8% for apples.

To the extent that our estimated 4.4% post-harvest labor shortage creates a bottleneck in the distribution and transportation network, additional harms are created by the increased spoilage as produce awaits shipment to market. The peach industry is more vulnerable to these transportation delays as peaches spoil 33% faster than apples. Though we do not explicitly consider international competition, we nevertheless speculate that the additional price premium created by the labor shortages could open up the US market to increased foreign competition.

### Acknowledgements

We thank Mike Brady and Xiaojiao Jiang. State funds for this project were matched with Federal funds under the Federal-State Marketing Improvement Program of the Agricultural Marketing Service, USDA, 2013. Cassey acknowledges financial support from Washington State University Agricultural Research Center project #0540.

### References


USDA-ERS. Various years. Fruit and Tree Nut Yearbook. Washington, DC.

