FINAL PROJECT REPORT

Project Title: Forecasting the Demand and Supply for Tree Fruit Farm Labor

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Cooperators: David Allan and Charles de la Chapelle

Percentage time per crop: Apple: 50% Pear: 25% Cherry:25% Stone Fruit:
(Whole % only)

Other funding sources

Agency Name: None
Amount awarded:
Notes:

Total Project Funding: $146,109

Budget History:

Item	Year 1:	Year 2:	Year 3:
Salaries[1]	$ 101,281		
Benefits[2]	$ 25,827		
Wages[3]	$ 4,313		
Benefits[4]	$ 418		
Equipment	0		
Supplies[5]	$ 4,000		
Travel[6]	$ 10,270		
Miscellaneous	0		
Plot Fees	0		
Total	**$ 146,109**		

[1] One month salary for PI Karina Gallardo ($6,875/mo), CoPI Michael Brady ($9,111/mo), Associate in Research ($60,000/year) and Master Student ($25,925/9-mos).
[2] Benefits for PI Karina Gallardo ($1,905), CoPI Michael Brady ($2,265), Associate in Research ($19,464) and Master Student ($2,183).

[3] Three-month summer wages for Master Student ($4,313/3-mos).
[4] Benefits for Master Student ($418).
[5] Materials such as paper, printing, postage, miscellaneous for the survey and supplies for focus groups ($2,000) and publication charges ($2,000)
[6] Travel to collect data in focus groups for PI and Associate in Research. Includes 4 trips for PI Karina Gallardo to Yakima ($488/4 trips), Chelan ($168/4 trips) and Royal City ($324/4 trips) summing $980. It also includes trips for Associate in Research based in Pullman to growers' sites in Yakima ($3,410/10 trips), Wenatchee ($2,784 /8 trips), and Chelan ($3,096/8 trips) summing $9,290.

Recap of Original Objectives

1. Forecast the seasonal demand and supply for labor for the Washington apple and pear industries.

2. Build support from industry stakeholders and legislators to procure funding for a research program to develop a total automation systems approach for apples and pears.

Significant Findings

- An estimated 12% of orchard acres are on farms large enough to consider mechanization.

- The number of migrant workers is forecasted to decrease by 1% per year.

- From the migration labor supply model we forecast a drop of 7% in the number of migrant workers in 5 years. We report upper and lower bounds on labor costs using 95% confidence intervals on the migration forecast, which extends between 11% and 2% for the model that had a point estimate of 7%. We report the results of the aggregate model assuming a capital/labor elasticity of substitution of 0.75 and a labor supply elasticity of 1.55. A 7% decrease in labor supply was estimated to increase wages 8.3%, and the 95% confidence interval of the wage increase was 5.6% and 10.5%. Output price for the final good increases by 3% if a 7% drop in labor supply occurs. The 95% confidence interval extends between 2% and 3.7%.

- A labor supply drop of 7% with a 95% confidence interval of 2% and 11% were modeled. Compared to the baseline, a 7% labor supply decrease results in output decreases of 3.84%, 2.91%, 2.36%, and 1% for cherries, pears, grapes, and apples, respectively. The associated projected price for cherries, pears, grapes, and apples increases by 1.5%, 1.62%, 1.60%, and 1.30%, respectively.

- The labor supply shock also creates consumer surplus loss because fruit prices increase. Consumer surplus losses are estimated to be approximately $91 million for apples, $99 million for grapes, $25.5 million for cherries, and $21million for pears when there is a 7% decline in labor supply. The corresponding confidence intervals are $26.06 million and $142.06 million for apples, $28.62 million and $155.16 million for grapes, $7.36 million and $39.78 million for cherries, $6.15 million and $33.30 million for pears

- Farm workers for the four major crops are predicted to account for 80% of total farm workers employment in Washington in 2034.

- The increase in additional workers for the apple industry over the next 20% is estimated to be 47%. Corresponding values for the cherry, grape, and pear industry are 34%, 53%, and 31%, respectively.

- The present value of operating expenses with mechanized harvesting are $75,190.08 over 20 years. The present value of labor cost with hand harvesting are $65,254.23 over 20 years. The

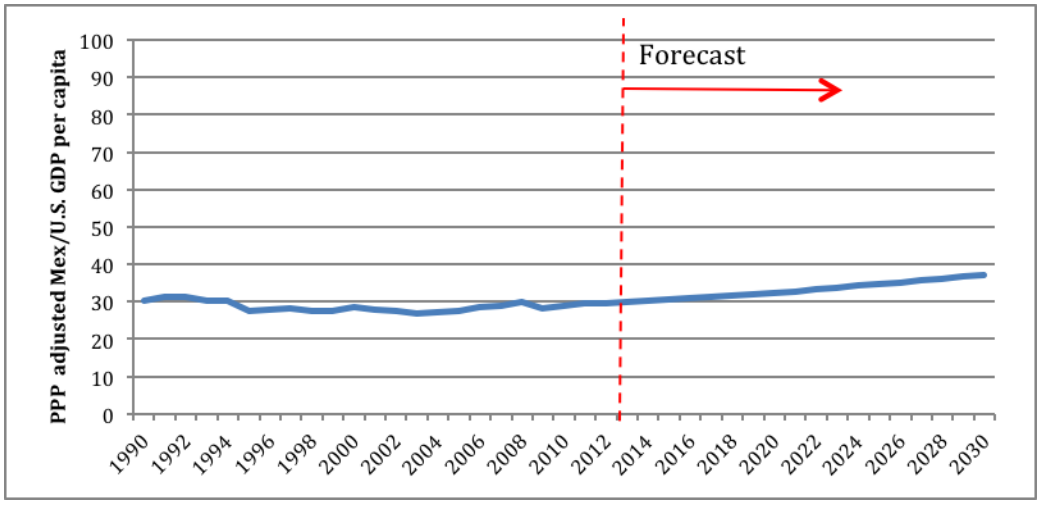
present value of operating expenses for mechanized harvesting is between $5371.22/acre and $9935.85/acre higher than hand harvesting, so we conclude that the current technology is not adopted widely.

- Based on this information, improvements to the current technology would be needed either in terms of cost or productivity. We estimate that if the labor saving rate increases from 36% to 50%, and the machine cost is the same, then it is feasible to adopt the technology. Or with the current technology, it would be feasible to adopt the technology if the wage rate is between $16/hour and $17/hour.

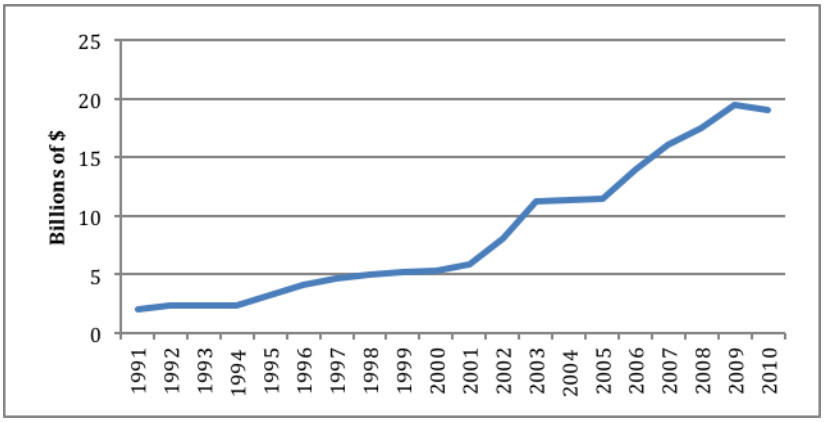
- With additional 1% of H-2A guest workers, the wage rate is 0.54% lower than without it. Consumers benefit from more fruit available at a lower price. We estimate consumer gains by estimating a consumer surplus of $33.57 million for apples, grapes, cherries, and pears produced in Washington State.

Results and Discussion

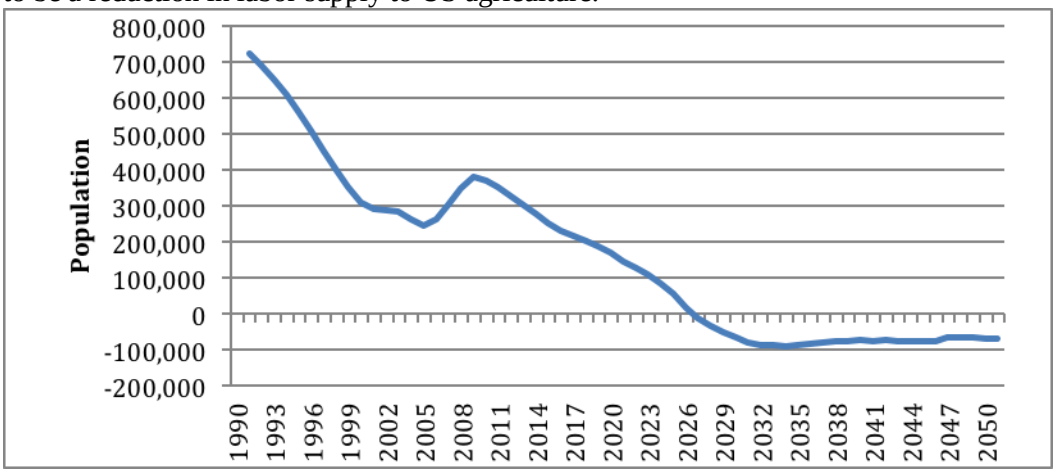
Increased competition for the workers that have traditionally migrated to work in the U.S. is coming from both the agriculture and non-agriculture sectors in Mexico. The Mexican economy is expected to grow faster than the US in the next couple decades.



At the same time increased border enforcement has reduced migration.



Together with a reduction in the growth of the number of working age adults in Mexico there is likely to be a reduction in labor supply to US agriculture.



We model the impact of the coinciding labor supply reduction on wages and production. From the migration labor supply model we forecast a drop of 7% in the number of migrant workers in 5 years. We report upper and lower bounds on labor costs using 95% confidence intervals on the migration forecast, which extends between 11% and 2% for the model that had a point estimate of 7%. We report the results of the aggregate model assuming a capital/labor elasticity of substitution of 0.75 and a labor supply elasticity of 1.55. A 7% decrease in labor supply was estimated to increase wages 8.3%, and the 95% confidence interval of the wage increase was 5.6% and 10.5%. Output price for the final good increases by 3% if a 7% drop in labor supply occurs. The 95% confidence interval extends between 2% and 3.7%.

We then take the projected wage change for labor intensive crops in the first stage as given (or fixed) and then in the second stage consider the change in production decisions in response to the change in the wage level of each individual crop. We account for consumer substitution which introduces interactions between the fnal demand for crops through the cross price elasticity. The effect of reduced labor supply on specific commodities is shown in the table below. The primary columns of interest are the change in the commodity price and output.

A labor supply drop of 7% with a 95% confidence interval of 2% and 11% were modeled. Compared to the baseline, a 7% labor supply decrease results in output decreases of 3.84%, 2.91%, 2.36%, and 1% for cherries, pears, grapes, and apples, respectively. The associated projected price for cherries, pears, grapes, and apples increases by 1.5%, 1.62%, 1.60%, and 1.30%, respectively.

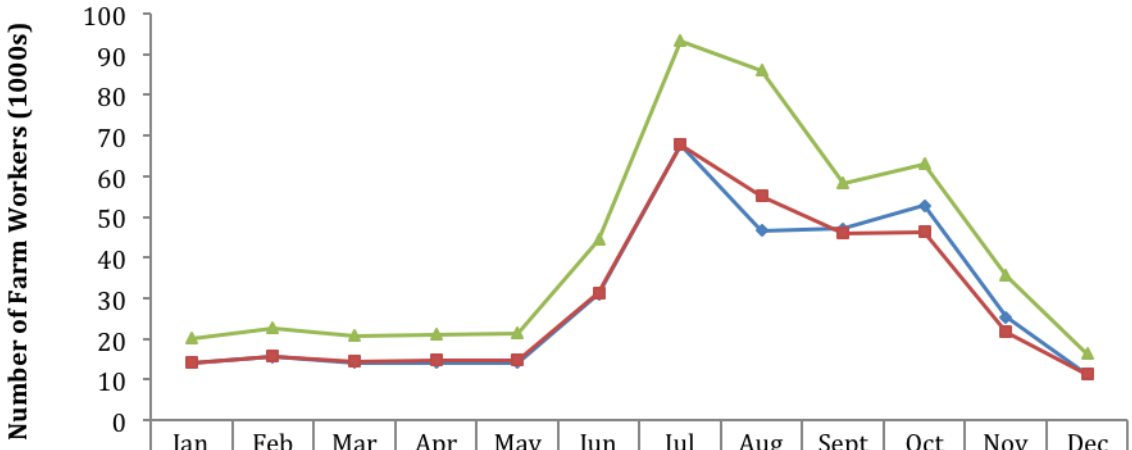
The labor supply shock also creates consumer surplus loss because fruit prices increase. Consumer surplus losses are estimated to be approximately $91 million for apples, $99 million for grapes, $25.5 million for cherries, and $21million for pears when there is a 7% decline in labor supply. The corresponding confidence intervals are $26.06 million and $142.06 million for apples, $28.62 million

and $155.16 million for grapes, $7.36 million and $39.78 million for cherries, $6.15 million and $33.30 million for pears

Labor shift	Commodity	Demand elasticity	Demand shift [b]	Labor share	Substitution elasticity	output change	Price change	Labor change
Baseline	Apples	-1.09	0.089	0.35	0.75	0.0849	0.0161	0.0625
2%						0.0821	0.0197	0.0547
7%						0.0749	0.0291	0.0344
11%						0.0691	0.0366	0.0182
Baseline	Grapes	-1.38	0.131	0.43	0.75	0.1521	0.0198	0.1324
2%						0.1455	0.0242	0.1215
7%						0.1285	0.0357	0.0929
11%						0.1148	0.0450	0.0701
Baseline	Pears	-1.5	-0.01	0.44	0.75	-0.053	0.02	-0.0721
2%						-0.0610	0.0245	-0.0845
7%						-0.0821	0.0362	-0.1166
11%						-0.0989	0.0455	-0.1424
Baseline	Cherries	-1.792	0.138	0.4	0.75	0.1989	0.0184	0.1783
2%						0.1883	0.0225	0.1630
7%						0.1605	0.0332	0.1231
11%						0.1383	0.0418	0.0912

[a] Wage shift is 4.6%, 5.6%, 8.3% and 10.5% for baseline, 2%, 7% , and 11% decline in labor supply, respectively.
[b] Demand shift was estimated by authors

We also forecast changes in apple varieties to look at the change in the period of peak labor demand, as shown below.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2011	14163	15615	14106	14183	14123	31123	67856	46605	47102	52843	25431	11297
2013	14180	15801	14621	14759	14899	31445	67954	55189	46044	46421	21880	11394
2034	20314	22752	20987	21179	21548	44467	93543	86244	58459	63008	35755	16401

This shows a clear increase in the relative demand in July compared to other months.

When facing higher prices, farm owners could adopt less labor-intensive practices by investing in labor saving machinery. It is difficult to assess this question with a great deal of specifics right now because there is uncertainty over the productivity and cost structure of available technologies, although some data was available. This information is used to answer the question: how high do labor costs have to get before the existing technology is a worthwhile investment? We use the present value method to estimate when the current mechanical harvesting technology is going to generate a positive economic return compared to hand harvesting.

Gallardo and Juraqulova (2013) provide an economic analysis of apple mechanical harvester aid. We use their statistical data on the apple mechanical harvester aid on honey crispy to estimate the timing of when mechanical harvester generate a positive economic return compared to hand harvesting. The machine's cost is $50,000 and estimated life is 20 years. The machine reduces labor inputs by 36%. For example, a 10 acre orchard requires 25 pickers to work 12 hours per day for 12 days to finish harvesting. With mechanical harvesting, it requires 16 pickers to work 12 hours per day for 12 days. The machine also saves the cost of ladders. The labor cost saving is estimated to be $1830.60 /acre. The estimated cost for one mechanical harvesting aid is $2788/acre each year. These costs include depreciation, interest, taxes, fuel, and maintenance. The operating expenses for machinery also includes labor with the machinery. The labor cost with machinery is assumed to be the same each year, which is approximately $2458/acre. The total operating expenses with machinery are $5246.2/acre in 2013. The present value of operating expenses for using machinery is $70,725.45 over the useful life of 20 years using a constant wage rate. We also estimated the present value of costs under hand harvesting versus and mechanical harvesting with wage increases from the equilibrium displacement model. The present value of operating expenses with mechanized harvesting are $75,190.08 over 20 years. The present value of labor cost with hand harvesting are $65,254.23 over 20 years. The present value of operating expenses for mechanized harvesting is between $5371.22/acre and $9935.85/acre higher than hand harvesting, so we conclude that the current technology is not adopted widely.

Based on this information, improvements to the current technology would be needed either in terms of cost or productivity. We estimate that if the labor saving rate increases from 36% to 50%, and the machine cost is the same, then it is feasible to adopt the technology. Or with the current technology, it would be feasible to adopt the technology if the wage rate is between $16/hour and $17/hour.

The H-2A program is a guest worker program that enables farm owners to apply to the Department of Labor (DOL) to bring in "low-skilled laborers" for agricultural work. H-2A workers only make up about 2-5% of the farm workforce. In 2011, there were roughly 79,794 H-2A workers certified by DOL. H-2A program connects farm owners and guest farm workers directly and has been considered as an important migration policy to alleviate regional or seasonal labor shortage. We model the effect of expanded H-2A on labor costs by keeping other factors constant, and then reduce the magnitude of the reduced labor supply. A lower wage rate induced by H-2A program relative to not having the program results in increased output at a lower price. We use a Muth model to quantify the impact of a scenario where the H-2A program generates 1% of total farm workers along with a 7% drop in labor supply. With additional 1% of H-2A guest workers, the wage rate is 0.54% lower than without it. Consumers benefit from more fruit available at a lower price. We estimate consumer gains by estimating a consumer surplus of $33.57 million for apples, grapes, cherries, and pears produced in Washington State.

Executive Summary
The objective of this study is to forecast labor costs to the Washington tree fruit industry and estimate the impact of higher labor costs on production, profitability, and the timing of labor saving harvesting technologies. The availability of abundant labor from abroad, primarily Mexico, has kept wages low in labor intensive agriculture in the U.S. for a number of decades. This has reduced incentives for developing labor saving technologies, particularly at the point of harvesting. While agriculture in the U.S. has shown a substantial ability to develop and adopt new technologies there are a number of significant obstacles to overcome for a number of crops that rely heavily on hand harvesting. The adoption of such technologies will also require significant capital outlays that will affect the financial structure and debt load of many operations. Thus, maintaining profitability in the tree fruit industry will require both farm-level planning in terms of production and finances, as well as concentrated R&D in new technologies at both the development and implementation phases.
The immediate cause for concern is that the number of available workers has been dropping. Demographic trends, increased competition for workers in Mexico, and continued high levels of border enforcement in the absence of comprehensive immigration reform are likely to continue to reduce the supply of workers to the labor intensive crop industries in the U.S. which will put upward pressure on labor costs. We forecast a drop of 1% in the number of migrant workers per year as the most likely scenario. Higher and lower estimates are also forecasted by considering other realistic outcomes for economic growth in Mexico and changes in immigration policy and border enforcement. Momentum in demographic trends are established and cannot change in a time frame relevant to this study. A range of scenarios are developed to account for uncertainty over future outcomes of relevant conditions with respect to the magnitude of the labor supply reduction (depending on immigration policy and competition for labor in Mexico), technological change in the productivity of harvesting technologies, and the baseline crop mix.
Reduced labor supply is forecasted to increase wages by 8.31% in five years' time. The increase in the price of labor intensive crops on average (across all crops) is estimated to be 2.9% as a result. Based on this forecasted change in wage levels it is expected that existing harvesting technologies would not generate a positive return on investment in the next 20 years. Based on the information, we predict that a technology that increases the labor saving rate from 36% to 50% would be feasible given growth in labor costs. This corresponds to a wage rate between $16/hour and $17/hour. The optimal response for some orchard producers to this type of technology and wage level would be to switch crops. Analysis of individual landowner and cropland cover data showed that approximately 12% of all land in orchards is owned by an entity that is likely to be too small to make investments in harvesting technologies realistic. Increased mechanization would likely also lead to consolidation and increased farm size in orchard production. Based on a sample enterprise budget, the difference in profitability at the point where adoption of harvesting technologies occurs relative to now (current wages and input levels) is $957 per acre.
The impact of an expanded guest worker program reduces the labor supply shock by 1-3% in Washington which delays the widespread adoption of harvesting technologies by 1-2 years. The model scenario with additional 1% of H-2A guest workers that accounts for changes in the crop mix find that the wage rate decreases by 0.54%.