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## Impact of Hired Foreign Labor on Milk Production and Herd Size in the United States

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### Abstract

Foreign labor has become increasingly important component of U.S. agriculture. Disruption in the supply of agricultural labor has been argued to significantly affect agricultural production. This study analyzes the impacts of foreign labor shortages on the dairy industry using national survey data. The results suggest that a 30 percent hired foreign labor shortage will result in 10.1 billion pound decline in total U.S. milk production. This is equivalent to a loss of 458.9 thousand dairy cows. One of the key implications of this study is the need for immigration or labor policies that help maintain consistent labor availability and stability of the dairy farm workforce.

### Introduction

U.S. agriculture is dependent on foreign workers. It is estimated that about 42 percent of total farm workers are foreign born, with most originating in Mexico and Central American countries (ERS, 2009). USDA (United States Department of Agriculture) data indicate that the number of hired workers on U.S. farms has shown a declining trend since 2000. Some argue that labor shortages in agriculture are attributed to immigration policies including increased enforcement of immigration regulations, longer wait periods for acquiring work permits, and longer border crossing times. Economic factors such as higher wages and better working conditions offered by non-farm industries may draw people away from farm jobs.

Shortages in agricultural labor can significantly affect agricultural production and result in severe financial problems. Recent labor shortages in the agricultural sector, for example, have resulted in average wage increases from \$10.20 in 2007 to \$10.60 in 2008 (NASS, 2008). A report by the American Farm Bureau Federation indicated that the elimination of migrant labor would cost U.S. agriculture annual losses of \$1.5 to \$5.0 billion and about 10 to 20 percent of fruit and vegetable producers would go out of business (AFBF, 2006).



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The dairy industry, similar to others within agriculture, appears likely to experience substantial negative economic impacts attributed to labor shortages should those shortages become frequent and sustained over time. A recent study, for example, shows that a 50 percent reduction in foreign-born dairy workers would lead to an additional 66,000 jobs being lost due to the closure of some dairy farms, and the resulting multiplier effect of fewer jobs in input supply sectors and other sectors that support dairy production (Rosson, et al, 2009).

The purpose of this study is to analyze the impacts of hired foreign labor shortages on milk production and herd size in the U.S. dairy industry. The analysis is conducted through estimating a milk production function using the panel data method. The impacts of probable foreign labor losses on herd size and milk production are simulated using the estimates. The results of the study provide useful information for evaluating recent concerns regarding immigration policy, its impacts on the availability of farm labor, and subsequent impacts on U.S. dairy farms.

## Data and Methodology

### Data

A mail survey of 5,005 dairy farmers across the United States was conducted between June and August 2008 to gather the data for this analysis. The survey was conducted using stratified sampling with state and herd size as the distinct categories. Of the 5,005 survey questionnaires, 2,071 were returned by dairy farmers and 1,213 were utilized in this analysis. Factors that decreased the number of respondents used in this study include the exclusion of small dairy farmers with less than 50 cows and partially completed questionnaires. Farms with cow numbers less than 50 were excluded from the analysis because they are not considered to be economically viable. Data on hired labor and cow numbers were recorded for the last three years (2006 to 2008). Milk production data were calculated by multiplying the number of cows in the region by production per cow of the corresponding region. Definitions of regions and herd sizes are given in Table 1 and sample distributions are given in Table 2.

The distributions of the samples given in Table 2 show that approximately 71 percent of sample falls in the size 1 category with herd size less than 200 cows. Most of the size 1 farms are in regions 3, 4, 5, and 7, comprising 55 percent of total sample or 78 percent of total farms in size 1 category. Most of size 4 (between 1,000 and 1,999

cows) farms are in region 1 (California) and region 5 (Southwest), accounting for 67 percent of total sample from this category. Comparing across regions and herd sizes, it is obvious that larger farms are located in regions 1, 2, and 5. The distribution of the sample is similar to the distribution of dairy farm population published by the USDA.

### Econometric Model and Estimation

The translog (Transcendental Logarithmic) function is used to estimate the milk production function because it provides a good first-order approximation to a broad class of functions, including the CES (Constant Elasticity of Substitution) and the Cobb-Douglas functions. The flexible nature of the translog function has proven quite useful in applied production analysis and is, by far, the most widely used in production analysis (Tzouvelekas, 2000). This functional form has both linear and quadratic terms.

Milk production depends on many factors including labor, capital, technology, and prices. It is unfortunate that we were not able to gather the data on capital and other input factors other than labor during this survey. Therefore, our focus is on a single factor input: hired labor. Capital is assumed to be pre-defined and technology is assumed to be constant. The assumption of constant technology is reasonable given that our data cover a short period of time from 2006 to 2008. We believe that during this period, technological advancement did not change substantially. Excluding non-labor input factors gives some limitations on the estimation results. However, given that dairy farms rely heavily on hired labor as an input and the fact that hired foreign labor is crucial to most farms, the results of this study remain important. The results, for example, provide the likely impacts of labor shortages on milk production and herd sizes. The results also give rise to discussions about the impact of labor shortages, particularly those related to immigration policies which are considered to be one of the important driving forces of labor shortages in the agricultural sector.

Focusing on the impact of foreign hired labor, the labor input is broken down into two categories: foreign hired labor and domestic hired labor. Furthermore, the availability of cross section and time series data enables the specification of the production function in a panel data model.

The production function with one-two category labor input is given by

$$(1) MP_{it} = \beta_0 + \beta_1 FL_{it} + \beta_2 DL_{it} + \frac{1}{2} \beta_3 FL_{it}^2 + \frac{1}{2} \beta_4 DL_{it}^2 + \beta_5 FLDL_{it} + \varepsilon_{it}$$

where  $MP$  is milk production,  $FL$  is hired foreign labor,  $DL$  is hired domestic labor, and  $FLDL$  is hired foreign labor multiplied by hired domestic labor. Subscripts  $i$  and  $t$  indicate farm and year, respectively, and  $\varepsilon_{it}$  is the error term.

Milk production is likely to vary across regions and herd sizes in response to changes in hired labor. Dairies in California, for example, are relatively large when compared to those in the North East. To account for such differences, interaction terms of dummy variables representing both region and herd size ( $RSD$ ) and  $FLDL$  are used. In this case,  $RSD$  takes a value of one if an observation falls within region ( $r$ ) and herd size ( $s$ ), zero otherwise. The new production function then becomes:

$$(2) MP_{it} = \beta_0 + \beta_1 FL_{it} + \beta_2 DL_{it} + \frac{1}{2} \beta_3 FL_{it}^2 + \frac{1}{2} \beta_4 DL_{it}^2 + \sum_r \sum_s \beta_{rs} (RSD)FLDL_{it} + \varepsilon_{it}$$

The labor input elasticity can be obtained by taking the first derivative of milk production with respect to labor input (Chambers, 1988). In this study, estimates of elasticity are average elasticities. These elasticities are then used to simulate the effects of changes in hired foreign labor.

The main technique used for analysis of panel data is a fixed effects model, which controls for omitted variables that differ between individuals but are constant over time. The validity of using fixed effects models can be tested using the F-test. If we have reason to believe that some omitted variables may be constant over time but vary between individuals, and others may be fixed between individuals, but vary over time, then we can include both types by using random effects. The choice between the two models can be performed using the Hausman test. Failing to reject the null hypothesis suggests that the random effects model is the better choice (more efficient) than the fixed effects model (Green, 2008; Wooldridge, 2002).

## Regression Results and Discussion

### Milk Production Equation

Table 3 contains the econometric results for milk production.  $MP$ ,  $FL$ , and  $DL$  are in log values. In the case that  $FL$  and/or  $DL$  equal zero, we assigned these variables with a value of 1 in order to perform

the logarithmic function. The variable  $(RSD)FLDL$  measures heterogeneity in labor elasticity across herd size and regions. There are five herd size categories and seven regions, giving a total of thirty-five dummy variables and hence thirty-five multiplicative variables. Because of the excessive number of parameters representing the variable  $(RSD)FLDL$ , we do not present their estimated values.

The F-statistics for testing the joint significance of the individual dairy farms strongly suggest the presence of individual heterogeneity in the data. Therefore, the use of fixed effects model is justified. Furthermore, the Hausman statistic suggests that the random effects model is the better choice than the fixed effects model. Therefore, further discussions are based on the random effects model. As shown in Table 3, the variables and their squares are all significant at the five or one percent level of significance. In the case of variable  $(RSD)FLDL$  (not shown), 19 of the 35 parameter estimates are significant at least at the 10 percent level of significance.

The estimated parameters in Table 3 were used to calculate the production elasticity for hired labor. Because the elasticity can be obtained for a single observation, the elasticity estimates are averaged across all observations. The elasticity estimates are given in Table 4. All estimates of elasticity of hired foreign labor have the expected signs and indicate inelastic elasticity of labor for milk production. Positive elasticities indicate that an increase in the use of labor inputs will result in an increase in milk production. As can be seen from Table 4, foreign labor elasticity in farm size 5 in California is 0.28 suggesting that a one percent increase in hired foreign labor will increase milk production in this farm category by 0.28 percent. The highest elasticity for hired foreign labor was found in farm size 5 in South East region with the magnitude of 0.79. On the other hand, all elasticity estimates for hired foreign labor in farm size 1 are nearly zero. A possible explanation is that dairy farms of size 1 hired less foreign labor than larger farm sizes. In California, for example, the average of hired foreign labor in size 1 was 1.2 employees and size 5 was 26.5 employees. The survey data also indicated that some small dairy farms did not hire foreign labor for their dairy operations. Therefore, with relatively low levels of hired foreign labor, it is unlikely that changing in the number of hired foreign workers will significantly affect milk production.

A closer investigation of Table 4 indicates that the magnitudes of hired foreign labor elasticities are consistent across herd sizes within regions. That is, the larger the herd size, the greater the elasticity

estimates. It is concluded that larger farms are more responsive to changes in hired foreign labor than smaller farms.

Elasticity estimates for hired domestic labor contained in Table 4 show that all estimated elasticities have positive signs, except for Size 4 in the Midwest region with negative elasticity of -0.02. This negative sign is not expected, but the impact is negligible because the magnitude is nearly zero. Our estimates show that, unlike elasticity for hired foreign labor, there is no clear trend whether elasticities of domestic labor are positively related with herd sizes (i.e., the magnitude elasticities increase as herd size increases). Three regions (North, Northeast, and Southeast) have domestic elasticities that vary positively with herd size, while the other four regions have no such patterns. Furthermore, our estimates suggest that, in general, the magnitudes of hired domestic labor elasticities are smaller than those of hired foreign labor, with the exception in size 1 farm and the SE region.

#### **Impact of Hired Foreign Labor on Milk Production and Cow Numbers**

The elasticity estimates in Table 4 are used to conduct simulation of the effects of labor shortages on milk production and cow numbers. The simulation was conducted using 2007 data obtained from USDA as the base scenario with a hypothetical scenario simulating a 30 percent shortage of hired foreign labor. The simulation assumed that hired domestic labor does not change and that there is no substitution effect for labor inputs. This assumption may limit the simulation results as dairy farmers may attempt to substitute domestic labor for foreign labor as they face foreign labor shortages. However, our field interviews suggest that it is less likely because it is relatively difficult to find domestic laborers who are willing to work year around. Therefore, the substitution effects are expected to be insignificant. The simulation results are presented in Table 5.

As contained in Table 5, assuming a 30 percent shortage in hired foreign labor, the United States is expected to experience a loss of approximately 10.1 billion pounds of fluid milk or a reduction of 5.8 percent from the base line. This reduction is the result of declining cow numbers because technology is assumed to be constant, as previously discussed. As expected, the loss in milk production increases with herd size. Size 5 farms would be expected to experience a loss of 4.6 billion pounds, about 13.4 times the amount of size 1 farms. Converted into cow numbers, it is expected that with a 30 percent shortage of hired foreign labor, the number of cows in the U.S.

would decrease by 458.9 thousand head, or approximately 5.4 percent. The number of cows eliminated as a result of labor shortages also increases with herd size.

It can also be seen from Table 5 that the impacts of labor shortages on milk production and cow numbers vary by region. California is projected to experience the greatest loss in milk production followed by the Southwest, Northwest, and North regions. With a 30 percent hired foreign labor shortage, milk production is projected to decline by 3.1 billion pounds, 1.9 billion pounds, 1.6 billion pounds, and 1.0 billion pounds in these regions, respectively. The other three regions are expected to experience milk reductions of approximately 0.8 billion pounds

In terms of cow numbers, the simulation indicates that with a 30 percent hired foreign labor shortage, cow numbers in California would decline by 138.6 thousand head, the largest decline among all regions. The Northeast region, on the other hand, is expected to experience the smallest cow herd reduction, at 33.7 thousand head.

#### **Summary and Conclusions**

The objective of this study was to analyze the impacts of hired foreign labor shortages on milk production and cow numbers in the United States based on survey results from 1,213 dairy farmers across the United States. The data represent a three year period from 2006 to 2008. A translog production function was used to estimate milk production function with two input variables: hired foreign labor and hired domestic labor. The production function was analyzed using a panel data model.

The regression results show that hired foreign labor and hired domestic labor significantly impact milk production. Most of the interaction terms between hired foreign labor, hired domestic labor, and a dummy variable for region and size are significant, suggesting that milk production varies by region and herd size. The labor elasticity of production was found to inelastic with its magnitudes ranging from 0.02 to 0.79 for foreign labor and from -0.02 to 0.87 for domestic labor. In general, the magnitude of hired foreign labor elasticity increases with herd size and differs across regions, but it is not the case with hired domestic labor.

The simulation conducted using the elasticity estimates indicate that a 30% hired foreign labor shortage will result in a decline in total U.S. milk production of 10.1 billion pounds, which is approximately 5.8

percent of the 2007 base line production. Converted into cow numbers, this reduction is equivalent to a loss of 458.9 thousand head or 5.4 percent of the number of cows in the 2007 base line herd. These estimates emphasize the importance of hired foreign labor to U.S. dairy farms. The potential implications of this study suggest that

immigration policies or labor policies that help maintain consistent labor availability and stability of the dairy farm workforce are crucial to the economic well-being of the U.S. dairy industry. Neglecting this workforce would likely bring negative ripple effects nationwide.

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*Table 1. Definitions of regions and herd sizes*

Region/Size	Definitions
California (1)	Includes: CA
Northwest (2)	Includes: ID, MT, NV, OR, UT, WA, and WY
North (3)	Includes: MN, ND, and WI
Midwest (4)	Includes: IA, IL, IN, MI, MO, NE, OH, and, SD
Southwest (5)	Includes: AZ, CO, KS, NM, OK, and TX
Northeast (6)	Includes: DE, CT, MA, ME, NH, NJ, NY, PA, and VT
Southeast (7)	Includes: AL, AR, GA, FL, KY, LA, MD, MS, NC, SC, TN, VA, and WV
Size 1	Farms with herd size between 50 and 199
Size 2	Farms with herd size between 200 and 499
Size 3	Farms with herd size between 500 and 999
Size 4	Farms with herd size between 1000 and 1999
Size 5	Farms with herd size 2000 and more

Table 2. Sample distribution across herd size and region

Frequency Percent Row Pct Column Pct	Size 1	Size 2	Size 3	Size 4	Size 5	Total
California	16	38	42	32	23	151
	1.32	3.13	3.46	2.64	1.90	12.45
	10.60	25.17	27.81	21.19	15.23	
	2.15	18.27	34.15	48.48	32.39	
Northwest	82	55	36	14	13	200
	6.76	4.53	2.97	1.15	1.07	16.49
	41.00	27.50	18.00	7.00	6.50	
	11.01	26.44	29.27	21.21	18.31	
North	177	18	8	4	1	208
	14.59	1.48	0.66	0.33	0.08	17.15
	85.10	8.65	3.85	1.92	0.48	
	23.76	8.65	6.50	6.06	1.41	
Midwest	126	31	6	2	1	166
	10.39	2.56	0.49	0.16	0.08	13.69
	75.90	18.67	3.61	1.20	0.60	
	16.91	14.90	4.88	3.03	1.41	
Southwest	84	29	21	9	27	170
	6.92	2.39	1.73	0.74	2.23	14.01
	49.41	17.06	12.35	5.29	15.88	
	11.28	13.94	17.07	13.64	38.03	
Northeast	127	19	9	2	3	160
	10.47	1.57	0.74	0.16	0.25	13.19
	79.38	11.88	5.63	1.25	1.88	
	17.05	9.13	7.32	3.03	4.23	
Southeast	133	18	1	3	3	158
	10.96	1.48	0.08	0.25	0.25	13.03
	84.18	11.39	0.63	1.90	1.90	
	17.85	8.65	0.81	4.55	4.23	
Total	745	208	123	66	71	1213
	61.42	17.15	10.14	5.44	5.85	100.00

Note: Distribution is based on the year of 2008.

*Table 3. Unconstrained parameter estimates of translog milk production function: with multiplicative variables (fixed effects and random effects model)*

Variables	Fixed Effects Model		Random Effects Model	
	PrEst	Std	PrEst	Std
Intercept	13.528***	0.1567	14.911***	0.1312
FL	0.1338***	0.0516	0.1463***	0.0415
DL	0.1366***	0.0396	0.1354***	0.0320
FL <sup>2</sup>	0.0201**	0.0099	0.0223***	0.0080
DL <sup>2</sup>	0.0203***	0.0067	0.0202***	0.0054
R <sup>2</sup>		0.98		0.13
F Statistic		28.1 (0.00)		
Hausman Statistic				0.60 (1.00)
No. of cross sections		1213		1213
No. of time series		3		3

Due to excessive number of the parameters of the variables (RSD)FLDL, we do not present their estimates. \*\* and \*\*\* are significant at the 5% and 1% levels, respectively. F Statistics and Hausman are statistics for fixed effects and random effects tests, respectively. PrEst is parameter estimates and Std is estimated standard errors.

*Table 4. Estimates of input labor elasticity for milk production: by herd size and region*

Region	Foreign Labor					Domestic Labor				
	S-1	S-2	S-3	S-4	S-5	S-1	S-2	S-3	S-4	S-5
CA	0.08	0.21	0.25	0.24	0.28	0.07	0.08	0.04	0.08	0.02
NW	0.07	0.16	0.23	0.24	0.33	0.12	0.14	0.08	0.09	0.24
NO	0.02	0.12	0.20	0.34	0.36	0.11	0.18	0.17	0.32	0.34
MW	0.02	0.06	0.22	0.30	0.25	0.12	0.17	0.12	-0.02	0.14
SW	0.04	0.21	0.27	0.27	0.31	0.07	0.12	0.02	0.11	0.15
NE	0.02	0.08	0.12	0.28	0.36	0.10	0.19	0.21	0.25	0.34
SE	0.04	0.06	0.30	0.51	0.79	0.11	0.21	0.30	0.55	0.87

Notes: Estimates are average elasticities calculated based on the Random Effects Model given in Table 3. Size 1: less than 200 cows, Size 2: 200-499 cows, Size 3: 500-999 cows, Size 4: 1000-1999 cows, and Size 5: greater than 1999 cows.

*Table 5. Impacts of a 30 percent shortage in hired foreign labor on milk production and cow numbers by region and herd size*

Milk Production (mill Lbs.)						
REGION	SIZE 1	SIZE 2	SIZE 3	SIZE 4	SIZE 5	TOTAL
CA	-12.8	-253.3	-618.0	-785.1	-1,455.0	-3,124.3
NW	-38.3	-149.7	-268.6	-366.9	-787.9	-1,611.4
NO	-107.7	-232.6	-97.8	-219.5	-371.4	-1,029.0
MW	-63.9	-90.3	-127.0	-230.4	-311.0	-822.6
SW	-16.2	-80.8	-407.9	-518.3	-918.2	-1,941.5
NE	-57.8	-124.7	-56.5	-167.0	-344.9	-750.9
SE	-48.8	-41.5	-81.4	-176.1	-447.1	-794.9
TOTAL	-345.6	-973.0	-1,657.1	-2,463.4	-4,635.6	-10,074.5

Cow Number (Head)						
REGION	SIZE 1	SIZE 2	SIZE 3	SIZE 4	SIZE 5	TOTAL
CA	-790	-11,854	-30,613	-31,616	-63,750	-138,624
NW	-2,136	-7,122	-13,181	-14,635	-34,195	-71,268
NO	-5,869	-11,298	-4,829	-8,810	-16,218	-47,023
MW	-3,535	-4,306	-6,052	-8,927	-13,114	-35,933
SW	-1,056	-4,290	-20,681	-21,363	-41,178	-88,568
NE	-3,243	-6,080	-2,763	-6,644	-14,930	-33,660
SE	-3,112	-2,464	-5,014	-8,822	-24,364	-43,776
TOTAL	-19,740	-47,415	-83,133	-100,816	-207,749	-458,852