Farm Labor Demand and Supply:

A Meta-analysis of Wage Elasticities

By Dawn D. Thilmany and Molly Espey

Colorado State University and University of Nevada-Reno

Presented at the 1998 American Agricultural Economics Association Annual Meetings

August 1998

Salt Lake City, Utah

Abstract: This study reviews previous research on labor supply and demand wage responsiveness. A meta-analysis of estimated demand wage elasticities was conducted to better understand any systematic factors that influence such estimates. Factors studied include short versus long run response, family versus hired labor, functional form, time span of the study.

Introduction:

The focus of farm labor studies has changed greatly over time. The farm labor market has evolved from a fairly large, labor-intensive sector to a small supply of skilled farm operators supplemented by an unskilled, migrant seasonal labor force. Moreover, the sophistication of economic models and estimation procedures has allowed economists to develop full systems of labor supply and demand which incorporate a diverse set of variables including, but not limited to, technological change, income effects and joint household production functions. The focus and method of demand and supply analysis has likely affected the elasticity estimates reported in farm labor research. This study reviews previous studies of wage responsiveness for labor demand and analyzes the likely effects that estimation procedures and modeling have on elasticities.

Studies of labor demand tend to be either independent estimates of the workforce needed in markets dominated by seasonal agriculture, or part of entire production systems that allow for input substitution in more highly mechanized farm operations. However, labor is included in many studies since it is a primary input in agriculture, has been greatly affected by agricultural research, and has a significant effect on farm household production decisions. Several of the studies analyzed here did not have labor as their primary focus, but it was still possible to determine the estimated wage elasticity.

This paper begins with a review of farm labor market research, focusing on the evolution and diversity of household and hired farm labor studies. Both labor supply and demand models are included in the overview, but empirical analysis will focus on labor demand (see Data for further explanation). The methodology used to conduct analysis on the various farm labor demand estimates is meta-analysis, an approach which uses inter-study differences as explanatory variables for estimated wage elasticities. Factors which vary across studies include short versus long run response, geographic region (international, national and regional), family versus hired labor, functional form (production vs. ad hoc), complexity of model (systems vs. single equations),

controlling for technological change and income (compensated vs. uncompensated), and year or range of years included in the analysis.

Labor Market Research

As Schuh (1962) notes in his seminal piece, the number of persons engaged in farming has changed markedly throughout history, peaking in 1929 at 12.7 million, declining to 7.1 million in 1960 and stabilizing at around 4 million in the late 1980's. However, little attention was paid to the changing role of labor in agriculture or whether supply or demand was the primary impetus for the exodus of labor from farms. Beginning with Schuh's structural, dynamic estimates of labor supply and demand elasticities, labor market modeling has become a more complex, integrated part of farm production research.

Historically, there was interest in research on labor saving technology since decreasing demand for farm labor would fuel urban industrialization efforts. There is continued interest in the off-farm labor supply choices of farm operators and their families, but now this interest is more closely related to human capital issues and rural development goals. Moreover, off-farm labor participation rates of operators and their families will likely affect and be affected by the availability and prevailing wages in the hired labor market.

One farm labor market trend is clear: fewer farmers are active in the farm labor market. However, seasonal labor demand remains stable and relatively high. Great interest remains in whether farms are able to secure sufficient seasonal workers during peak labor demand periods. This is especially true since labor-saving technology has made fewer inroads in the growing fruit-vegetable-horticulture sector (FVH) and because current seasonal labor markets are so closely tied to immigration policies and reforms (Taylor and Thilmany).

Labor is a complex input in the production process. In addition to being an important factor of production (16% of costs, down from 45% in the 1940's), labor is also part of the household

consumption choice set. As farm household incomes increase, the choice to release family members from farm work may increase, thereby increasing the demand for hired labor. In short, farm labor demand is a function of both prevailing wage rates and household income levels. Moreover, off-farm labor supply decisions will be affected by hired labor supply and demand. However, some of the explanatory variables in the meta-analysis demonstrate the complexity of labor demand models (including some studies that control for income effects).

It is argued in this paper that labor elasticities vary because of differences in either the theoretical basis of the study, data included in the analysis, complexity of the labor market representation or the restrictions imposed in the econometric estimation. These differences will be discussed in length in the modeling section below.

Data

Eighty-four price elasticities from twenty-nine studies (Table 1) are included in this analysis. Elasticity estimates are used as dependent variables because they are unit-free, as well as easy to interpret and compare across studies. The elasticity estimates were either directly reported in the study or were calculated using reported coefficients and the means of the relevant variables. The studies included are all based on hired, family or aggregate farm labor estimates. Although some of the cross-sectional studies rely on farm survey responses, the majority of the studies use aggregate USDA worker and wage estimates. The dates of the studies range from 1962 to 1995 while the data included in the studies ranges from 1912 to the late 1980's.

It should be noted that only studies from developed countries were used since labor markets in developing countries are far less complete and because labor choices are so greatly affected by income levels. As mentioned in the introduction, only labor demand elasticities will be analyzed in this study. There are fewer labor supply estimates available to analyze, and such estimates are

divided among hired labor supply and off-farm family labor supply (which cannot be interpreted or modeled similarly).

The labor demand price elasticity estimates range from 0.22 to -4.42 (see Figure 1 for the distribution). The mean elasticity was -0.74 and over 85% of the estimates fall within the 0 to -1.5 range. The positive elasticity estimates would seem problematic from a theoretical perspective, but only two positive estimates were statistically significant, and they represent short-run estimates in the relatively tight, highly seasonal hired labor market. Since higher wages may represent record yields or extremely short harvest periods in that market, a small and positive labor demand elasticity may be plausible. However, as noted above, for the meta-analysis models presented here the data was truncated at zero.

Model

Differences in wage elasticities seem problematic in that one might have difficulty in assessing which set of estimates is correct. Meta-analysis, however, is not used to determine what the correct estimate is, but rather to analyze how different estimation techniques and the inclusion or exclusion of factors systematically affects the estimates. Since labor responsiveness is a fairly complex issue, illustrating what factors play a significant role may be helpful to producers and policymakers, in addition to those who research these labor markets in the future.

A meta-analysis of labor demand wage elasticities is somewhat of a challenge to undertake. First, there is little uniformity across labor studies due to the great number of factors that influence work choices. It is also likely that the wage elasticities are part of a system of estimates, rather than independent estimates from a study focusing specifically on labor response. Finally, there has been a significant structural change in the role of labor in agriculture due to various factors including mechanization, immigration and the increasing importance of off-farm income for many

agricultural households. However, such factors also increase the potential benefits of increasing the awareness of how wage elasticities vary across studies.

The model characteristics can be described by three broad categories: (a) the nature of the data, (b) model specification, and (c) econometric methods used to estimate the model. The nature of the data varies greatly across studies. Features included in this study are: the type of labor (hired or family), detail on operations (general or commodity-specific), geographic location, years of analysis and type of data (time series vs. cross sectional or cross sectional-time series). Three time periods were included (pre-World War 2, post-1955, and an interim period from 1945 to 1955) to determine if wage elasticities have changed over time.

Model specifications varied in three primary ways. The earliest innovations in labor models focused on dynamic rather than static models. Another important distinction is whether labor demand is modeled independently or structurally (with simultaneous supply and demand equations). Finally, more recent studies have included labor decisions as part of a full production or household system rather than as independent, ad hoc estimates. These estimates are categorized as being derived from translog models, Cobb-Douglas models, or utility maximization models.

Econometric estimation differences simply relate to whether the elasticities are the result of least squares, least square in stages, maximum likelihood or equilibrium estimations. There were only two studies that used maximum likelihood estimation and only one study that used an equilibrium model, so these two variables were not used in the final estimation below. Since there were also only two estimates specifically focusing on the Midwest and two on the eastern U.S., these variables were also omitted from the final meta-analysis.

Table 2 shows the average wage elasticity estimates of labor demand studies by study characteristic for both the truncated and untruncated data sets.

Estimation

The meta-analysis model is estimating using three different models: a linear model, a semi-log model (using the log of the elasticity), and a gamma model. All of the explanatory variables are 0-1 dummy variables indicating whether or not the study had the particular data, model, or estimation characteristic. Because the gamma model requires truncation at zero, positive price elasticities were omitted. In addition, since the semi-log model requires all variables to be positive, the wage elasticities were multiplied by negative one before estimation, hence a positive coefficient indicates a more elastic demand and a negative coefficient indicates a less elastic demand.

The distribution of the wage elasticities of labor demand, as shown in Figure 1, is skewed toward zero, a feature of the gamma distribution. However, the gamma distribution is not defined for values less than or equal to zero, so estimation using the gamma requires truncation of the data set. As discussed above, only four estimates were greater than zero, only two of which were statistically significant. Based on the linear ordinary least squares meta-analysis estimates, truncation of the data does not significantly affect the results. Maximum likelihood estimation is used to estimate the gamma model, including the gamma shape parameter. Gourieoux et al (1984) have shown that the linear exponential family, of which the gamma is a member, gives consistent and asymptotically normal estimators of the parameters of the first order moment of the true distribution.

Findings and Discussion

In the meta-analysis, one variable from each set of mutually exclusive variables must be excluded for estimation, hence estimated coefficients can be interpreted as variations from the base model of excluded variables. The base in this study is a short run, dynamic, single equation estimation using aggregate, U.S.-aggregate, time series data and ordinary least squares estimation.

The results of the meta-analysis of labor demand elasticities are shown in Table 3. It appears that several features of data, modeling, and estimation have a significant effect on the elasticity estimates from labor demand studies. First, and not surprising, is that the long-run response of employers to wage changes is significantly more elastic than short-run response. Labor elasticity estimates also appear to have varied over time, even when controlling for the increasing sophistication of the economic modeling and estimation procedures used in studies. The results of this study suggest that the labor market prior to World War 2 was less elastic. Given the labor intensity of farm production and few alternatives for mechanization at that time, this result is not surprising. Over time, advances in technology and production methods have given producers greater flexibility, perhaps resulting in the higher elasticity after 1955 implied by the meta-analysis.

The demand for hired labor appears to be relatively more elastic while the demand for family labor tends to be less elastic. We can infer that family labor is a more stable, consistent component of the farm production process which may encompass some very firm-specific skills, and thus, is not as substitutable whereas hired labor may be more easily replaced by mechanization if prevailing wages increase. Interestingly, cross sectional studies have produced more elastic estimates of the demand for labor than time series studies. Yet, cross sectional-time series studies have produced less elastic estimates.

Demand elasticities in specific commodity markets (including dairy, beef and various field crops and modeled as SECTOR) were found to be less elastic than aggregate farm labor demand. This could imply that workers are not extremely substitutable across certain crops and commodities. Or, given the relatively skilled nature of the labor in the particular sectors analyzed, we would argue that less elastic demand would be expected relative to more seasonal, unskilled FVH labor markets. Farm labor markets in the Western U.S. appear to have a more elastic demand than the U.S. in general. The results on hired labor and Western labor markets are not surprising given the seasonal,

unskilled nature of those specific labor markets. Also, it should be noted that farm labor markets in other countries (Canada, Israel and Japan) appear to have a less elastic demand than the US market.

Elasticity estimates also vary somewhat depending on the economic modeling and econometric methods used. These results are of general interest to empirical researchers, as they may indicate biases present when various methodologies are chosen to estimate demand for any product or factor. Those labor market systems estimated with structural equations using two or three stage least squares (SLS) and generalized least squares found more elastic labor demand estimates than those using ordinary least squares. As SLS is a technique often used to obtain consistent estimates when there is correlation between one of the explanatory variables and the error term, this finding could be very significant for future estimation of labor demand. Simultaneity bias caused by correlation between price and the error term would bias the estimate of the coefficient on price toward zero. Hence correction for simultaneity bias would result in a more elastic estimate, as implied by the meta-analysis (i.e., positive coefficient on SLS).

Labor demand estimates (in the form of factor demand elasticities) are often a secondary result of studies that focus on more general farm production issues. For example, some labor demand studies controlled for income effects given the direct and indirect implications of such effects in farm household labor decisions. These compensated demand models produced less elastic demand estimates, as would be expected given that only substitution effects were measured.

Of those studies that included labor within a production or household system, those that used Cobb-Douglas or translog systems were statistically significant in all three models estimated, suggesting a relatively greater elasticity. Theoretically, such systems would give less elastic demand estimates due to the fact that they assume fixed input shares. But, to understand these results, one must understand the basic tenets of the literature in production research. As mentioned before, the significant decline in labor share over the past century would lead one to believe that labor is very elastic relative to other inputs in a full production system (thereby explaining the

positive coefficients on Cobb-Douglas and translog). However, this does not account for any possible bias in research and technical change in the agricultural industry. Several studies of agricultural research cited in this study (Capalbo and Denny; Lambert and Shonkwhiler) have found a bias towards labor-savings technology throughout the 1900's. Not surprisingly, studies that corrected for technological bias (all of which were full production systems) produced less elastic estimates of demand than the other complete production systems. This also illustrates how findings from the meta-analysis connect labor market research to more general production and policy issues.

Conclusions:

Although farm labor research still draws from a few seminal pieces, methods and models have evolved greatly over time. Such evolution has occurred in all fields of the economic literature, but it is far more pronounced in the labor research due to the structural change in the U.S. labor market and, in the case of agriculture, the markedly lower production cost share that labor represents. Yet, it is difficult to ascertain the degree to which labor demand elasticity estimates have actually changed relative to estimates that simply vary based on the method in which they were analyzed. Meta-analysis provides an interesting way to determine which economic trends or modeling and estimation innovations (or to what degree both) have affected the estimates. In addition to noting differences in results across time and approach, a meta-analysis of estimated elasticities was conducted to better understand any systematic factors that influence such estimates. Thus, cross-study comparisons should be more clear and precise.

As discussed previously, similar analysis could be performed on farm labor supply estimates, but the development of the meta-analysis would need to be more complete to account for the subtle and complex income and substitution effects inherent in such models. There are also potential applications for specific agricultural labor markets. For example, similar analysis across farm labor demand and supply elasticity estimates in developing countries would likely produce

different results. Yet, some meta-analysis results (such as the type of economic system or econometric method) may be generalizable across developed and developing labor markets.

There are also some interesting implications for labor research in other areas. The results and discussion on the labor demand estimates from the research and production fields demonstrated how labor elasticity estimates across time may even be impacted by U.S. agricultural research policy. As research monies were directed at labor-saving technologies earlier in the century (as part of urban, and then rural, development strategies), labor elasticities were likely altered.

Future researchers will be able to infer whether labor elasticity estimates are relatively higher or lower due to labor market structural changes, or perhaps instead, because of the way in which they chose to model the labor market. There is one clear implication from this meta-analysis: any and all labor estimates should be framed in the context of the studies from which they were drawn. This is especially true in cases where labor responsiveness is a critical determinant in immigration, research or rural development policies.

Table 1- Studies Reviewed

Study	Useable Estimates
Bauer, L. [1969]	1
Binswanger, H.P. [1974]	1
Binswanger, H.P. [1974]	6
Capalbo and Denny [1986]	2
Duffield, J. [1990]	2
Duffield, J.; Coltrane, R. [1992]	2
Griliches, Z. [1959]	2
Gunter, Jarrett and Duffield [1992]	1
Gunter and Vasavada [1988]	6
Hammonds, T.; Yadav, R.; Vathana, C. [1973]	10
Heady, E.O. and L.G. Tweeten [1963]	4
Hertel, T. [1989]	1
Hoch, I. [1955]	2
Kuroda [1987]	1
Lambert, D.K. and J.S. Shonkwiler [1995]	6
Lianos, T.P. [1972]	2
Lopez, R.E. [1984]	2
Lopez, R.E. [1980]	3
Martinos, N.S.A. [1973]	1
Melton, B.E. and W.E. Huffman [1995]	2
Mundiak, Y. [1962]	3
Schuh, G.E. [1962]	10
Schuh, G.E. and J.R. Leeds [1963]	4
Shumway, C. R. [1983]	2
Thornton, J. [1994]	2
Tyrchniewicz, E.W. and G.E. Schuh [1969]	2
Vasavada, U.; Chambers, R. [1986]	2
Wallace, T., and D. Hoover [1966]	1
Wang, G.H.K. and E.O. Heady [1980]	1

Table 2 - Estimated Labor Demand Wage Elasticites Categorized by Model Characteristic

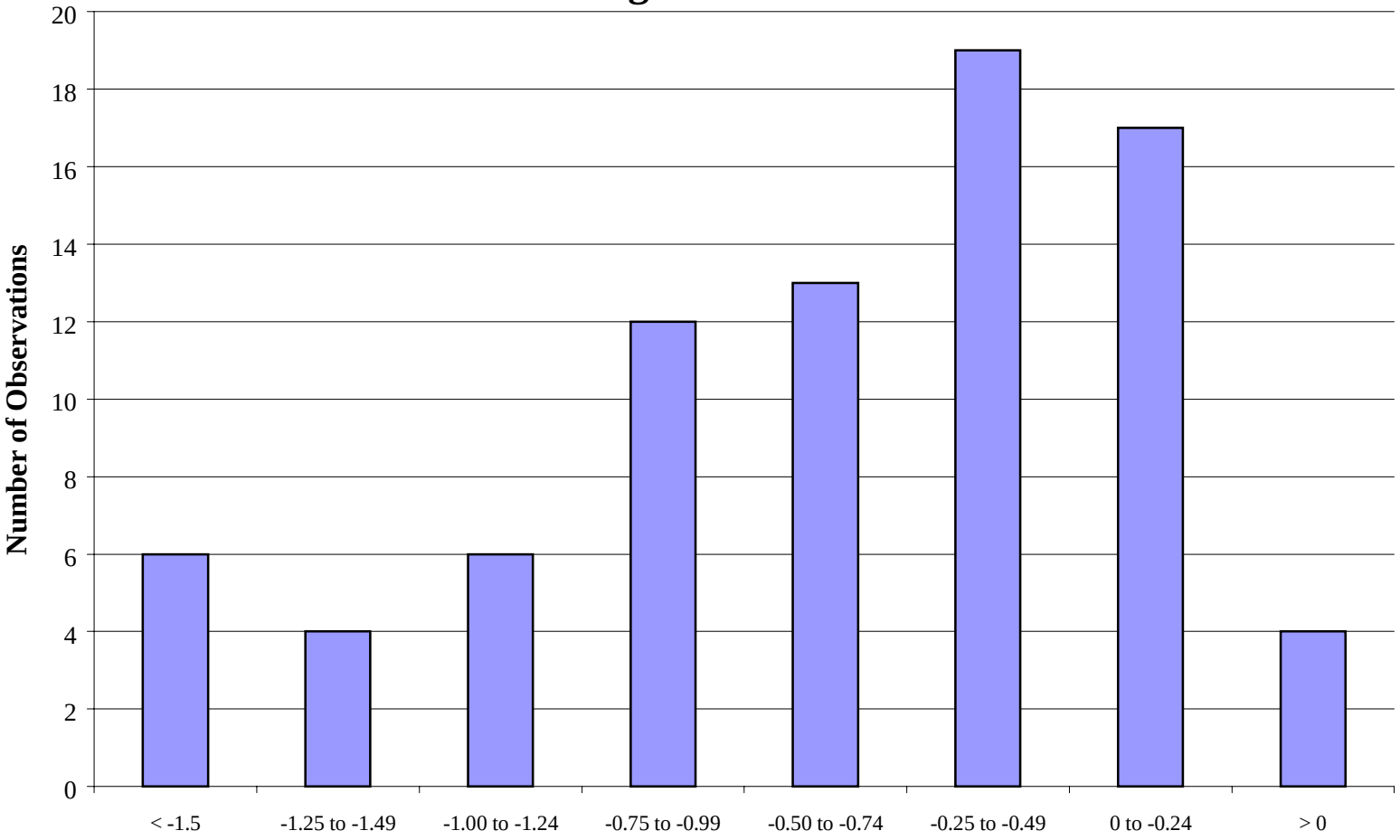
Variable	Number of Observations	Average Elasticity (untruncated)	Number of Observations	Average Elasticity (truncated)
Data:				
Short Run	62	-0.60	59	-0.64
Long Run	22	-1.11	21	-1.18
Pre-WW2	19	-0.41	19	-0.41
1941-1955	42	-0.66	42	-0.66
Post-1955	54	-0.82	50	-0.90
Time Series	65	-0.75	61	-0.81
Cross Sectional	6	-0.99	6	-0.99
CSTS	12	-0.59	12	-0.59
Sector	5	-0.87	5	-0.87
Aggregate	79	-0.73	75	-0.77
West	10	-1.63	10	-1.63
Midwest	2	-0.15	2	-0.15
East	2	-0.56	2	-0.56
United States	59	-0.67	55	-0.73
International	10	-0.42	10	-0.42
Hired Labor	78	-0.79	77	-0.80
Family Labor	10	-0.29	9	-0.33
Model:				
Dynamic	46	-0.85	43	-0.92
Static	37	-0.62	36	-0.64
Single equation	43	-0.57	40	-0.62
System of equations	41	-0.91	40	-0.94
Translog	19	-0.64	18	-0.68
Cobb Douglas	14	-0.76	14	-0.76
Utility Maximization	5	-0.56	4	-0.70
Equilibrium	1	-0.02	1	-0.02
Bias Corrected	10	-0.50	10	-0.50
Compensated	6	-0.77	6	-0.77
Econometric Estimation:				
OLS	38	-0.54	36	-0.58
MLE	2	-0.25	1	-0.51
GLS	10	-0.80	10	-0.80
SLS	33	-1.00	32	-1.03
Total	84	-0.74	80	-0.78

Table 3 – Estimation Results

	Linear		Semi-Log		Gamma	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Data:						
Long Run	0.52**	(2.69)	0.92**	(5.44)	0.85**	(5.38)
Pre-World War 2	-0.52**	(-3.44)	-0.47**	(-2.13)	-0.64**	(-3.26)
1945-1955	-0.05	(-0.31)	0.16	(1.04)	0.08	(0.51)
Post-1955	0.32**	(2.23)	0.45**	(3.01)	0.42**	(3.12)
Cross Sectional	0.68**	(1.76)	1.01**	(2.51)	0.87**	(2.49)
CS-Time Series	-0.23	(-0.87)	-0.96**	(-3.48)	-1.02**	(-3.97)
Sector Study	-1.37**	(-3.16)	-1.40**	(-3.20)	-1.29**	(-2.93)
Western U.S.	1.01**	(3.03)	0.91**	(3.69)	0.80**	(3.57)
International	-0.60**	(-3.72)	-0.91**	(-3.43)	-0.83**	(-3.37)
Hired Labor	0.57	(1.28)	1.03**	(2.11)	1.35**	(2.54)
Family Labor	-0.67**	(-2.04)	-1.48**	(-3.70)	-1.29**	(-3.00)
Model:						
Static	-0.48**	(-1.85)	-0.06	(-0.21)	-0.11	(-0.57)
System of Equations	-0.44*	(-1.58)	-0.90**	(-2.32)	-0.58**	(-2.09)
Translog	0.76**	(1.83)	1.61**	(3.27)	1.25**	(2.64)
Cobb-Douglas	0.71*	(1.60)	1.06**	(2.38)	0.87**	(2.35)
Utility Maximization	0.19	(0.52)	0.70**	(1.76)	0.60*	(1.48)
Bias Corrected	-0.15*	(-1.59)	-0.22*	(-1.40)	-0.23**	(-1.66)
Compensated Demand	-0.29	(-0.97)	-0.77**	(-1.91)	-0.74*	(-1.54)
Econometric Estimation:						
Generalized Least Squares	0.66**	(2.49)	1.34**	(3.71)	1.21**	(3.20)
2 or 3-Stage Least Squares	0.75**	(2.94)	1.24**	(3.41)	0.91**	(3.39)
Other:						
Constant	-0.06	(-0.15)	-2.52**	(-5.51)	-2.45**	(-5.10)
Shape Parameter					4.18**	(5.18)
Log Likelihood	-57.74		-7.98		-5.84	
Adjusted R^2	0.47		0.63			

* Significant at the 10% level
** Significant at the 5% level

Figure 1
Distribution of Wage Elasticities of Demand



Bibliography

Bauer, L. "The Effect of Technology on the Farm Labor Market," *American Journal of Agricultural Economics.* 51(1969): 605-18.

Binswanger, H.P., "The measurement of technical change biases with many factors of production," *American Economic Review* 64(1974a): 964-76.

_____ "A Cost Function Approach to the Measurement of Elasticities of Factor Demand and Elasticities of Substitution," *American Journal of Agricultural Economics* 56(1974b) 377-386.

Capalbo, S.M. and M.G.S. Denny, "Testing Long-Run Productivity Models for the Canadian and U.S. Agricultural Sectors," *American Journal of Agricultural Economics* 68(1986): 615-625.

Duffield, J.A. "Estimating Farm Labor Elasticities to Analyze the Effects of Immigration Reform," Economic Research Service, USDA, Staff Report No. AGES 9013.

Duffield, J.A. and R. Coltrane. "Testing for Disequilibrium in the Hired Farm Labor Market," *American Journal of Agricultural Economics* 74(1992): 412-420.

Gourieoux, C., A. Montfort, and A. Trognon (1984). "Pseudo-Maximum Likelihood Methods: Theory", *Econometrica*, 52(3).

Griliches, Z. "The Demand for Inputs in Agriculture and a Derived Supply Elasticity," *Journal of Farm Economics* 41(1959): 309-322.

Gunter, L.F., J.C. Jarrett and J.A. Duffield, "Effect of U.S. Immigration Reform on Labor-Intensive Agricultural Commodities," *American Journal of Agricultural Economics* 74(1992): 897-906.

Gunter, L and U. Vasavada. "Dynamic Labor Demand Schedules for U.S. Agriculture" *Applied Economics* 20(1988): 803-813.

Heady, E.O. and L.G. Tweeten, Resource Demand and Structure of the Agricultural Industry, Ames, Iowa State University Press, 1963.

Hammonds, Yadav, & Vathaana. "The Elasticity of Demand for Hired Farm Labor." *American Journal Agricultural Economics* 55(1973): 242-245

Hoch, I. "Estimation of Production Function Parameters and Testing for Efficiency," *Econometrica* 23(1955): 326.

Kuroda, Y. "The Production Structure and Demand for Labor in Postwar Japanese Agriculture," *American Journal of Agricultural Economics* 69(1987): 328-337

Lambert, D.K. and J.S. Shonkwiler, "Factor Bias Under Stochastic Technical Change," *American Journal of Agricultural Economics* 77(1995): 578-90.

Lau, L.J. and P.A. Yotopoulos, "Profit, Supply and Factor Demand Functions," *American Journal of Agricultural Economics* 54(1972): 11-18

Lianos, T.P., "Impact of Minimum Wages Upon the Level and Composition of Agricultural Employment." *American Journal of Agricultural Economics.* 54(1972): 477-83.

Lopez, R.E., "Estimating Labor Supply and Production Decisions of Self-Employed Farm Producers," *European Economic Review* 24(1984): 61-82.

_____ "The Structure of Production and the Derived Demand for Inputs in Canadian Agriculture, *American Journal of Agricultural Economics* 62(1980): 38-45

Martinos, N.S.A. "Econometric Models of the Labor Market in the Farm Sector of the North Central Region of the United States: The Demand for Farm Labor in the United States." Unpublished Ph.D. Dissertation. Iowa State University, 1973.

Melton, B.E. and W.E. Huffman, "NAFTA and U.S.-Mexican Beef Trade: Long-run Implications for Changes in Trade Flows from Technology Transfers," Iowa State University Working Paper, 1995.

Mundlak, Y. "Empirical Production Function Free of Management Bias," *Journal of Farm Economics* 43(1961): 44-56.

Schuh, G. "An econometric investigation of the hired farm labor market," *Journal of Farm Economics*. 44(1962): 307-321.

Schuh, G.E. and J.R. Leeds, "A Regional Analysis of the Demand for Hired Agricultural Labor," Papers and Proceedings of the Regional Science Association, ed. M.D. Thomas, Vol. 11, Philadelphia, 1963, pp. 295-308.

Shumway, C.R. "Supply, Demand and Technology in a Multiproduct Industry: Texas Field Crops," *American Journal of Agricultural Economics* 65 (November 1983): 748-760.

Thornton, J. "Estimating the Choice Behavior of Self-Employed Business Proprietors: An Application to Dairy Farmers," *Southern Economic Journal* 60(January 1994): 579-95

Tyrchniewicz, E.W. and G.E. Schuh, "Econometric Analysis of the Agricultural Labor Market," *American Journal of Agricultural Economics* 51(November 1969) 770-87.

Vasavada, U. and R.G. Chambers, "Investment in United States Agriculture," *American Journal of Agricultural Economics* 68(1986): 950-60.

Wallace, T., and D. Hoover, "Income Effects of Innovation: The Case of Labor in Agriculture," *Journal of Farm Economics* 48(1966): 325-36.

Wang, G.H.K. and E.O. Heady, Econometric Analysis of U.S. Farm Labor Markets, CARD Report 91, Center for Agricultural and Rural Development, Ames: Iowa State University Press, May 1980.