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Farm Labor Demand: A Meta-Regression Analysis of Wage Elasticities

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Previous research on farm labor demand is reviewed to empirically explore what has been learned over the past 50 years. Following the example of Hamermesh, studies were differentiated by numerous factors. A meta-regression analysis of estimated demand wage elasticities was conducted to more clearly identify any systematic factors that influence such estimates. Results of the analysis show that the magnitudes of own-price demand elasticities are affected by differences including type and area of labor market, methodology, and the time period covered by the data. Understanding variations due to model specification is important when interpreting current and future agricultural labor and policy research.

Key words: farm labor demand, meta-regression analysis, wage elasticities

Introduction

The focus of farm labor studies has changed greatly over time. The farm labor market in industrialized countries 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. As Hamermesh argues in *Labor Demand*, the focus and method of factor demand analysis have likely affected the elasticity estimates reported in labor research.

As in many fields, findings from the diverse set of labor studies may vary greatly (see figure 1). Determining the common results and important differences among studies and methodologies presents a challenge to researchers and policy makers who may use these findings in further research or decision making. Meta-regression analysis (MRA) has been used to estimate how various cross-study factors affect elasticities from economic studies without imposing subjective bias for any one approach (see, e.g., Assmus, Farley, and Lehmann; Tellis; Espey, Espey, and Shaw; and Espey).

MRA has also been used to examine a variety of other issues, including the gap between union and nonunion wages (Jarrell and Stanley), the relationship between

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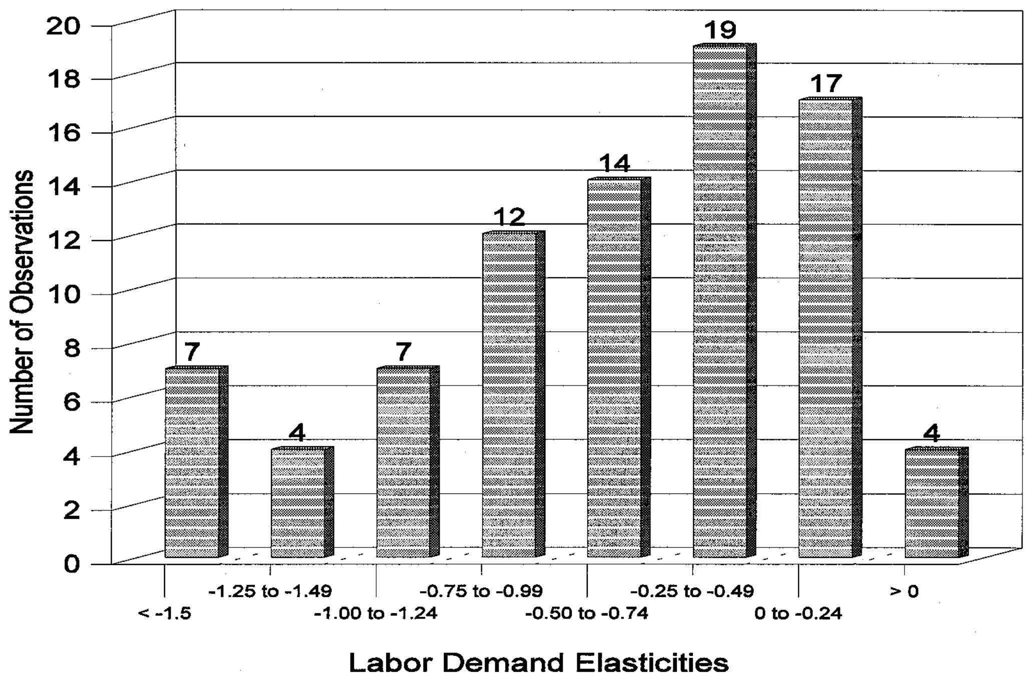

Figure 1. Distribution of wage elasticities of labor demand

taxes and economic growth (Phillips and Goss), and the relationship between education and farmer efficiency (Phillips). In this investigation, we review previous studies of wage responsiveness for farm labor demand and implement meta-regression analysis to determine the likely effects that estimation procedures and modeling have on elasticities.

Like the general labor economics literature, studies of farm labor demand tend to be either independent estimates of the workforce needed in markets dominated by seasonal agriculture, or part of aggregate production systems that allow for input substitution among more highly mechanized operations. Labor is included in many analyses 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. Although several studies examined in the current research did not have labor as a primary focus, the wage elasticities from those studies were included for comparative purposes.

This article begins with a review of general labor and farm labor market research, and focuses on the evolution and diversity of labor studies. The diversity of these earlier investigations allows us to conduct an econometric analysis in which we can assess how a number of diverse factors affect the elasticities reported by various researchers. The methodology used to analyze the various farm labor demand estimates is meta-regression analysis, an approach that uses inter-study differences to explain the variation in estimated wage elasticities across studies. Factors which may vary across studies include: short- versus long-run response; geographic region (international, national, and regional); family versus hired labor; functional form (production versus ad hoc); complexity of model (systems versus single equations); controlling for technological change and income (compensated versus uncompensated); and the time period of data used in the analysis.

Labor Market Research

As noted by Schuh in his 1962 seminal work, the number of persons engaged in farming in the United States has changed markedly throughout history, peaking in 1916 at 13.6 million, and declining to 7.1 million in 1960. Since that time, the farm workforce has stabilized at around 4 million. Originally, 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 supply and demand, labor market modeling has included more complete systems of employer and worker choices. More recent estimates of labor demand and supply were determined from complete household or firm production systems.

There is historical interest in research on labor-saving technology and its effects on labor demand for several reasons. In the United States, decreasing demand for farm labor was intended to fuel urban industrialization efforts in the early part of the century. The direction of causality associated with increased demand for labor-saving technology, farm size growth, and the decline in farm family size is not as clear. In the second half of the century, interest in the effects of various immigration and guest-worker policies on farmworker markets shifted the focus of labor studies to sector- or region-specific markets, as well as the difference in hired and family labor response.

There is continued interest in the off-farm labor supply choices of farm operators and their families, but now this focus is more closely related to human capital issues and rural development goals. There has been continued political support and policy for maintaining incomes of farm families, but there is also renewed concern for farmworkers who have settled in rural areas. Moreover, off-farm labor participation rates of operators and their families will likely affect and be affected by employment opportunities and prevailing wages in the hired labor market. In short, farm labor demand analysis may be necessary to ascertain and distinguish between the likely effects of labor market policies or shocks on both populations.

The number of farms and operators has greatly declined over the last century. However, seasonal labor demand remains stable and relatively high given the number of year-round workers in agriculture. Seasonal workers (defined as those who work less than 150 days a year in agriculture) made up over 10% of the farm workforce in 1990, with far greater concentrations in states with labor-intensive agriculture. An issue of continuing concern is whether farms are able to secure sufficient seasonal workers during peak labor demand periods—particularly since labor-saving technology has made fewer inroads in the expanding fruit-vegetable-horticulture (FVH) sector, and because current seasonal labor markets are so closely tied to immigration policies and reforms (Taylor and Thilmany).

Labor is a complex input to investigate for several reasons. In addition to being an important factor of production (16% of costs, down from 45% in the 1940s), labor is also part of the household consumption choice set. As farm household incomes rise, the choice to release family members from farm work may be made more frequently, thereby increasing the demand for hired labor. In short, farm labor demand is a function of both prevailing wage rates and household income levels. The explanatory variables in the MRA demonstrate the increasing complexity of labor models.

An overview of general labor demand studies by Hamermesh attempted to develop some broad statements on the status of the field. He argued that "No single empirical study can provide definitive measures of a particular parameter.... [Thus,] the multiplicity of estimates imposes the burden of evaluating the design of each empirical study" (p. 21). Hamermesh's contribution to the literature was quite substantial in that a thorough overview and classification of numerous labor demand studies was completed. Although comparisons and contrasts were based on qualitative or casual observation, many factors (including the type of data, modeling, and objective/focus of the study) were considered. In this analysis, we follow a labor demand classification scheme similar to that outlined by Hamermesh, but control for such differences using an econometric estimation approach.

Data

Eighty-four price elasticities from 29 studies (table 1) are included in this analysis.[1] Demand 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 were all based on hired, family, or aggregate farm labor estimates. Although some of the cross-sectional studies relied on farm survey responses, the majority used aggregate U.S. Department of Agriculture (USDA) worker and wage estimates. The publication dates of the studies ranged from 1962 to 1995, while the corresponding data periods ranged from 1912 to the late 1980s.

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. Two studies from other developed countries (Canada, Israel, and Japan) were included for several reasons. First, including studies from other countries increases the variability among the estimates, which is especially important given that a large share of the U.S. studies are authored by only a handful of researchers. Also, given that differential research agendas and immigration policies may influence how U.S. labor markets respond relative to other countries, the inclusion of international estimates is necessary to capture these effects.

The labor demand price elasticity estimates ranged from 0.22 to –4.42 (see figure 1 for the distribution). While the mean elasticity was –0.74, the median elasticity was –0.54, and over 85% of the estimates fell within the 0 to –1.5 range (table 2). Hamermesh reported similar ranges for approximately 200 studies from the general labor literature that were included in his analysis. Among those studies, the mean elasticity was –0.39 for studies from aggregate data sets and –0.45 for those based on micro-level data. He observed that the majority of studies fell within a reasonable confidence interval of –0.15 to –0.75.

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[1] All labor demand studies that reported elasticities were included in this investigation. More general production studies were included only in cases where sufficient information was available to estimate labor elasticities.

Table 1. Studies Reviewed and Number of Usable Estimates

	Study	Publication Year	Usable Estimates
1	Bauer	1969	1
2	Binswanger	1974a	6
3	Binswanger	1974b	1
4	Capalbo and Denny	1986	2
5	Duffield	1990	2
6	Duffield and Coltrane	1992	2
7	Griliches	1959	2
8	Gunter, Jarrett, and Duffield	1992	1
9	Gunter and Vasavada	1988	6
10	Hammonds, Yadav, and Vathana	1973	10
11	Heady and Tweeten	1963	4
12	Hertel	1989	1
13	Hoch	1955	2
14	Kuroda	1987	1
15	Lambert and Shonkwiler	1995	6
16	Lianos	1972	2
17	Lopez	1984	2
18	Lopez	1980	3
19	Martinos	1973	1
20	Melton and Huffman	1995	2
21	Mundlak	1961	3
22	Schuh	1962	10
23	Schuh and Leeds	1963	4
24	Shumway	1983	2
25	Thornton	1994	2
26	Tyrchniewicz and Schuh	1969	2
27	Vasavada and Chambers	1986	2
28	Wallace and Hoover	1966	1
29	Wang and Heady	1980	1

The positive elasticity estimates in our study would seem problematic from a theoretical perspective, but only two positive estimates were statistically significant, and they represent short-run estimates in a relatively tight, highly seasonal hired labor market. Since higher wages may signal record yields or extremely short harvest periods in a particular labor market, small and positive short-run labor demand elasticities may be plausible (there were several reported in Hamermesh as well). However, for the MRA models presented here, the data were truncated at zero, so the four positive elasticity estimates were omitted from the econometric analysis.[2]

[2] This did not significantly influence the results. Results from the untruncated linear OLS model are available from the authors upon request.

Table 2. Estimated Labor Demand Wage Elasticities Categorized by Model Characteristic (based on 29 studies reviewed)

Variable	Number of Observations	Average Elasticity (untruncated)
Data:		
Short Run	62	-0.60
Long Run	22	-1.11
Pre-World War II	19	-0.41
1941–1955	42	-0.66
Post-1955	54	-0.82
Time Series	65	-0.75
Cross-Sectional	6	-0.99
Cross-Sectional/Time Series	12	-0.59
Sector	5	-0.87
Aggregate	79	-0.73
West	10	-1.63
Midwest	2	-0.15
East	2	-0.56
United States	59	-0.67
International	10	-0.42
Hired Labor	78	-0.79
Family Labor	10	-0.29
Model:		
Dynamic	46	-0.85
Static	37	-0.62
Single Equation	43	-0.57
System of Equations	41	-0.91
Translog	19	-0.64
Cobb-Douglas	14	-0.76
Utility Maximization	5	-0.56
Equilibrium	1	-0.02
Bias Corrected	10	-0.50
Compensated Demand	6	-0.77
Econometric Estimation:		
Ordinary Least Squares (OLS)	38	-0.54
Maximum-Likelihood Estimation (MLE)	2	-0.25
Generalized Least Squares (GLS)	10	-0.80
2- or 3-Stage Least Squares (SLS)	33	-1.00
Total	84	-0.74

The Model

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

In developing the meta-regression analysis, we recognized that there is little uniformity across labor studies due to the great number of factors that influence work choices. It is also likely that some wage elasticities are part of a system of estimates, rather than independent estimates from studies 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. Yet, these factors also increase the potential benefits of assessing how wage elasticities vary across time and methodology.

The meta-regression model can be written as follows:

$$b_j = \beta + \sum_{k=1}^{K} \alpha_k Z_{jk} + \varepsilon_j \quad (j = 1, 2, \ldots, N),$$

where b_j is the reported estimate of the wage demand elasticity in the jth study, β is the intercept term for the MRA and approximates the demand elasticity for the "base" model,[3] the Z_{jk} terms are the study characteristics that explain the variation in the elasticity estimates across studies, the α_k's are the MRA coefficients that reflect the impact of the various study characteristics, and ε_j is the MRA disturbance term (Stanley and Jarrell).

The Z_{jk} model characteristics in this study 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. In this study, each Z_{jk} is a binary variable, indicating whether or not the particular characteristic was present in the study. Although these categories loosely follow Hamermesh's classification of labor studies, our analysis focuses more specifically on theoretical modeling (i.e., technical bias) and econometric issues.

The nature of the data varies greatly across studies. Features included in this study are indicators of: the type of labor (hired or family), detail on operations (general or commodity-specific), geographic location, years of analysis, type of data (time series versus cross-sectional or cross-sectional/time series), and whether short-run or long-run elasticity was estimated. Three time periods were considered (pre-World War II, post-1955, and an interim period from 1945–55) to determine if wage elasticities have changed over time. These time periods are not mutually exclusive. That is, if a labor demand study used data covering the period from 1947–90, both the interim time variable (defined above) and the post-1955 time variable would take on a value of one.

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[3] The base model is defined in the "Findings and Discussion" section.

The model specification variables include indicators of static versus dynamic specifications, simultaneous equations estimation, various production or household systems models, bias correction, and compensated demand models. The earliest innovations in labor models focused on dynamic rather than static models. Although these variables are somewhat interdependent with the short-run/long-run (SR/LR) variables (only dynamic models could allow a differentiation between SR and LR responses), both sets of variables are included in the model. Testing dynamic estimates against static estimates will distinguish whether elasticity estimates are affected by including lagged variables, whereas the SR versus LR result will indicate how specific elasticities vary when producers have time to adapt. In short, the former tests how model specification may affect wage responses, while the latter will quantify how estimates will differ with adjustment time.

An important distinction that will be taken into account among studies 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, Cobb-Douglas, or utility-maximization models. The utility-maximization models are somewhat ad hoc but, in general, attempt to maximize profits while minimizing costs, with special attention given to how family labor input choices vary with income and farm labor wage levels.

Econometric estimation differences simply relate to whether the elasticities are the result of least squares, least squares in stages, maximum-likelihood, or equilibrium estimations. There were only two studies in our analysis that used maximum-likelihood estimation, and only one that used an equilibrium model, so these two variables were not included in the final estimation.

Where several elasticity estimates are derived from the same data set, inferences from the meta-regression analysis model may be compromised due to a lack of independence among observations. The potential impact of such intra-study correlation was estimated by calculating the correlation among the error terms for each of the studies with more than four elasticity estimates. These correlations ranged from −0.12 to 0.06 for the five studies with more than four elasticity estimates, suggesting that dependence across elasticity estimates is not a major concern.[4] Another way to test for effects caused by a disproportionate number of estimates from one study or researcher is to include a dummy variable for each study of potential concern. In our analysis, two such dummy variables are included—one for the study by Hammonds, Yadav, and Vathana from which 10 labor demand elasticities were derived, and one for all elasticity estimates derived from studies that were authored or co-authored by Schuh, totaling 16 estimates.

Estimation

The meta-regression analysis model is estimated 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

[4] Some have suggested weighting observations by "reliability"—for example, by the standard error of the original elasticity estimate (Saxonhouse). However, because these standard errors are not generally reported (or otherwise available), this is not attempted here.

had the particular data, model, or estimation characteristic. Since the semi-log model requires a positive dependent variable, the wage elasticities were multiplied by −1 before estimation. Hence, a positive coefficient indicates a more elastic demand, and a negative coefficient indicates a less elastic demand. For ease of comparison, this transformation was also performed for the linear and gamma models.

The distribution of the wage elasticities of labor demand (as shown in figure 1) is skewed, 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, and only two of these were statistically significant. Based on the linear ordinary least squares MRA 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.[5] Gourieroux, Montfort, and Trognon 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. In all of the MRA models, White's heteroskedasticity-consistent standard errors are used.

Findings and Discussion

In the MRA, one variable from each set of mutually exclusive explanatory 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 model. The base model's data represent an aggregate of United States hired labor time series prior to 1941, estimated by ordinary least squares.

Table 3 presents the results of the meta-regression analysis of labor demand elasticities. Since the relative effect varies depending on the econometric method used in the MRA, and since the gamma model has a higher log likelihood than either the linear or the semi-log models, the estimation results from the gamma model will be used for discussion purposes.

The results do offer a generalized sensitivity analysis for labor demand specification. It appears that several features of data, modeling, and estimation have a significant effect on the elasticity estimates from labor demand studies. Although these numbers give some general magnitudes and directions, it is important to exercise caution in concluding too much from the magnitude of independent impacts.

The one group of variables that may offer valuable information—given the significance, sign, *and* magnitude of findings—consists of those related to the period of time, commodity-specific, region, and type of farm labor data. Labor elasticity estimates have varied over time, even when controlling for the increasing sophistication of the economic modeling and estimation procedures used in various studies. Our results suggest that the labor market prior to World War II was less elastic than the post-1955 market. Given the labor intensity of farm production and few alternatives for mechanization prior to World War II, this result is not surprising. Over time, advances in technology and production methods have given producers greater flexibility, perhaps resulting in the significantly higher elasticity after 1955 implied by the MRA.

[5] To ensure positivity of the conditional mean, it is parameterized as $\exp(\beta + \Sigma\alpha_K Z_K)$.

Table 3. Estimation Results of Meta-Regression Analysis (dependent variable is negative of reported demand elasticity)

	Linear		Semi-Log		Gamma	
Variable	Coefficient	*t*-Statis.	Coefficient	*t*-Statis.	Coefficient	*t*-Statis.
Data:						
Long Run	0.50**	2.68	0.88**	5.15	0.82**	4.91
1941–1955	-0.21	-1.22	0.004	0.03	-0.03	-0.21
Post-1955	0.35**	2.19	0.46**	3.27	0.45**	3.32
Cross-Sectional	0.70**	1.95	1.26**	3.31	1.08**	2.93
Cross-Sectional/Time Series	-0.30	-1.21	-1.15**	-4.10	-1.28**	-4.23
Sector Study	-1.60**	-3.29	-1.72**	-3.72	-1.86**	-3.83
Western U.S.	1.02**	3.39	0.79**	3.47	0.80**	3.21
International	-0.69**	-3.81	-1.04**	-3.30	-0.93**	-2.93
Family Labor	-0.98**	-4.06	-2.01**	-5.94	-2.09**	-4.82
Model:						
Static	-0.33	-1.22	0.14	0.47	0.11	0.46
System of Equations	-0.50**	-1.72	-1.12**	-2.53	-0.73**	-1.88
Translog	0.87**	2.42	2.13**	3.99	1.90**	3.52
Cobb-Douglas	0.70*	1.60	1.27**	2.51	1.13**	2.47
Utility Maximization	-0.09	-0.20	0.24	0.54	0.13	0.23
Bias Corrected	-0.09	-0.93	-0.12	-0.77	-0.13	-0.96
Compensated Demand	-0.19	-0.61	-0.68**	-1.70	-0.62*	-1.33
Econometric Estimation:						
Generalized Least Squares	0.60**	2.28	1.22**	3.29	0.97**	2.41
2- or 3-Stage Least Squares	0.86**	3.44	1.33**	4.90	1.09**	4.58
Other:						
Schuh (as author/co-author)	-0.45**	-2.85	-0.17	-0.70	-0.41**	-1.70
Hammonds, Yadav & Vathana	0.004	0.01	0.44	1.09	0.16	0.37
Constant	0.48**	2.88	-1.61**	-6.05	-1.29**	-4.92
Shape Parameter					3.82**	5.87
Log Likelihood	-57.87		-9.91		-9.72	
Adjusted R^2	0.46		0.61			

Note: Single and double asterisks (*) denote significance at the 10% and 5% levels, respectively.

The demand for family labor is estimated to be significantly less elastic than the demand for hired labor. There are several potential reasons why there is a significant difference between elasticities for these two groups of workers. It may be that there is little substitutability among the types of farm work they perform. Hamermesh concluded that long-run demand elasticities are lower as the skill of a particular workforce increases. We can infer that family labor is a more skilled component of the farm production process, and thus is not as substitutable; in contrast, hired labor may be more easily replaced by mechanization if prevailing wages increase. Another potential explanation is that family labor is somewhat "fixed" in the farm sector and will not exit without significant changes in wage levels. Finally, family labor may be less affected by any scale or income effect of a wage change (which augments the substitution effect).

Rather than scale back on labor in periods of high wages, a farm may choose to provide more family labor, and vice versa. This theory is supported by high, positive cross-price elasticities between hired and family labor reported in several of the MRA studies.

Consistent with theoretical expectations, the long-run response of employers to wage changes is significantly more elastic than the short-run response. Other than the actual differences between short- and long-run responses, there do not appear to be any significant differences between estimates from dynamic and static models.

The nature of the data set analyzed by various studies is expected to affect elasticity estimates for both theoretical and econometric reasons. In the MRA, cross-sectional studies produced more elastic estimates of the demand for labor than did time-series studies. The highly aggregated nature of the data used for most U.S.-based time-series studies (i.e., USDA farm labor estimates) may dampen wage response since there is no accounting for inter-employer migration and adjustment. Individual employer effects (such as adopted technology and labor management skills) may account for higher reported wage elasticities in cross-section models. Pooled data analysis controls for farm-specific effects (cross-section) and captures each employer's wage adjustment (time series), solving both aggregation and employer-specific bias in estimates. Pooled cross-section/time-series studies reported significantly less elastic estimates than the base, time-series model. Less elastic estimates are plausible since the time series of the pooled studies is never more than 10 years and the farm employer is somewhat fixed in terms of enterprise mix, technology, and production practices.

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 implies that workers are not extremely substitutable across certain crops and commodities, or that there are higher skill levels for particular farm sectors. Moreover, it may indicate that workers move more easily between farm and nonfarm activities than across specific farm activities. This may seem a bit counterintuitive, but is not unrealistic. There are arguably fewer similarities between dairy and field crop skills than between dairy and food processing skills.

Farm labor markets in the western U.S. appear to have a more elastic demand than the U.S. in general. Since western labor markets have a higher proportion of seasonal and unskilled workers, this result is not surprising. Also, it should be noted that farm labor markets in other countries (Canada, Israel, and Japan) appear to have less elastic labor demand than those in the United States—a finding consistent with Hamermesh's observations. This result should be interpreted cautiously given the scarce number of international studies and the diverse nature of these three countries. It does indicate, however, that U.S. policies on immigration or supporting labor-saving research may affect the wage responsiveness of farm employers relative to other countries.

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 (GLS) reported significantly more elastic labor demand estimates than those using ordinary least squares (OLS). SLS is a technique used to obtain consistent estimates when there is correlation between one of the explanatory variables and the error term. Simultaneity bias caused by correlation between price and the error term may tend to 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 MRA (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. Although the coefficient is insignificant, these compensated demand models report less elastic demand estimates (an expected result since only substitution effects are measured).

Those studies that included labor within Cobb-Douglas or translog systems reported significantly higher wage elasticities. Hamermesh concluded that the Cobb-Douglas model appeared to be a good approximation for *non*agricultural labor response, with an elasticity of substitution between capital and labor of one. However, he noted that general labor demand elasticities did not seem to differ significantly based on this, or any other, functional form. Thus, the specification of the labor demand model may be relatively more important in the farm sector.

To better understand the effects of specified production systems on farm labor elasticities, one should be aware of the basic tenets of the literature in agricultural production research. 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 higher elasticities from the Cobb-Douglas and translog models). However, this does not account for any possible bias in research and technical change in the agricultural industry. Several studies of agricultural research cited here (e.g., Capalbo and Denny; Lambert and Shonkwiler) have found a bias toward labor-saving technology, implying that elasticity estimates are biased upward. Although studies that corrected for technological bias (all of which were full production systems) were not significantly different from other production systems, the coefficient on bias-corrected estimates is negative.

The labor demand estimates from studies that focused on research and production issues demonstrate how labor elasticity estimates across time may 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. This illustrates how findings from the meta-regression analysis connect labor market research to more general production and policy issues.

Finally, the dummy variable for Hammonds, Yadav, and Vathana was not statistically significant, while the dummy for Schuh (as author or co-author) was significant and negative. The author-specific effect is likely due to the relative simplicity of Schuh's modeling. Given highly aggregated data, and no explanatory variables except for a constant and prices, the estimates and/or standard errors from Schuh's studies may be biased. Inclusion of these dummy variables, however, did not significantly affect the estimates of other coefficients.

Conclusions

Although farm labor research still draws from a few seminal works, methods and models have evolved greatly over time. Structural changes in the U.S. labor market and the markedly lower production cost share that labor now represents in agriculture raise great interest in intertemporal analysis of farm labor demand. Yet, it is difficult to ascertain the degree to which labor demand elasticity estimates have actually changed relative to estimates that simply vary due to the method of analysis used. Determining the change in labor demand estimates across time was the initial objective of this study, but the empirical method developed to capture historical changes necessarily encompassed a large set of cross-study differences.

Meta-regression analysis provides a quantitative method to determine the direction and degree that labor market conditions, modeling, and estimation innovations have affected estimates. This study has gone beyond the casual categorization of labor demand estimates by Hamermesh, and formally modeled the likely effects of different data and methods on empirical results. In addition to noting differences in results across time and approach, some general "rules of thumb" can be inferred about the magnitude of elasticities and systematic factors that influence such estimates. Thus, cross-study comparisons can be facilitated.

The results of this study illustrate why the elasticities chosen to model labor's effect in the broader economy, or to determine policy impacts, should be chosen carefully. The focus of labor demand studies is likely either to be with respect to a specific labor market (e.g., western fruit harvesters), a particular policy analysis (i.e., minimum wage laws, H2-A justification, or impacts from immigration policies), or as a part of full production systems. This research identifies some clear implications for studies with different objectives and methods, but such findings are not problematic if the magnitudes of elasticities are discussed in the context of how they were obtained.

The implications of this study are clear for those searching for the "right" estimate to include in an equilibrium model or quick calculation of expected policy impacts. It is rare that any one study will specifically address the sector, region, or period of the labor market of interest to a specific case. However, the meta-regression analysis results offer some guidelines on how to adjust estimates from the study most closely aligned to the labor market of interest.

For example, Duffield (1990) reported a short-run elasticity of demand of –1.44, representing the most recent estimate for the general hired labor market. But one might be uncomfortable with Duffield's assumption that the labor demand is determined independently of other production costs. The MRA results make it possible for a researcher to estimate an elasticity, or range of elasticities, that takes a translog production system, corrected for technical bias, into account. Given these conditions, Duffield's estimate could be adjusted to be less elastic.

In general, future researchers will be able to infer whether the relative size of specific labor elasticity estimates is due to labor market structural changes, or perhaps instead is a result of the way in which the farm labor market is modeled. The magnitude (relative elasticity) can also be altered based on a decision maker's interest or modeling preferences before the elasticity is applied to a specific case. There is one clear implication from this MRA: 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 labor market, immigration, research, or rural development policies.

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