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Three essays on the labor allocation decisions of the modern farm family

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FAMILY

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ABSTRACT

The goal of this dissertation is to address the role of government payments in the allocation of farm labor through three essays.

Government payments have been a part of agriculture since 1933 and at no time has the government stated a policy objective of decreasing the agricultural labor force. Using time series data and new econometric techniques, the first essay finds agricultural policy may have an unintended impact on labor migration. Specifically, we find that government payments increased labor migration from the farm. From 1939 to 2007, increased direct government payments resulted in greater migration of labor from agriculture.

The second essay assesses the degree of differentiation between family and hired labor. This addresses the ease at which decoupled government payments can subsidize off-farm labor. Intuitively, these forms of farm labor should have different impacts on production. We test this assumption by estimating the elasticity of substitution between hired and family labor using the ARMS dataset. The results provide little evidence to support the homogeneity assumption and further indicate that the elasticity of substitution is unitary under most scenarios.

The final essay addresses the determinants of off-farm labor supply by incorporating both modern issues and techniques. The goal of this research is to determine the impact of health insurance coverage and government payments on the off-farm labor supply of the farm operator and spouse. We first test for dependence in the off-farm labor allocation of the operator and spouse using copulas. We then account for endogeneity in the health insurance variable and jointly estimate off-farm labor supply using a bivariate tobit model. The data used in this research is from 2006-2008 Agricultural Resource Management Survey (ARMS). The results of this study show that the off-farm labor supply of the operator and spouse is positively correlated

and that there is a highly significant, positive impact of off-farm insurance coverage on the hours worked off-farm. The results further demonstrate the importance of fringe benefits as a component of the total wage and find significant evidence that greater government payments decrease the number of hours that both the operator and spouse work off-farm.

CHAPTER 1: INTRODUCTION

This dissertation addresses three key questions the farm family faces regarding the decision to work off-farm. How powerful are the incentives to leave? How powerful are the incentives to stay? How replaceable is my labor on the farm? Specifically discussed hereafter is the success of government payments in retaining the farm labor force, the substitutability of family labor, and the impact of modern incentives, like health insurance, on the number of hours farm families work off-farm.

The second chapter of this dissertation provides an analysis of where we've been. It addresses the government's role in preserving the farm labor force over the last 68 years. Government payments to agriculture have grown considerably over this period of time. Not only have payments grown, the composition of government payment has changed considerably over this time period. The most marked changes in composition occurred in 1996 with the emergence of decoupled government payments. This shift in payment structure occurred in part as a result of pressure from the World Trade Organization. The driving for change was, as the name implies, to decouple agricultural subsidies form commodity prices. This prevents the policy actions of the US government from significantly influencing world commodity prices.

At the moment, the 2012 Farm Bill is being debated. Due to the current fiscal environment, decreased aggregate spending on agricultural subsidies is expected. Particularly, decoupled payments are expected to receive significant decreases in funding. From this perspective, it is vitally important to understand how aggregate changes to farm programs will impact the flow of workers from agriculture. The knowledge provided the by the second chapter, especially regarding the changing in policy composition, will help us form expectations of what is likely to occur if these changes are essentially reversed in the latest Farm Bill. In a more general sense, it

is also important to assess whether the government's effort to preserve the farm labor force have been successful. This is a common theme used by policymakers when proposing these policies; therefore, feedback on the aggregate effectiveness of the policies is needed.

While the second chapter address government's role in farm exits, it's also important to consider the role of dual employment in agriculture. The third chapter analyzes how easily a farm family member can work off-farm and simultaneously hire a worker to fill in on the farm. In the literature, it is often assumed that family member's labor can be substituted perfectly with other sources of labor. The question of interest is how easily can family labor be replaced on the farm if the farm household can benefit from either the operator or spouse devoting time to off-farm work? The fourth chapter analyzes the power of fringe benefits as an incentive for the farm household to allocate labor off-farm. Together, these chapters provide new perspectives on how willing and able are family members to work off-farm.

From a practical perspective, there are multiple reasons for addressing these topics. First, consider the old maxim "Never work for family" which implies some inherent difficulty in family working together in a business environment. If there is merit to this statement and the only alternative form of labor is non-family, then you can reason that these forms of labor are not perfectly equivalent. The goal of the third essay is to provide statistical evidence to measure this relationship between forms of farm labor.

If the assumption of homogenous farm labor is upheld, then there are implications for farm policy research both theoretically and empirically. Theoretically, the validity of models used to represent the farm household previously is upheld. The results of which are essentially a single demand curve representing family and hired farm labor. This implies that hired and family labor receive the same wage for farm labor. Intuitively, it is implausible that a family laborer will

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receive the exact same hourly wage, fringe benefits, and identical working environment as a hired worker. Empirically, the substitutability of farm labor has implications for model specification. If labor is homogenous, there only a single labor input is required in production models. Otherwise, failure to include both forms of labor as separate inputs may result in misspecification.

After addressing the ability of the farm household to engage in dual employment, the fourth essay focuses on the power of the incentives to engage in this behavior. Specifically, the final essay looks at the interaction between one of the predominant social issues facing the nation, health care, and the off-farm labor decisions of farm households. Like small businesses in other sectors, the potential financial burden created by employee sponsored health insurance plans are considerable for farms. Many families with small business have a family member that engages in labor outside of the family business primarily to provide fringe benefits like health insurance.

Coupled with the financial risk inherent to farming, it may be even more difficult for farm businesses to provide these benefits. This implies that farm households may be even more likely to have members allocating hours to off-farm labor for fringe benefits. Full consideration has not been given to this aspect of the off-farm wage and the role it plays in the labor allocation decision of farm households. If this component of the full off-farm wage is significant, then the estimates provided by previous studies of off-farm labor allocation may be biased.

A related issue addressed in the fourth chapter is the jointness of labor decisions in the farm household. Most studies in this area employ a theoretical model that assumes labor decisions are made independently. This means that when an operator or spouse makes a decision as to how they will allocate their time, they make this decision irrespective of their significant other's time allocation decisions. It is implausible that a household will function in this manner in either the

short or long run. A hallmark of a well-functioning household is effective communication between the husband and wife. Assuming labor decisions are made independently thereby assumes a lack of communication between the operator and spouse. Even the household can function with an absence of communication in the short run, how reasonable is it to expect this behavior to persist in the long run. A worst, the absence of communication result in deterioration of the household to the point of divorce and thereby render our entire model inapplicable.

From a practical perspective, the reasoning clearly supports the joint modeling of household labor allocation. The empirical evidence provides mixed support in this regard. The final essay provides a convenient statistical test to empirical determine whether labor allocation decisions are made jointly. Once this relationship is established, we incorporate this information into our decision of how to most appropriate model the off-farm labor supply of the farm operator and spouse. As a result, a bivariate tobit model is used to determine the importance of insurance coverage on hours worked off-farm by the operator and spouse.

Further, prior research has demonstrated a negative relationship between off-farm labor and government payments. These studies neither adequately account for fringe benefits nor provide clear reasoning on the jointness of labor decisions. As a result, we include government payments in the model to determine whether this relationship changes when fully accounting for the components of off-farm wage.

The results of this dissertation allow us to address various shortcomings in the farm household and labor economics literature. A key void that is addressed by the sum of this research is the impact of government payments on farm household labor allocation. Specifically, we can gain some key insights into the empirical question of the impact of government payments on the allocation of farm labor. This information will be of vital importance as budget constraints

persist and the Farm Bill debates continue. An accurate picture of how each aspect of government policy impacts the welfare of farm households is needed by policymakers to correctly determine the gains/losses from alternative proposals.

CHAPTER 2: FEAST OR FLEE: GOVERNMENT PAYMENTS AND LABOR MIGRATION FROM AGRICULTURE[1]

Introduction

The government has provided financial assistance to farmers since the 1930's. The various programs suggested by policymakers are often proposed under the moniker of preserving the farm family. Attempts to uphold this way of life have been in the face of rapid industrial growth, dramatic technological advance, sharp population growth, and a rise in relative wages off-farm. These changes over past decades have impacted all sectors of the economy including agriculture. According to Mishra, El-Osta, and Gillespie (2009), if the purpose of farm policy is to raise farmers' income and standard of living, then policy provisions need to be reconsidered as changes occur in farm households and businesses.

Today, off-farm income is approximately six times greater than cash farm income and comprises nearly 80% of total household income (Mishra et al. 2002; El-Osta, Mishra, and Morehart 2008). Off-farm labor is no longer classified as transitional but rather the primary source of income for farm households. Considering the nature of government payments remained relatively unchanged until the development of decoupled payments in the 1996 Farm Bill, the performance of government programs in achieving their stated goals is unclear.

Considerable research has focused on the effects of government payments on the labor allocation decisions of farm operators and spouses (Ahearn and El-Osta 1992; Ahearn, El-Osta, and Dewbre 2006; El-Osta, Mishra, and Ahearn 2004; Mishra and Goodwin 1997; Goodwin and Mishra 2004). These studies have largely been cross-sectional in nature and often used farm-level data. Results from the above studies indicate that increased government payments,

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[1]This chapter has been reproduced courtesy of *Journal of Policy Modeling*. Authorization from publisher, Elsevier, for reproduction is found in the appendix. Article can be found online at http://dx.doi.org/10.1016/j.jpolmod.2011.10.002.

particularly decoupled payments (direct payments), decreased the number of hours worked off-farm by operators—essentially reinforcing the wealth effect.

Only a few studies have focused on how government payments have affected the migration of labor from a macroeconomic perspective. Barkley (1990) while studying the effect of government payments on labor migration concludes that total government payments have no effect on the migration of labor from agriculture from 1940 to 1985. His results are inconsistent with the findings obtained in the micro-level analysis (farm-level data) of U.S. farm households (Dewbre and Mishra 2007; El-Osta, Mishra, and Ahearn 2004).

The objective of this paper is to re-assess the impact of government payments on agricultural labor force migration now that more data and newer methodology has become available since the work of Barkley (1990). Specifically, the primary research question is presented by the following null and alternative hypotheses:

H_o: Increased direct government payments has had no effect on the

migration of labor from agriculture.

H_a: Increased direct government payments has altered the migration

of labor from agriculture.

Our results provide evidence for rejecting the null and indicate that increased government payments are positively correlated with greater migration of labor from agriculture from 1939 to 2007. A shrinking agricultural labor force is certainly not desirable by policymakers' standards and lends supports the proposition that policy provisions have not been adequately reconsidered as changes have occurred in farm households and businesses. There is evidence to suggest longstanding programs designed for conservation and commodity buyouts may be attributable to migration from agriculture (Snell 2005; Gardner 1999; USDA 2010; Edwards and DeHaven

2001). More recent trends in agricultural programs, like decoupling of payments, may also be

credited with the out-migration of labor (El-Osta, Mishra, and Morehart 2008).

Background and Conceptual Model

Direct government payments in the U.S. began modestly in the early 1930's and

remained relatively stable through the 1960's (Figure 1). With the passage of the 1973 Farm Bill

direct government payments began an upward climb. Today, an average of $18.2 billion is

distributed annually by the federal government to farmers in the form of direct government

payments. These payments comprise nearly 30% of farm net income on average (USDA 2009)

and include fixed direct payments, emergency/disaster payments, commodity programs, counter-

cyclical payments, marketing loan benefits, tobacco transition payments, and conservation
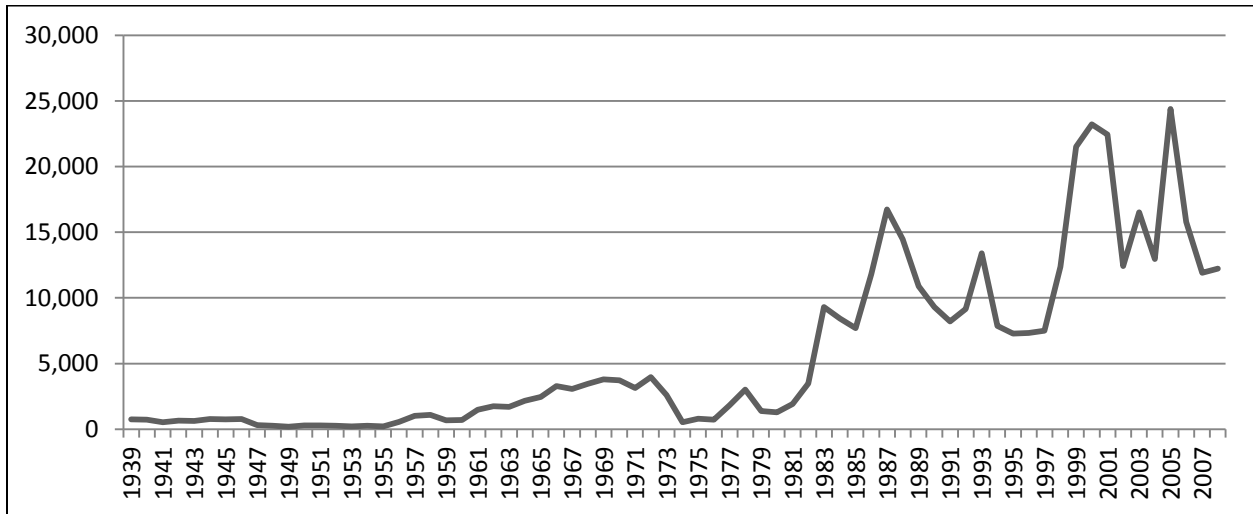
program payments.

Figure 1: Direct Governemnt Payments (1939-2008)

A comprehensive list of programs included in direct government payments is presented in

Table 1, both preceding and following the 1996 Farm Bill. The 1996 Farm Bill legislation

established production flexibility contract (PFC) payments and significantly altered the manner

in which payments are distributed to farmers. The 2002 Farm Bill later reclassified PFC

payments as fixed direct or decoupled government payments.

Table 1: Definition of Direct Government Payment before and after 1996

1939 to 1995	1996 to 2007
Feed Grain, Wheat, Rice Cotton, and Wool (Crop Specific) Program Payments Conservation Program Payments Miscellaneous Programs[2]	Production Flexibility Contract (PFC)/Fixed Direct Payments Counter-cyclical Payments Marketing Loan Gains Loan Deficiency Payments (LDP) Certificate Exchange Gains Peanut Quota Buyouts Milk Income Loss Payments Tobacco Transition Conservation Program Ad Hoc Emergency Program Miscellaneous Programs[3]
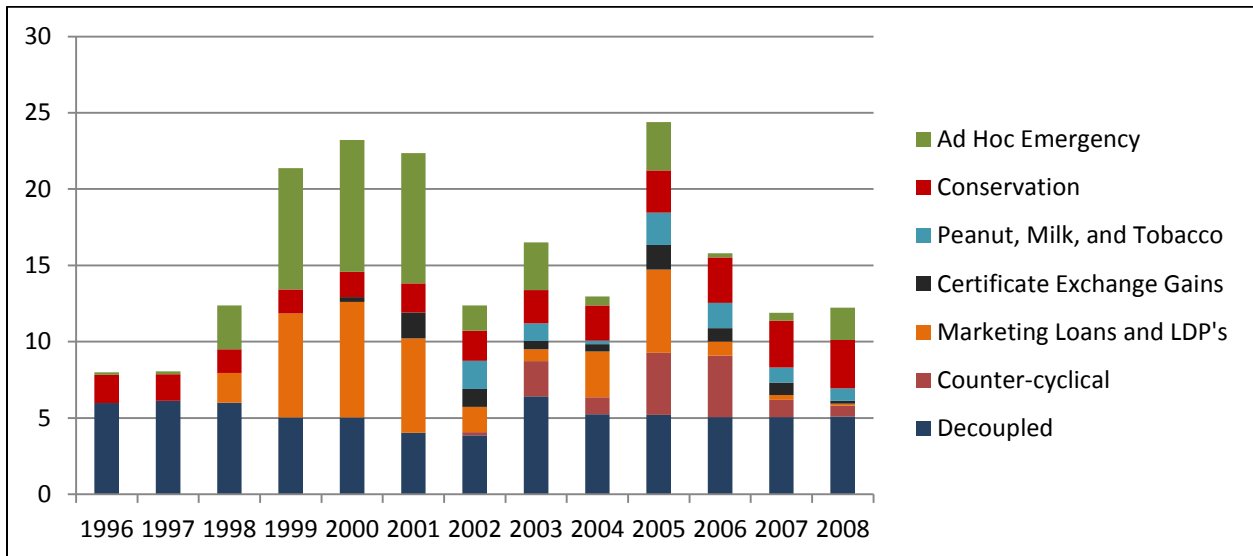
Figure 2: Direct Government Payments (1996-2008)

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[2] Miscellaneous programs from 1939-1949 are attributed to the Sugar Act, Price Adj and Parity, and Wartime Production/Subsidy. From 1950-1955, Miscellaneous payments were relatively low and source unknown. From 1956-1970 payments are completely attributable to the Soil Bank Program (ended in 1971) and from 1971-1996 include all other programs. From 1990 -1996, loan deficiency payments and marketing loan gains were included in Miscellaneous Payments

[3] Miscellaneous programs (post 1996) include Acreage Grazing Payments, Additional Interest Payments, American Indian Livestock Feed Program, American Indian Livestock Feed Program--Apportioned, DCC--Fruit

Figure 2 shows the prominence of decoupled payments, especially in 1996 and 1997, when decoupled payments accounted for 81% of direct government payments. While the share of decoupled payments has declined in recent years, the average has remained relatively stable at $5.244 billion (see Table 2). Together, the average amount of marketing loan gains, loss deficiency payments (LDP), and ad hoc emergency payments are approximately equal to decoupled payments but exhibit greater variation.

Table 2: Summary statistics for various components of Direct Government Payment (1996-2007), (millions of $)

Government Program	Mean	Std Dev	Coefficient of Variation
Decoupled Payments	5,244.37	751.42	0.14
Counter-cyclical Payments	1,044.05	1,502.19	1.44
Marketing Loans and LDP's	2,671.37	2,822.27	1.06
Certificate Exchange Gains	595.94	605.17	1.02
Peanut, Milk, and Tobacco Payments	676.06	799.61	1.18
Conservation Programs	2,206.77	592.06	0.27
Ad Hoc Emergency Programs	3,064.11	3,223.47	1.05
Total	15,431.89	5,801.80	0.38

The components of direct government payments from 1939 to 1996 are also presented in Table 1. From 1961 to 1996, crop specific payments averaged about 70% of total direct government payments. Feed grains comprised a maximal share of 56% of direct payments in 1965 and minimal share of 4% in 1984. Table 3 provides additional summary statistics on the four largest components of direct government payments prior to 1996. While feed grain payments were the primary component of direct government payments from 1961-1996, significant resources were also devoted to conservation and miscellaneous payments over this period. Conservation and miscellaneous payments were also significant sources of variability for this period.

Table 3: Summary statistics for various components of Direct Government Payment (1961-1995), (millions of $)

Government Program	Mean	Std Dev	Coefficient of Variation
Feed Grains	1,863.86	1,907.34	1.02
Wheat	980.53	828.38	0.84
Conservation Programs	479.10	572.97	1.20
Misc Programs	692.85	1,133.87	1.64

Coinciding with the trends in direct government payments has been a steady migration of labor from agriculture. Bloom and Freeman (1988) document the shift in labor forces of developing countries from agriculture to industry and service sectors during the period of 1965 to 1985. In the U.S., farm labor has declined over 50% in just under 50 years, from total employment of 5.5 million in 1960 to 2.1 million in 2007 (U.S. Department of Labor 2009). Cochrane (1993) describes a structural change in U.S. agriculture. He notes a long-run trend of declining inputs of human labor and increasing inputs of mechanical power/machinery. This trend still holds in agriculture domestically and abroad, thereby resulting in downward pressure on agricultural labor. Prior studies using a time series approach have provided little evidence of a significant relationship between direct government payments and migration of labor from agriculture. Barkley (1990) found there was no significant relationship between migration from agriculture and total direct government payments.

A theoretical model for labor migration was originally proposed by Mundlak (2000) and further developed by Barkley (1990), where an individual exists in a two-sector economy and faces a decision to allocate labor to agriculture or non-agriculture. The individual will migrate from agriculture to the non-agricultural sector if their expected discounted utility from non-agricultural employment is greatest. Specifically, let us assume that the indirect utility functions for an individual i is evaluated for the conditions in agriculture and non-agriculture by $V_i(a)$ and

$V_i(n)$, respectively, and introduce an index function J that takes on value 0 or 1 to be determined by:

$$[V_i(n) - V_i(a)] J_i(a, n) \geq 0 \tag{1}$$

In equation 1, if the first term is positive then the individual benefits from migration and the function $J_i(a, n)$ takes on a value 1 and 0 otherwise. Potential migrants must estimate the probability of obtaining a job in nonagricultural sector. This probability is incorporated into the empirical model through inclusion of variables like non-agricultural unemployment rate and relative size of the sectoral labor force. Finally, economic conditions within the agricultural sector, such as, government payments to farmers and farmland values are also expected to affect the flow of labor out of agriculture. On the other hand, labor can also migrate into agriculture and can be represented as:

$$[V_i(a) - V_i(n)] J_i(n, a) \geq 0 \tag{2}$$

Summing equation 1 and 2 yields the number of migrants:

$$M(a, n) = \sum_i^{L_a} J_i(a, n) - \sum_i^{L_n} J_i(n, a) \tag{3}$$

In equation 3, $M(a, n)$ is a function of the arguments of the indirect utility functions in the two sectors $(\lambda(a, n))$ and is also a function of the size of the labor force in the origin. The number of migrants generated by the same economic environment characterized by (a, n) will vary by the size of the labor force and its sectoral composition. A larger labor force in agriculture results in greater potential for migration. Similarly, larger the labor market in the destination, the easier it should be for the new migrants to find employment. Finally, labor force can be introduced in equation 3 while maintaining the constant-returns-to-scale property with respect to the sectoral labor:

$$M(t) = \lambda(a, n) L_F(t)^{1-\alpha} L_{off}(t)^{\alpha} \qquad \forall \quad 0 \leq \alpha \leq 1 \tag{4}$$

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where $L_F(t)$ and $L_{off}(t)$ are the labor force in agriculture and non-agriculture, respectively.

After dividing both sides of equation 4 by $L_F(t-1)$, the migration as a proportion of

agricultural labor is represented by $m = \left(\frac{M}{L_F}\right)$, the sectoral labor ratio by $r = \left(\frac{L_{off}}{L_F}\right)$, and the ratio

of sectoral income by $\eta = \left(\frac{W_{off}}{W_F}\right)$. When $(\eta = 1)$ the sectoral incomes are equal and no

migration takes place. However, due to cost associated with migration (c) there are reasons to

believe that migration will stop when $(\eta = c)$.

Data and Empirical Model

In addition to the explanatory variable for government payments, controls for the relative

size of the agricultural labor force, probability of obtaining work off-farm, the relative returns to

working off-farm, and farmers' expectations for the future of agriculture were also included in

the model. The time-series data used for this research was collected from multiple sources and

covers the years 1939 to 2007. First was the Current Population Survey (CPS), a monthly survey

collected by the Bureau of Labor Statistics (BLS). It is important to note that there were several

changes in variable definitions and survey methods for the CPS over the period of study. Dummy

variables were included for these years to control for these transitional periods. Three of the

years in which the survey methodology changed were found significant (1972, 1978, and 2000).

The CPS was the source for the employment data used to calculate the dependent

variable, labor migration, and the explanatory variable representing the probability of obtaining

work off-farm. An empirical measure of outmigration follows the work of Mundlak (1979)

where labor migration is limited to occupational migration at the aggregate level. In particular,

migration from the agricultural sector is defined as the percentage change in agricultural

employment from one year, say (*t-1*) to the next year (*t*). Here the definition considers only

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changes in the number of jobs in the farm agricultural sector. In particular, the dependent

variable is defined as:

$$m = \frac{L_{F,t-1} - L_{F,t}}{L_{F,t-1}} \qquad (5)$$

where $L_{F,t-1}$ is total agricultural employment in previous year (*t-1*) and $L_{F,t}$ is the total

agricultural employment in current year (*t*).[4] Also provided by the CPS was the annual non-

farm, unemployment rate (*U*) used as a proxy for the probability of obtaining off-farm work. As

the probability of obtaining a job off-farm falls (unemployment increases), the migration of labor

from agriculture is expected to decrease.

Data on direct government payments, net farm income, and nominal land values are from

the "Farm Income Data" produced by the Economic Research Service (ERS) (USDA 2009).

Land values are then deflated using the Producer Price Index (PPI) for Farm Equipment (U.S.

Department of Labor 2009) to obtain the real land values (*Land*). This inflation measure is used

rather than the PPI for farm products because, like equipment, farmland is a capital input in the

production process. Assuming efficient land markets, the real land value represents farmers'

expectations for the future of the agricultural sector. The real land price is the present value of

all expected future cash flows; therefore, greater belief in the future of agriculture will increase

the expected future cash flows and thereby increase land values.

Government payments (*Gov*) is defined as,

$$Gov = \frac{Direct\ Government\ Payments}{Net\ Farm\ Income} \qquad (6)$$

The *Gov* ratio measures government payments as a proportion of the annual net farm income

(Barkley 1990). One potential issue with this definition of government payments is the accuracy

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[4] Although Mishra et al. 2002 point out that part-time farming is becoming a permanent feature in American agriculture, due to data limitations this development is ignored in this study.

of net farm income. Questions arise from the manner in which farm operators are generally

compensated and the disincentive that arises from reporting net farm income on an annual basis.

First, operators generally are compensated by an "owner's draw" paid from the farm profits.

Secondly, greater pre-tax profits result in large tax liabilities; therefore, when faced with the

decision of paying additional taxes on farm income or spending the farm earnings elsewhere the

farmer is expected to choose the latter.

In light these measurement issues, separate models with alternative definitions of

government payments are estimated in this study. The first model follows the definition provided

in equation (6). The second simply uses direct government payments, thereby assuming net farm

income equal to one. These models will be referred to in Table 4 as "*Gov Ratio*" and "*Gov

Pmts*", respectively.

A measure of the relative returns of working in agriculture compared to the non-

agricultural sector is included. The expectation is that as the returns to agriculture increase on a

relative basis, labor migration from agriculture will decrease. The return to labor in each sector

is measured by the average product of labor (APL) in the respective sectors. As defined by

Barkley (1990) the returns ratio (Ret) is calculated as,

$$Ret = \frac{APL_{off}}{APL_F} = \frac{GDP_{off}}{L_{off}} \Big/ \frac{GDP_F}{L_F} \tag{7}$$

The variables APL_{off} and APL_F represent the average product of labor for the non-agricultural

and agricultural sectors, respectively. Specifically, non-agricultural average product of labor

(APL_{off}) is defined as the gross domestic product from the non-agriculture sector (GDP_{off})

divided non-agriculture labor force (L_{0ff}). APL_F is defined as the gross domestic product from

the agriculture sector (GDP$_F$) divided by the agricultural labor force (L$_F$). Data used to calculate

GDP_{off} and GDP_F is from the Bureau of Economic Analysis (U.S. Department of Commerce 2009), while the labor force data for L_{off} and L_F is from the CPS.

A measure of the relative size of the agricultural and non-agricultural labor force is also included. *LF* represents the ability of the non-agricultural sector to absorb workers from agriculture.

$$LF = \frac{L_{off}}{L_F} \tag{8}$$

According to Barkley (1990), as the non-agricultural labor force grows relative to the agricultural labor force (*LF* increases), the non-agricultural sectors of the economy are expected to be increasingly able to absorb farm workers. Therefore, a positive correlation between *LF* and *m* is expected.

A function describing the migration of labor from agriculture can then be developed using the time varying explanatory variables, a vector of dummy variables (*z*), and stochastic disturbance term (ε).

$$M = z^{\alpha_i} U^{\beta_1} Gov^{\beta_2} Ret^{\beta_3} LF^{\beta_4} Land^{\beta_5} \varepsilon \tag{9}$$

A semi-logarithmic transformation of the explanatory variables was then used and each variable was tested for stationarity via an augmented Dickey-Fuller test. With exception to the annual unemployment rate, all explanatory variables were found non-stationary. Therefore, the first difference (denoted by Δ) of the following variables was taken: $\ln(Gov)$, $\ln(Ret)$, $\ln(Land)$, and $\ln(LF)$. The first differences were stationary but not co-integrated. Using the first differences alters the interpretation of the results. Consider the government payment variable, greater changes in log government payments from (*t-1*) to (*t*) will increase/decrease migration of labor from agriculture in time (*t*).

Prior labor migration models lagged all dependent variables one period (Barkley 1990; Mundlak 2000). This was done to decrease the likelihood of simultaneity and accounts for the time delay required for farmers to observe, process, and formulate expectations. The first difference was not used for the non-agricultural unemployment rate so the variable was lagged one period. Meaning, the probability of finding off-farm work in the prior period (*t-1*) determines whether the farmer will decide to migrate from agriculture in the current period (*t*).

The migration of labor from agriculture is estimated by ordinary least squares (OLS) of the following form,

$$M = \alpha_1 + \alpha_2 Yr1972 + \alpha_3 Yr1978 + \alpha_4 Yr2000 + \beta_1 \ln(U_{t-1}) + \tag{10}$$

$$\beta_2 \Delta \ln(Gov) + \beta_3 \Delta \ln(Ret) + \beta_4 \Delta \ln(LF) + \beta_5 \Delta \ln(Land) + \varepsilon_t$$

This model was estimated using alternative definitions of government payments. In each case, migration would be a strictly increasing/decreasing function in direct government payments and there will exist a constant elasticity ($E_{\Delta Gov}$),

$$\frac{dM}{d\Delta \ln(Gov)} = \frac{dM}{d\Delta Gov} \Delta Gov \;\Rightarrow\; E_{\Delta Gov} = \beta_2 \left(\frac{1}{M}\right) \tag{11}$$

In addition to estimating the model for the full data set, the model was partitioned in two groups, 1939–1995 and 1996–2007, to evaluate the importance of decoupled payments on the migration of labor from agriculture. In the time-partitioned models, government payments are included as a ratio of net farm income as described in equation (6). Following each estimated model, the Breush-Godfrey test and residual correlogram were used to test for autocorrelation.

This model was also estimated as an AR(1), autoregressive distributed lag model with M_{t-1} included as an explanatory variable. This approach yielded nearly identical results to ordinary least squares (OLS) in terms of coefficient estimates and significance. Using OLS allowed for an additional year of data to be used relative to the autoregressive model. One

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drawback to using OLS rather than the AR(1) model was evidence of serial correlation for 1996-2007, but the magnitude and significance of the coefficient estimates were equivalent across models for this time period. For these reasons, only the results using OLS are reported.

Results and Discussion

The primary result of this research is that increases in government payments result in increased migration of labor from agriculture (Table 4). This result is consistent using both definitions of government payments (column 2 and 3). These definitions produced nearly identical results; although, the government payment ratio appears to be more robust to serial correlation as evidenced by the Breusch-Pagan tests.

Table 4: Parameter estimates of labor migration from agriculture

Variable	Gov Pmts	Gov Ratio	1939-1995	1996-2007
$\Delta lnGov$	0.0086**	0.0106***	0.0105**	0.0015
	(0.0038)	(0.0040)	(0.0043)	(0.0087)
$\Delta lnLF$	0.6875***	0.6771***	0.6973***	0.7733***
	(0.0491)	(0.0489)	(0.0533)	(0.1507)
$\Delta lnLand$	-0.0508	-0.0521	-0.0542	-0.0237
	(0.0333)	(0.0325)	(0.0368)	(0.0684)
$\Delta lnRet$	0.0070	-0.0086	0.0069	-0.0163
	(0.0117)	(0.0136)	(0.0166)	(0.0219)
lnU_{t-1}	-0.0219***	-0.0214***	-0.0210***	-0.0473*
	(0.0040)	(0.0040)	(0.0041)	(0.0233)
$Yr1972$	-0.0226*	-0.0220*	-0.0193	
	(0.0131)	(0.0128)	(0.0136)	
$Yr1978$	-0.0285**	-0.0285**	-0.0264*	
	(0.0132)	(0.0129)	(0.0134)	
$Yr2000$	0.0358*	0.0346*	0	-0.0043
	(0.0181)	(0.0178)	0	(0.0376)
$Constant$	-0.0710***	-0.0692***	-0.0698***	-0.1464*
	(0.0119)	(0.0118)	(0.0123)	(0.0676)
N	68	68	56	12
R^2	0.913	0.916	0.849	0.996
Breusch–Godfrey (p-value)	0.1083	0.1532	0.3442	0.0022
* p<0.10, ** p<0.05, *** p<0.01				

We provide four possibilities for the positive and significant relationship between labor migration and farm program payments. The first explanation for this result involves increased decoupled payments. Assuming off-farm wages are greater than farm wages, a profit maximizing farm household may choose to devote greater hours to off-farm work and spend their increased income (total) on hiring an additional farm worker. This profit maximizing behavior may occur to the extent where farmers and/or spouses work full-time off-farm and effectively leave the agriculture labor force. Similarly, El-Osta, Mishra, and Morehart (2008) found that a $10,000 increase in expected government payments increased the probability of the farm operator's wife working off-farm when she is the only one devoting time off-farm.

The second explanation for the positive relationship between changes in direct government payments and migration from agriculture involve commodity buyout programs. From 2002 to 2008, peanut and tobacco quota buyouts were introduced. According to Snell (2005), the reaction from farmers to these programs was similar in the first year following the legislation. The response was a double-digit percentage decline in the number of peanut and tobacco acres planted. With steep declines in production, farm operators, spouses, and/or hired laborers may have sought employment in the non-agricultural sector.

Third, conservation programs have been a part of agricultural policy since the 1930's. In 1985, the Conservation Reserve Program (CRP) was established to idle marginally productive farmland, particularly in environmentally sensitive areas. According to Gardner (1999), USDA (2010), and Edward and DeHaven (2001), nearly 34 million acres of land had been idled due to CRP through 2006. As a result of the retired acreage, there are fewer hired laborers needed for production and less acreage for the operator to manage, thereby increasing the time available for the farm operator to engage in off-farm labor, *ceteris paribus*.

Fourth, agricultural labor has also been replaced over time by capital and machinery improvements on the farm. Cochrane (1993) describes a structural change in U.S. agriculture resulting from a long-run trend of declining inputs of human labor, increasing inputs of mechanical power, machinery, and agricultural chemicals. Burfisher and Hopkins (2003) also noted a trend of declining labor intensity and increasing capital intensity in U.S. agriculture as evidence of the ease of input substitution in the long run. If increases in direct government payments are invested in capital improvements then migration of labor from agriculture would increase, *ceteris paribus*.

Considering the possible explanations provided for the relationship between direct government payments and labor migration, the impact of the 1996 Farm Bill's introduction of the free market concept in agriculture was also evaluated. Table 4 shows the estimated coefficients for the model from 1939-1995 and 1996-2007 (column 4 and 5, table 4). Using a Chow test, the null hypothesis of equality between the coefficient estimates for the change in direct government payments for 1939-1995 and full model (column 2 and 3) could not be rejected. Conversely, the coefficient estimate for 1996-2007 was not statistically significant. We can conclude that the 1996 Farm Bill did not significantly alter the impact of government payment on the migration of labor from agriculture.

The change in log real land values and return ratio were both found insignificant across all models. This result was surprising considering the results of Barkley (1990), who found the relationship between migration and the return ratio positive and highly significant, meaning increases in non-agricultural returns, *ceteris paribus*, entice farm worker to leave the agricultural sector. The results of the current research show that larger changes in returns ratio do not have a significant impact on migration. Real land values were also meant to capture the expectations

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future conditions in the agricultural sector, assuming efficient land markets hold. Therefore, changes in the log expectations of farmers were not found to have a significant impact on labor migration.

The log change in the labor force ratio ($\Delta lnLF$) is positive and significantly correlated with migration of labor from agriculture in all models, meaning that larger increases in the log labor force ratio result in greater absorption of agricultural labor into the off-farm labor force and hence increased migration from agriculture. Additionally, the non-farm unemployment rate (ΔlnU_{t-1}) is negative and significantly correlated with migration of labor from agriculture. When the non-farm unemployment rate increases, farm workers' prospect for off-farm labor diminishes and the rate of migration from agriculture declines. Additionally, the constant and all dummy variables were found significant for the model using the government payment ratio.

Conclusions

The results of this research indicated that government payments have had a positive influence on farm operators, spouses, and hired workers leaving the agriculture labor force from 1939 to 2007. Perhaps this is due to the direct consequence of conservation programs, commodity buyouts, decoupling of payments, or the substitution effect of lower cost capital as well. Perhaps changes in economic conditions for both the non-farm and farm sectors have occurred at such a continuous, rapid, and unpredictable pace that policymakers have been unable to modernize policy quickly enough to increase the standard of living in the farm economy.

Regardless, it is encouraging from a policy perspective that the positive relationship between labor migration and government payments has diminished in recent years. This could be a sign of more effective government policy and a sign of increased initiatives designed to promote a more sustainable agricultural labor force. Consider the inclusion of initiatives aimed at

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young and beginning farmers in the 2008 Farm Bill, such as the Beginning Farmer and Rancher

Development Program, Down-Payment Loan Program, and the Beginning and Socially

Disadvantaged Farm and Rancher Land Contract Payment (Iowa State University 2009).

These programs are in response to a concerning trend in agriculture, the aging of the farm

population which threatens to further weaken the industry over the long-term. According to Gale

(1994), entry into farming by the 'next generation' holds a place of central importance in the

determination of industry structure and the total number of farmers and farm families. Currently,

these young and beginning farmers are receiving a minority share of direct government

payments. Mishra et al (2002) shows government assistance is most often received by large,

wealthier farms that are less likely to work off-farm. More effective government policy could be

a viable option to slow the drift of younger, more educated workers from the farm labor force

and preserve the next generation of farmers' migration from agriculture.

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CHAPTER 3: DOES FAMILY MATTER? EXAMINING LABOR SUBSTITUTION ON U.S. FARMS

Introduction

An often discussed issue in farm policy is the effect of government payments on the allocation of labor between farm and off-farm work. Some forms of payments provide clear theoretical implications for the hours devoted to farm labor, namely coupled payments (Dewbre and Mishra 2007). An increase in coupled payments is expected to unambiguously increase the hours devoted to farm labor. Conversely, an increase in decoupled payments can either have no effect or decrease the number of hours worked on the farm. In which case, the impact of decouple payments is an empirical questions. From a policy perspective, a common criticism of decoupled payments is this exact situation where decoupled payments are thought to decrease the hours worked on farm and essentially subsidize greater off-farm labor.

A key piece of information required to address this proposed criticism is the substitutability of farm labor. The more homogenous is family and hired labor, the easier farm operators and spouses can use decoupled government payments to hire replacement workers on the farm. The operator and spouse can then engage in the profit maximizing behavior of working higher earning jobs off-farm or simply enjoy greater hours of leisure. Aside from profit maximization, farm operators and their family members may be attracted to less variable off-farm wages (Mishra and Goodwin 1997). These results of homogenous farm labor make sense intuitively, but intuitively can we expect these forms of labor to be equivalent.

For example, consider a situation in which a farm operator's child is now of legal age to work full-time on the farm. This individual has been raised on the land, has likely established a relationship with their co-workers, and is familiar with the farm operations. Contrast this with a hired worker who does not have in–depth knowledge of the particular farmland, does not have

longstanding relationships with their co-workers, and must learn the daily workings of the farm operation. A steeper learning curve can be expected for the hired worker relative to family labor, *ceteris paribus*. Conversely, family labor might lack consistency because family members might perceive greater job security and less motivation to work at maximum productivity. It can be argued that hired labor would then have a greater contribution to production than family laborers, and again, farm labor would not be homogeneous. Regardless of which form of labor is more productive, it is logical to expect productivity differences in the types of farm labor.

The objective of this paper is to test the homogeneity of farm labor hypothesis while making no *a priori* assumptions as to the substitution relationship between hired and family labor. A flexible cost function approach is used, thereby allowing the data to reveal the true relationship between hired and family labor. Specifically, we use farm-level data from the Agricultural Resource Management Survey (ARMS) to estimate a translog cost function jointly with factor share equations via seemingly-unrelated regression (SUR). Controlling for both farm size and production regions, the results provide little evidence to support the homogeneity assumption and further indicate that the elasticity of substitution is unitary under most scenarios. However, a notable exception was found when controlling for farm size. Our results show that the largest hog and cash grain farms have the highest elasticity of substitution (120.95 and 36.60).

Theoretical Considerations and Literature Review

In the foundational work on farm household models by Singh, Squire, and Strauss (1986), it is stated that family and hired labor are assumed perfect substitutes and can be added directly. This assumption implies that each additional unit of family and hired labor has an identical impact on production, costs, and profits. This notion continues in more recent research (Blanc, Cahuzac,

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and Elyakime 2008); however, family and hired labor may result in differing impacts on the production processes of the farm (Deolalikar and Vijverberg 1982, 1978; Huffman 1976). Consider the farm household model as proposed by Blanc et al. (2008) and derived from Dawson (1984), where the decision to allocate labor to off-farm work and hire farm labor is separated into four regimes—assuming hired and family labor are perfectly substitutable. The farm household is expected to follow a utility maximization framework where U denotes utility. The utility is a function of leisure ($L_{ei}(L_F, L_O)$) and income (($I(L_F, L_O)$). Both farm household income and the time devoted to leisure are a function of the time devoted to farm labor (L_F) and off-farm labor (L_O).

$$Max \ U = U(L_{ei}(L_F, L_O), I(L_F, L_O)) \tag{1}$$

$s.t.$

$$L_{ei} + L_F + L_O - T = 0 \tag{2}$$

$$w_O L_O + \pi_F + V - I = 0 \tag{3}$$

$$L_{ei}, L_F, L_O \geq 0 \tag{4}$$

Utility maximization in equation 1 is subject to the total available hours (T) allocable to leisure, farm labor, and off-farm labor (equation 2), the full income constraint (equation 3), and non-negativity constraints (equation 4). The full income constraint is defined as the sum of income from off-farm labor ($w_O L_O$), farm profits (π_F), and other household non-labor income (V) minus the total income (I). Farm profits are further defined as the value of farm production minus the input costs. Specifically,

$$\pi_F = P_f f\big(L(L_F, L_H), X_f\big) - w_f X_f - w_H L_H \tag{5}$$

where P_f is the price of farm outputs, $f(.)$ is the farm production function, w_f is a vector of prices for inputs to production X_f, and w_H is the wage paid to hired labor L_H. Now, let the farm

production function $f\big(L(L_F, L_H), X_f\big)$ be a Cobb-Douglas production function of the following

form:

$$f\big(L(L_F, L_H), X_f\big) = AL^{\beta_1} \prod_{i=1}^{n} x_i^{\beta_i} \tag{6}$$

where X_f is a vector of farm inputs and $L(L_F, L_H)$ describes the farm labor input as a function of

hired and family labor. The Lagrangian ($\mathcal{L}$) can be constructed for the outlined maximization

problem with the following first order conditions:

$$U(L_{ei}(L_F, L_O), I(L_F, L_O)) + \lambda(L_{ei} + L_F + L_O - T) \tag{7}$$

$$+\delta(wL_O + \pi_F + V - I)$$

$$\frac{\partial \mathcal{L}}{\partial L_O} = -\frac{\partial U}{\partial L_{ei}} + w_O \frac{\partial U}{\partial I} = 0 \longrightarrow w_O = MRS_{L_{ei}, I} \tag{8}$$

$$\frac{\partial \mathcal{L}}{\partial L_F} = -\frac{\partial U}{\partial L_{ei}} + \left(\frac{\partial U}{\partial I}\right)\left(\frac{\partial I}{\partial \pi_F}\right)\left(\frac{\partial \pi_F}{\partial f(L(L_F, L_H))}\right)\left(\frac{\partial f(L(L_F, L_H))}{\partial L(L_H, L_F)}\right)\left(\frac{\partial L(L_F, L_H)}{\partial L_F}\right) = 0$$

$$\Longrightarrow MRS_{L_{ei}, I} = \left(\frac{\partial L(L_F, L_H)}{\partial L_F}\right)(VMP_L) \tag{9}$$

where VMP_L is equal to the value marginal product of farm labor and $MRS_{L_{ei}, I}$

Let us now consider two alternative definitions for $L(L_F, L_H)$. The common approach to

the farm household model, which assumes perfect substitution between labor inputs, is

represented by L^O:

$$L^O(L_F, L_H) = \alpha_1 L_F + (1 - \alpha_1)L_H \tag{10}$$

Alternatively, the relationship can be characterized by a quadratic function where the elasticity of

substitution between hired and family labor is non-constant.

$$L'(L_F, L_H) = \alpha_0 + \alpha_1 L_F + \alpha_2 L_H + b_1 L_F^2 + b_2 L_H^2 + b_3 L_F L_H \tag{11}$$

From the first order conditions described by equations 8 and 9, we can derive four labor regimes

from our utility maximization framework (Blanc, Cahuzac, and Elyakime 2008). The value of ϕ

in the following regimes is dictated by our choice of functional form for $L(L_F, L_H)$ and the

resulting marginal physical product of family labor $\left(\frac{\partial L(L_F, L_H)}{\partial L_F} \right)$.

$$w_O < MRS_{L_{ei}, I} < \alpha_1 VMP_L + \phi VMP_L \longrightarrow L_O = 0 \text{ and } L_H = 0 \tag{12}$$

$$w_O = MRS_{L_{ei}, I} < \alpha_1 VMP_L + \phi VMP_L \longrightarrow L_O > 0 \text{ and } L_H = 0 \tag{13}$$

$$w_O < MRS_{L_{ei}, I} = \alpha_1 VMP_L + \phi VMP_L \longrightarrow L_O = 0 \text{ and } L_H > 0 \tag{14}$$

$$w_O = MRS_{L_{ei}, I} = \alpha_1 VMP_L + \phi VMP_L \longrightarrow L_O > 0 \text{ and } L_H > 0 \tag{15}$$

If we assume perfect substitution between labor inputs then $L^O(L_F, L_H)$ is the labor input

included in the farm production function (equation 6), which results in a very simplistic

representation of our labor regimes where $\phi = 0$. Under the case of perfect substitutability,

$VMP_L = w_f = w_H$ which implies a single wage for farm labor and thereby a shared demand

curve for hired and family labor.

Graphically, Figure 3 illustrates the effects of increases in decoupled government

payments on the labor-leisure mix of farmers currently devoting some time to off-farm work

under the assumption that farm labor is characterized by $L^O(L_F, L_H)$. An increase in (V) in our

theoretical model is equivalent to a increase in decoupled government payments. This will have

the effect of increasing household income at all points along the household income curve

($Y_A \rightarrow Y_B$). Again, greater levels of income are preferred to less, therefore the household obtain a

higher level of utility ($U_1 \rightarrow U_2$) from the increased decoupled payments. The increased income

from decoupled government payments will either cause the hours of farm labor to remain

constant or increase. Time devoted to off-farm labor decreases from T_{Ea} to T_{Eb} or from length (*b*

+ *c*) to (*b*), while leisure increases from (*d*) to (*c* + *d*). Again, there will either be no effect or

decrease hours worked by the operator and spouse on the farm.

Alternatively, if farm labor is represented by equation (11) then $\phi = (2b_1 L_F + b_3 L_H)$ and there is not a single wage or single demand curve for farm labor. If $\phi = (2b_1 L_F + b_3 L_H) > 0$, then as hired and family labor become more highly substitutable ($\phi \to 0$) the number of hired workers will increase. The more highly substitutable is farm labor, the more freely the farm operator and change labor allocations to maximize income and leisure. The inverse is also true that as ϕ increases, the hours of labor from hired workers will fall. This implies that an increase in decoupled payments will be less likely to subsidize increased hired labor the lower the rate of substitution between types of farm labor.
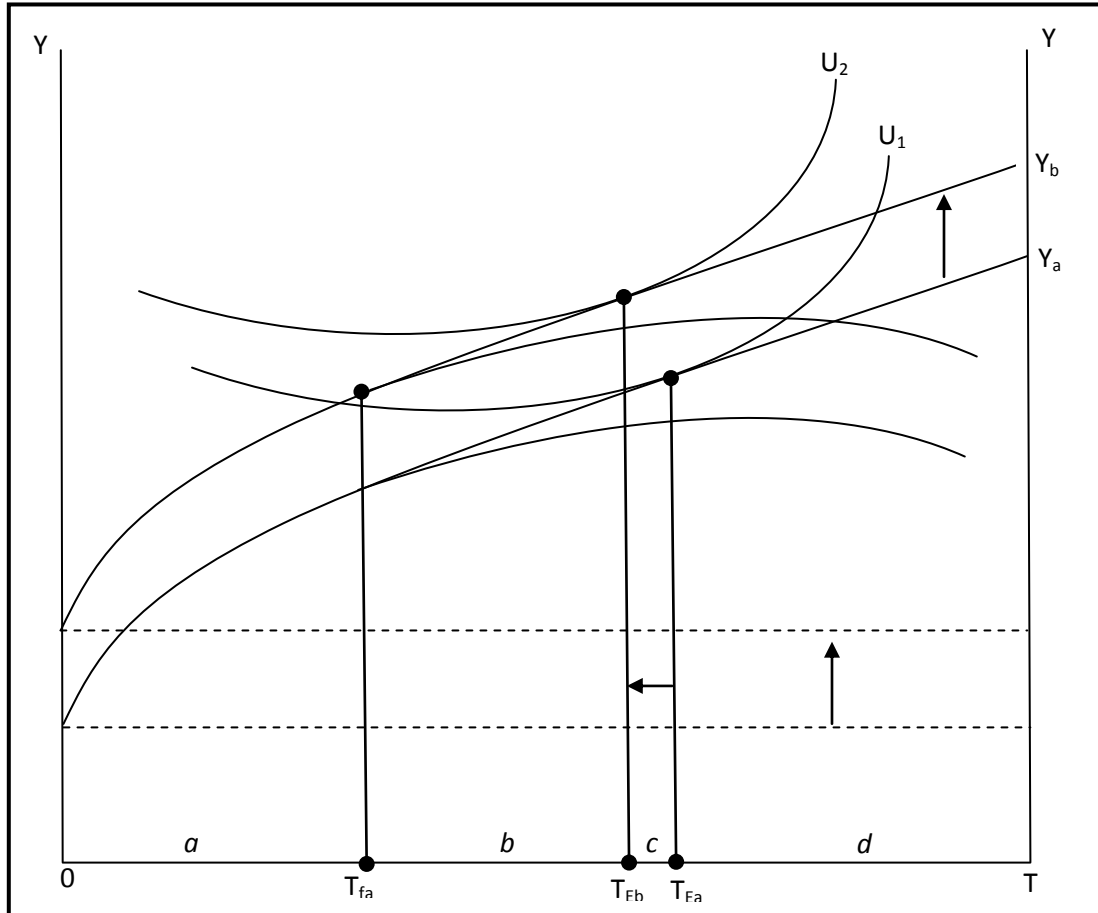

Figure 3: Effect of Decoupled Payments on Time Allocation of Farm Family When Working Some Off-Farm (Dewbre and Mishra, 2007)

Prior research has attempted to measure the elasticity of substitution between hired and family labor. The studies have largely been limited to estimation of production functions for farm output, generally using a Cobb-Douglas functional form (Deolalikar and Vijverberg 1982; 1978). These two studies analyze the substitutability of farm labor in India and Asia. Deolalikar and Vijverberg (1982) estimated a Cobb-Douglas production function for farm outputs as a function of farm labor and other farm inputs. The farm labor input is then represented by a second production function nested within the farm production function. Using data from 268 districts in India (1970-1971) the authors estimated the aggregate output of 22 major crops. The best-fit production model, as determined by a standard F-test, included a nested CES production function for farm labor which was restricted to a Cobb-Douglas specification. Deolalikar and Vijverberg (1987) extended the 1982 study to include farms in both India and Malaysia. A Cobb-Douglas production function was once again used for farm outputs, while a generalized quadratic production function was used to represent hired and family labor. A sample of 476 Indian and 100 Malaysian farm households, for 1974-1975 and 1976-1977, were used in the estimation of aggregate output. In both of these studies, perfect substitutability of hired and family labor was rejected.

Huffman (1976) demonstrated a similar result using a cross section of aggregate county data from the 1964 Census of Agriculture. Specifically, Huffman used data for 276 counties in Iowa, North Carolina, and Oklahoma and estimated the ratio of hired labor (L_H) and farm husband or wife (L_{Op}). The elasticity of substitution, σ_{ij}, between hired labor and farm wives was 1.152. However, the elasticity of substitution was much lower between hired labor and farm husbands (0.682); therefore, the rate at which farm husbands can be replaced by hired labor is

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relatively lower than that of farm wives. In an absolute sense, both farm husbands and wives do not exhibit perfect substitutability with hired labor.

There are several weaknesses to the above mentioned studies. First, the studies are small in scope and regionally focused. Secondly, some models have imposed *a priori* relationships regarding the elasticity of substitution for farm labor. The current research has the advantage of an improved methodological approach and a more recent farm-level data. We use a large, nationwide dataset comprising farms of different economic sizes and locations in the United States.

Empirical Model

The flexible translog functional form is well established in the literature (Binswanger 1974; Berndt and Wood 1975; Diewert and Wales 1987; Bigsby 1994; Greene 2008). It allows for estimation with an unrestricted substitution relationship between factors of production.

$$ln(C_k) = a_0 + a_Y \, ln(Y_k) + \frac{1}{2}a_{YY} ln(Y_k)^2 + \sum_{i=1}^{5} \beta_i ln(P_i) + \tag{16}$$

$$\frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5} \beta_{ij} ln(P_i)ln(P_j) + \sum_{i=1}^{5} d_{iY} ln(P_i)ln(Y_k) +$$

$$a_T T + \frac{1}{2}a_{TT}T^2 + \sum_{i=1}^{5} g_{iT} ln(P_i)T$$

The variable Y_k represents the respective quantities of hogs, all cash grains, and cash grains excluding corn outputs. Hog farms were chosen because these operations are vertically integrated and generally more labor intensive than other farm types. Cash grain farms are relatively less reliant on labor due to the increasing use of specialized machinery and receive significant farm program payments (USDA 2010). Additionally, there is empirical evidence that the operators and spouses of cash grain farms have a higher likelihood of participating in off–farm work (Ahearn et al 2006).

The input prices for hired labor, family labor, capital, land, and feed expense (specific to

hog production) or fertilizer/chemical/pesticide expense (specific to cash grains) are represented

by the variables (P_i, P_j) in equation (16). Also included in the model are the constant (a_c) and

time trend (T). The parameters $a_0, a_Y, a_{YY}, a_T, a_{TT}, \beta_i, \beta_{ij}, g_{iT}$ and d_{iY} are estimated, with

particular attention given to the interaction term (β_{ij}) for hired labor and family labor. The cost

function is estimated jointly with *(n-1)* factors of production. By dropping one share equation

(equation 17), the system becomes non-singular and can be estimated by SUR (Greene 2008).

$$S_i = \frac{\partial \ln(C_k)}{\partial \ln(P_i)} = \frac{X_i P_i}{C_k} = \beta_i + \sum_{i=1}^{5} \beta_{ij} \ln(P_i) + d_{iY} \ln(Y_k) + g_{iT} T \qquad (17)$$

A homogeneity restriction (equation 18) is included to ensure a proportional increase in all factor

costs results in a proportional increase in production. This assumption also maintains that a

change in all factor prices will not change the relative quantities of each factor used in

production (Bigsby 1994).

$$\sum_{m=1}^{3} a_m ; \; m = constant, Y, YY \qquad (18)$$

$$\sum_{i=1}^{5} \beta_{ij} = \sum_{i=1}^{5} g_{iT} = \sum_{i=1}^{5} d_{iY} = 0$$

From the cost share equations (17) and the interaction effect (β_{ij}) from the estimated cost

function, the Allen partial elasticity of substitution can be calculated using the following

equation.

$$\sigma_{ij} = \frac{\beta_{ij}}{S_i S_j} + 1 \qquad (19)$$

If β_{L_H, L_F} is positive and significant, then as σ_{L_H, L_F} approaches infinity the assumption of perfect

substitution between hired and family labor is increasingly justified. If β_{L_H, L_F} is insignificant,

then $\sigma_{L_H, L_F} = 1$ and the substitution relationship between family and hired labor is unitary. We

also include a variable for time in the model which helps determine the appropriate functional

form for modeling farm labor. If the elasticity of substitution is unitary, then the significance of the time trend variables will help us determine whether the Cobb-Douglass function is an appropriate representation of this relationship.

Data

The data used in this research is pooled from the 2006-2008 Agricultural Resource Management Survey (ARMS). ARMS is conducted annually by ERS and the National Agricultural Statistics Service (NASS). The survey collects data to measure the financial condition and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households.

The target population of the survey is operators associated with farm businesses representing agricultural production in the 48 contiguous states. A farm is defined as an establishment that sold or normally would have sold at least $1,000 of agricultural products during the year. Farms can be organized as proprietorships, partnerships, family corporations, nonfamily corporations, or cooperatives. Data is collected from a single, senior farm operator, who makes most of the day-to-day management decisions.

The survey design of ARMS allows each sampled farm to represent a number of farms that are similar, referred to as a survey expansion factor. The Jackknife variance estimation method is commonly used to calculate the standard errors when using the full dataset under this survey design (Dubman 2000). This research utilizes a subset of the data; therefore, the Jackknife method is not used. However, hypothesis tests for parameter significance were performed using both z tests and t tests because of the relatively small samples for some trials. There was no significant difference in results between the two tests, but the likelihood of rejection in a small sample is still theoretically higher for the t test. Recall, the null hypothesis of farm labor

homogeneity rests primarily on the magnitude and significance of the interaction parameter

(β_{L_H, L_F}). Considering the goals of this study, the z test serves as a more conservative procedure;

therefore, it is used exclusively in the reported results.

Data on production cost, input prices, and output quantities were taken from ARMS for

both hog producers and an aggregate of cash grain crops. Both livestock and crop production are

analyzed in this study to determine whether farm type has a significant effect on labor

substitutability. The cash grains included in this study are corn, soybean, wheat, sorghum, and

barley. Models are estimated both including and excluding corn from this group to determine

whether there is a structural difference between corn and the remaining cash grains.

Table 5: Share of U.S. Farms Belonging to Each Organization Typology (Hoppe et al, 2007)

	Share
Small Family Farms	90.28%
Low Sales	18.78
Medium Sales	6.32
Residential/Lifestyle	39.73
Retirement	16.07
Limited Resource	9.38
Large Family Farms	7.49%
Large	4.08
Very Large	3.40
Non-Family Farms	2.23%

The sample data is restricted to family farms only, which account for approximately 98

percent of all U.S. farms (see Table 5). Additionally, 85 percent of total production and nearly

90 percent of all cash grain production can be attributed to family farms (Hoppe et al. 2007).

Large and very large family farms also specialize in cash grains more than any other agricultural

commodity and tend to employ the majority of hired farm workers. The share of work hours

accounted for by hired labor on large and very large family farms amounts to 21.8% and 55.5%,

respectively. Therefore, controls for farm size are included in the model to capture the scale

effects. Farms with sales less than $250,000 are considered small, those with sales between

$250,000 and $499,999 are considered large, and farms with sales of $500,000 or more are considered very large.
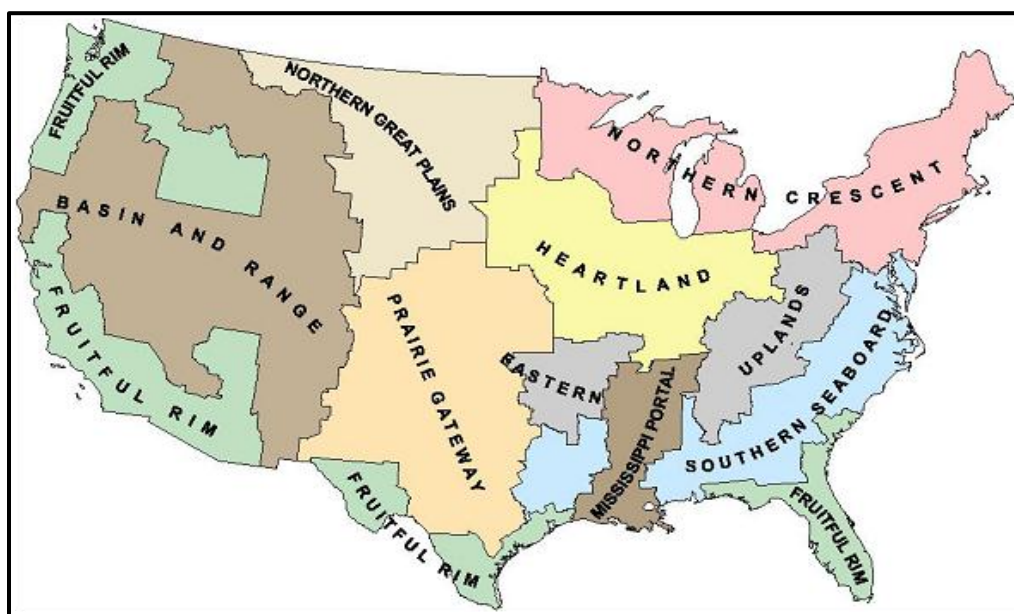

Figure 4: ERS Resource Regions

Farming regions are defined by Economic Research Service (ERS). ERS Resource Regions (Figure 4) are used to determine financial, economic, and resource-related issues affecting farmers and are characterized by similar farm attributes, commodities produced, physiographic, soil, and climate conditions (Isserman, 2002). Controls for region are included to determine whether the heterogeneous product mix and/or labor market conditions in alternative regions influence the substitutability of farm labor. Notably, approximately half of all hired farm labor is located in the West and Southwest U.S. The Northeast is the most populated region in the U.S. yet employs the fewest number of hired farm laborers for crops or livestock. According to ERS (2000), the Fruitful Rim accounts for the largest share of large and very large family farms, while the Northern Great Plains has the largest of all U.S. farm operations.

The cost of hired labor (P_{L_H}) is defined as *WAGERATE* in the ARMS dataset. This is the National Agricultural Statistics Service (NASS) average wage rate for hired labor, including

Social Security taxes for the year. The cost of family labor (P_{L_F}) is calculated as *(OPPD +*

SPPD)/ (OPHRS + SPHRS), where *OPPD* is the amount paid to the principal operator for farm

work, *SPPD* is the amount paid to the spouse for farm work, *OPHRS* and *SPHRS* is the total

annual hours worked on the farm by the operator and spouse. Other family members, such as

children and siblings, devoting labor to the farm are omitted from the family farm wage

calculation due to data limitations.

The price of land (P_{Land}) is calculated as the value of land and buildings per acre. Cost

of capital (P_K) is calculated as the ratio of total interest expense to total farm debt. In the case of

hogs, the feed price per hog (P_{Feed}) is in included in the model. In the case of cash grains, the

fertilizer, lime, and chemical expense per acre (P_{Chem}) is included in the model. The farm

expenses related to interest payments, fertilizer/chemical/pesticides, and feed were reported

directly by farmers in the ARMS survey. Total costs (C) are assumed to be variable; therefore,

total cash operating expense is used as the dependent variable in the cost function. The cost

function is estimated for three groups (*K*) of farm products: hogs, all cash grains, and cash

grains excluding corn. The output (Y_K) of each product groups is included in the cost function

for the respective models.

Cost share equations are estimated for four of the five variable inputs to permit estimation

of the system of equations. The cost shares for capital, hired labor, family labor,

fertilizer/chemical/pesticide expense, and feed expense were included in the model. The reported

value for each of these expenses was divided by total operating expenses to obtain cost shares.

Specifically, the cost share for hired farm labor (S_{L_H}) was calculated as the sum of hired labor

expense, contract labor expense, and labor fringe benefit expenses divided by total operating

expenses. This definition fully accounts for the farm expenses attributable to hiring farm labor.

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The cost share for family labor (S_{L_F}) was calculated as the total amount paid to operators and spouses divided by the total operating costs. The cost share equation for land was omitted from the system for multiple reasons. First, it was a common input across all of our product classes. Second, neither labor cost share equation could be omitted due to the focus of our study. These two considerations reduced our choices to either capital or land, and our confidence in accurately specifying the cost share for capital was greater than for land.

Our dataset is pooled from 2006 to 2008; therefore, a time trend is included in the model. Linear, squared, and interaction terms between time and each input price are included. The primary goal of the time variables is not to make strong conclusions regarding the changes in technology over this short period, but rather the interaction effects between time and the labor input variables will determine whether Hicks-neutrality can be assumed. This information is important when consider the proper specification of $L(L_F, L_H)$.

Results and Discussion

Our results for cash grains farms, both including and excluding corn, provide little evidence to support the notion that hired and family labor are perfect substitutes. Table 6 shows that in all but one case the elasticity of substitution is unitary. The analysis of cash grains with no regional controls resulted in an elasticity of substitution of 20.64, which still provides considerably weak support for the notion of perfect substitution. In light of this result, we then consider the trials for the Heartland, Northern Great Plains, Prairie Gateway, Fruitful Rim, and Basin and Range regions. The entire east coast, namely the Northern Crescent, is omitted from this group. For the all regions trials, including corn, the addition of the Northern Crescent region and other East/Southeastern regions did not change the results. When the 203 corn farms in the Eastern region were removed from the sample, the results changed significantly for the all regions group

of cash grains, excluding corn. This result may indicate a structural difference in labor

heterogeneity between corn farms and the remaining cash grains for the Eastern U.S.

Table 6: Elasticity of Substitution, Cost Shares, and Estimated Interaction Effect for Hired and
Family Farm Labor on Cash Grain Farms by Regions

ERS Resource Regions	Including Corn					Excluding Corn				
	N	β_{ij}	$\widehat{S}_{HL}$	$\widehat{S}_{FL}$	σ_{ij}	N	β_{ij}	$\widehat{S}_{HL}$	$\widehat{S}_{FL}$	σ_{ij}
Heartland, Northern Great Plains, Prairie Gateway, and Fruitful Rim	1081	0	11%	3%	1	983	0	11%	3%	1
Heartland, Northern Great Plains, Prairie Gateway, and Basin and Range	1049	0	10%	3%	1	958	0	10%	3%	1
Heartland, Northern Great Plains, Prairie Gateway, Fruitful Rim, and Basin and Range	1133	0	11%	3%	1	1034	0	11%	3%	1
Prairie Gateway, Fruitful Rim, and Basin and Range	355	0	12%	2%	1	329	0	12%	3%	1
All Regions	1577	0	12%	3%	1	1374	0.07	12%	3%	20.64

The results for hog farms (Table 7) were consistent across regions as well. These trials

exhibited little variation in sample size and composition. The concentration of hog farms to a

core regional set of the Heartland, Northern Great Plains, Northern Crescent, Prairie Gateway,

and Eastern Uplands is not surprising considering the documented consolidation and

concentration of the hog industry.[5] In every regional setting, the elasticity of substitution is

unitary.

Table 7: Elasticity of Substitution, Cost Share, and Estimated Interaction Effect for Hired and
Family Farm Labor on Hog Farms by Regions

ERS Resource Regions	N	β_{ij}	$\widehat{S}_{HL}$	$\widehat{S}_{FL}$	σ_{ij}
Heartland, Northern Great Plains, Northern Crescent, Prairie Gateway, Eastern Uplands, Southern Seaboard, and Mississippi Portal	185	0	10	2	1
Heartland, Northern Great Plains, Northern Crescent, Prairie Gateway, Eastern Uplands, and Southern Seaboard	185	0	10	2	1
Heartland, Northern Great Plains, Northern Crescent, Prairie Gateway, Eastern Uplands, and Mississippi Portal	181	0	10	2	1
Heartland, Northern Great Plains, Northern Crescent, Prairie Gateway, and Eastern Uplands	181	0	10	2	1
All Regions	190	0	10	2	1

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[5] According to data from the USDA (2010), the top five hog producing states in 2007 (Iowa, North Carolina, Minnesota, Illinois, and Indiana) were responsible for 67 percent of all hogs produced domestically.

Especially applicable to hog operations, the standardization of tasks and scale economies of larger farms are expected to have important implications on labor substitutability. Testing for heterogeneity of farm labor across farm sizes resulted in three test groups for each output (Table 8). Results indicate that the scale of operation indeed had an impact on the substitutability of farm labor. Interestingly, labor on cash grain farms including corn exhibited a complimentary relationship for the smallest farms. Perhaps this reflects the relationship between farm profits and the family wage. For example, as the quantity of hired labor declines, a farm's operating costs decline. Holding revenue constant, this results in greater farm profits. As farm profits increase, we would also expect higher farm household wages.

Table 8: Elasticity of Substitution for Hired and Family Farm Labor Controlling for Farm Size

Farm Size	Cash Grains Including Corn	Cash Grains Excluding Corn	Hogs
Small	-39.30	1	1
Large	36.58	1	1
Very Large	36.60	1	120.95

For cash grains including corn, the elasticity of substitution was approximately 37 for both large and very large farms. However, when excluding corn, the elasticity of substitution was unitary for both large and very large farms. Large and very large cash grain farms were found to be substitutable at an approximately equal rate, but this was not the case with hog farms. These farms exhibited a dramatic increase in labor substitutability from large to very large farms. Specifically, the elasticity of substitution was unitary for small and large hog farms but increased to 120.95 for very large farms. As expected, hog operations with the greatest mechanization and standardization display the greatest labor substitutability. Similarly, Blanc et al. (2008) found family farms in Europe were more likely to use permanent hired labor as farm size increased

thereby allowing family labor to specialize in managerial tasks while hired labor specializes in other non-managerial and operational labor.

Using regional controls provides a different view of the relationship between farm labor. It was consistently shown that farm labor is not perfectly substitutable and has an elasticity of substitution of one. In particular, notice the difference in the elasticity of substitution for hog farms when controlling for regions and farm size. The results for the regional trials would lead you to believe all hog farms have the same labor characteristics as a small or large hog farms, whereas, the bulk of hog production results from the very large operations. The effects of farm size appear to be more significant than regional location for hog farms in this situation. This also appears to be the case with the cash grains that include corn.

Also included in our model were time trend variables to help determine the appropriate functional form for farm labor (Table 9). For hog farms, the interaction effect between hired labor/time and family labor/time was found insignificant in all trials; therefore, the cost-minimizing ratio of these inputs can be assumed to be constant over the period of study. From this perspective, our evidence leads to the conclusion that labor on small and large hog farms is best represented in the farm household model by a Cobb-Douglas production function across all regions. However, labor on very large hog farms may be best represented by a quadratic production function. Relative to our other trials, very large hog farms provide the most compelling evidence for the linear production function as well.

The results in Table 9 support Hicks-Neutrality for cash grain farms, both with and without corn production, located Prairie Gateway, Fruitful Rim, and Basin and Range. The remaining trials demonstrated consistently that, over time, increases in the cost of hired labor are positively correlated with farm production costs. Family labor costs were found to have a

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negative relationship to farm production costs over time. This is consistent with the fact that, in most cases, family labor receives net profits at the end of the crop season as payment for hours worked on the farm. Farm operators and spouses are often paid by withdrawing these farm profits in the form of an owner's draw. Assuming farm revenue holds constant, declining farm production costs will increase profits, resulting in a rising family labor wages.

Table 9: Interaction Effect of Hired and Family Labor Prices with Time for Cash Grain Farms

Cash Grains Including Corn	Hired Labor				Family Labor			
ERS Resource Regions	g_{iT}	Std Error	Z	P>|z|	g_{iT}	Std Error	Z	P>|z|
Heartland, Northern Great Plains, Prairie Gateway, and Fruitful Rim	0.102	0.039	2.64	0.008	-0.060	0.018	-3.36	0.001
Heartland, Northern Great Plains, Prairie Gateway, and Basin and Range	0.087	0.039	2.24	0.025	-0.051	0.018	-2.82	0.005
Heartland, Northern Great Plains, Prairie Gateway, Fruitful Rim, and Basin and Range	0.106	0.037	2.86	0.004	-0.053	0.017	-3.07	0.002
Prairie Gateway, Fruitful Rim, and Basin and Range	0.046	0.057	0.81	0.419	-0.037	0.031	-1.20	0.232
All Regions	0.083	0.03	2.73	0.006	-0.047	0.014	-3.26	0.001

Cash Grains Excluding Corn	Hired Labor				Family Labor			
ERS Resource Regions	g_{iT}	Std Error	Z	P>|z|	g_{iT}	Std Error	Z	P>|z|
Heartland, Northern Great Plains, Prairie Gateway, and Fruitful Rim	0.073	0.038	1.92	0.055	-0.065	0.018	-3.62	0.000
Heartland, Northern Great Plains, Prairie Gateway, and Basin and Range	0.068	0.039	1.76	0.079	-0.052	0.018	-2.88	0.004
Heartland, Northern Great Plains, Prairie Gateway, Fruitful Rim, and Basin and Range	0.084	0.036	2.35	0.019	-0.061	0.017	-3.54	0.000
Prairie Gateway, Fruitful Rim, and Basin and Range	0.035	0.057	0.62	0.537	-0.044	0.031	-1.39	0.166
All Regions	0.054	0.031	1.78	0.076	-0.043	0.015	-2.91	0.004

This evidence leads to the conclusion that labor on cash grain farms, including corn, might be best represented in the farm household model by a translog or quadratic production function. For cash grains excluding corn, we repeatedly found evidence that the substitution relationship is unitary. This group may lead the researcher to utilize a more stringent functional form, like the Cobb-Douglass production function, and ignore the effects of time. Alternatively,

the researcher may choose a more flexible, yet computationally burdensome, approach like the translog production function that allows for a unitary elasticity of substitution and controls for time. Further, when controlling for farm size, our results found no evidence for rejecting Hicks-neutrality with respect to farm labor in either of our cash grain groups. Due to the variability in elasticity of substitution, a translog or quadratic functional form might be the most appropriate representation of the farm labor in the farm household model when controlling for farm size.

Conclusions

This study addresses the issue of labor substitutability from two perspectives. First, if the farm household can benefit from either the operator or spouse devoting time to off-farm work then how easily can they be replaced on the farm? Second, if the forgoing assumption in the literature is correct, then hired and family labor are perfectly substitutable and can be replaced without additional costs. Our results provide further insights into these questions and reflect the inherent difficulties in replacing family labor on the farm.

Addressing the assumption of perfect substitution, this study compliments the literature by both addressing some of the weaknesses of prior research and re-affirming the results through alternative methods. The particular weaknesses addressed were data quality and the imposition of *a priori* relationships between farm labor imposed by functional forms. This research allowed the data to reveal the underlying true nature of labor substitutability with minimal assumptions. The results largely indicate that the assumption of perfect substitutability between hired and family labor is weak in most cases. Prior studies provided evidence of this relationship being unitary but did address the impacts of farm size, region, and farm type. Our results largely support the prior literature when addressing the question from a regional perspective. However,

we provide new insights and gain greater knowledge of situations where assuming perfect substitutability is more suitable by controlling for farm size.

From the perspective of labor allocation, it appears less plausible that farm operators and spouses can seamlessly allocate labor off-farm while hired hands fulfill their duties on-farm. This appears true for all but the operators and spouses of very large farms. An interesting question then is how off-farm labor has become the primary source of income for farm families. It is possible that the availability of inexpensive, immigrant labor has allowed the farmer to work off-farm with little impact on production in previous periods. Perhaps the wages paid to immigrant labor have either increased to that of native workers in recent periods or have simply gone unreported. In either case, the data from 2006 to 2008 does not reflect a situation where farm families can freely allocate labor off-farm.

The issue of labor substitutability also extends beyond off-farm labor allocation. With the aging of the farm population, it will become ever more important for operators to decrease their responsibilities on the farm without negatively impacting the operation. Future changes may stem from new technologies like real-time kinematic autosteer. These technologies decrease the specialized knowledge needed to operate farm machinery and allow the farm operator to track the exact movements of machinery in the field. As the cost to adoption declines, this may allow farm operators to increasingly hire labor to fulfill their responsibilities without detriment to production.

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CHAPTER 4: WORKING OFF-FARM: JOINT DECISIONS OF THE OPERATOR AND SPOUSE

Introduction

There are four well documented trends occurring nationally and in U.S. agriculture. First, the increasing presence of diabetes, obesity, and heart disease have contributed to declining levels of national health and increased the need for healthcare. Second, the cost of health insurance has risen dramatically over recent decades. Third, off-farm labor has increasingly become the primary source of income for farm households. Finally, there has been a significant "aging" of the farm population. At the convergence of these trends lies the issue of how the off-farm labor decisions of farm operators and spouses are affected by the increasing needs and costs of health insurance.

The high cost of health insurance and the burden placed on businesses in all sectors of the economy to provide these benefits to their employees has been well publicized by the media. The high risk and financial stress inherent in the farm business makes it increasingly important to address the impact on the farm household. The farm family is faced with the choice of assuming the greater financial risk necessary to fund their health insurance benefits or have at least one member of the family work off-farm to obtain these benefits from an outside employer. In essence, working off-farm for fringe benefits decreases the financial stress placed on the farm. If you consider that fringe benefits and hourly labor wages account for the total wage earned off-farm, the results of Mishra and Goodwin (1997) support the notion of a positive relationship between income stability and off-farm labor.

A 2004 survey conducted by the Economic Research Service asked farm operators and spouses the most important factor in their decisions to work off-farm. The most important reason was increasing household income. Obtaining health insurance was also listed as an important

reason for particularly the spouse allocating labor off-farm (USDA 2005). Further consider that approximately 98% of all domestic farms are family owned and off-farm income accounts for approximately 80% of total household earnings (USDA 2010 and Mishra et al. 2002; El-Osta, Mishra, and Morehart 2008). It is clear that off-farm income is not transitional but rather the primary source of income (Ahearn, El-Osta, and Dewbre 1992).

Another subtly related issue is the debate surrounding the next Farm Bill. There have been rumors of removing decoupled payments due to budgetary pressures. In most studies of the impact of decoupled payments on farm household labor allocation, the role of fringe benefits is ignored. As insurance costs continue to rise and changes in the nature of farm payments become increasingly likely, fringe benefits will continue to grow in importance as a component of the total wage and be even more vital to consider when evaluating the effects of agricultural policy. As will be further discussed, omitting fringe benefits from the full wage will result in the farm household's welfare lost being underestimated when decoupled payments are reduced.

Rather than address the decision to participate in off-farm labor, we choose to focus on the hours of labor supplied off-farm. Specifically, we model labor allocation as a joint decision in the farm household and determine the impact of health insurance coverage from off-farm sources. We further contribute to the literature by utilizing copulas to empirically test for joint decision-making between the operator and spouse prior to estimating the labor supply model. This improves our analysis in multiple ways. First, the results of the copula test are used to guide model selection. Prior literature verifies the accuracy of the jointness assumption post-estimation. Second, we find that insurance coverage for the operator and spouse is endogenous. Knowledge of the jointness in our data allows us to confidently estimate the predicted values of

these values using a bivariate probit model. These predicted values can then be incorporated into the joint estimated labor supply equations.

Following from the results of the copula test and auxiliary bivariate probit regression, we estimate the off-farm labor supply of the operator and spouse using a bivariate tobit model. The data used in this research is from 2006-2008 Agricultural Resource Management Survey (ARMS). Most notably, the results of this study demonstrate that the off-farm labor supply of the operator and spouse are positively correlated and that there is a highly significant, positive impact of off-farm insurance coverage on the hours worked off-farm. These results further demonstrate the importance of fringe benefits as a component of the total wage. We also find significant evidence that greater government payments decrease the number of hours that both the operator and spouse work off-farm.

Literature Review

During the past three decades, self-employed farm households have engaged in dual employment where married farm couples (operators and spouses) allocate their labor to farm work and off-farm work. Dual employment has provided a critical income source to a majority of self-employed farm households not only in the US and Western European countries but also in developing countries (e.g., Benjamin, Corsi, and Guyomard, 1996; Mishra et al. 2002; Ahearn, El-Osta & Dewbre, 2006; Benjamin and Kimhi, 2006; El-Osta, Mishra and Morehart, 2008; Glauben et al. 2008). Economists have investigated issues, including public policy, education, and wealth, that impact labor allocation decisions in dual employment for self-employed farm couples.

Most dual employment studies use a theoretical model that posits jointness by married farm couples in the decision to participate in off-farm work. In each of these studies researchers begin

by implementing a theoretical household model where the labor allocation decision is jointly determined. Researchers then use post-estimation methods following probit/tobit models to test for jointness in the decision model. Dependence is measured by a correlation parameter (*rho*) between the error terms of two simultaneous off-farm labor supply functions, either Tobit or probit, of farm operators and spouses. Hypothesis testing of whether *rho* is significantly different from zero then follows the estimation.

The empirical evidence of dependence in these studies is inconclusive. [1] For example, although Lass, Findeis, and Hallberg (1989), Lass and Gempesaw (1992), Mishra and Goodwin (1997), El-Osta, Mishra and Ahearn (2004), and El-Osta, Mishra and Morehart (2008) use a theoretical model that jointly determines labor allocation decision, none of the empirical testing and evaluation of the models demonstrates evidence of joint labor decision-making in U.S farm households. Further, this method assesses the appropriateness of the empirical model for the theory *post hoc*. In these studies, testing the dependence between operator and spouse labor decisions has been approached more from the perspective of testing "goodness of fit" rather than as a useful tool for guiding model selection.

Copulas provide a consistent procedure for testing dependence and guiding the choice of empirical model. Copulas are functions that parameterize the dependence between univariate marginal distribution functions to form a joint distribution function (Quinn, 2007). Copulas can be used to measure the dependence between the off-farm labor supply by married farm couples by assembling a joint distribution for household labor allocation decisions from the respective marginal distributions of the hours worked off-farm by the operator and spouse. Another benefit is flexibility in the distributional assumptions of both marginal distributions and copula function.

This method allows us to move past the issue of whether to model jointness as a guided choice and instead formulated a tested modeling decision. The work of Ahearn, El-Osta, and Dewbre (2006) provides an excellent point of reference for the current research and helps motivate further the value of this test. The authors dedicate considerable time and discussion to the motivation of their decision to model off-farm labor participation of the operator and spouse jointly. The current research aims to build upon their findings with regards to the off-farm labor participation decision of the operator and spouse. This research found that the formulation of government payments was less relevant to the off-farm labor participation decision of the operator and spouse than the amount of payments. They found that government payments have a negative impact on the off-farm labor participation of the farm operator and spouse. Similarly, the results of Chang and Mishra (2008) further demonstrate the negative relationship between government payments and off-farm labor participation. In addition to focusing on the labor supply rather than participation decision, we also build upon this research investigating the role of fringe benefits.

Fringe benefits can be viewed as a component of off-farm wage. According to Findeis (2002), as off-farm wages increase labor is pulled "off" the farm and into the off-farm labor market, whereby the expected result is more off-farm work and less self-employment to the extent that the marginal returns to off-farm work exceed the marginal returns to self-employment. Jensen and Salant (1985) demonstrated fringe benefits have a positive correlation with the hours farmers are employed off the farm. These studies demonstrate the parallel between off-farm wages and fringe benefits, as well as the common effect they have on hours worked off-farm.

Including fringe benefits in full off-farm wage can have significant implications on the welfare analysis of the farm household following policy changes. A brief example from an aggregate level can be found in Figure 5. The market demand curves for leisure and farm labor is illustrated in the left-hand graph, while the market supply curve for off-farm labor is represented on the right-hand side.
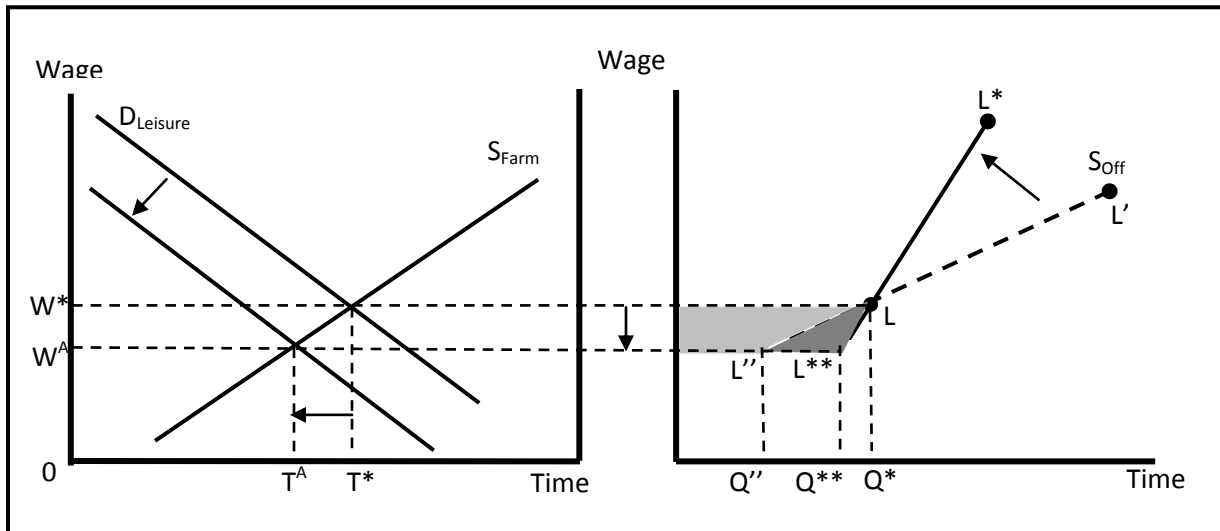

Figure 5: Effect of Decoupled Government Payments, including Fringe Benefits, on the Market Model for Farm Labor, Leisure and Off-Farm Labor

From the market supply and demand curves, the welfare effects of changes in decoupled government payments and fringe benefits can be visualized. In Figure 5, an decrease in decoupled government payments shifts the demand curve for leisure downward. As a result, the reservation wage falls from W^* to W^A, a less time is supplied to farm labor (T^* to T^A), and fewer hours of leisure is demanded. This decreased demand for leisure and related decrease in reservation wage implies that farmer will devote the same amount of time to off-farm labor even at a lower off-farm wages such that the new reservation wage is exceeded. This causes the off-farm labor supply curve, excluding fringe benefits, to increase in length from ($L \rightarrow L'$) to ($L'' \rightarrow L'$). The off-farm labor supply curve, including fringe benefits, increases in length from

(L→L*) to (L**→L*). The dark gray triangle represents the increased welfare lost association with a decline in government payments when fringe benefits are considered. Note that this representation does not indicate whether the hours of off-farm labor will change or in which direction, it only demonstrates a change in the reservation wage and therefore the length of the supply function on which the operator and spouse will work.

The most important implication for this brief welfare discussion is the importance of these considerations in policy analysis. With the current debate about the Farm Bill and coming changes in healthcare coverage, understanding how these pieces fit together and ultimately impact the farm household is crucial. The following section outlines a more rigorous examination of the farm household while addressing the consequences of joint decision-making and inclusion of fringe benefits in the theoretical model.

Theoretical Model

The following theoretical model of the farm household model illustrates the dependence between the off-farm labor allocation decision of the operator and spouse (Ahearn, El-Osta, and Dewbre 2006; Singh, Squire, and Strauss 1986). The farm household follows a utility maximization framework where it's assumed that the farm operator (O) and spouse (S) comprise the farm household and utility (U) is a function of leisure ($L_{ei}(L_F, L_O)$) and income ($I(L_F, L_O)$). Both farm household income and the time devoted to leisure are a function of the time devoted to farm labor (L_F) and off-farm labor (L_O).

$$Max\ U = U(L_{ei}^o(L_F^o, L_O^o), L_{ei}^s(L_F^s, L_O^s), I(L_F, L_O)) \tag{1}$$

$$s.t.$$

$$L_{ei}^o + L_F^o + L_O^o(L_O^s) - T = 0 \tag{2}$$

$$L_{ei}^s + L_F^s + L_O^s(L_O^o) - T = 0 \tag{3}$$

$$w^o_{Off} L^o_O(L^s_O) + w^s_{Off} L^s_O(L^o_O) + \pi_F + V - I = 0 \tag{4}$$

$$L^o_{ei}, L^o_F, L^o_O(L^s_O) \geq 0 \qquad L^s_{ei}, L^s_F, L^s_O(L^o_O) \geq 0 \tag{5}$$

Utility maximization in equation (1) is subject to the total available hours (T) allocable to leisure

(L_{ei}), farm labor (L_F), and off-farm labor (L_O) of the operator (equation 2) and spouse (equation

3), the full income constraint (equation 4), and non-negativity constraints (equations 5). Notice

that L^o_O is a function of the off-farm hours worked by the spouse (L^s_O). This allows for jointness

in off-farm labor allocation decisions. The full income constraint is defined as the sum of income

from the operator's off-farm labor ($w^o_{Off} L^o_O(L^s_O)$), spouse's off-farm labor ($w^s_{Off} L^s_O(L^o_O)$), farm

profits (π_F), and other household non-labor income (V) minus the total income (I). Farm profits

are further defined as the value of farm production minus the input costs. Specifically,

$$\pi_F = P_f f\left(L^o_F, L^s_F, X_f\right) - vX_f \tag{6}$$

The Lagrangian ($\mathcal{L}$) can be constructed for the outlined maximization problem with the

following first order conditions for off-farm labor:

$$U(L^o_{ei}(L^o_F, L^o_O), L^s_{ei}(L^s_F, L^s_O), I(L_F, L_O)) \tag{7}$$

$$+ \delta(w^o_{Off} L^o_O(L^s_O) + w^s_{Off} L^s_O(L^o_O) + \pi_F + V - P_y Y)$$

$$+ \lambda_1(L^o_{ei} + L^o_F + L^o_O(L^s_O) - T)$$

$$+ \lambda_2(L^s_{ei} + L^s_F + L^s_O(L^o_O) - T)$$

$$\frac{\partial \mathcal{L}}{\partial L^o_O} \Longrightarrow MRS^o_{L_{ei},I} - w^o_{Off} = \left(\frac{\partial L^s_O}{\partial L^o_O}\right)\{w^s_{Off} - MRS^s_{L_{ei},I}\} \tag{8}$$

$$\frac{\partial \mathcal{L}}{\partial L^s_O} \Longrightarrow MRS^s_{L_{ei},I} - w^s_{Off} = \left(\frac{\partial L^o_O}{\partial L^s_O}\right)\{w^o_{Off} - MRS^o_{L_{ei},I}\} \tag{9}$$

Per the cross-partial derivative in equations (8) and (9) if the off-farm labor allocation

decision of the spouse is independent of the operator, then $\frac{\partial L^s_O}{\partial L^o_O} = \frac{\partial L^o_O}{\partial L^s_O} = 0$. For the operator, this

implies that utility is maximized where the marginal rate of substitution ($MRS^o_{L_{ei},I}$) between

leisure and income is exactly equal to the off-farm wage. This is the representation of off-farm

labor allocation often assumed. According to Ahearn, El-Osta, and Dewbre (2006), there is

conflicting empirical evidence supporting the validity of this dependence. A method of testing

this dependence prior will be proposed in the following section.

Further consider the concept of the full wage. This implies that the off-farm wage is a

function of both the hourly wage (w) and fringe benefits (f_b); therefore, w_{Off}^o and w_{Off}^s can be

further defined $\overline{w}_{Off}^o(w_{Off}^o, f_b)$ and $\overline{w}_{Off}^s(w_{Off}^s, f_b)$. By rearranging the first order conditions in

equations (8) and (9) and including our newly defined terms for off-farm wage, we can see more

clearly the impact of health insurance on the off-farm labor allocation decisions of farm families.

$$\frac{\partial \mathcal{L}}{\partial L_O^o} \Longrightarrow MRS_{L_{ei},I}^o + \left(\frac{\partial L_O^s}{\partial L_O^o}\right) MRS_{L_{ei},I}^s = \overline{w}_{Off}^o(w_{Off}^o, f_b) + \left(\frac{\partial L_O^s}{\partial L_O^o}\right) \overline{w}_{Off}^s(w_{Off}^s, f_b) \qquad (10)$$

$$\frac{\partial \mathcal{L}}{\partial L_O^s} \Longrightarrow MRS_{L_{ei},I}^s + \left(\frac{\partial L_O^o}{\partial L_O^s}\right) MRS_{L_{ei},I}^o = \overline{w}_{Off}^s(w_{Off}^s, f_b) + \left(\frac{\partial L_O^o}{\partial L_O^s}\right) \overline{w}_{Off}^o(w_{Off}^o, f_b) \qquad (11)$$

The total wage is non-decreasing in w_{Off}^o, w_{Off}^s, and f_b holding all else constant. For example,

an increase in health insurance benefits received off-farm will increase f_b. In equation 11, an

increase in f_b will result in an increase in $\overline{w}_{Off}^s(w_{Off}^s, f_b)$ and if labor decisions are made jointly

$\left(\frac{\partial L_O^o}{\partial L_O^s}\right) \overline{w}_{Off}^o(w_{Off}^o, f_b)$ will increase or decrease depending on the direction of dependence. Our

expectations for changes in off-farm labor supply will also depend on the relative magnitudes of

the marginal effects. For example, if $\left(\frac{\partial L_O^o}{\partial L_O^s}\right) < 0$ then a change in fringe benefits can have the

following effects:

$$\frac{\partial\left[\overline{w}_{Off}^s(w_{Off}^s, f_b)\right]}{\partial f_b} > \left(\frac{\partial L_O^o}{\partial L_O^s}\right)\frac{\partial\left[\overline{w}_{Off}^o(w_{Off}^o, f_b)\right]}{\partial f_b} \rightarrow MRS_{L_{ei},I}^s > \left(\frac{\partial L_O^o}{\partial L_O^s}\right) MRS_{L_{ei},I}^o \qquad (12)$$

$$\frac{\partial\left[\overline{w}_{Off}^s(w_{Off}^s, f_b)\right]}{\partial f_b} < \left(\frac{\partial L_O^o}{\partial L_O^s}\right)\frac{\partial\left[\overline{w}_{Off}^o(w_{Off}^o, f_b)\right]}{\partial f_b} \rightarrow MRS_{L_{ei},I}^s < \left(\frac{\partial L_O^o}{\partial L_O^s}\right) MRS_{L_{ei},I}^o \qquad (13)$$

$$\frac{\partial\left[\bar{w}_{Off}^s\left(w_{Off}^s, f_b\right)\right]}{\partial f_b} = \left(\frac{\partial L_O^o}{\partial L_O^s}\right)\frac{\partial\left[\bar{w}_{Off}^o\left(w_{Off}^o, f_b\right)\right]}{\partial f_b} \rightarrow MRS_{L_{ei},I}^s = \left(\frac{\partial L_O^o}{\partial L_O^s}\right)MRS_{L_{ei},I}^o \qquad (14)$$

According to (12), an increase in health insurance will increase the total off-farm wage earned by the spouse by a greater amount than the dependence weighted increase of the operator. This will result in a greater marginal rate of substitution of leisure for income for the spouse and therefore greater hours worked off-farm. Conversely, equation (13) describes a situation where an increase in health insurance impacts the operator's off-farm wage by a greater amount than the spouse. This results in the spouse substituting fewer hours of leisure for income and working fewer hours off the farm. Equation (14) demonstrates equally offsetting results from increased health insurance and no effect on the off-farm labor supply of the spouse.

More simply, if $\left(\frac{\partial L_O^o}{\partial L_O^s}\right) > 0$ then an increase in health insurance will increase fringe benefits and thereby increase the total off-farm wage earned by the spouse. This results in an increase in the right hand side of the equality in equation (11) which then implies greater substitution of leisure for income and greater hours worked off-farm. It's important to note that the discussed changes in fringe benefits under joint labor decisions will alter the off-farm labor supply of both the operator and spouse. The discussion was limited only to the changes in off-farm hours of the spouse for brevity and clarity.

Data

This research utilizes Agricultural Resource Management Survey (ARMS) data from 2006 to 2008. The ARMS is conducted annually by the Economic Research Service and the National Agricultural Statistics Service (for more detail, see http://www.ers.usda.gov/Briefing/ARMS/). The survey collects data to measure the financial condition (farm income, expenses, assets, and debts) and operating characteristics of farm businesses, the cost of producing agricultural

commodities, and the well-being of farm operator households. The target population of the survey is operators associated with farm businesses representing agricultural production in the 48 contiguous states. Data is collected from a single, senior farm operator, who makes most of the day-to-day management decisions. Also collected was wage data from the Bureau of Labor Statistic (2011). By state and year, we calculate the weighted average wage earned from off-farm work. The weight used is the portion of the state population employed in each sector.

The list of variables, with summary statistics, used in our labor supply model can be found in Table 10. We limited our study to farm households where either the farm operator or spouse is under the age of 65. This excludes all households that are fully covered by Medicare. We also exclude all households that did not respond to hours worked off-farm or reported hours per week worked on or off-farm greater than 140. This applies to farms that reported 140 worked at either location separately or additively. In other words, any operator or spouse responding that they on average sleep fewer than four hours per night is assumed to have incorrectly completed the survey and are dropped.

The dependent variables in our bivariate tobit equations are the hours per week worked off-farm by the operator and spouse, respectively. For each equation, we include explanatory variables for age, age squared, education, household size, distance from the off-farm job, off-farm wage, and whether they obtain health insurance from an off-farm source. The specific survey question asks respondents under the age of 65 whether they have insurance coverage from an off-farm job. 21% of the operators in our sample report that they are covered by an off-farm job. As expected, more spouses (30%) reported that they received insurance coverage from an off-farm source.

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Table 10: Summary Statistics

Variables	Description	Mean	Std Dev
Operator Off-farm Hours	Off-Farm hours per week	13.99	(20.14)
Spouse Off-farm Hours	Off-Farm hours per week	22.58	(19.59)
Operator Age	Age in years	51.74	(9.61)
Spouse Age	Age in years	49.34	(9.15)
Operator Education	Total years of education	13.62	(1.85)
Spouse Education	Total years of education	13.94	(1.91)
Operator Miles from Job	Miles from off-farm job	5.79	(29.64)
Spouse Miles from Job	Miles from off-farm job	9.96	(97.84)
Operator Insurance	1 if the operator has health insurance through off-farm work; 0 Otherwise	0.21	(0.41)
Spouse Insurance	1 if the spouse has health insurance through off-farm work; 0 Otherwise	0.30	(0.46)
Off Farm Wage	Hourly wage	21.11	(1.80)
Government Payments	Annual payments in $1,000	20.67	(50.80)
Sales	Total value of farm sales in $1,000	370.42	(2423.67)
Household Size	Number of members of household	3.17	(1.43)
Metro/Non-Metro	1 if the farm is located in 2000 Population Census metro area; 0 Otherwise	0.38	(0.49)
Dairy	1 if the farm specializes in dairy farming; 0 Otherwise	0.12	(0.32)
Heartland	1 if farm located in the Heartland region; 0 Otherwise	0.17	(0.38)
Northern Crescent	1 if farm located in the Northern Crescent region; 0 Otherwise	0.16	(0.37)
Northern Great Plains	1 if farm located in the Northern Great Plains region; 0 Otherwise	0.06	(0.24)
Prairie Gateway	1 if farm located in the Prairie Gateway region; 0 Otherwise	0.11	(0.31)
Eastern Upland	1 if farm located in the Easter Upland region; 0 Otherwise	0.10	(0.30)
Southern Seaboard	1 if farm located in the Southern Seaboard region; 0 Otherwise	0.14	(0.34)
Fruitful Rim	1 if farm located in the Fruitful Rim region; 0 Otherwise	0.16	(0.37)
Basin and Range	1 if farm located in the Basin and Range region; 0 Otherwise	0.05	(0.22)
Mississippi Portal	1 if farm located in the Mississippi Portal region; 0 Otherwise	0.05	(0.22)
y2006	1 if data from year 2006; 0 Otherwise	0.35	(0.48)
y2007	1 if data from year 2007; 0 Otherwise	0.34	(0.47)
y2008	1 if data from year 2008; 0 Otherwise	0.32	(0.47)

As will be determined in the following section, we suspect that off-farm insurance coverage is jointly determined with the hours worked off-farm. Individuals working greater hours off-farm are more like to receive health insurance benefits and off-farm benefits are not likely to be received until a certain number of hours are accrued each week. If the operator insurance and spouse insurance variables are found endogenous, then we will estimate the predicted probability of insurance coverage and include these estimates as explanatory variables in our labor supply equation.

In addition to operator and spouse specific variables, we use farm, location, and time specific variables as explanatory variables. Farm specific, we include variables for total government payments, total farm sales, and an indicator variable for dairy farms. Dairy farms were specified due to the labor intensive nature of these farms. Location specific variables include an indicator for metro/non-metro location and ERS Resource Region (Figure 6). For the ERS Resource regions, the Mississippi Portal is used as the reference region in our study. Because we utilize a pooled sample, indicator variables for year are included. The reference year in this research is 2006.

The ARMS has a complex stratified, multiframe design where observation in the ARMS represents a number of similar farms when using the provided expansion factors. The expansion factors are most useful and recommended when the goal of the research is making generalizations about the population of farms or the full survey is used. The recommended procedure in this scenario is the delete-a-group jackknife procedure (Dubman 2000; National Research Council of the National Academies 2007). There is not clear or unanimous support for using the jackknife approach when using subsets of the data or complex, multivariate analyses. Goodwin and Mishra (2006) argue that it is not clear whether stratification alters the likelihood

function beyond the simple weights and whether it is appropriate to apply the predefined

jackknife replicate weights to subsamples of the ARMS data. Similar to El-Osta (2011), we

employ a bootstrapping technique rather than the jackknife procedure for remedying the sample
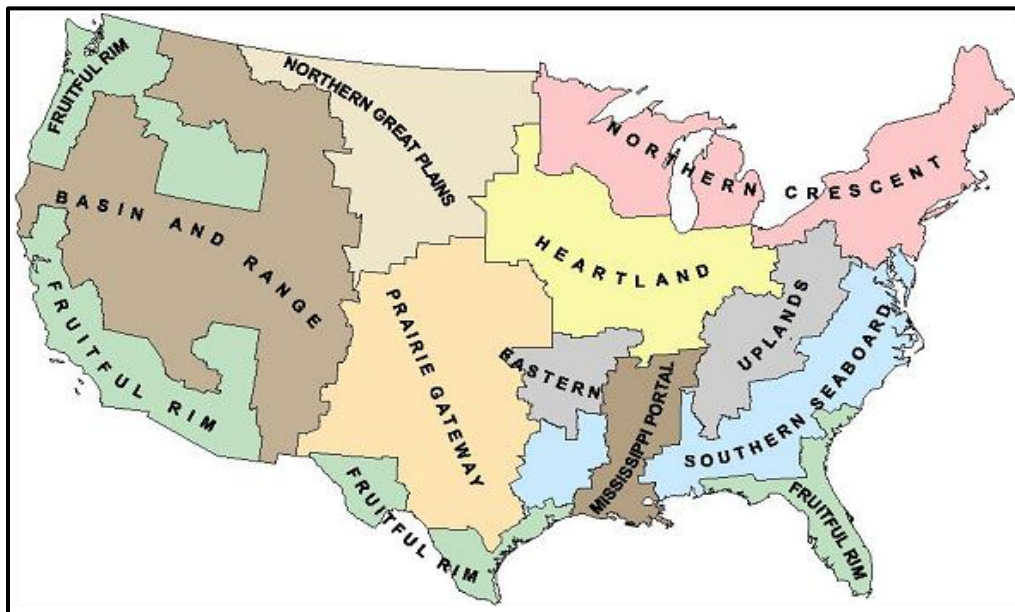
design problems in this subsample.

Figure 6: ERS Resource Regions

Empirical Methods

Copulas[6] can be used to test whether $\frac{\partial L_O^s}{\partial L_O^o}$ and $\frac{\partial L_O^o}{\partial L_O^s}$ are significantly different from zero

and determine whether there is positive or negative dependence. Copulas allow us to assemble a

joint distribution for household labor allocation decisions from the marginal distributions of the

hours worked off-farm by the operator and spouse. In this context, the test of $\frac{\partial L_O^s}{\partial L_O^o} = \frac{\partial L_O^o}{\partial L_O^s} \neq 0$ can

be viewed as whether the joint distribution is significantly different than the product of the

marginal distributions for the farm operator and spouse off-farm work hours.

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[6] This application of copulas is reproduced from a manuscript in press in *Applied Economic Letters.* See Appendix
for authorization from the publisher, Taylor & Francis Group.

An m-dimensional copula (C) connects an m-dimensional cumulative distribution function (F) to the one-dimensional marginals ($F_1,....,F_m$) such that

$$F(y_1, \ldots, y_m) = C(F_1(y_1), \ldots, F_m(y_m)) \tag{15}$$

where y represents the variables of interest. Specifically, a two dimensional copula using off-farm labor allocation of the operator (y_1) and spouse (y_2) is presented as

$$F(y_1, y_2) = C(F_1(y_1), F_2(y_2); \theta) \tag{16}$$

and includes a dependence parameter (θ). This parameter measures the dependence between the marginal distributions. If $\theta=0$, then the marginal distributions are statistically independent. Some copula functions reduce directly to the product copula in the case where the joint probability distribution is the product of the marginal distributions. If θ is significantly different than zero, then we can use the information to guide our model selection decisions for estimating functions of off-farm labor supply by farm households. Both copula functions and the respective marginal distributions are fit to the data via maximum likelihood estimation. The log likelihood function takes the following form:

$$\mathcal{L}(\theta) = \sum_{i=1}^{n} \log C \ (F_1(y_{i1}), F_2(y_{i2}); \ \theta) + \sum_{i=1}^{n} \sum_{j=1}^{p} \log f_i(y_{ij}) \tag{17}$$

An important advantage of copulas in this regard is flexibility in distributional assumptions. The marginal distributions can be chosen independently of each other. Additionally, the copula function can be chosen independently of the marginal distributions. We chose to specify the marginal distributions for operator and spouse off-farm labor as normally distributed. Aside from the large number of observations at zero hours worked off-farm, the histograms for both the operator and spouse appeared normal. Other trials were performed with more flexible distributions, but none offered significant benefits above the normal distribution.

We provide results for two functional forms of the copula. First, the Frank copula is a symmetric copula function permitting both positive and negative dependence.

$$C_F(u_1, u_2,; \theta) = \theta^{-1} \log\{1 + (e^{-\theta u_1} - 1)(e^{-\theta u_2} - 1)/(e^{-\theta} - 1)\} \tag{18}$$

The marginal distributions are represented by u_1 and u_2 in equation (18). This function permits $\theta \subset (-\infty, \infty)$ where the Frechet lower and upper bounds are defined at these limits. The dependence parameter is reported in our results as the Kendall's tau (ρ_F), which is defined as

$$\rho_t = 1 - \frac{4}{\theta}[1 - D_1(\theta)] \tag{19}$$

and $D_1(\theta)$ is the Debye function

$$D_1(\theta) = \frac{1}{\theta} \int_0^\theta \frac{t}{(e^t - 1)} dt \tag{20}$$

where $\rho_t \subset (-1, 1)$ thereby implying perfect negative and perfect positive correlation as the dependence parameter approaches the Frechet lower and upper bounds.

The Clayton copula is also used in this research. Unlike the Frank copula, the Clayton is not symmetric. Only positive dependence is permitted by the Clayton copula; therefore, the dependence parameter $\theta \subset (0, \infty)$. At zero, the marginal distributions are statistically independent. The Frechet upper bound is obtained at the upper limit. The Clayton copula is defined:

$$C_C(u_1, u_2,; \theta) = (u_1^{-\theta} + u_2^{-\theta} - 1)^{-1/\theta} \tag{21}$$

and our results for the dependence parameter (θ) are reported using the the Kendall's tau (ρ_C) where

$$\rho_C = \frac{\theta}{\theta + 2} \tag{22}$$

where $\rho_C \subset (0, 1)$ thereby implying zero correlation and perfect positive correlation.

Tables 11 and 12 present the estimates of dependence in dual employment using Frank and Clayton methods, respectively. First, we consider the results of the symmetric Frank Copula. We find evidence of a positive and highly significant relationship between off-farm labor supply of farm operators and spouses. The correlation measure for this trial is consistent and ranges from 0.23 in 2006 to 0.19 in 2008. Also, the pooled test of dependence is about 0.22. These estimates add to the confidence and power in using copulas to test for dependence. Finally, the dependence parameter estimates (column 3) are very consistent across the three surveys and pooled data as well. Findings from the Frank copula procedure guided our decision to use the Clayton copula to constrain the dependence parameter to $(0, \infty)$.

Table 11: Testing for Dependence between Hours Worked Off-farm by Operator and Spouse: Frank Copula Method

Frank Copula	Kendall's τ	Dependence Parameter	Standard Error
Pooled	0.2250	1.3844***	(0.0490)
2008	0.1896	1.1576***	(0.0858)
2007	0.2543	1.5760***	(0.0863)
2006	0.2280	1.4035***	(0.0827)

Table 12: Testing for Dependence between Hours Worked Off-farm by Operator and Spouse: Clayton Copula Method

Clayton Copula	Kendall's τ	Dependence Parameter	Standard Error
Pooled	0.2744	0.7563***	(0.0230)
2008	0.2317	0.6030***	(0.0385)
2007	0.3135	0.9135***	(0.0426)
2006	0.2737	0.7536***	(0.0383)

Results from the Clayton copula functional form are presented in Table 12 Again, as in Table 11, we find evidence of a positive and highly significant relationship between the off-farm labor supply of farm operators and spouses. Interestingly, the correlation increases in magnitude. For example, the correlation measure ranges from 0.27 in 2006 to 0.23 in 2008. Finally, the dependence parameter estimates (column 3) are very consistent across the four surveys and

pooled data as well. Interestingly, the parameter estimates are close to those obtained in the

Frank procedure (Table 11). Findings here suggest that an increase in operators' off-farm labor

supply increases spouses' off-farm labor supply. This may result from a variety of reasons but

measure of dependence does not provide any intuition as to why. What is does provide is

guidance in our modeling decision for addressing these questions. Now we choose to model the

determinants of off-farm labor supply of the farm operator and spouse using a bivariate tobit

model rather than independent tobit models.

A seemingly unrelated regression model can be adapted such that a tobit model can be

used rather than simple regression (Brown and Taylor 2008). Specifically,

$$Y_1^* = X_i \beta_i + \delta_O I_O + \varepsilon_1 \tag{23}$$

$$Y_1 = \begin{cases} Y_1^* & if \quad Y_1^* > 0 \\ 0 & Otherwise \end{cases} \tag{24}$$

$$Y_2^* = X_k \beta_k + \delta_S I_S + \varepsilon_2 \tag{25}$$

$$Y_2 = \begin{cases} Y_2^* & if \quad Y_2^* > 0 \\ 0 & Otherwise \end{cases} \tag{26}$$

Equations (23) and (24) represent off-farm labor supply equations for the operator and spouse.

Y_1^* and Y_2^* are the untruncated latent variables allowing for theoretically negative values

representing the hours worked off-farm by the operator and spouse, respectively. Y_1 and Y_2 are

the left censored dependent variable for off-farm hours worked by the operator and spouse.

Vectors of i and k explanatory variables (X_i and X_k) and parameters (β_i and β_k) are included in

the model. We denote separately the explanatory variable and parameters for insurance coverage

for the operator and spouse. The parameter value and explanatory variable for the operator is

represented by δ_O and I_O. Similarly, the parameter value and explanatory variable for the spouse

is denoted δ_S and I_S. The error terms are denoted ε_1 and ε_2. These disturbances are joint

normally distributed with variances σ_1^2 and σ_2^2 where $\varepsilon_1, \varepsilon_2 \sim N(0, 0, \sigma_1^2, \sigma_2^2, \rho)$ and the

covariance is given by $\sigma_{1,2} = \rho\sigma_1\sigma_2$. From the estimated parameter ρ we can verify post-

estimation the results of our copula test. If this parameter is non-zero, then joint estimation

results in greater efficiency and implies dependency between the dependent variables. The

results from this model are not directly interpretable as the marginal effect of the independent

variable on the dependent variable; therefore, we further calculate the marginal effects.

According to Greene (2008) the marginal effects in a bivariate tobit context can be calculated in

the same manner as a univariate model:

$$\frac{\partial E(Y)}{\partial X} = \Phi(X\beta/\sigma)\beta \tag{27}$$

where $\Phi(X\beta/\sigma)$ is the cumulative normal distribution function.

Our explanatory variables I_O and I_S are dummy variables representing whether the

operator or spouse obtains health insurance coverage from off-farm sources. We suspect that this

variable is determined jointly with the number of off-farm hours worked. The Smith-Blundell

test is used to test for endogeneity because the structural model is a tobit (Baum 1999). Under

this test, the null hypothesis states that all variables are exogenous. Under the alternative

hypothesis, the insurance coverage variable is expressed as a linear projection of a set of

instruments. The residuals from this first stage regression are added to the model. If the null is

not rejected, then these residuals have no explanatory power. For both the operator and spouse

equations the null hypothesis is rejected –with a *p-value*=8.0e-128 and *p-value*=3.1e-64,

respectively.

To address endogeneity of the health insurance variable in our model, we use the predicted

probability of insurance coverage for the operator and spouse. Recall the results of our copula

test that off-farm labor allocation decisions are made jointly; therefore, we will model the

predicted probability of insurance coverage jointly using the bivariate probit model. According to Greene (2008) and Ahearn, El-Osta, and Dewbre (2006):

$$y_1^* = \begin{cases} \beta_1'X_1 + \varepsilon_1 & if \ \ y_1 = 1 \\ 0 & if \ \ y_1 = 0 \end{cases} \tag{28}$$

$$y_2^* = \begin{cases} \beta_2'X_2 + \varepsilon_2 & if \ \ y_2 = 1 \\ 0 & if \ \ y_2 = 0 \end{cases} \tag{29}$$

$$E[\varepsilon_1|X_1, X_2] = E[\varepsilon_2|X_1, X_2] = 0 \tag{30}$$

$$var[\varepsilon_1|X_1, X_2] = var[\varepsilon_2|X_1, X_2] = 1 \tag{31}$$

$$E[\varepsilon_1, \varepsilon_2|X_1, X_2] = \theta \tag{32}$$

where y_1 and y_2 are binary variables indicating health insurance coverage from off-farm work for the operator and spouse, X_1 and X_2 are vectors of exogenous variables, β_1 and β_2 are vectors of estimated parameters, ε_1 and ε_2 are error terms, and θ is the coefficient of correlation between the error terms.

When specifying the equations in the bivariate probit model, there must be at least one variable that is highly correlated with the dependent variable in equations (28) and (29) but uncorrelated with the dependent variables in (23) and (25). The exogenous instruments used in these equations are a variable indicating personal expenditure on insurance, health, and retirement benefits and a variable indicating expenditure on fringe benefits for hired workers. The payment of fringe benefits to hired workers is expected to be negatively correlated with insurance coverage from off-farm work of the operator or spouse. If a farmer is going to pay for benefits to cover their workers, then they are more likely to cover themselves as well. Personal expenditure on insurance, health, and retirement benefits is indeterminate in sign. It can be argued that those expending personal funds on these benefits are less likely to be covered from other sources and therefore pay these expenses out of necessity. Conversely, it can be argued that

those paying for these expenses are more concerned about being fully insured and financially secure; therefore, they seek out off-farm employment providing these benefits as well.

Table 13: Results from Bivariate Probit Estimation for Predicted Value Insurance Coverage

Variable	Operator Coefficient (Std Error)	Spouse Coefficient (Std Error)
Age	0.0735***	0.0708***
	(0.0120)	(0.0119)
Age Squared	-0.0008***	-0.0008***
	(0.0001)	(0.0001)
Education	0.0714***	0.1411***
	(0.0077)	(0.0072)
Household Size	-0.0414***	-0.0747***
	(0.0114)	(0.0110)
Personal Insurance Policy	0.1736***	0.2188***
	(0.0293)	(0.0267)
Fringe Benefit to Hired Labor	-1.0846***	-0.3356***
	(0.0320)	(0.0260)
Constant	-2.8621***	-3.6140***
	(0.3175)	(0.2972)
N	11,262	
χ^2	2,118.71***	

In addition to these exogenous instruments, we regress operator and spouse insurance coverage on age, age squared, education, and household size. The results from this regression are found in Table 13. Notice the explanatory variables are all significant at 1%. We further test for instrument strength using a joint F-test for the operator and spouse equations. The F-test value for each equation was large and significant at 1%; therefore, we can reject the null that all parameters are jointly equal to zero and conclude that at least one of our instruments in each equation is not weak.

From these results, we calculate the predicted probability of the operator having health insurance from off-farm sources holding the spouse's equation constant and vice versa. These predicted values will then be used in our structural model outlined by equations (23) through (26). These equations can be rewritten with the predicted values notated $\hat{I}_O$ and $\hat{I}_S$ as:

$$Y_1^* = X_i\beta_i + \delta_O\hat{I}_O + \varepsilon_1 \tag{33}$$

$$Y_1 = \begin{cases} Y_1^* & if \quad Y_1^* > 0 \\ 0 & Otherwise \end{cases} \tag{34}$$

$$Y_2^* = X_k\beta_k + \delta_S\hat{I}_S + \varepsilon_2 \tag{35}$$

$$Y_2 = \begin{cases} Y_2^* & if \quad Y_2^* > 0 \\ 0 & Otherwise \end{cases} \tag{36}$$

This bivariate tobit model will be estimated via maximum likelihood. Due to the use of predicted values, standard errors were calculated using bootstrapping techniques. Following Cameron and Trivedi (2009), 500 iterations were used in our calculation of standard errors.

Estimation Results

Our results for the estimation of off-farm labor supply indicate a positive and highly significant relationship between the predicted probability of insurance coverage and the hours worked off-farm for both the operator and spouse (Tables 14 & 15). Recall the estimated dependence parameters from the copula tests were positive (Tables 11 and 12). The estimated dependence parameter from the bivariate tobit model servers as a post-estimation check figure. Our results indicated ρ is equal to 0.3704. This estimate is slightly higher than our copula results, but still within a reasonable proximity. Jointly considering the results of our dependence estimates and insurance coverage variables, our empirical results support the theory that greater fringe benefits will increase hours worked off the farm when $\left(\frac{\partial L_O^o}{\partial L_O^s}\right) > 0$. Surprisingly, the hourly wage earned off-farm was not significant in either equation. This finding does not invalidate numerous studies that have established this relationship, yet it does lend support to the relative importance of the fringe benefits component of the full off-farm wage.

Table 14: Results from Bivariate Tobit Estimation for Hours Worked Off-farm by Operator

Variables	Coefficient	Marginal Effects	Standard Error
Operator Age	-0.1799	-0.4936	(0.3229)
Operator Age Squared	-0.0015	-0.0021	(0.0032)
Operator Education	-0.2420	-0.8891	(0.2178)
Operator Miles from Job	0.2026***	0.0193	(0.0108)
Operator Insurance	108.1474***	83.6783	(3.2627)
Off Farm Wage	0.2178	1.2511	(0.2915)
Government Payments	-0.1531***	-0.0283	(0.0121)
Sales	-0.0010**	-0.0001	(0.0004)
Household Size	1.0018***	1.0427	(0.3210)
Metro/Non-Metro	0.9708	0.3636	(0.8467)
Dairy	-27.6412***	-4.3565	(1.7389)
Heartland	-0.7148	-0.1451	(2.1102)
Northern Crescent	3.7994*	0.7281	(2.2959)
Northern Great Plains	-1.5110	-0.1662	(2.4173)
Prairie Gateway	3.6410*	0.5457	(2.1794)
Eastern Upland	3.4081	0.5042	(2.1667)
Southern Seaboard	-3.6316*	-0.6294	(2.1607)
Fruitful Rim	2.0463	0.3769	(2.2711)
Basin and Range	0.0888	0.0090	(2.5539)
y2007	-2.9753***		(0.9746)
y2008	-3.9621***		(1.0480)
Constant	-16.6355*		(10.0375)
Sigma Operator	34.6483***		(0.4162)
Rho	0.3704***		(0.0214)
N	11,262		
χ^2	2,842.78***		

The demographic information on the operator and spouse had differential impacts. The operator, age, age squared, and education were all insignificant. Alternatively, the age of the spouse was found to increase the hours worked off-farm at a decreasing rate. Surprisingly, more educated spouses were found to work fewer hours off-farm. Aside from the unexpected sign, this is interesting considering spouses in the sample were found to be more highly educated than the operator on average (Table 10). Household size also had differential impacts on the hours worked off-farm by the operator and spouse. Larger households were positively correlated with

greater hours worked off-farm by the operator. Considering the documented relationship between

income stability and off-farm labor supply (Mishra and Goodwin 1997), this makes senses

considering operators will need a larger, more stable income to support larger families. Larger

households were found negatively correlated with the hours worked off-farm by the spouse. This

is likely due to the spouse being increasingly responsible for dedicating labor to household labor

rather than monetary wages as the household size grows.

Table 15: Results from Bivariate Tobit Estimation for Hours Worked Off-farm by Spouse

Variables	Coefficient	Marginal Effects	Standard Error
Spouse Age	0.8500***	2.264631	(0.2570)
Spouse Age Squared	-0.0110***	-0.0109	(0.0028)
Spouse Education	-0.6915***	-2.63409	(0.2469)
Spouse Miles from Job	0.0213***	0.001253	(0.0024)
Spouse Insurance	87.1231***	113.4051	(4.3200)
Off Farm Wage	-0.1183	-0.6808	(0.1967)
Government Payments	-0.0272***	-0.00501	(0.0058)
Sales	-0.0012***	-0.00013	(0.0002)
Household Size	-0.4879**	-0.51148	(0.2428)
Metro/Non-Metro	-1.7034***	-0.64733	(0.5770)
Dairy	-6.6748***	-1.0922	(0.9767)
Heartland	1.1450	0.227157	(1.3928)
Northern Crescent	-0.7660	-0.14923	(1.5238)
Northern Great Plains	-1.4808	-0.16374	(1.5944)
Prairie Gateway	-1.6964	-0.25571	(1.4488)
Eastern Upland	-1.9914	-0.28937	(1.4597)
Southern Seaboard	-0.8757	-0.15022	(1.4207)
Fruitful Rim	-3.4057**	-0.63741	(1.5104)
Basin and Range	-2.5794	-0.26432	(1.7094)
y2007	-1.4037**		(0.6595)
y2008	-0.6052		(0.7129)
Constant	-7.1355		(7.4901)
Sigma Spouse	26.4551***		(0.2440)
Rho	0.3704***		(0.0214)
N	11,262		
χ^2	2,842.78***		

In addition to operator and spouse characteristics, farm characteristics and location also have important effects on off-farm labor supply. We find for both the operator and spouse that dairy farmers work fewer hours off-farm. This result is expected due to the labor intensity of the dairy farms. A greater distance from the off-farm job was also found positively correlated with the number of hours worked off-farm by both operator and spouse. If you consider the mileage traveled to work a fixed cost to the employee, then greater travel distances required higher earnings to justify the trip. Therefore, the worker must work greater hours off-farm to increase earnings, all else constant. Location of the farm is also an important factor in determining off-farm labor supply. Farms classified as metro were found to have spouses allocating fewer hours to off-farm work. While location in a general sense has an impact on off-farm labor supply, limited evidence was found of a strong regional impact on off-farm labor supply. Dummy variables were included for year. Relative to 2006, both operators and spouse worked fewer hours off-farm in 2007 and operators only worked fewer hours off-farm in 2008.

Conclusion

This research contributes to the literature threefold. First, it provides a formal test and empirical evidence of jointness in the off-farm labor allocation decisions of operators and spouses. Second, it controls for endogeneity between off-farm hours and insurance coverage from an off-farm source. In calculating the predicted values, we further allow for jointness in the operator and spouse decision-making. Third, we demonstrate the strong positively relationship between the probability of insurance coverage and the number of hours worked off-farm by the operator and spouse. This result in conjunction with our theoretical model and evidence of jointness provide confident conclusions from these estimates.

The magnitude, direction, and significance of the insurance coverage and government payment variables tie back to our proposed link between changes in health care policy and the Farm Bill legislation. In this setting, significant decreases in decoupled payment can be expected to lead to greater hours worked off the farm by both operators and spouses. We can see clearly that insurance coverage is a substantial factor in their full off-farm wage; therefore, from a welfare perspective this must be accounted for when discussing the impacts of policy changes on the farm household. Otherwise, you possibly underestimate the degree to which welfare is lost by the farm household.

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CHAPTER 5: CONCLUSION

This dissertation provides new knowledge on the labor allocation of the farm family. The second and fourth chapter provides insights on the incentives to leave the agricultural sector. Specifically, the second chapter provides evidence of increased government payments increasing migration of agriculture from 1940 to 2007. A closer examination shows that this effect was dominate from 1940 until 1996 and weakened in the years following 1996. In fact, the link between increased government payments and labor migration disappeared completely in recent years. The fourth essay demonstrates the powerful impact of health insurance coverage. We find that both the operator and spouse work greater hours off-farm as the probability of health insurance coverage increases. We also find that as government payments increase, the hours worked off-farm decline significantly for both the operator and spouse.

The third chapter provides new knowledge on how replaceable operator and spouse labor are on the farm. If their labor can be freely replaced by hired workers, then the operator and spouse can more easily capitalize on opportunities off-farm. This is important when considering the role of both fringe benefits and government payments. First, the more highly substitutable is family labor the greater the net benefits accrued to the farm household by engaging in dual employment for insurance coverage. The farm can operate at the same level of efficiency from a unit of family or hired labor and the farm business escapes the financial burden imposed by providing full benefits. As substitutability declines, the tradeoff between the lost returns to the farm business from loss of family labor must be compared to the gains accrued from working off-farm. In which case, the expectations for labor allocation become less clear.

A similar result holds for government payments. Under homogenous farm labor, the prospect of farm households using decoupled government payments to subsidize greater hours of

leisure or off-farm work become increasingly probable. As substitutability declines, the cost to decreasing farm labor become greater and subsidized off-farm labor or leisure become less probable for the farm family.

Consider what these results may imply for the period of study prior to 1996. In Figure 7, the axes are represented by income (Y) and Time (T), where T=24 hours and is allocated to farm labor, off-farm labor, and leisure. An increase direct government payments will result in an upward shift in the household earnings curves ($Y_a \rightarrow Y_b$) and greater income results in a higher level of utility for the farm household ($U_1 \rightarrow U_2$). In this case, greater government payments lead to fewer hours worked on the farm and greater hours worked off-farm.

As discussed in the second chapter, this effect can be reasoned through multiple avenues. It can be assumed that all payments will behave in a similar manner to decoupled payments and that the relevant concern is only the magnitude of payments. Alternatively, the positive relationship between government payments and labor migration can be reasoned through the impact of Conservation Reserve or Commodity Buyout Program payments. In both cases, we will get an upward shift in the household earnings curves. In either case, this results in the hours devoted to farm labor decreasing from ($a + b$) to (a), and the hours devoted to off-farm labor to increase from ($c + d$) to ($b+c$) where ($b>d$). The hours devoted to leisure then increase from (d) to ($d + e$). A further consideration is the relative dominance of the income and substitution effects. As the income effect increases, the hours of leisure will increase relative to hours of total work.

Now consider the breakdown in the relationship between government payments and labor migration following 1996. Together with the evidence of heterogeneity of farm labor from the

third chapter, Figure 8 demonstrates that farm labor is less likely to adjust to a change in government payments.
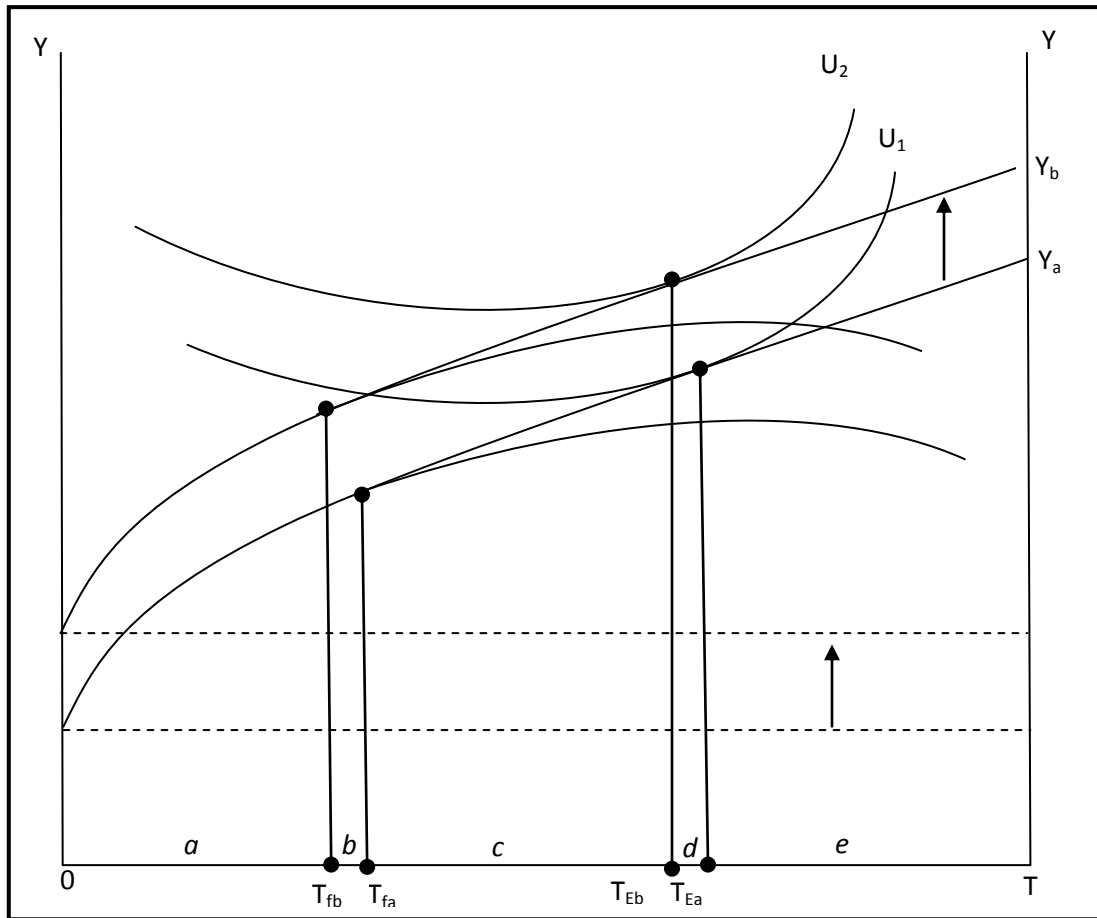

Figure 7: Effect of Decoupled Payments on the Time Allocation of Farm Family When Working Some Off-Farm (Pre-1996)

As a result of the increased payments, the hours of farm labor remains constant (*a*) in Figure 8. Whether hours worked off-farm increases/decreases rests on the whether the substitution effect outweighs the income effect. If the income effect is relatively stronger ($U_{2,a}$) then the hours of off-farm labor will decrease from (*b* + *c*) to (*b*). This will result in a decrease in total hours of labor and increased leisure from (*d* + *e*) to (*c* + *d* + *e*). If the substitution effect ($U_{2,b}$) is relatively stronger then off-farm labor will increase from (*b* + *c*) to (*b* + *c* + *d*). In this case, total hours of labor will increase and leisure will decrease from (*d* + *e*) to (*e*).
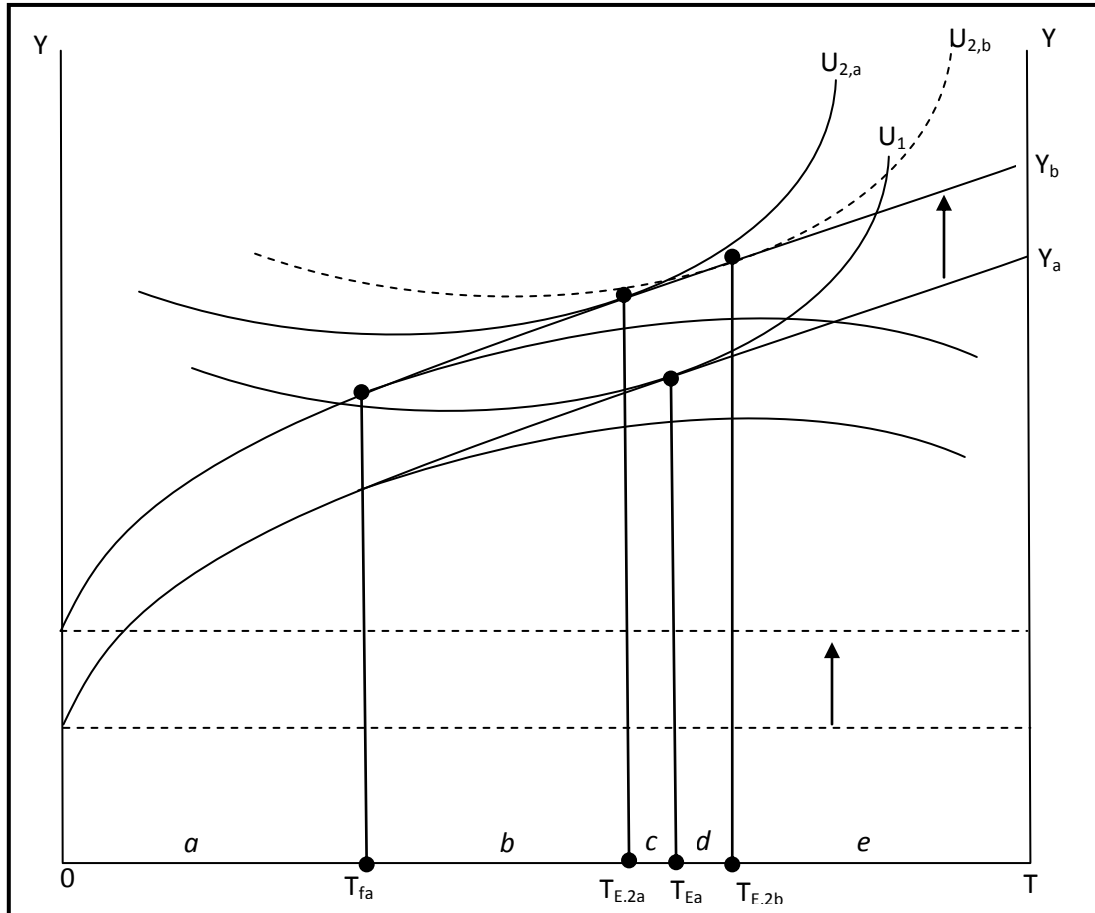
Figure 8: Effect of Decoupled Payments on Time Allocation of Farm Family When Working Some Off-Farm (post 1996)

Following 1996, this analysis indicates that an increase in government payments will influence the total number of hours worked through the impact on off-farm labor supply. In Figure 8, off-farm labor supply is dictated by whether the income or substitution effect is dominant. As payments become larger, the income effect will increasingly dominate as the farm household becomes wealthier. A more subtly factor that affects off-farm labor supply is the definition of the off-farm wage.

Figure 9 incorporates fringe benefits in this discussion of labor allocation of the farm household. Including fringe benefits in the off-farm wage will result in an increased slope of the linear portion of Y_a. This change results in a decrease in farm labor by (*b*). Off-farm labor

increase from (*c*) to (*b* + *c* + *d*) and leisure declines by (*d*). This result assumes a dominant
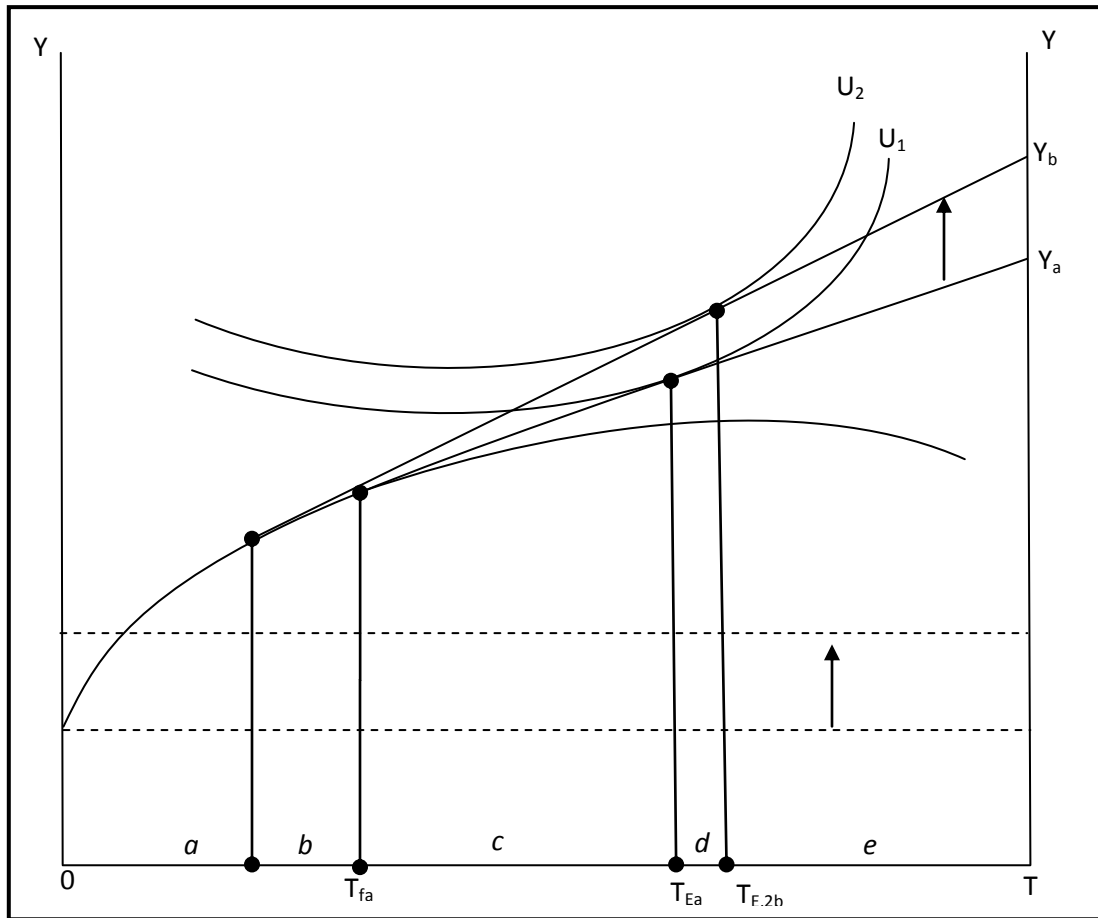
substitution effect.

Figure 9: Effect of Fringe Benefits on Time Allocation of Farm Family When Working
         Some Off-Farm (post 1996)

Figure 10 demonstrates the effect of increased decoupled payments on labor allocation

when considering the fringe benefits as a component of off-farm wage. If you compare Figures 8

and 10, you will notice that for an equal magnitude increase in government payments the change

in off-farm labor is smaller when fringe benefits are included in the off-farm wage. This reflects

a more inelastic off-farm labor supply curve. The fringe benefits earned off-farm are not

available from farm work; therefore, an increase in payments will not induce the farm household

to reduce off-farm labor beyond the hours required to obtain these benefits. Again, the change in

off-farm labor will be dependent on the relative magnitude of the income and substitution effects.
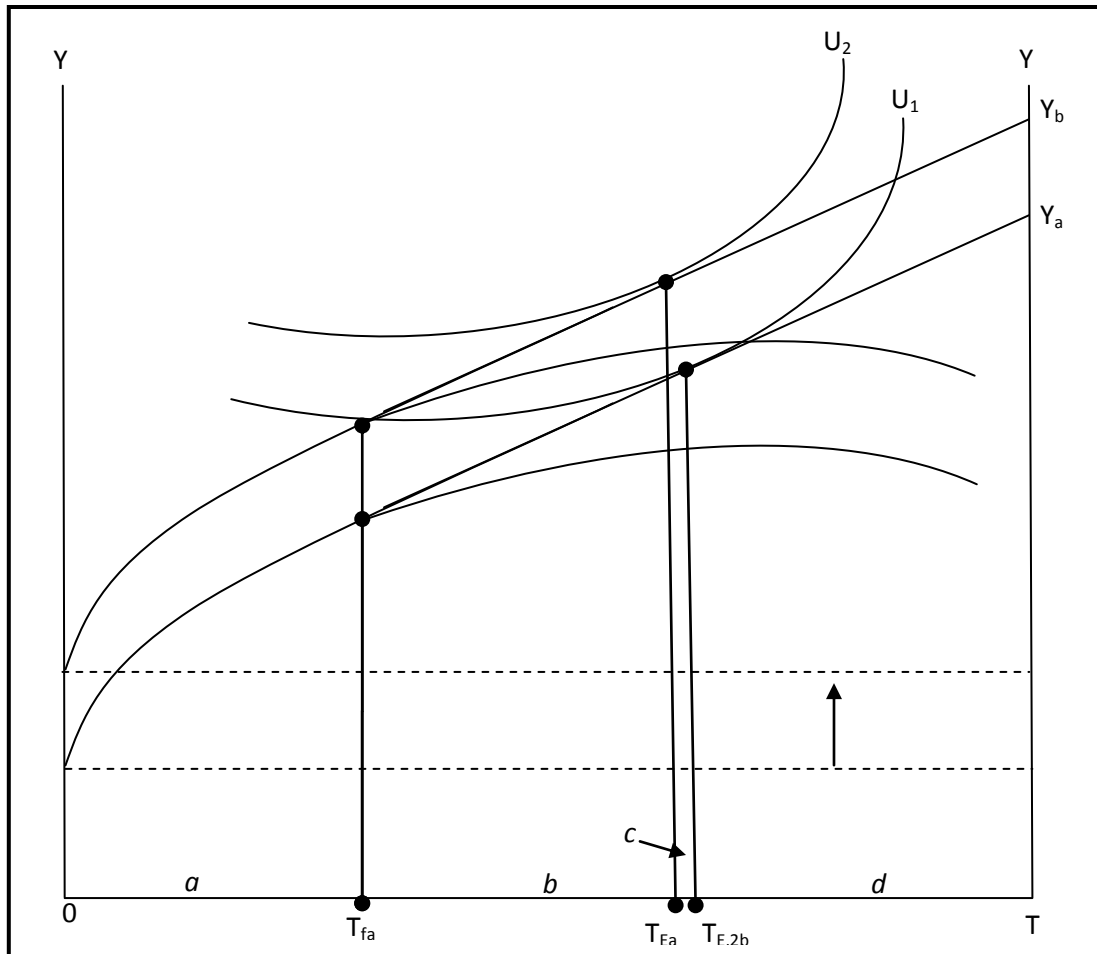

Figure 10: Effect of Decoupled Payments on Time Allocation of Farm Family When Working Some Off-Farm (post 1996 including fringe benefits)

It is important to note that this discussion is centered upon a simplistic representation of the farm household model that yields a more concise, illustrative discussion of the results. As was demonstrated in chapter four, the labor decisions of the operator and spouse are dependent. A graphical representation of the operator's labor allocation decisions, with respect to the spouse's allocation decisions, stemming from a change in government payments would be intractable. While rigorous analysis of these complexities is clearly necessary for accurate

theoretical and empirical modeling, these considerations are worthy sacrifices for the clarity and understanding of the reader in graphical representations.

In conclusion, the findings of this dissertation indicate that in recent years government policy has decreased the number of hours farm households work off-farm and slowed the rate at which they exit the agricultural labor force. This is a change in guard from the years prior to 1996 where programs like the Conservation Reserve and Commodity Buyout programs may have contributed to the migration of labor from agriculture. We also find that the ability of farm operator and spouse to replace their labor on the farm is not without cost. Together, these results allow us to gain some new insights into how agricultural labor markets functions in dynamic policy environments. Finally, this dissertation demonstrates the strong link between fringe benefits, like health insurance coverage, and the supply of labor off-farm of the operator and spouse. Using copulas, dependence between the off-farm labor decisions of the operator and spouse is established. Joint estimation of the operator and spouse labor supply equations then indicates the number of hours worked off-farm increases as the probability of insurance coverage from off-farm sources increases. Further, it is shown that increases in governments payments result in fewer hours of work off-farm.

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VITA

Jeremy is from Baton Rouge, Louisiana. He graduated from high school at Central High School in 2002. Afterward, he enrolled at Louisiana State University to pursue a Bachelor of Science in finance. He graduate *summa cum laude* in 2006 and began working in private industry. In January 2008, Jeremy enrolled in the doctorate program in agricultural economics.

During his graduate program, Jeremy has authored or coauthored four peer reviewed journal articles, submitted four additional articles, and presented original research at various conferences. His research has focused on the areas of agricultural finance, agribusiness, labor economics, and agricultural policy. Jeremy was also President and Co-Founder of the Agricultural Economics Graduate Student Association. He served as Fundraising Chairman for the Louisiana State University Graduate Student Association and Member-at-Large for Activities in the Agricultural and Applied Economics Association Graduate Student Section.

He also had the honor of being nominated for the Presidential Management Fellowship by Louisiana State University. In the summer of 2011, Jeremy was awarded an internship by the Economic Research Service of the United States Department of Agriculture. In December 2011, he will complete his doctorate degree and begin the next stage of his career.