Farm Income Variability and the Supply of Off-Farm Labor

Ashok K. Mishra and Barry K. Goodwin

If farmers are risk averse, greater farm income variability should increase off-farm labor supply. This effect is confirmed for a sample of Kansas farmers. Off-farm employment of farmers and their spouses is also found to be significantly influenced by farm experience, off-farm work experience, farm size, leverage, efficiency, and farm-specific education. In addition, farm operators and spouses who receive significant income support through government farm programs are less likely to work off the farm. This may suggest that policy changes reducing farm income support payments may increase off-farm employment of farmers and their spouses.

Key words: income variability, off-farm labor supply, risk.

The total number of farms in the United States decreased by 63.5% between 1950 and 1993. Over the same period, the total number of farm operators decreased by 18.9% (U.S. Department of Commerce). The primary reasons for these changes are that the supply of agricultural products grew faster (due to technical change) than demand and relative wage rates rose in nonfarm sectors. These changes were paralleled by significantly greater work off the farm by U.S. farmers. In 1992, over 83% of U.S. farmers worked off the farm more than 100 days per year, up from 62% in 1974 (U.S. Department of Commerce).

Economic theory maintains that risk-neutral farmers will divide their labor supply between farm and nonfarm employment opportunities such that expected marginal returns are equalized. If expected marginal returns are greater in one opportunity, more labor will be devoted to that alternative. However, if producers are risk averse and perceive the variance of wages (or earnings) to be greater in one occupation than another, they will allocate less time to the risky job and will be willing to accept lower wages in the less risky alternative. Changes in the riskiness of employment alternatives thus change the allocation of labor. The 1980s are commonly perceived to have been a volatile period for U.S. agriculture. Farm earnings, debt, and asset holdings were highly variable in the early 1980s. Such changes brought about increased variability of farm wages and thus may have influenced off-farm labor supplies.

Schultz pointed out that off-farm employment is an important means by which farmers and their spouses may attempt to reduce the variance of total income. Recent studies have shown that off-farm employment is influenced by a number of demographic and economic factors. However, limited attention has been given to the role of farm income variability in empirical studies. In a survey of farmers' attitudes and motivations, Barlett found that the primary reason that farmers worked off the farm was the variability, risk, and uncertainty associated with farm income. However, her analysis did not explicitly model off-farm labor supply. Sander (1986) found that total income was significantly less variable when farmers and their spouses worked off the farm. Rosenfeld suggested that off-farm work by farm wives was a means of responding to the riskiness of agricultural income by diversifying income sources. Huffman found that the cross-sectional variance of gross farm sales was significantly correlated with off-farm labor supply. However, in his cross-sectional analysis of county-average data, the variance of sales represented size-distribution effects rather than the volatility of income over time. Furtan, Van Kooten, and Thompson

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found that the net worth of farm households was a significant determinant of off-farm labor supply. However, their study did not consider the variation of worth or income.

The objective of this study is to evaluate the effect of farm income variability on the off-farm labor supply decisions of a sample of Kansas farmers and their spouses. The analysis applies Tobit estimation techniques to a consideration of off-farm labor supply. Recent research by Huffman and Lange and by Lass and Gempesaw has argued that the off-farm labor supply decisions of farmers and their spouses are jointly determined. In this light, an empirical model that allows for such joint decision making is estimated using a simplified simultaneous-equations Tobit estimator.

Theoretical Framework

Consider a farm household consisting of two members (a farm operator and spouse). We assume that income-generating options exist for each household member in farming (supplying F hours of labor to farming) and through off-farm employment (supplying H hours of labor to off-farm work). Perfect competition exists in the labor market such that farm operators' labor allocation decisions have no effect on the aggregate demand, supply, and price of labor. The farm household maximizes the expected value of a von Neumann-Morgenstern utility function subject to production and time constraints, where utility is a function of household income and leisure:

$$(1) \quad U = U(\pi, L_O, L_S)$$

where π represents the household's net income and L_i represents the leisure consumed by agent i ($i = O$ for operator and S for spouse). The farm household's profit function, assuming separability of operator time and other inputs in farm production, is given by

$$(2) \quad \pi = PQ(K_O, K_S, F_O, F_S, \beta) - C(Q, \mathbf{r}) + A + W_O H_O + W_S H_S$$

where K_i is individual i's stock of human capital, H_i is the time allocated by agent i to off-farm work, F_i is the time allocated by agent i to on-farm work, T_i is individual i's total available time, W_1 is the off-farm wage available to agent i, P is the price of farm output, $\mathbf{r}$ is a vector of input prices, A is the household's nonearned income, $Q(.)$ is the (concave) farm production function, and β is a vector of farm and operator characteristics affecting production. The household's time constraint is given by

$$(3) \quad T_i = F_i + L_i + H_i,\ F_i,\ H_i \geq 0 \quad \text{for } i = O, S.$$

Capital is assumed to be fixed in the short run and the utility and production functions are assumed to be concave, ensuring a utility-maximizing solution. Uncertainty in farm earnings is assumed to arise because of a random farm output price, assumed to be normally distributed with mean μ and variance σ^2.[1]

To derive testable implications, we adopt a negative-exponential (constant absolute risk aversion) expected utility function, which implies

$$(4) \quad \mathrm{EU}(\pi) = \int_{-\infty}^{\infty} -e^{-\alpha[PQ(\cdot)-C(\cdot)+A+W_O H_O+W_S H_S]} k e^{-\frac{(P-\mu)^2}{s\sigma^2}} dP$$

where k is a constant equal to $[1/(\sigma(2\pi)^{1/2})]$. Maximizing equation (4) is equivalent to maximizing

$$(5) \quad \Theta = \mathrm{E}(\pi) - \frac{\alpha}{2}\sigma_\pi^2$$

which is equivalent to

$$(6) \quad \mu Q(F_O, F_S, K_O, K_S) - C(Q, \mathbf{r}, \beta) + W_O H_O + W_S H_S + A - \frac{\alpha}{2}\left[Q^2(F_O, F_S, K_O, K_S)\sigma_P^2\right].$$

In considering the operator's labor allocation decision, we assume that leisure and the spouse's work decisions are exogenously fixed. Substituting for H_O and H_S from the time constraints [equation (3)] and solving for the first-order conditions yields

$$(7) \quad Q_{F_O}\left(\mu - \frac{\partial C}{\partial Q}\right) - W_O - \alpha\left[Q(\cdot)Q_{F_O}\sigma_P^2\right] = 0$$

where Q_{FO} represents $\partial Q/\partial F_O$. The first term of equation (7) is positive if the household is risk averse because the second and third terms are negative. Totally differentiating equation (7) with respect to F_O and σ_P^2 and solving for $dF_O/d\sigma_P^2$ yields

[1] Identical implications are obtained if the source of farm income uncertainty is random output. Likewise, the results are similar though their derivation is much more complex when both output and price are allowed to vary randomly with a nonzero covariance.

$$(8)\quad \frac{dF_O}{d\sigma_P^2} = \frac{\alpha Q Q_{F_O}}{\left[Q_{F_O F_O}(\mu - MC) - Q_{F_O}^2 \frac{\partial^2 C}{\partial Q^2} - \alpha\sigma_P^2(Q_{F_O}^2 + Q Q_{F_O F_O})\right]}.$$

The numerator of equation (8) is positive and the denominator is negative (by virtue of the second-order conditions for profit maximization). Therefore, with F_S, L_S, and L_O held constant, one can conclude that

$$(9)\quad \frac{\partial F_O}{\partial \sigma_P^2} < 0$$

or that increased variation in farm earnings will decrease the supply of labor to the farm and therefore increase off-farm labor supply. An analogous condition exists for the spouse. These results assume that the labor supplies of producers and their spouses are independent. Identical implications are obtained in the more general case where decisions are made jointly, although additional assumptions regarding the effect of one individual's farm effort on the marginal productivity of the other individual must be made.[2]

These results can be illustrated from figure 1. A risk-neutral individual will allocate his or her fixed labor supply (holding leisure fixed exogenously determines overall labor supply) among alternative employment opportunities without regard to risk. In this way, risk-neutral individuals will allocate their labor to equalize expected marginal returns (wages) among alternative opportunities. Consider a risk-neutral farmer facing a riskless, exogenously fixed market wage W and a risky marginal farm wage. Marginal farm wages, represented by VMP_F^{RN}, are determined by the price of farm output and the marginal productivity of farm labor and thus diminish as more labor is supplied to the farm. The risk-neutral producer allocates labor to equalize marginal returns among the alternatives (point A). However, a risk-averse producer discounts the risky expected farm wage and thus perceives a lower marginal value to each hour worked on the farm. This can be represented by VMP_F^{RA}, which lies below VMP_F^{RN}. In this case, the farmer allocates more time to off-farm labor and less to farming (point B), thereby settling for a market wage that is lower than the expected farm wage. The wage differential, $WF_2 - WF_1$, represents a compensating differential that accounts for the riskiness of farm labor.

Empirical Framework and Econometric Procedures

An empirical model of off-farm labor supply will relate off-farm work (i.e., hours per year) to observable variables representing farm and operator characteristics relevant to labor supply decisions. The riskiness of farm earnings is measured by the coefficient of variation (CV) on farm income.[3] Human capital is represented by academic and extension program education and off-farm labor experience. Farm characteristics included size (total acres), the leverage ratio (debts/assets), government payment receipts, livestock sales, and cropping efficiency (gross crop sales/purchased crop production input costs). Variables representing the farm family size and the presence of children under age fifteen were included to represent demographic factors that may constrain off-farm labor supply. Miles from the nearest town were included to represent the availability and costs associated with off-farm work.

Most analyses of labor supply encounter situations where many individuals are not employed, thus raising the issue of selectivity or censored samples. Standard approaches to dealing with such censoring include the methods of Heckman and standard Tobit models (Tobin). In this analysis, significant proportions of the farmers (74.79%) and spouses (55.43%) did not work off the farm. This censoring is recognized through the application of maximum likelihood

[2] In particular, one must assume that the marginal product of a farmer's labor increases as the spouse's supply of farm labor rises (i.e., that $Q_{F_O F_S} > 0$) and vice versa. This condition is guaranteed by many common production function, including a Cobb-Douglas. An appendix to this paper which discusses comparative statics in the case where farmers' and spouses' decisions are made jointly is available from the authors upon request.

[3] The CV of income was calculated over the preceding ten years' incomes. Representation of risk by the CV assumes that only the first two moments of the distribution are relevant. This can be justified by assuming that the distribution is normal or by assuming that a second-order Taylor's series expansion of the distribution is sufficient to capture relevant risk characteristics.

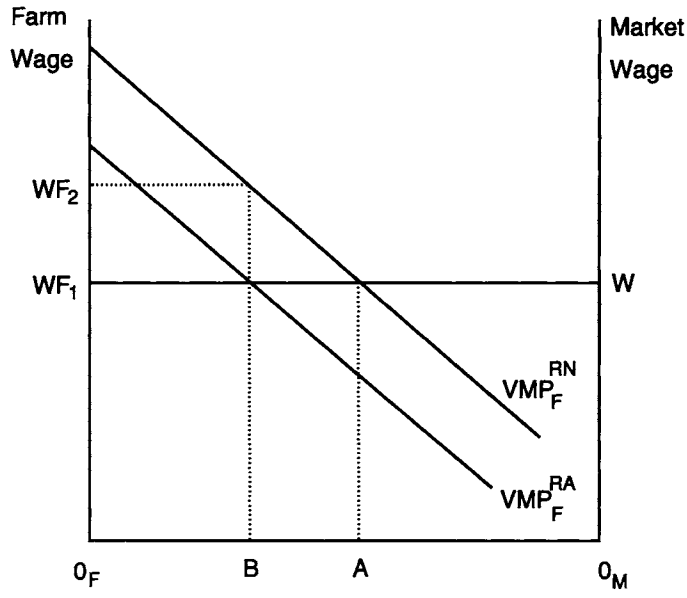

Figure 1. Labor allocation decisions of risk-neutral and risk-averse producers

estimation of a Tobit model.

Previous research has suggested that farmers' labor decisions may be made jointly with those of their spouses and thus that simultaneous equation estimators should be adopted. Procedures for estimating simultaneous equation models with censored endogenous variables have been developed by Amemiya (1974, 1979); Nelson and Olson; Lee, Maddala, and Trost; Newey; and Vella. Nelson and Olson suggest a simple two-stage estimation procedure whereby endogenous variables are replaced by predicted values obtained in a first stage by regression upon an instrument set. However, Nelson and Olson's estimator misrepresents the true variance of the parameters in that it ignores the fact that the reduced-form equations are estimated in the first stage. In this analysis, bootstrapping procedures are utilized to obtain consistent estimates of the parameters' covariance matrices.[4]

Empirical Application

This study utilizes data collected from a survey of 1,963 Kansas farm households in September 1992. The survey data were matched to farm records in the Kansas Farm Management Association data bank. Of the 1,963 farms surveyed, 618 surveys were returned. Farms that did not have income records for at least eight of the preceding ten years were dropped from the sample. In addition, several farms were dropped from the sample because of incomplete survey responses or farm records. This left a total of 300 farms, most of which were observed in both 1991 and 1992.[5] In total, 599 observations were used in the analysis. Summary statistics and definitions of the variables utilized in the analysis are presented in table 1.

In light of the potential endogeneity of labor supply decisions of farmers and their spouses,

[4] Under the bootstrapping approach, a large number of pseudo samples of size N (where N is the number of observations in the estimating sample) are drawn from the estimation data with replacement. For each pseudo-sample, Nelson and Olson's two-step procedures are applied in order to generate a distribution of the consistently estimated structural parameters. From the sample of replicate parameter estimates, covariance matrices for the structural parameters can be consistently estimated.

[5] As a reviewer correctly pointed out, incomplete survey responses and missing data can lead to inferential biases. An examination of farm characteristics not included in the models did not reveal significant differences for excluded farms. A formal statistical test for selection bias is precluded by the analytical complexity of the simultaneous equation Tobit model.

Table 1. Variable Definitions and Summary Statistics

Variable	Definition	Mean	Standard Deviation
Farmer hours	Total hours worked off the farm per year by the farmer	256.6945	612.5784
Spouse hours	Total hours worked off the farm per year by the spouse	608.6728	889.2790
CV income	Coefficient of variation of gross farm income	27.6599	16.3536
Farm experience	Years of farming experience (farmer)	31.0952	11.8400
	Years of farming experience (spouse)	25.4424	13.7334
Education	Years of formal education (farmer)	14.1327	2.1302
	Years of formal education (spouse)	14.2813	2.1246
Total acres	Total farm size (hundred acres)	16.5163	13.4463
Off-farm experience	Years of off-farm experience (farmer)	4.5301	6.9114
	Years of off-farm experience (spouse)	9.0351	8.5074
Miles to town	Miles to the nearest town	7.4893	4.8462
Debts/assets	Ratio of total debts to total assets	0.4149	0.3858
Government payments	Total dollar value of direct government payment receipts (thousands)	18.6330	15.3876
Livestock sales	Livestock revenues / total revenues	0.2229	0.3020
Cropping efficiency	Gross value of crop sales divided by variable crop production costs	1.7369	0.8939
Seminar	1 if farmer has attended extension or private risk management/marketing educational seminar, 0 otherwise	0.6861	0.4644
Family size	Number of dependents in farm household	3.1219	1.4562
Children	1 if household's oldest child is 15 years of age or less, 0 otherwise	0.1870	0.3902

the bootstrapped simultaneous-equation Tobit estimator (2,000 replications) was applied. The empirical models related the total number of hours worked per year to the observable farm and operator variables. Off-farm labor supply equations were estimated for both the farm operator and the operator's spouse. Parameter estimates, derivatives, and summary statistics are presented in table 2. In contrast to the results of Huffman and Lange and of Lass and Gempesaw, the results do not appear to suggest that the labor supply decisions of farmers and their spouses are jointly determined, at least for this sample. The spouses' off-farm labor effort does not appear to significantly influence the operator's supply of labor to off-farm employment activities. Likewise, the farmer's hours worked off the farm do not significantly influence the off-farm labor supply of spouses.

An important result is that farm income variability, as represented by the coefficient of variation on farm income, has a significant positive effect on the off-farm labor supply of farmers. This result confirms expectations in that increases in the variability of farm earnings evoke significant increases in the off-farm labor supply of farmers. A 10% increase in the coefficient of variation for farm earnings increases the expected value of off-farm labor supply by almost twenty-one hours per year for farmers. In contrast, farm income variation is not statistically significant in the labor supply function for spouses.

Years of farm experience is a statistically significant determinant of the off-farm labor supply of farmers and their spouses. Confirming expectations, more farming experience corresponds to less work off the farm. This likely reflects the fact that farming experience builds farming-specific human capital and thus raises farming's relative wages. Counter to expectations, education does not have a significant effect on the off-farm labor supply of farmers or their spouses. This may suggest, at least for this sample, that marginal returns from academic education are the same in both farm and nonfarm employment activities. Off-farm work experience is significantly correlated with off-farm work for both the operator and spouse. Further, the effect of off-farm experience on off-farm labor supply is relatively large. An additional year of off-farm experience increases off-farm labor supply by 17 hours per year for the farmer and 42.5 hours per year for the spouse. More off-farm experience implies a greater accumulation of human capital specific to off-farm work and thus suggests larger relative returns to off-farm work.

Table 2. Parameter Estimates and Summary Statistics for Tobit Model of Off-Farm Labor Supply

Variable	Farmer Estimate	$\partial E(y)/\partial x^a$	Spouse Estimate	$\partial E(y)/\partial x^a$
Intercept	−912.7078		−1,149.6173	
	(848.9679)		(636.2700)	
CV income	10.6457	2.0862	1.5393	0.3641
	(4.1217)**	(0.8330)**	(4.4067)	(2.0351)
Farm experience	−23.9811	−4.5383	−34.6910	−15.7640
	(9.5490)**	(1.7107)**	(7.9952)**	(3.1379)**
Education	51.9685	9.7834	39.5515	17.6487
	(40.6483)	(7.3546)	(36.6072)	(16.9503)
Total acres	−13.9016	−2.6550	4.2872	1.8969
	(8.0854)*	(1.5174)*	(6.5069)	(3.0532)
Off-farm experience	90.7358	17.0514	92.3917	42.5428
	(8.7345)**	(2.1620)**	(8.7847)**	(4.8366)**
Miles to town	10.4799	1.8428	20.0669	9.2237
	(16.3046)	(3.0385)	(15.3937)	(6.9392)
Debts/assets	468.6502	85.8157	607.8277	286.5885
	(170.5815)**	(29.8132)**	(190.1988)**	(81.6906)**
Government payments	−19.9710	−3.7017	−10.0543	−4.5444
	(6.9103)**	(1.2626)**	(5.7289)*	(2.5501)*
Livestock sales	85.4687	14.8844	−197.6840	−89.2472
	(269.9284)	(50.5847)	(242.5283)	(112.5029)
Cropping efficiency	−285.3920	−55.1651	−51.3555	−27.3509
	(121.6288)**	(22.3297)**	(91.7905)	(41.4698)
Seminar	−410.1923	−87.6384	329.0864	143.6049
	(157.0843)**	(37.4336)**	(159.8865)*	(73.0640)**
Family size	87.2644	16.0327	60.2448	28.1994
	(53.2178)	(10.0704)	(58.0656)	(27.0206)
Children	321.1048	72.0392	−583.7250	−236.5415
	(193.4484)*	(47.4487)	(162.6859)**	(62.4369)**
Hours of spouse	−0.0124	−0.0008		
	(0.0810)	(0.0152)		
Hours of farmer			0.0338	0.0207
			(0.1014)	(0.0476)
σ	1,134.6439		1,235.7033	
	(63.0017)**		(83.0626)**	
Likelihood ratio test	231.5363**		264.0682**	

Note: Numbers in parentheses are standard errors. Single and double asterisks indicate statistical significance at the $\alpha = 0.10$ and 0.05 levels, respectively.

[a] Marginal effects are given by $\Phi(X\beta/\sigma)\beta_k$, where $\Phi(\cdot)$ is the normal cumulative distribution function. For discrete variables, $E(y)$ is evaluated at alternative discrete values of X_k. Marginal effects are for the entire sample. The effects on the uncensored observations will be greater.

Several farm characteristics are significant determinants of the off-farm labor supply of farmers and their spouses. Farm size is negatively correlated with farmers' off-farm labor supply. Operators of larger farms likely have less flexibility in supplying labor to off-farm work activities than do operators of small farms. In contrast, farm size is not significantly related to the off-farm work decisions of spouses. This result is consistent with the findings of Sumner and of Lass and Gempesaw. The leverage (debts to assets) position of the farm is a significant determinant of off-farm labor supplies. Farmers and spouses who operate farms with higher debt-to-asset ratios supply more labor to the off-farm sector. This result is consistent with the findings of Furtan, Van Kooten, and Thompson. Miles to the nearest town was not found to be a significant determinant of off-farm employment for either farmers or their spouses.[6]

Government programs may lessen the need for off-farm labor activities by providing farm

[6] Miles to the nearest city with a population greater than 50,000 yielded identical results. Because fewer survey respondents indicated their distance from cities, distance to the nearest town was included in the empirical models.

households with an alternative source of farm income. Both models indicated that larger receipts of government farm program payments were significantly correlated with less off-farm work by farmers and their spouses. This result may imply that reductions in direct farm payments, as are expected to occur as farm legislation develops, may result in increased off-farm employment by farmers and their spouses.

The proportion of farm sales accounted for by livestock and dairy operations was included in the labor supply models. Livestock and dairy operations are typically more labor intensive than crop enterprises, implying fewer opportunities for off-farm employment. However, no significant relationship between livestock and dairy sales and off-farm work is revealed.

Farmer participation in public extension education programs and other private (e.g., Farm Bureau seminars) educational activities would be expected to enhance farm-specific skills, thus increasing relative returns to farm labor and decreasing off-farm labor supply. This effect is confirmed in the farmers' off-farm labor supply equations. Attendance at such educational seminars significantly lowers the off-farm labor supply of farmers. In particular, the results suggest that farmers that had attended such seminars would be expected to work eighty-eight hours less per year off the farm. The magnitude of this effect is quite large and may imply that seminar attendance is correlated with omitted variables relevant to off-farm employment. In particular, seminar attendance may reflect the intensity of a farmer's involvement and interest in agricultural issues, a characteristic likely to be correlated with less work off the farm. Farmer participation in seminars also tends to increase the spouse's off-farm labor supply.[7]

Cropping efficiency is expected to be an important indicator of a farmers' crop production skills. More efficient farms would be expected to have higher relative returns to farm labor and thus would be expected to supply less labor to off-farm activities. This effect is confirmed for farmers. However, cropping efficiency does not affect the off-farm work activities of spouses.[8]

The size of the farm household does not have a significant effect on the off-farm labor supply of farmers or their spouses. However, the presence of children in the farm household has a significant effect on the off-farm work activities of farmers and their spouses. Spouses from farm households with children under age fifteen are significantly less likely to work off the farm. In contrast, having children in the household results in more labor being supplied to off-farm employment opportunities by farmers. Gronau suggested that women have a comparative advantage in homemaking and child care and thus that the presence of children in a household was likely to imply less work outside of the home. A similar result was found by Furtan, Van Kooten, and Thompson and by Sander (1983). The finding that farmers with children tend to work more off the farm may reflect the possibility that such farmers work more in total. Reed and Harford found that workers with children tended to work more hours.

Concluding Remarks

In this paper we evaluate the role of farm income variability and a number of other factors in the off-farm labor supply decisions of a sample of Kansas farmers and their spouses. The analysis uses a simultaneous-equations Tobit estimator that accounts for joint labor supply decisions. The results confirm that the off-farm labor supply of farmers is positively correlated with the riskiness of farm incomes. Although farm income risk has often been advanced as an important factor determining off-farm labor supply (see, for example, Barlett), this study is one of the first to directly confirm this effect. Farmers who experienced greater farm income variability in the 1980s were significantly more likely to work off the farm.

Farmers and spouses with more farming experience were found to be less likely to work off the farm. The off-farm labor supply of farmers and their spouses was positively correlated with off-farm experience. Although academic education was not significantly correlated with off-farm labor supply, farmers that had participated in farm-specific educational activities were significantly less likely to work off the farm. Operators of larger farms were less likely to work off the farm. The off-farm labor supply of farmers and their spouses was found to be significantly higher for highly leveraged operations. Spouses with small children were significantly less likely to work off the farm. Finally, farmers and spouses on farms that received more government support were less likely to pursue off-farm employment.

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[7] Spouses' participation in nonacademic seminars was not known and thus was not considered in the empirical analysis.

[8] Simultaneity between efficiency and off-farm labor supply is possible since increased off-farm labor activities might decrease returns to purchased inputs if complementarity exists between labor and purchased inputs. Such simultaneity is an important topic for future research.

These results may have important implications for farm policy. The 1996 farm bill replaced price supports with direct payments which are to be phased out over the next seven years and eliminated acreage planting restrictions. Such changes may increase price and income volatility. Our results imply that such changes may result in more off-farm work by both farmers and their spouses. Farm policy debates and research and extension efforts have given relatively little consideration to off-farm employment issues. Our results suggest that these issues may take on greater importance as farm policies adjust and more farm families seek off-farm employment. This may suggest a greater role for extension education and research programs that address off-farm employment issues.

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