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Determinants of Poverty among U.S. Farm Households

Hisham S. El-Osta and Mitchell J. Morehart

This research uses data from the 2004 Agricultural Resource Management Survey and probit regression to examine the determinants of poverty among U.S. farm households. The findings reveal, among others, the importance of a livelihood strategy that combines participation in government programs and off-farm work in lowering poverty rates. Findings also show the importance of educational attainment of the farm operator in mitigating poverty, but only when poverty is measured on a relative rather than an absolute basis. Policy recommendations are provided in the context of these findings.

Key Words: composite measure of economic well-being, government programs, off-farm work, poverty

JEL Classifications: J23, J24, D3, I21, I32, C81

The rationale for federal farm policies when they were first introduced during the 1930s was to alleviate poverty among farmers while attempting to lessen the extent of disparity between farm and nonfarm incomes (Houthakker; Offutt). However, despite the increasing evidence that farm households are no longer disadvantaged relative to their nonfarm counterparts (Gardner; Mishra et al.), the agricultural sector continues to receive large sums in farm program payments, with amounts totaling nearly \$144 billion between 1995 and 2004. To the extent that eligibility for farm subsidies is determined by a limited number of “program crops” and not by income or poverty standards, a consequence of this is that agricultural program payments

end up targeting primarily large and profitable farms rather than family farms (Riedl). A recent study by Hoppe demonstrates the unevenness in the distribution of farm payments. For example, while less than half of all farms received farm program payments in 2005, the share of payments received by large family farms, which account for 8% of all farms, was at 58%. The failing in the design of farm policies to improve the welfare of the “financially” most vulnerable farm households is evident by further noting that two-thirds of recipient farms received less than \$10,000 in payments, an amount that accounts for only 7% of their cash farm income (Hoppe).

Yet an alternative source of income for farm households with a proven welfare-improving propensity lies in the income earned from an off-farm job.¹ For many U.S. farm

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¹For example, a study by El-Osta, Bernat, and Ahearn has found marginal increases in earned off-farm income to have nearly twice the size of impact of marginal increases in government income in reducing inequality in the distribution of total household income.

households, multiple jobholding has been the norm for over 60 years, with further evidence of the increased reliance on off-farm income by these households documented in a number of studies (e.g., Huffman, 1991; Mishra et al.; Sumner; among others). The study by Mishra et al., for example, points out that while a little more than a fourth of farm operators worked off farm in the mid-1940s, nearly four-fifths did so by 2002 and mostly full time.

While most of farm household income (91%) is currently derived from off-farm sources, the importance of government payments in terms of welfare, unlike in the 1930s when farm policies achieved broader coverage of farm families, continues to decline (Dimitri, Effland, and Conklin). The primary objective of this paper thus is to deepen the understanding of the role of participation in government programs, if any, and that of off-farm employment in mitigating poverty among U.S. farm households using data from the 2004 Agricultural Resource Management Survey (ARMS). The importance of considering participation in farm programs and in off-farm work by farm operator households as plausible determinants of poverty stems from their use as a livelihood strategy, among others, by these households in mitigating the effects of agricultural risk on farm household income (Harwood et al.; Robison and Barry).

Many researchers have documented the direct linkage between low educational levels and poverty (e.g., Blank; Deavers and Hoppe; Parker and Gibbs; Schiller), which stems from a reduction in the incentive to enter the labor market and from the increased likelihood of limited opportunities for higher earnings and stable employment. Studies by Schultz (1975) and by Huffman (1985) have emphasized the importance of the ability to adapt to exogenous market forces and to structural changes as a relevant concept of human capital of farm operators.² Households with low education, as noted by a 2002 UN report, are highly vulnerable to ill health and disability, price

and credit swings, and natural and environmental disasters. The report further notes, as in other studies (McPherson), that education helps protect households against such shocks by allowing for a more secure employment, higher incomes, and a wider access to credit and economic assets. In fact, many practitioners in the United States have advocated redirecting the farm policy toward developing the human capital of poor people rather than simply providing them with a minimal level of program payment (e.g., Isengildina, White, and Morehart). To this extent, a subsidiary objective of the paper is to examine the impact of human capital on the likelihood of a farm household being poor.³

Information obtained from this paper is particularly relevant to the farm safety-net debate by policymakers, a concern that, among others, has resulted in the implementation of price and income support programs aimed at providing financial assistance to farms, farm people, and rural areas for over 70 years. The study will contribute to the literature by utilizing, in the process of examining factors contributing to poverty among farm households, a composite measure of economic well-being (*CMW*) where an annualized level of household's marketable wealth is added to its income. While this measure of economic well-being is not new (e.g., see Lerman and Mikesell 1988, 1989; Weisbrod and Hansen), its empirical use in examining poverty among farm households based on a nationally recognized survey as in the case of ARMS, to the best of our knowledge, is new.

The paper is organized as follows. The first section reviews the literature on the subject of poverty and its determinants. In the second section, a delineation of the *absolute* and *relative* poverty measures adopted for this paper is provided along with a description of the underlying well-being measure used in the

²The phrase "human capital" as it relates to a person's own educational attainment was coined first by Theodore Schultz (see Schultz, 1960).

³Human capital is generally represented by education and job experience (see Mincer and Polacheck). In this study, only education is used as a proxy for human capital because of its policy relevance in terms of its potential impact at reducing poverty.

analysis. The third section discusses the empirical specification used to model poverty along with a general description of the data and the sample used in the analysis while attending to some econometric concerns inherent in both the data and the model. This is followed by a section on results. The final section summarizes the findings and provides some policy implications.

Literature Review

A large body of literature has been written on the causes and consequences of poverty and on ways to mitigate the likelihood of its occurrence. For example, an attempt by Sawhill to explain why poverty in the United States is so persistent finds, among others, that economic growth need not lead to a reduction in poverty, particularly if such growth is accompanied by a greater inequality of income. A study by LeBlanc on how poverty is impacted by prevailing macroeconomic conditions suggests that low wages and not the unemployment rates are the most important determinant of poverty in the long run. The study further suggests that a key to permanently reducing poverty is to improve the returns to labor, which could be achieved by improving education and job training. Creedy provides a comparison between alternative tax and transfer payment schemes in the context of poverty assessment. Findings indicate that means testing as a way of alleviating poverty dominates if the head count poverty measure is used; otherwise, a universal transfer system, such as a linear tax, seems to be the preferred approach. Hoynes, Page, and Stevens note that because government tax and transfer programs provide households with cash and other benefits, they can have a direct impact on income and poverty.

A paper by Haveman and Wolff finds that poverty, when based on the stock of assets that is sufficient to sustain a basic needs level of consumption during temporary hard times, falls monotonically with both age and education of the head of the household. The paper also finds that asset poverty rates tend to be higher for renters than for home owners and

that, based on the type of family considered, these rates range from a low of 5% for elderly couples to 71% for households headed by single females. The effect of adding annuitized wealth to money income when measuring poverty is investigated by Lerman and Mikese (1988, 1989). Results indicate a change in the makeup of both the rural and the urban poor. Specifically, the changes are relatively large by certain characteristics, such as age, tenure, location of residence, employment status, and family size, and are relatively small for yet other characteristics, such as urban/rural status, race, sex, and marital status. A study by Allen and Thompson uses data from the 1988 Current Population Survey conducted by the Bureau of the Census and logistic regression to examine the determinants of rural poverty. Findings show that persons in female-headed families are significantly more likely to be in poverty than persons in families headed by a married couple or a male householder. In addition, the study points to the importance of race, family size, education, number of earners in the family, and industry structure as important in explaining poverty. A common thread among the many studies that have investigated the characteristics of people in poverty is the finding that poverty rates are higher among minorities than whites (Danziger; Levernier; Moen).

Garrett, Ng'andu, and Ferron use data from the 1986 cross section of the National Longitudinal Survey of Youth in conjunction with logistic regression to measure the influence of rural variables on young children's chronic poverty status. Among the study's major findings is the strong relationship between the persistence of poverty and the proportion of life lived in rural areas. Logistic regression and data from the 1985 cross section of the Panel Study of Income Dynamics are used by Brown and Hirschl to examine the determinants of poverty in rural and metropolitan-core areas of the United States. Results find that rural households have a higher probability of poverty than metro-core households.

Hopkins and Morehart note a great deal of variation in poverty when poverty in farm household income is measured based on either

the head count method, which describes incidence of poverty, or the poverty gap method, which measures the depth of poverty. A report by Jolliffe (2003) asserts the generally accepted finding among researchers that a greater incidence of poverty occurs in nonmetro areas relative to metro areas. However, the study notes the sensitivity of the findings when the standard practice of examining poverty, which is based on the head count method, is replaced by the poverty gap method.

Recent studies by Gundersen and Offutt and Offutt and Gundersen find that contemporary farm programs are incapable of providing guarantees against poverty among farm households. Instead, the studies have pointed to the importance of the general social safety net (e.g., widening eligibility for the Food Stamp Program and Medicaid) as well as economic development and improved access to off-farm job opportunities. A study by de Janvry, Runsten, and Sadoulet notes that increasing access to off-farm job opportunities is a viable tool in the fight against poverty. Danes and Keskinen assert that off-farm labor employment has allowed family farm operations, particularly in the small to medium-size range, to stay farming by acting as a "safety net."

Many studies have pointed to the positive correlation between education and earnings of the population at large (Dooley and Gottschalk; Freeman; Welch) and between education and earnings from off-farm sources of people involved in farming (El-Osta and Bellamy; Gunter and McNamara). Studies by Blackwell and McLaughlin, McGranahan and Gale, and Reeder and Brown associate the lower levels of educational attainment that typify residents of rural areas with the likelihood of reduced access to existing occupational opportunities and lower earnings.

Poverty and Composite Measures of Well-Being

Poverty Measures

Poverty measures fall under two broad categories: those that examine poverty either in absolute or in relative terms.

Absolute measures. These measures of poverty compare household income with the cost of a basket of specific goods and services (see Séguin). Examples of these measures are those used in the United States where poverty statistics are based on a definition developed by the Social Security Administration in 1964. Under the definition, a family is considered in poverty if its pretax money income is below the official poverty threshold, which consists of three times the cost of a minimum adequate diet. This diet is based on the 1961 Department of Agriculture's Economy Food Plan (i.e., the least expensive of the four food plans), and it varies by the size and type of the family. The Bureau of the Census uses 48 poverty thresholds to determine poverty status of U.S. households. To illustrate, in 2004, the average poverty threshold for a family of four was \$19,307. For a family of at least nine persons, the threshold was \$39,048. The poverty thresholds (T_j), which are set by the Office of Management and Budget, are updated annually to reflect changes in the Consumer Price Index for All Urban Consumers (Dalaker and Naifeh). The proportion of income-poor households based on this absolute measure of poverty (P_A) is calculated as

$$(1) \quad P_A = \frac{1}{N} \sum_{i=1}^N I_i (Y_i \leq T_j),$$

where Y_i is the income of the i th household, N is the total number of households and I_i is an indicator function (see Deaton) that is 1 if its argument is true and 0 otherwise.

A 1997 study by Betson and Michael points to the deficiencies inherent in the official poverty measure as described in Equation (1). These deficiencies, which were identified by a panel of academics assembled by the National Academy of Sciences (NAS) in response to a call by Congress for a scientific review of the measure, are multifaceted. First, the official measure excludes from income government transfer programs (e.g., food stamps and public housing subsidies) that have been on the rise since the mid-1960s, a result of which is the

potential to seriously overstate measured poverty. Second, the current measure ignores paid taxes, and, considering the fact that the poor are being subjected to considerably higher federal and state earnings taxes and higher Social Security taxes, the measure has the potential of understating poverty. Third, reporting of understated poverty rates may result from the fact that the current measure does not allow for the subtraction from earnings of certain child care costs for married women in the labor force who have young children. Fourth, not allowing the inclusion of rising health care expenditures when measuring poverty or adjusting for differences in the cost of living across the United States potentially biases poverty rates' estimates. The NAS panel of experts on poverty provided several recommendations aimed at improving how the federal government measures poverty, including the need to adjust these measures for geographic differences in the cost of living (Citro and Michael), an issue that was further investigated and supported by Jolliffe (2006).

Relative measures. These measures of poverty compare household income and spending patterns with income and spending patterns (Séguin) of the general population. One example of these measures is Statistics Canada's "low-income cutoffs" (*LICOs*). This measure, which is updated annually by the Consumer Price Index (annual average, all items), delineates family units into "low income" and "other" groups (Statistics Canada). Here, family units with income below the cutoff for their family sizes and urbanization classification are considered "low-income families." In contrast, those family units with incomes equal to or above the cutoff fall into the "other" category. Yet another example, originally due to Fuchs, is "low-income measures" (*LIMs*), which are set at one-half median (M) adjusted family before-tax income (Y^*), where "adjusted" indicates a consideration of different needs for families of varying size. Using the indicator function I as defined previously, the proportion of households considered money poor based on this relative concept of poverty (P_R) is

computed as

$$(2) \quad P_R = \frac{1}{N} \sum_{i=1}^N I_i \left(Y_i^* \leq \frac{M}{2} \right),$$

where Y_i^* is the adjusted income (also known as equivalent income of the household) and is obtained from income Y according to the following:

$$(3) \quad Y_i^* = \frac{Y_i}{S^\varepsilon},$$

where S and ε are, respectively, the number of household members and the elasticity of household "need" (also referred to as the elasticity of the scale rate) with respect to household size (see Burkhauser, Smeeding, and Merz; Daly and Royer). At one extreme, if ε is 1, this is the per capita notion of income, and it indicates the presence of no economies of scale, and at the other extreme where ε is 0, this is the per household notion of income, where economies of scale are assumed perfect. In this paper, ε is valued at 0.5, which assumes that the true economies of scale lies directly in between these two extremes.⁴

Relative poverty measures are criticized as being measures of income inequality rather than measures of poverty. This criticism is demonstrated by using the example of a society where an equal but a large sum of money is being given to all individuals (see Séguin). Based on a relative measure of poverty, the percentage of poor would not change even after this equal but sizable increase in people's income. Instead, what would get altered is the degree of income inequality, which presumably would exhibit improvement.

The previous discussion points to the apparent deficiencies inherent in each of these broad poverty measures. Yet a common dispiriting aspect of these measures is their inability to account for the depth or the

⁴ Many welfare studies also utilize $\varepsilon = 0.5$ in order to facilitate cross-national comparison of disparities in income distributions (see Atkinson, Rainwater, and Smeeding; Gottschalk).

severity of poverty in the population as allowed by the concept of the "poverty gap" (Deaton; Hopkins and Morehart). However, despite these limitations, the official absolute poverty measure, for example, remains useful in that it serves as a reference point when discussing and researching issues on poverty (Betson and Michael). Similarly, the relative poverty measures (e.g., the *LICO* and *LIM* concepts) remain useful as they allow, because of their simplicity of calculation, for making poverty comparisons between countries (Statistics Canada).

Composite Well-Being Measure

For the general population, income has traditionally been used as an indicator by which the economic well-being of a household can be assessed and, as such, has also provided the means by which national estimates of poverty rates are measured. For farm households, while both income and wealth are important indicators of well-being, they often give conflicting signals. Income tends to be more variable than wealth in the short run, so when viewed in combination for any particular year, they can reveal farm households with low income and high wealth. In some cases, this situation reflects a temporary disturbance to income, particularly farm income. The combination of low income and high wealth may also be motivated by attempts to minimize tax burden. Life cycle effects also influence the relationship between income and wealth. For example, households with older, perhaps retired individuals tend to have higher wealth and lower income when compared with younger households.

While income is often used synonymously with economic well-being, the concept refers to the command over goods and services and is distinct from notions of welfare or happiness (Hill). One way to construct a composite measure of economic well-being that is particularly useful in addressing poverty concerns and in assessing the economic welfare of farm households is to estimate the annuity value of net worth and add it to current income (Carlin

and Reinsel; Chase and Lerohl; Weisbrod and Hansen). This recognizes the role of wealth in supporting consumption during times of low income and allows for an intrafarm household comparison of economic well-being. This type of approach is not new, although the practical application involves several tenuous assumptions. The annuity formula depends on the life expectancy of the recipient and the rate of interest. More important, the components of household net worth deemed appropriate for consideration as an income equivalent must be identified.

The challenge in determining the annuity value of net worth for farm households is that farm assets provide the basis for earning current income. A more suitable concept for this type of application is marketable wealth (or net worth). Marketable wealth is defined in this paper as the current market value of all fungible assets less the current value of debts. Assets include owner-occupied housing, bank accounts and certificates of deposit, corporate stocks, and other types of financial assets. Marketable farm inventories of crops and livestock are also included. This measure considers only those assets that are easily converted to cash and purposely excludes farm production assets and household durable goods. An additional consideration in determining the income stream from marketable wealth is transaction costs. To more accurately portray the annuity, some allowance must be made for costs incurred in the disposal of assets.

Unfortunately, data limitations in the ARMS prevent a complete specification of marketable wealth. In particular, there is no distinction between nonfarm household liquid and durable assets. Nor is there any similar division of household nonfarm debt. In 2004, average farm household net worth was \$793,365. On average, marketable net worth was about a fourth of total household net worth. Marketable net worth represented at least half of total household net worth for about 22% of farm households. There was no addition to current income for the 13% of households with negative values of marketable net worth.

For each farm household, the composite measure of well-being is defined as

$$(4) \quad CWB_i = HHMI_i + (tc \text{ MNW}_i) \frac{r}{[1 - (1+r)^{-n_i}]},$$

where tc represents transaction costs in percentage terms, n is the life expectancy of the unit, r is an assumed interest rate set at 4% for this paper, and $HHMI_i$ and MNW_i represent the i th household's money income and marketable net worth, respectively.⁵

It is this notion of economic well-being where income and annuitized marketable wealth are combined together based on Equation (4), rather than just income alone, that is used to examine the determinants of poverty among farm households. Accordingly, rather than using Y_i and Y_i^* in Equations (1) and (2), CWB_i and CWB_i^* (i.e., CWB_i adjusted for family size) are used, respectively, instead.

Empirical Specification and Data

The Model

The main objective of this paper is to examine the roles government program participation and off-farm work play in mitigating poverty among U.S. farm operator households. A subsidiary objective is to investigate the relationship between poverty and the farm operator's human capital. The following is a binomial probit (BNP) model that estimates

the probability that a particular farm operator household is in poverty:

$$(5) \quad \begin{aligned} I_i^* &= \beta_0 + \beta'_1 X_{1i} + \beta'_2 X_{2i} + \varepsilon_i \\ &= \beta' X_i + \varepsilon_i, \quad \varepsilon_i \sim N(0, 1) \\ I_i &= 1 \quad \text{if } I_i^* > 0 (\text{household in poverty}), \\ &= 0 \quad \text{if } I_i^* \leq 0 (\text{otherwise}), \end{aligned}$$

where X is a matrix of explanatory variables and β is a vector of parameters to be estimated. Unlike the random variable I_i ($i = 1, \dots, n$), which is observable, I_i^* is an unobservable latent variable that reflects a persistent or an unforeseen transient economic shortfall facing the farm household. In Equation (5), X_{1i} comprises a set of three dummy variables that describes the decision to participate in government programs and in off-farm work, either jointly or separately, by the farm household (a fourth dummy variable reflecting a decision of not participating in either government programs or off-farm work is suppressed to allow for model convergence), and X_{2i} represents a set of continuous and dummy variables tailored at capturing other farm household and farm business characteristics (e.g., education, age, regional location of the farm, and so on).⁶

The expected value of I_i can be expressed in terms of the probability (P) of the farm household being poor as in

$$(6) \quad \begin{aligned} E[I_i|X] &= P(I_i = 1) \\ &= P(I_i^* > 0) \\ &= P(-\varepsilon_i < \beta' X_i), \end{aligned}$$

⁵The definition of money income used in the analysis follows that of the Current Population Survey (CPS), which is conducted by the Bureau of the Census. Specifically, the CPS definition of farm self-employment income includes income received as a cash but excludes in-kind or nonmoney receipts (for more detail, see Mishra et al., p. 10). A nonmonetary income that is not included in standard measures of household income and that might be particularly relevant to poor households is the value of farm products consumed on the farm. Based on the 1993 ARMS (when data on this income item were available), nearly 20% of the farm households are found with a nonzero value for farm products consumed on the farm and with a reported average for this income component of \$642.

⁶It is important to note that off-farm work by the farm operator household is assumed to have taken place if any member of the household has reported in the 2004 ARMS to have received any off-farm wage/salary income and/or any income from an off-farm business. This assumption further views the farm household, as has originally been utilized by Mincer and Polachek in their study of effect of human capital on women earnings, as an economic unit that shares consumption and allocates production and time on and off farm (see also studies by Benjamin and Kimhi; Newman and Gertler). In considering the farm household as whole and by not considering the off-farm work decision of the operator and the spouse separately (e.g., when a spouse is present), the modeling of the impact of off-farm work by the household on poverty becomes more tractable.

Because the probit model in Equation (6) is associated with the standard cumulative distribution function $\Phi(\cdot)$, its parameter estimates are obtained by means of a maximum likelihood procedure that allows for the estimation of the probability (\hat{P}_i) that the i th farm household is in poverty as in

$$(7) \quad \begin{aligned} \hat{P}_i = \Phi(\hat{z}_i) &= \int_{-\infty}^{\hat{z}_i} \phi(u_i) du_i \\ &= \int_{-\infty}^{\hat{z}_i} (2\pi)^{-1/2} \exp(-u_i^2/2) du_i, \end{aligned}$$

where $\phi(\cdot)$ is the probability density function of the standard normal, u_i (equivalent to $-\varepsilon_i$ in Equation [6], which is redefined to keep the algebra simple) is a random variable with mean zero and unit variance, and $\hat{z} = \hat{\beta}'X$.

The probability density function (ϕ) and the estimated parameters $\hat{\beta}$ from Equation (1) are then used to estimate the marginal effects (Greene, p. 668) as in⁷

$$(8) \quad \frac{\partial E[I_i | X]}{\partial X_i} = \frac{\partial P_i}{\partial X_i} = \phi(\hat{\beta}'X_i)\hat{\beta}.$$

The Data

The data source for this article is the 2004 ARMS. The ARMS, which has a complex stratified, multiframe design, is a national survey conducted annually by the National Agricultural Statistics Service and the Economic Research Service (for more detail, see www.ers.usda.gov/Briefing/ARMS). Each observation in the ARMS represents a number of similar farms (e.g., based on land use, economic size of farm, and so on), the particular number being the survey expansion factor (or the inverse of the probability of the surveyed farm being selected for surveying),

⁷This method of measuring the marginal changes in probability due to a unit increase in the explanatory variable is appropriate when the variable is continuous. For a k th dummy variable x_k , the marginal change in probability for the i th farm household is computed alternatively as (see Greene, p. 676) $\Delta_{ik} = P_{ik}(x_k = 1) - P_{ik}(x_k = 0)$.

and is referred to henceforth as survey weight. To demonstrate, the size of the sample considered in the analysis is 6,706, which, when properly expanded using survey weights, yielded 2,067,373 farm operator households.

Computational Issues

The vector X in Equation (5), as defined, is partitioned into $[X_1 X_2]$, with X_1 representing a set of endogenous variables so that $\text{Cov}(X_{1i}, \varepsilon_i) \neq 0$ and X_2 representing a set of exogenous variables. Clearly the government programs and off-farm work participation dummy variables, in addition to a possible correlation between them, are endogenous, as both income from government payments and from off-farm work by the farm operator household enter in the computation of farm household total income, a component of the composite measure of well-being on which poverty of the household is assessed. If left in their existing forms, estimation of Equation (5) would result in inconsistent and biased parameter estimates. To circumvent this problem, the method of instrumental variables is used where the potentially defective discrete vectors are replaced by their predictors using a bivariate probit (*BVP*) regression model as in the following (see Evans, Farrelly, and Montgomery; Greene, p. 721):⁸

⁸A reviewer correctly pointed to the likelihood of the education variable being endogenous to the poverty variable since a poor household lacks the resources to invest in education and a low level of education contributes to the likelihood of the household to be poor. A study by Angrist and Krueger (1991), for example, estimated the impact of compulsory schooling on earnings by using quarter of birth as an instrument for education. Card, on the other hand, handled the potential simultaneity between the schooling variable and wages by using region and time variation in school construction as instruments for education. However, the lack of valid instruments in the ARMS data set makes it nearly impossible to deal with the potential simultaneity that might exist between poverty and education. Accordingly, this issue is left in the paper as a caveat.

$$\begin{aligned}
y_1^* &= \alpha_1' Z_1 + \varepsilon_1, \\
y_1 &= 1 \text{ (participation in government programs,} \\
&0 \text{ otherwise),} \\
y_2^* &= \alpha_2' Z_2 + \varepsilon_2, \\
(9) \quad y_2 &= 1 \text{ (participation in nonfarm work,} \\
&0 \text{ otherwise),} \\
E[\varepsilon_1|Z_1, Z_2] &= E[\varepsilon_2|Z_1, Z_2] = 0, \\
Var[\varepsilon_1|Z_1, Z_2] &= Var[\varepsilon_2|Z_1, Z_2] = 1, \\
Cov[\varepsilon_1, \varepsilon_2|Z_1, Z_2] &= \rho,
\end{aligned}$$

where Z_j ($j = 1, 2$) are, each, composite vectors of a set of k_j potential instruments, \bar{X}_{1j} ($j = 1, 2$), and a set of l “exogenous” conditioning variables, X_2 , from the *BNP* model in Equation (5); α_1 and α_2 are vectors of parameters to be estimated; ε_1 and ε_2 are vectors of error terms; and ρ is the coefficient of correlation between ε_1 and ε_2 .⁹ It is posited here that the instrumental variables in Z_1 and Z_2 , also known as “exclusion restriction” variables, are determinants of participation in government programs and in off-farm work, respectively, but are uncorrelated with the poverty status of the farm household (for more detail, see Angrist and Krueger, 2001; Bound, Jaeger, and Baker; Mallar; Wooldridge, p. 212).

Finding valid (i.e., variables that are orthogonal to the structural errors, ε_i , in Equation [5]) and strong instruments for the variables depicting government program and off-farm labor participation has proven to be extremely difficult, as has been the case in the literature where similar approaches have been used to mitigate the econometric problems associated with the presence of endogenous variables. A study by Bound, Jaeger, and Baker, for example, has demonstrated the ill effect of using weak instruments (i.e., when the relationship between the instrument and the endoge-

nous variable is trivial) in that the predictors based on such instruments will be biased.

In this paper, dummy variables depicting *Access to the Internet* and the farm typology *Residentiallifestyle* are used as instruments for government program participation and for off-farm work, respectively. The search for valid instruments was based on examination of sample means, among others, to find the extent of which the respective chosen instruments represent substantial population characteristics. For example, farm households with access to the Internet, in comparison to their counterparts without such access, report nearly twice as much government payments (\$14,895 versus \$7,914) based on 2004 ARMS. In addition, although farm households with reported access to the Internet represent over 50% of all farm households, they disproportionately receive nearly three-quarters of all government payments. A study by Mishra and Park has noted that farmers use the Internet to perform many tasks, including paying bills, obtaining loans, input and commodity price tracking, contacting advisory services, and gathering information from an array of sources, including the U.S. Department of Agriculture (USDA). Findings of the study have indicated the importance of farm size and the educational attainment of the farm operator, among others, to the number of Internet application used. Considering the complexity of the laws surrounding government payments and the burden of establishing eligibility for payments, coupled with the fact that farms receiving payments tend to be larger and operated by farmers with higher levels of education than nonparticipating farms (see Gulati and Mishra), the assumption of a potential link between *Access to the Internet* and government program participation becomes more credible.

With regard to using the dummy variable *Residentiallifestyle* as an instrument for the endogenous variable depicting the off-farm labor participation decision of the farm household, the justification for this was based on the nature of how this variable is defined along with some relevant accompanying population characteristics. Specifically—and

⁹ Under the assumption that the dimensions of Z_1 and Z_2 after the inclusion of l “exogenous” conditioning variables represented by X_2 are n -by- m , identification of the model in Equation (5) (i.e., β can be estimated in terms of population moments in observable variables) requires that $m \geq l$ (for more detail, see Wooldridge, pp. 85, 211).

based on the recommendations of the National Commission on Small Farms that was established by the Secretary of Agriculture in 1997—a typology of farms was constructed that groups farms on the basis of the occupation of the operator and on income and/or sales levels in any one of nine categories (for more detail, see Hoppe et al.). “Residential/lifestyle” farms, a group of farms within this farm typology, are defined as farms with annual sales of less than \$250,000 whose operators report a major occupation other than farming. Based on the 2004 ARMS, while farm households in this group make up nearly 40% of all farm households, they tend to capture disproportionately 70% of all the incomes earned by all farm households from off-farm wages and/or salaries and from off-farm businesses. On average, these farm households, in comparison to all other farm households in the other farm typology groupings, report earning nearly twice as much from these types of earned incomes (\$85,393 versus \$45,501). In addition, 99% of Residential/lifestyle farm households reported earning these types of off-farm incomes in 2004 compared to 54% for all other households.

The bivariate probit model described in Equation (9) has four possible outcomes concerning a farm household’s participation strategy: both government programs and off-farm work, government programs only, off-farm work only, and neither. These outcomes, respectively, are captured in four distinct probability vectors (P_{jk} for $j, k = 0, 1$):

$$\begin{aligned}
 P_{11i} &= \Pr(y_{1i} = 1, y_{2i} = 1 | Z_{1i}, Z_{2i}) \\
 &= \Phi_2(\alpha'_1 Z_{1i}, \alpha'_2 Z_{2i}; \rho), \\
 P_{10i} &= \Pr(y_{1i} = 1, y_{2i} = 0 | Z_{1i}, Z_{2i}) \\
 &= \Phi_2(\alpha'_1 Z_{1i}, -\alpha'_2 Z_{2i}; -\rho), \\
 P_{01i} &= \Pr(y_{1i} = 0, y_{2i} = 1 | Z_{1i}, Z_{2i}) \\
 &= \Phi_2(-\alpha'_1 Z_{1i}, \alpha'_2 Z_{2i}; -\rho), \\
 P_{00i} &= \Pr(y_{1i} = 0, y_{2i} = 0 | Z_{1i}, Z_{2i}) \\
 &= \Phi_2(-\alpha'_1 Z_{1i}, -\alpha'_2 Z_{2i}; \rho),
 \end{aligned}
 \tag{10}$$

where $\Phi_2(\cdot, \cdot; \rho)$ is the bivariate normal cumulative density function of the model’s error terms (see Fabbri, Monfardini, and

Radice). The two-stage estimation procedure characterized by the *BVP* and the *BNP* regression analyses then provides the estimates of the coefficients in Equation (5) after purging from the model those variables that were deemed endogenous, which was done by using \hat{P}_{11i} , \hat{P}_{10i} , and \hat{P}_{01i} as their replacements.

Yet another computational concern pertains to the nature of the ARMS. Specifically, since the data underlying the two *BVP* and the *BNP* models described previously are from a multi-phase stratified survey with its attending pre- and postsampling complexity, any inference based on estimated parameters from classical statistical algorithms is suspect. This is because the estimation of the variances of these parameters, when the structure of the sampling process is complex, becomes more involved than in the case when the variances of these estimates are based on simple random samples. To attend to this complexity, the paper estimates the variances of parameters of all regression models using the jackknife delete-a-group variance (*JV*) estimation method, which is an approach of estimating variances similar to that of bootstrapping and which dates back to the work of Layard, Miller, and Quenouille, among others (for further detail in the context of the ARMS, see Dubman; Kott).

Results

Table 1 provides the results of the first stage of estimating the poverty model (see Equation [5]). Specifically, it lists the findings pertaining to the *BVP* regression model used in the derivation of the predicted probabilities of the farm household participating in government programs and/or off-farm work. The table indicates, based on the statistical significance of parameters of *Access to the Internet* and *Residential/lifestyle* variables, that these variables are good instruments (i.e., $\text{Cov}(\hat{X}_{11}, y_1)$ and $\text{Cov}(\hat{X}_{12}, y_2) \neq 0$; Equation [9]), respectively, for capturing the decision of the farm household to participate in government programs and for the decision to work off farm. However, the lack of significance on the coefficient of ρ indicates that these decisions are not made jointly by the farm household.

Table 1. Bivariate Probit Estimates of Factors Affecting the Decision to Participate in Government Programs and in Off-Farm Work by Farm Operator Households, 2004

Variables	Participation in Government Programs	Participation in Off-Farm Work
Conditioning variables		
<i>Intercept</i>	-2.9714	-1.4872***
<i>Education</i>	0.0437	0.0597
<i>Age</i>	-0.0002	-0.0006*
<i>Age, squared</i>	0.0174	0.0369
<i>White</i>	0.1903	-0.2694
<i>Male</i>	0.1590	-0.0208
<i>Married with children, under 65</i>	0.1652	0.9028***
<i>Married and childless, under 65</i>	-0.0312	0.6507***
<i>Married, 65 or older</i>	-0.1195	0.1076
<i>Renter</i>	0.1622	0.1006
<i>Sole proprietorship</i>	-0.3238	0.1040
<i>Partnership</i>	-0.2843	-0.0301
<i>Acreage fully owned</i>	-0.4652***	-0.1480
<i>Acreage partly owned</i>	-0.0404	0.0777
<i>Cash grains</i>	2.7845***	0.0111
<i>Other crops</i>	1.4393***	-0.2287
<i>Fruits and vegetables</i>	-0.0021	0.0078
<i>Dairy</i>	2.0589***	-0.7116***
<i>Beef and hogs</i>	0.5376***	-0.0704
<i>Metro county</i>	-0.5013**	-0.0658
Exclusion restriction variables		
<i>Access to the Internet</i>	0.3271***	
<i>Residential/lifestyle</i>		2.0396***
ρ^a		0.0384

Note: Log pseudolikelihood = -1,706,093.8. Sample size = 6,706. Population = 2,067,373.

Source: 2004 Agricultural Resource Management Survey.

^a ρ is the disturbance correlation.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

Table 2 gives the expected values of the exogenous variables that are used in the poverty models and that to a large extent closely follow those used by Haveman and Wolff. The table demonstrates that farm operator households in the poverty category (when absolute measure of poverty is used), in comparison to that group not in poverty, tend to have operators who are much younger. It also shows that farm operator households that are in poverty (based on a relative measure), in contrast to those that are not, tend to have operators with lower levels of education.

Table 3 presents the findings of the two *BNP* regression models that are reached based

on maximum likelihood and jackknife delete-a-group variance estimation methods. Regardless of the type of poverty measure used, whether based on an absolute or a relative definition, the poverty models have reasonable fit considering the fact that the underlying data are cross sectional in nature, as indicated by values of McFadden pseudo- R^2 (0.1988 and 0.1960, respectively).¹⁰

¹⁰ McFadden's $R^2 = [1 - L/L_0]$, where L_0 is maximum of the log likelihood function L subject to the constraint that all the regression coefficients except the intercept are zero, and L is the same function without such restriction (Amemiya, p. 1505).

Table 2. Weighted Means of Variables Used in the Poverty Models, 2004

Variables/Definition	Absolute Measure		Relative Measure		
	Not in Poverty	In Poverty	Not in Poverty	In Poverty	All ARMS Sample
<i>Age</i> (years)	57*	53	57	56	57
<i>Education</i> (years)	13.35	12.52	13.56*	12.29	13.29
<i>Race</i> (1 if white; 0 otherwise)	0.93	0.86	0.96	0.81	0.93
<i>Gender</i> (1 if male; 0 otherwise)	0.91	0.89	0.91	0.91	0.91
<i>Marital status1</i> (1 if married with children, under 65; 0 otherwise)	0.26	0.42	0.25	0.37	0.28
<i>Marital status2</i> (1 if married and childless, under 65; 0 otherwise)	0.36	0.17	0.39	0.19	0.34
<i>Marital status3</i> (1 if married, 65 or older; 0 otherwise)	0.23	0.12	0.23	0.17	0.22
<i>Renter</i>	0.22	0.21	0.22	0.22	0.22
<i>Probability of participating in government programs and off-farm work (%)</i>	28.3	25.7	29.3	24.0	28.1
<i>Probability of participation in government program only (%)</i>	11.9	14.1	11.6	13.7	12.0
<i>Probability of participating in off-farm work only (%)</i>	44.5	36.0	45.0	39.5	43.8
<i>Farm organization1</i> (1 if sole proprietorship; 0 otherwise)	0.92	0.89	0.92	0.93	0.92
<i>Farm organization2</i> (1 if partnership; 0 otherwise)	0.05	0.05	0.05	0.04	0.05
<i>Farm tenure1</i> (1 if acreage fully owned; 0 otherwise)	0.61	0.51	0.61	0.56	0.60
<i>Farm tenure2</i> (1 if acreage partly owned; 0 otherwise)	0.34	0.37	0.33	0.36	0.34
<i>Farm specialization1</i> (1 if cash grains; 0 otherwise)	0.11	0.13	0.12	0.10	0.12
<i>Farm specialization2</i> (1 if other crops; 0 otherwise)	0.25	0.17	0.25	0.24	0.23
<i>Farm specialization3</i> (1 if fruits and vegetables; 0 otherwise)	0.05	0.11	0.05	0.08	0.06
<i>Farm specialization4</i> (1 if dairy; 0 otherwise)	0.03	0.09	0.03	0.05	0.03
<i>Farm specialization5</i> (1 if beef and hogs; 0 otherwise)	0.38	0.32	0.39	0.34	0.39
<i>Farm location</i> (1 if in metro county; 0 otherwise)	0.39	0.32	0.40	0.36	0.11
Total households	1,907,942	160,278	1,622,811	444,562	2,067,373
Distribution of households (%)	92.2	7.8	78.5	21.5	100.0

Source: 2004 Agricultural Resource Management Survey. Also, the coefficients of variation (CVs) of all continuous variables are below 25%. Differences in the means of continuous variables based on poverty status (i.e., "Not in poverty" versus "In poverty") are examined with * indicating that the respective means within each row are statistically different (at the 10% level or better).

Based on the absolute measure of poverty, the probit regression results show that married farm couples, with or without children, when the age of the farm operator is older than 65,

are less likely to be in poverty. Based on the relative measure of poverty, results indicate only married farm couples with no children and, with operators aged 65 years or older,

Table 3. Probit Estimates of Factors Affecting the Likelihood of Farm Operator Households Being in Poverty, 2004

Variables/Definition	Absolute Measure		Relative Measure	
	$\hat{\beta}$	$\frac{\partial P}{\partial x}$	$\hat{\beta}$	$\frac{\partial P}{\partial x}$
<i>Intercept</i>	2.76872***	—	3.57490	—
<i>Age</i>	0.06563**	0.00488***	0.05398*	0.01341***
<i>Age, squared</i>	-0.00092 ***	-0.00006***	-0.00062**	-0.00015***
<i>Education</i>	-0.02197	-0.00163	-0.10960**	-0.02724***
<i>White</i>	-0.45556*	-0.04813**	-0.81157***	-0.26158
<i>Male</i>	-0.08597	-0.00682	0.14423**	0.03377**
<i>Married with children, under 65</i>	1.14890***	0.14244***	0.41994***	0.11365**
<i>Married and childless, under 65</i>	0.50146	0.04386**	-0.18556	-0.04482
<i>Married, 65 or older</i>	-0.50881**	-0.02968***	-0.72932	-0.14646
<i>Renter</i>	0.01791	0.00134	0.10507	0.02686**
<i>Probability of participating in government programs and off-farm work</i>	-0.05668***	-0.00421***	-0.05129***	-0.01274**
<i>Probability of participating in government programs only</i>	-0.02031	-0.00151***	-0.03050**	-0.00758***
<i>Probability of participating in off-farm work only</i>	-0.04993***	-0.00371***	-0.02919**	-0.00725***
<i>Sole proprietorship</i>	-0.25578	-0.02316	-0.17913	-0.04776
<i>Partnership</i>	-0.29279	-0.01709*	-0.17254	-0.03962
<i>Acreage fully owned</i>	-0.57292*	-0.04865**	-0.50773	-0.13223
<i>Acreage partly owned</i>	-0.17719	-0.01254	-0.02425	-0.00600*
<i>Cash grains</i>	0.61794	0.07070	1.51260	0.51681
<i>Other crops</i>	-0.05778	-0.00418	0.74699	0.21747**
<i>Fruits and vegetables</i>	0.18732	0.01620	-0.02334	-0.00574*
<i>Dairy</i>	-0.19271	-0.01214	0.78962	0.25845
<i>Beef and hogs</i>	-0.04529	-0.00333	0.05914	0.01480
<i>Metro county</i>	-0.38102**	-0.02657***	-0.43326	-0.10263***
McFadden pseudo- R^2	0.1988		0.1960	

Note: Sample size = 6,706. Population = 2,067,373.

Source: 2004 Agricultural Resource Management Survey.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

with lower chances of being poor. In fact—and based on the signs and the statistical significance of the operator's age variable and of its squared term—the likelihood of a farm household falling in poverty peaks at the early ages of 36 or 44, depending, respectively, on whether the absolute or the relative poverty

measure is being used, and declines afterward even beyond the age of 65. This result, while in contrast to Rogers, who noted higher income-based poverty among the elderly in rural areas, is not surprising in the context of the income-wealth-based measure of poverty used in this paper, as older farmers, despite their

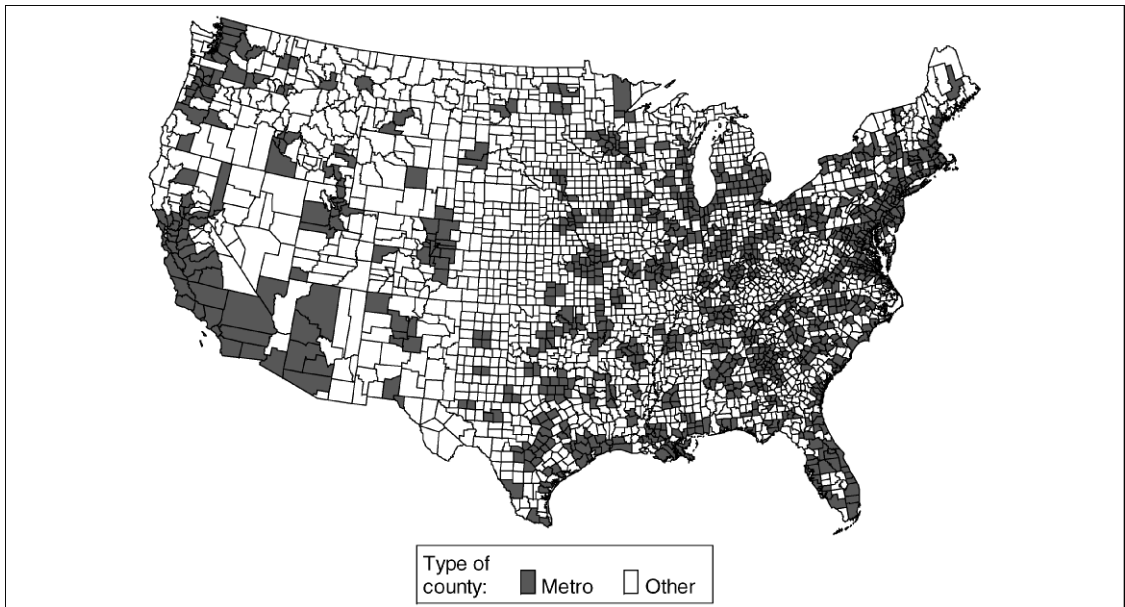


Figure 1. Farm Location as Defined by the U.S. Department of Agriculture

relatively lower incomes, tend to be significantly wealthier than their younger counterparts.¹¹

In both poverty models, the probit results show that farm households are less likely to be in poverty when the farm operator is white (relative to being black/Hispanic or other). Marginal effects findings, however, show that households headed by white farm operators are 5% less likely to be in poverty (relative to households headed by operators of other race) when poverty is based on an absolute measure, this compared to a 26% reduction in the likelihood of being poor when poverty is based on a relative measure.¹² Regardless of how poverty is measured, findings also point

toward metro counties, as delineated in Figure 1, with lower likelihoods of poverty than in nonmetro counties.

Regardless of the poverty definition, findings from Table 3 show that an increase in the likelihood of participating in both government program and off-farm work lowers the likelihood of the farm household falling in poverty. Similarly, while a household with a strategy of participating only in off-farm work is found less likely to be in poverty under both poverty measures, participating in only government payments leads to poverty reduction only when a relative measure of poverty is considered. Figure 2 presents simulated graphical depiction, with confidence intervals, of the relationship between poverty likelihoods and the likelihoods of a farm family participating in government payments and/or off-farm work under both definitions of poverty.¹³

¹¹Data from the 2004 ARMS show farm households with operators older than 65, for example, to have higher combined income and marketable wealth than households with operators younger than 35 (\$87,405 versus \$68,654, respectively). Of the total combined income-wealth measure, older farm households hold nearly five times more in marketable wealth than their younger counterparts (\$31,108 versus \$6,359).

¹²The marginal effects that capture the impact of changes in the explanatory variables on the probability of the farm household being in poverty along with their standard errors are computed using Stata, Version 9.2 (StataCorp).

¹³The simulated probabilities of a household being poor along with their confidence intervals, due to changes in the probabilities of participating in government programs and/or off-farm work, are computed with other explanatory variables being held at their means using the *Spost* package for Stata (see Long and Freese; Xu and Long).

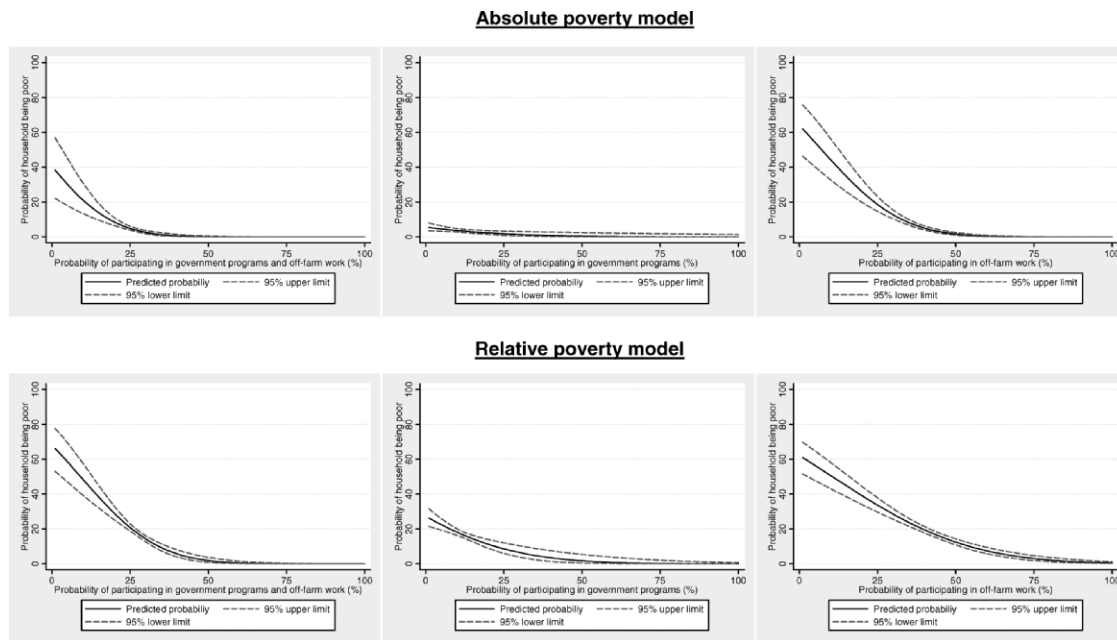


Figure 2. Probability (%) of a Farm Operator Household Being in Poverty: The Role of Participation in Government Programs and Off-Farm Work, 2004

To demonstrate, at a zero probability of participating in government payments and off-farm work by farm households (equivalent to participation rates of zero in both of these strategies), the simulated poverty probabilities (or, equivalently, poverty rates) range from around 40% to nearly 70%, depending on the measure of poverty used. These relatively high simulated poverty rates decrease monotonically

and reach zero levels as either or both strategies are adopted by all farm households. However, predicted probabilities are more uncertain at lower participation rates than they are at higher participation rates.

Figure 3 illustrates the finding of a reduction in poverty (only when the relative poverty measure is used) that results because of a marginal increase in the educational attain-

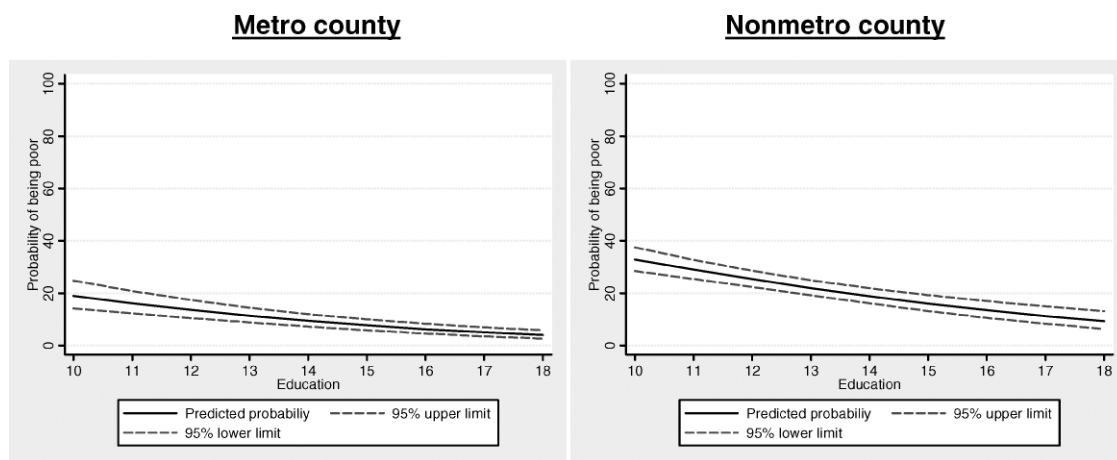


Figure 3. Probability (%) of a Farm Operator Household Being in Poverty Based on the Relative Poverty Model: The Role of Education and Farm Location, 2004

ment of the farm operator (while holding all other variables used in the model at their mean levels). The figure specifically demonstrates that while poverty rates tend to decrease with education, these rates nevertheless are higher at each successive level of education for farm households located in nonmetro counties than they are for their counterparts located in metro counties.

Summary and Policy Implications

Using 2004 data from a national survey of farms, the poverty rate for U.S. farm households based on an income definition of welfare was 11.8%. When a composite measure of well-being that considers both income and marketable wealth is used to measure poverty, less than 8% of farm households fell under the poverty threshold. Looking back, 2004 was an exceptional financial year for the farm sector, suggesting that even during the best of times for the agricultural economy, some farm households still live in poverty. It is the persistence of poverty, where year after year and despite changes in economic conditions households struggle to maintain basic consumption needs, that is of most interest to policy.

To be prescriptive, policymakers need to know the determinants of poverty. Our aim was to identify the characteristics associated with poverty, specifically distinguishing between farm operator human capital and other farm household and farm business attributes such as participation in federal farm programs, off-farm work, land tenure, and legal form of organization. Regardless of the definition of poverty, working off farm by the farm household members has the effect of significantly lowering the likelihood of poverty. The effect of working off farm in lowering poverty is accentuated by participation of the farm household in government programs. These findings suggest that poverty mitigation efforts should consider enhancing off-farm labor markets and retargeting government farm policy to address farm household poverty concerns. Results also have pointed toward the importance of educational attainment of the farm operator in lowering poverty (when

poverty is measured on a relative basis), particularly when the farm business is located in a nonmetro county.

Policies can address either side of potential shortcomings in terms of off-farm employment: the lack of available nonfarm jobs or the lack of skills necessary to compete for available off-farm jobs. The notion of fighting poverty by expanding educational and training opportunities is not new. It was, among others, a central recommendation in the 1964 report of the U.S. Council of Economic Advisors (see Sawhill). More recently, proposals directed at retraining and education for tobacco farmers have included education grants for farm families and job retraining assistance modeled on the Department of Labor's Trade Adjustment Assistance Program for displaced workers. In contrast with the traditional approach of income and price supports, job retraining would be viewed as a public investment with long-term payoff to help preserve the rural community and to help employ farmworkers in more productive activities. However, retraining programs by themselves do not necessarily increase the total number of job opportunities. Rural development initiatives aimed at encouraging investment in many low-income areas through venture capital and private investment programs and tax incentives must be part of the long-term solution. Recently, a number of USDA programs (the Rural Community Development Initiative and the Fund for Rural America) have been initiated to encourage rural business development and relocation. Greater incentives not only have the potential to increase the pool of rural nonfarm jobs but also present entrepreneurial opportunities for farmers to apply their management skills to nonfarm business. Access to labor markets could also be enhanced with the infusion of federal dollars through loans, grants, or direct payments to individuals to encourage the development and to help in lowering the costs of broadband Internet technologies in rural areas. The benefit of this technology in terms of its impact on job market growth has been highlighted in a recent study by Lehr et al. Yet other examples

that will positively impact labor markets, as has been demonstrated by several studies (see Reeder; Reeder and Brown), include improvement to the infrastructure (e.g., transportation, telecommunications, water, and energy) and the promotion of recreation and tourism in local areas.

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