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Non-farm sectors of the rural economy have always been inextricably tied to agriculture through input and output markets and as a source of employment for displaced agricultural labor, but over the past 25 years families remaining in agriculture have also come to depend on non-farm sources for a larger proportion of total family income. Nationally, about a third of farm family income was from non-farm sources in the 1950's, but by the mid-1960's farm and non-farm income were about equally important (Johnson *et al.* 1985). Recent data suggest that about 60% of farm family income comes from non-farm sources (USDA, 1986).

In the aggregate, this trend has contributed importantly to the improvement in the relative income position of farm families. Per capita incomes of farm families rose from 50% to 80% of that of their non-farm counterparts between the 1950's and the early 1980's. According to Johnson *et al.* (1985), had the relative importance of non-farm income remained at the 1960 level, per capita farm family income still would have been less than 65% that of non-farm families. This increased reliance on non-farm income has been one way for many farm families to participate in the Nation's overall economic growth, but for others, it may be necessary to offset recent financial problems in production agriculture. In addition to closing the gap between incomes in the farm and non-farm sectors, non-farm employment may affect the overall income inequality within the farm sector itself.

The purpose of this paper is to examine the importance of income from non-farm sources in New York, particularly in terms of its effect

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on income inequality within agriculture. Inequality of total family income is measured by a Gini coefficient, but this measure of overall inequality is also decomposed into the proportions due to the various sources of income. This decomposition is a significant new development because it allows one to determine the impact on total inequality from a marginal change in any particular source of income. Such comparisons are more meaningful in a policy context than asking what happens to inequality by recalculating the Gini index after eliminating a particular income source altogether. Special attention is also focused on an extended Gini which can reflect increased social aversion to inequality and to the interpretation of the Gini coefficient when, as is frequently the case in today's agriculture, farm family income in a given year (or major components of it) are negative.

Measuring Inequality

The Gini coefficient, usually defined as the ratio of the area between the Lorenz curve (which represents the fraction of total income possessed by the holders of the smallest p^{th} fraction of income) and the area under a 45^{o} line (Gastwirth, 1972), has been one of the most widely used measures of inequality in economic analysis. As such, it has been the subject of much criticism as well, the most serious being that for income distributions with the same mean, it is impossible to find an additive social-welfare function that ranks distributions by their Gini coefficients (Chipman, 1985). This type of criticism can be levelled at most rankings based on only two parameters of the distribution and at a theoretical level, what is needed is a multivariate measure that accounts for the heterogeneity of contemporary populations.

Despite this criticism, Lerman and Yitzhaki (1985) and others argue that the Gini index remains an important tool for examining income distribution. Their argument is based on the facts that: a) Gini measures and the mean permit one to form the necessary conditions for stochastic dominance, b) an extended Gini index can be used to reflect increasing social aversion to inequality in much the same way as Atkinson's (1970) index of inequality, c) both the Gini and the extended Gini can be decomposed, yielding an intuitive interpretation of the elements making up each source's contribution to inequality and d) the decomposition allows one to examine the marginal change in income by source on overall inequality.

This latter point is particularly attractive because despite one's inability to find additive social welfare functions consistent with a "mean-Gini" ranking, more general multivariate formulations still lead to social welfare functions whose partial derivatives are positive with respect to the mean and negative with respect to the Gini (Cumming, 1983, cited in Chipman, 1985). Thus, *ceteris paribus*, changes in any particular Gini coefficient due to marginal changes in income by source can be interpreted unambiguously.

Gini Ratio and Its Decomposition

Although the Gini coefficient is usually defined in relation to the Lorenz curve, Lerman and Yitzhaki (1985) demonstrate that it can also be derived directly from the formula for Gini's mean difference

$$(1) \quad A = \int_a^b F(y)\,[1-F(y)]\,dy,$$

where y is income ($a \leq y \leq b$) and F(y) is the cumulative distribution. Through integration by parts and variable transformations, they show

(2) $A = 2\ \mathrm{cov}[y,F(y)]$.

The Gini index (G) is then formed by dividing A by mean income, μ_y.

In most applications, the Gini ratio is thought to be bounded by zero and one. This is true only when all incomes are positive. However, Gastwirth (1972) shows that the Gini ratio is still defined when some incomes are negative but mean income remains positive. Then, the bounds on the Gini range from $0 \leq G \leq (\mu\text{-}a)(b\text{-}\mu)/\mu(b\text{-}a)$ and comparisons across populations become more difficult because the base is no longer unity. More is said about this later.

Letting $y_1,\ldots,y_K$ represent components of income such that $y = \sum_k y_k$, one can use the properties of the covariance of the sum of random variables (Mood *et al.*, 1974) to write

(3) $A = 2 \sum_k \mathrm{cov}(y_k,F(y))$.

Dividing (3) by μ_y and multiplying and dividing each component by $\mathrm{cov}(y_k,F(y_k))$ and μ_k yields the Gini decomposition on total income:

(4) $G = \sum_k [\mathrm{cov}(y_k,F(y))/\mathrm{cov}(y_k,F(y_k)]\cdot[2\ \mathrm{cov}(y_k,F(y_k)/\mu_k]\cdot[\mu_k/\mu_y]$

$= \sum_k R_k G_k S_k$,

where R_k is the correlation between y_k and the cumulative distribution of y, G_k is the Gini for y_k and S_k is y_k's share of y. Pyatt *et al.* (1980) prove that $-1 \leq R_k \leq 1$ and R_k takes on its extreme values when an income source is a decreasing (-1) or increasing (+1) function of total income and is zero if y_k is a constant.

To determine the change in inequality due to a marginal change in y_k, Lerman and Yitzhaki (1985) consider a change in each person's income from source k equal to $e_k y_k$ where, e_k is close to 1. Then, as proven by Stark *et al.* (1986), the partial derivative of (4) with respect to e_k is

(5) $dG/de_k = S_k(R_kG_k - G)$

and in elasticity terms

(6) $[\partial G/\delta e_k]/G = [S_kG_kR_k/G] - S_k$.

These elasticities sum to zero because a proportional increase in income from all sources would leave income inequality unaffected.

Yitzhaki (1983) derives an extension of the Gini index defined as

(7) $$G(v) = 1 - v(v-1)\int_0^1 (1-F(y))^{v-2} L(F(y))dF,$$

where L(F(y)) is the Lorenz curve. This extension includes a parameter v reflecting a relative social preference for equality. By changing v, one changes the weight attached to each point on the Lorenz curve. The weight is given by $v(v-1)(1-F(y))^{v-2} = w$. Values of v between zero and one reflect social aversion to equality; v=1 reflects equality neutrality and $v > 1$ indicates inequality aversion.

By differentiating w with respect to F(y),

(8) $\partial w/\delta F(y) = -v(v-1)(v-2)(1-F(y))^{v-3}$,

one can see that when v=2, the weights are independent of income rank. This yields the standard Gini index where everyone is weighted equally. For $1 < v < 2$ and $v > 2$, the weights increase and decrease respectively, as incomes rise. Thus, when $v > 2$, the index reflects relatively more social concern for those at the lower end of the income distribution.

The decomposition of the extended Gini G(v) is

(9) $$G(v) = \sum_k R_k(v)G_k(v)S_k,$$

where

(10) $R_k(v) = \text{cov}[y_k(1-F(y))^{v-1}]/\text{cov}[y_k(1-F(y_k))^{v-1}]$ and

(11) $G_k(v) = -v\ \text{cov}[y_k,(1-F(y_k))^{v-1})]/\mu_k$.

Application to New York Dairy Farms

For many policy purposes, it is desirable to analyze national farm-level data which include the distribution of income by source and examine regional differences. In recent years at least such data have been collected at the national level as part of USDA's Farm Costs and Return Survey. Using these data, Ahearn *et al.* (1985) analyzed the contribution of income by source at the national level, but they do not look at regional differences. In light of increasing financial stress in agriculture, New York and possibly other states have begun to ask for more information from farm families as part of their farm record programs. For example, 1985 was the first year that Cornell collected information on non-farm income, assets and liabilities as part of the Dairy Farm Business Project. These data are the basis for our analysis of the importance of non-farm income on farm family incomes in New York.

Because participation in this project is voluntary, these dairy farms may not be a representative sample. They constitute a cross section of better-than-average dairy farms in the State. Despite this limitation, the fact that 1985 was not a particularly good year for agriculture and some possibility of underreporting of non-farm income, the analysis provides a preliminary indication of the contribution of income from different sources to dairy farm family income inequality. We decompose inequality for all farms, as well as for subgroups of farms with and without income from non-farm sources. The subgroups are important because about 60% of the 491 farms had no non-farm income. Further, changes in agricultural profits, rural labor markets and government payments may affect family incomes on farms with and without non-farm income differently.

Average farm family income for participating farms was $25,420. For those with no non-farm income, the average was about $27,500 and for those with non-farm income, the average was $22,672. Net farm income (defined as the return to operator and unpaid family labor, management and equity) constitutes 73% of total income for the state sample. Non-farm income is 15% of the statewide total, but within the subgroup, it represents 40% of family income. Direct government payments are about 12% of family income in both groups.

Table 1 contains the decomposition of inequality for all farms and the two subgroups for three values of v, the parameter in the extended Gini reflecting degree of aversion to inequality. For the conventional Gini (v=2) the ratio for total income is about 0.75 for all three groups. The Gini ratio for farm income is consistently higher, while the ratios on the other two components are higher for the state and for farms without non-farm income. For the group with non-farm income, the Gini ratio for that source is below that of the total. Unfortunately, because some farm incomes and total incomes are negative, the upper bounds on these ratios differ, making it difficult to draw conclusions about degree of inequality by looking only at the Gini ratios.

Similar difficulties arise for $v \neq 2$, but there is no way to estimate upper bounds. However, as one would expect, the Gini ratios fall when relatively more weight is given to higher incomes (v=1.5). When the low end of the income scale receives a disproportionate weighting (v=5), the Gini ratios increase compared to the conventional values (v=2).

Despite these difficulties, one may still compare the contributions to inequality and the elasticities of total inequality by income

Table 1. Decomposition of New York Dairy Farm Family Income Inequality, 1985

Aversion to Inequality	Income Source	Correlation with Rank of Total Income (R_k)	Gini of Source (G_k)	Income Share (S_k)	Share of Inequality (R•G•S)	Share of Inequality (Proportion)	Elasticity of Total Inequality by Income Source
All Farms, number = 491; mean income = $25,420							
v=2	Farm	0.943	1.043 (4.633)	0.717	0.718	0.957	0.228
	Gov.	0.204	0.811	0.020	0.020	0.027	-0.093
	Non-farm	0.098	0.824	0.012	0.012	0.016	-0.135
	Total		0.749 (6.256)				
v=1.5	Farm	0.949	0.690	0.729	0.477	0.956	0.227
	Gov.	0.212	0.604	0.120	0.015	0.030	-0.090
	Non-Farm	0.075	0.617	0.151	0.007	0.014	-0.137
	Total		0.499				
v=5	Farm	0.935	2.002	0.729	1.365	0.980	0.251
	Gov.	0.075	0.990	0.120	0.009	0.007	-0.114
	Non-Farm	0.128	0.992	0.151	0.019	0.014	-0.137
	Total		1.393				
Farms without Non-farm Income, number = 280; mean income = $27,491							
v=2	Farm	0.986	0.825 (4.222)	0.878	0.714	0.966	0.088
	Gov.	0.252	0.809	0.122	0.025	0.034	-0.088
	Total		0.739 (3.658)				
v=1.5	Farm	0.984	0.544	0.878	0.470	0.959	0.081
	Gov.	0.263	0.608	0.122	0.020	0.041	-0.081
	Total		0.490				
v=5	Farm	0.989	1.586	0.878	1.377	0.994	0.116
	Gov.	0.065	0.987	0.122	0.008	0.006	-0.116
	Total		1.385				
Farms With Non-farm Income, number = 211; mean income = $22,672							
v=2	Farm	0.895	1.578 (7.864)	0.488	0.689	0.913	0.425
	Gov.	0.191	0.811	0.118	0.018	0.024	-0.094
	Non-farm	0.233	0.591	0.394	0.054	0.072	-0.322
	Total		0.755 (3.072)				
v=1.5	Farm	0.907	1.068	0.488	0.473	0.913	0.425
	Gov.	0.160	0.405	0.118	0.008	0.015	-0.103
	Non-Farm	0.223	0.415	0.394	0.037	0.071	-0.323
	Total		0.518				
v=5	Farm	0.884	3.045	0.488	1.314	0.927	0.439
	Gov.	0.316	0.987	0.118	0.037	0.026	-0.092
	Non-Farm	0.197	0.861	0.394	0.067	0.047	-0.347
	Total		1.418				

Source: Calculated from data on 491 farms cooperating in the dairy farm business summary project, Dept. of Agricultural Economics, Cornell University.

Note: The parameters v are for the extended Gini in equations (7-9). R_k, G_k, S_k and R•G•S are as defined in equations (4) and (7). The elasticity of source is from (6), or its extended Gini counterpart. The numbers in parentheses are the upper bound on the Gini index for when there are negative incomes.

source for any particular group. That is, equation (4) shows that the share of total income inequality due to a given source depends on the income share (S_k) and the source Gini (G_k), as well as where the recipients of different income sources are in the total income distribution, R_k. The values of R_k in the table reflect the correlations between each source of income and total income. The differences across sources are striking. For farm income, the correlations are 0.9 or above, while for the other two sources, the correlations range between 0.06 and 0.32. One implication of these differences is that in relative terms, government payments and non-farm income on dairy farms in New York are more equally distributed across families than is net farm income.

The importance of this "Gini correlation" is also evident when one compares the proportional contribution of each source to total inequality. In all cases, the high correlations between farm and total income explain why farm income's contribution to total inequality is much larger than its share of total income. For the subgroup with non-farm income, the contribution of farm income to inequality is just under twice its share of total income.

As suggested by equations (5) and (6), our understanding of the composition of inequality can be pushed one step further by examining the elasticity of total inequality due to a small change in income from a given source. These elasticities are shown in the last column of Table 1. Although these elasticities assume that all individuals' incomes from that source are increased proportionately, they do provide an initial indication of how changes in rural economic conditions and public policies affecting income by source are translated into the effects on income inequality.

To illustrate using the conventional Gini (v=2), a general increase of one percent in farm profitability resulting from something like a general reduction in feed prices would increase the disparity in total farm family income for the state as a whole by just over two-tenths of one percent. The effect would be quite different by subgroup. For those without non-farm income, the increase in inequality would be less than a tenth of one percent, while for the second subgroup it would be over four-tenths of one percent. This suggests that even though a general improvement in the agricultural economy might well raise average incomes to dairy farm families in New York, it's also likely that such improvements will increase income disparities, albeit less than proportionately.

Changes in farm programs that would lead to a slight increase in direct government payments would have the opposite effect on income inequality. This latter point seems counter to the commonly held view, nationally, that the distribution of government payments is skewed to higher income farms. The small correlation between direct government payments and total income is explained by the fact that dairy farms in New York are not major participants in farm programs where direct government payments are made. The situation might be much different if it were possible to estimate the indirect government payments associated with dairy price supports and include them in this government payments category.

Changes in economic conditions in the non-farm economy can also be evaluated in terms of their effect on farm family income inequality. As an illustration, consider a general increase in wage rates in rural non-farm labor markets. Initially, one might expect these wage rates to be

reflected in the incomes of those currently working off the farm. The corresponding initial impact on farm families would be to reduce income inequality. The statewide elasticity of (-0.135) would be a reasonable estimate of the percentage reduction in income inequality. However, this elasticity presumes that there is no increase in the proportion of families participating in off-farm employment. If higher rural wage rates are sustained, one would expect an increase in off-farm labor market participation. To the extent that this increased participation moves the composition of family income toward the pattern exhibited in our subsample, the longer term effect on inequality may lie somewhere between the statewide elasticity and the one for the subsample which is more than two times as large.

Conclusions

The purpose of this paper is to demonstrate how a new way of examining an old measure of income inequality (the Gini coefficient) can be used to determine the effect of marginal changes in income by source on overall farm family income inequality. As seen in the application to New York's dairy farms, this decomposition is a first step toward tying changes in economic conditions or public policy directly to changes in family income inequality. For New York dairy farms, it was seen that changes in economic conditions affecting farm profitability would exacerbate inequality, while a general improvement in wage levels in rural non-farm labor markets would have an opposite affect on inequality.

The decomposition also holds for an extended Gini measure of inequality that can reflect different social aversions to inequality. The methods of decomposition can accommodate negative components to total income often characteristic of today's agriculture and the analysis of

marginal changes in income by source remain valid under these conditions. However, negative incomes do present some difficulties in intergroup comparisons of inequality. Although an adjustment to facilitate such comparisons has been proposed (Chen *et al.* 1982, 1985; Berrebi and Silber, 1985), it remains to be seen if the decomposition holds after the adjustments. Additional work to resolve the difficulties when negative incomes are encountered seems warranted.

Finally, to affect a more direct linkage between income inequality in the agricultural sector or an entire rural region, this sort of inequality decomposition should be tied to a structural model relating general economic conditions and policy to initial changes in income by source. It is at this point that income inequality, as reflected by these summary measures, can be placed in proper context relative to other important issues in comprehensive policy analysis.

References

Ahearn, M., J. Johnson and R. Strickland. "The Distribution of Income and Wealth of Farm Operator Households". *American Journal of Agricultural Economics*, 67 (1985): 1087-1094.

Atkinson, A. "On the Measurement of Inequality". *Journal of Economic Theory*, 2(1970):244-63.

Berrebi, Z. and J. Silber. "The Gini Coefficient and Negative Income: A Comment". *Oxford Economic Papers*, 37(1985):525-26.

Chen, C., T. Tsaur and T. Hai. "The Gini Coefficient and Negative Income". *Oxford Economic Papers*, 34(1982):473-78.

_____. "The Gini Coefficient and Negative Income: Reply". *Oxford Economic Papers*, 37(1985):527-28.

Chipman, J. "The Theory and Measurement of Income Distribution". Eds. R. L. Basmann and G. F. Rhodes, Jr. *Advances in Econometrics*, Vol. 4, pp. 135-165, Greenwich, Ct.: Jai Press, Inc., 1985.

Cumming, C. *An International Comparison of Income Distribution*. Ph.D. Thesis, University of Minnesota, 1983.

Gastwirth, J. "The Estimation of the Lorenz Curve and Gini Index". *The Review of Economics and Statistics*, 54(1972):306-16.

Johnson, D. Gale, K. Hemmi and P. Lardinois. *Agricultural Policy and Trade*. New York: New York University Press, 1985.

Lerman, R. and S. Yitzhaki. "Income Inequality Effects by Income Source: A New Approach and Applications to the United States". *The Review of Economics and Statistics*, 67(1985):151-56.

Mood, A., F. Graybill and D. Boes. *Introduction to the Theory of Statistics*. 3rd ed., New York: McGraw-Hill Book Company, 1974.

Pyatt, G., C. Chen and J. Fei. "The Distribution of Income by Factor Components". *The Quarterly Journal of Economics*, November 1980, pp. 451-473.

Stark, O., J. Taylor, and S. Yitzhaki. *Remittance and Inequality*. Discussion Paper Number 1212, Harvard Institute of Economic Research, Harvard University, February 1986.

USDA. Economic Research Service. *Economic Indicators of the Farm Sector: National Financial Summary, 1985*. ECIFS 5-2, Washington, D.C., November 1986.

Yitzhaki, S. "On an Extension of the Gini Inequality Index". *International Economic Review*, 24(1983):617-27.