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On the comparative evaluation of agricultural income distributions in the European Union*

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Abstract

The paper reports a set of operational rules for ranking income distributions that could be used, given appropriate data, to address a range of policy issues concerning the economic welfare of the agricultural community, the comparability of agricultural and non-agricultural incomes, and the extent and depth of poverty in farming. The rules are based on stochastic dominance procedures and are consistent with social preferences for higher incomes and a more equal distribution of income. Their application is illustrated by means of a comparative analysis of the farm family income situation in the member states of the European Union based on FADN data.

Keywords: Economic welfare, poverty, European Union, agricultural income..

JEL Classification: D63, Q18, D31, D78.

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1. Introduction

The level of farming income in the European Union (EU) is expected to diminish as a result of the move towards liberalisation of the Common Agricultural Policy (CAP), begun with the MacSharry reforms and reinforced by international agreements under the World Trade Organisation. Moreover, changes in the method of domestic farm support, from high market prices to greater use of decoupled compensatory payments and premiums, are likely to have important implications for the way in which farming income is distributed both between and within member states. The level and distribution of farming income has been a subject of recurrent interest to agricultural economists, but rarely has this involved more than the reporting of average measures of income, the construction of Lorenz curves and the calculation of Gini coefficients.

Advances in the welfare economics literature on income and poverty now offer the opportunity for a more sophisticated analysis, and this is the subject of our paper. We report developments in welfare theory which extend the traditional approach through the definition of specific classes of welfare functions consistent with social preferences for higher incomes and a more equal distribution of incomes.[1] These developments have led to the derivation of operational rules for the ordinal ranking of income distributions that enable the comparative evaluation both of the overall well-being of communities and of the incidence and depth of poverty in those communities. Given appropriate data on the total income of farm households, these rules might be used to explore a range of policy issues concerning the economic well-being of the agricultural community and the agricultural poverty problem.

The structure of the paper is as follows. Section 2 reports the theory underlying the ordering of income distributions and outlines how welfare and poverty evaluations can be implemented using simple operational rules. Section 3 considers empirical issues of estimation and statistical inference from sample information, and outlines a non-parametric procedure to derive orderings of income distributions. Section 4 presents a comparative evaluation of the Farm Family Income situation in the member states of the Community of Twelve (EU12) based on an illustrative empirical analysis of Farm Accountancy Data Network (FADN) data for the years 1990/91 through 1994/95. The final section summarises the main findings of the paper and identifies the need for the establishment of a more satisfactory source of microeconomic information on the total income of agricultural households.

2. Ordering income distributions

The economic welfare of the farming community has been a fundamental concern of agricultural policy-makers within the European Union. Thus, the Treaty of Rome expresses a commitment to 'ensure a fair standard of living for the agricultural community, particularly by increasing the individual earnings of persons engaged in agriculture'. This has commonly been taken to mean that agricultural incomes should be comparable (in general or on average) with non-agricultural incomes or, at least, in excess of some arbitrary poverty threshold (see Hill, 1991; Zioganas, 1988). But the lack of any precise definition of the income objective has frustrated analysis of the economic well-being of the agricultural community for policy purposes (Blandford, 1996).

Recent developments in applied welfare theory, however, offer a solution to this problem by allowing comparisons to be made between income distributions without the need to fully specify the nature of the social welfare function. For this purpose, it is commonly assumed that the social welfare function W can be written as a symmetric function of individual incomes that is invariant to the size of the population (see Willig, 1981), from which it follows that cumulative distribution functions (CDFs) for income contain sufficient information to rank social states. In particular, social preferences based upon the class of increasing welfare functions imply that income distributions may be ranked using the criterion of first degree stochastic or rank dominance (Saposnik, 1981) while a further preference for mean-preserving progressive transfers implies ranking on the basis of second degree stochastic or generalised Lorenz dominance (Shorrocks, 1983). Moreover, equivalent orderings of income distributions can be generated by specific classes of poverty measure where these give rise to unambiguous rankings in the sense that the orderings are invariant to the arbitrary choice of poverty line (Foster and Shorrocks, 1988). These results can provide the basis for an analysis of agricultural income and poverty issues founded on explicit assumptions about the nature of social preferences.

First degree stochastic dominance (FSD)

To illustrate the concepts of first and second degree stochastic dominance, we consider three hypothetical distributions of income, $\mathbf{y}^R$, $\mathbf{y}^S$ and $\mathbf{y}^T$, among a population of size n. Each income vector $\mathbf{y}=(y_1, y_2, ..., y_n)$ is ordered in terms of increasing income with the minimum and maximum attainable incomes denoted respectively by y_{min} and y_{max} (i.e. $y_{min} \leq y_1 \leq y_2 \ldots \leq y_n \leq y_{max}$). Let F($y$) denote the CDF and Y($p$) the inverse CDF or quantile function, such that for some distribution $\mathbf{y}^R$, $F_R(y)$ is the proportion of the population whose income falls below any arbitrary income level y ($y_{min} \leq y \leq y_{max}$) and $Y_R(p)$ is the p-th income quantile of the population ($0 \leq p \leq 1$). According to the FSD criterion, $\mathbf{y}^R$ dominates $\mathbf{y}^S$ if and only if:

$$F_R(y) \leq F_S(y) \text{ for all } y \text{ and } F_R(y_i) \neq F_S(y_i) \text{ for some i} \quad (1)$$

or equivalently:

$$Y_R(p) \geq Y_S(p) \text{ for all } p \text{ and } Y_R(p_i) \neq Y_S(p_i) \text{ for some i} \qquad (1')$$

so that ranking involves comparison of either CDFs or inverse CDFs.

Saposnik (1981) identifies FSD with rank dominance given that the i-th poorest individual must be at least as well off, and at least one individual must be better off, for one distribution to be preferred to another. FSD thus derives its normative content from a combination of the Pareto principle with the axiom of anonymity, and is consistent with the entire class of increasing social welfare functions for which:

$$W(\mathbf{y}^R) > W(\mathbf{y}^S) \text{ iff } \mathbf{y}^R \neq \mathbf{y}^S \text{ and } y_i^R \geq y_i^S \text{ for all i} \qquad (2)$$

FSD may be interpreted as a pure efficiency criterion since it does not entail any preference for equality. In particular, mean-preserving income transfers between any pair of individuals can not lead to an improvement in welfare under any circumstances.

Foster and Shorrocks (1988) have also linked FSD with the head-count poverty ratio, $P(\alpha=1, z)$, which is the first member of the class of poverty measures $P(\alpha,z)$ proposed by Foster *et al.* (1984) where the value of α corresponds to the degree of stochastic dominance. (α=1, 2, ..., ∞.). The head-count ratio is defined as the proportion of the population at or below any poverty line z:

$$P(\alpha=1, z) = F(z) \text{ for } y_{min} \leq z \leq y_{max} \qquad (3)$$

from which it follows that if distribution $\mathbf{y}^R$ rank dominates $\mathbf{y}^S$ then head-count poverty in $\mathbf{y}^R$ cannot exceed that in $\mathbf{y}^S$, regardless of the choice of income threshold z.

Figure 1. Cumulative distribution functions (illustrating stochastic dominance relationships)

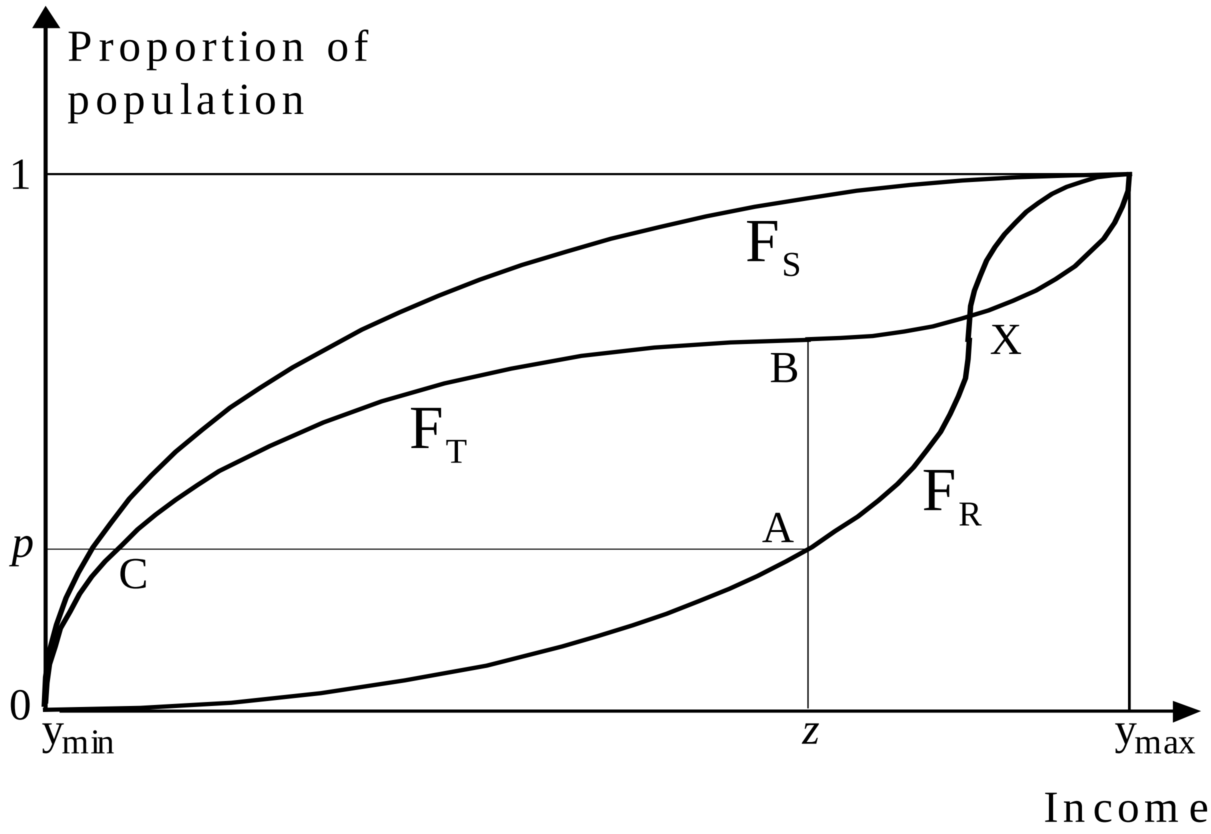


Figure 1 is adapted from Thistle (1989) and illustrates the concept of FSD by depicting the CDFs of the three hypothetical income distributions. The diagram is drawn so that $\mathbf{y}^R$ (and $\mathbf{y}^T$) dominates $\mathbf{y}^S$ according to the FSD criterion since F_R lies everywhere below F_S relative to the horizontal axis and everywhere above F_S relative to the vertical axis. Thus head-count poverty is unambiguously lower in y^R as the proportion of the population falling below any given level of income is lower for distribution $\mathbf{y}^R$ than for $\mathbf{y}^S$. In contrast, F_R and F_T cross, with the result that the two income distributions can not be ordered using the FSD criterion.

If the distribution functions cross in a pairwise comparison, the analysis may still be taken forward in one of two ways (Bishop *et al.*, 1993). First, despite the crossing it may be possible to draw conclusions about poverty if the poverty line *z* can reasonably be assumed to be below the crossing point. For example, the poverty line *z* in Figure 1 lies to the left of the crossing point X so the head-count poverty ratio is unambiguously lower in distribution y^R than in y^T since F_R rank dominates F_T at all income levels below that at X. Thus, testing for rank dominance on truncated distributions yields the dominance ordering of head-count poverty providing the poverty line can be assumed to be below the truncation point.

Second, further restrictions can be placed on the class of admissible welfare functions by assuming a social preference for equality. This leads to the application of the second degree stochastic or generalised Lorenz dominance criterion.

Second degree stochastic dominance (SSD)

Consider again the two distributions of income y^R and y^S, then y^R dominates y^S according to the SSD criterion if and only if:

$$\int_{y_{min}}^{y} F_R(u)du \leq \int_{y_{min}}^{y} F_S(u)du \text{ for all } y \text{ and } F_R(y_i) \neq F_S(y_i) \text{ for some i} \quad (4)$$

or equivalently:

$$\int_{0}^{p} Y_R(u)du \geq \int_{0}^{p} Y_S(u)du \text{ for all } p \text{ and } Y_R(p_i) \neq Y_S(p_i) \text{ for some i} \quad (4')$$

where *u* is a variable of integration. Ranking thus involves comparison either of the integrals of the CDFs or of the integrals of the inverse CDFs . Comparison of (1) with (4) indicates that FSD implies SSD in the sense that if y^R stochastically dominates y^S in the first degree then y^R will also stochastically dominate y^S in the second degree.

The integral of the inverse CDF is more commonly known as the generalised Lorenz curve, GL(*p*), and may be simply obtained by scaling up the ordinary Lorenz curve by the mean of the distribution. Shorrocks (1983) identifies SSD with Generalised Lorenz dominance given that the combined income of the poorest 100*p* per cent of the population is at least as large, and for at least one p_i is strictly larger, for one distribution to be preferred to another. SSD therefore embodies a preference for equality since mean-preserving income transfers from rich to poor will be welfare-improving. This proposition is known as Dalton's principle and is shown by Dasgupta *et al.* (1973) to imply that the welfare function is Schur-concave. Thus application of the SSD criterion is consistent with the class of increasing, Schur-concave social welfare functions W_S for which:

$$W(\mathbf{y}^R) > W(\mathbf{y}^S) \text{ iff } \mathbf{y}^R \neq \mathbf{y}^S \text{ and } \sum_{i=1}^{j} y_i^R \geq \sum_{i=1}^{j} y_i^S \text{ for all j = 1, 2, ..., n.} \tag{5}$$

SSD incorporates both preferences for efficiency and equality, and is compatible with the Utilitarian ethic that social welfare is the sum of individual utilities which are, in turn, concave in income (i.e., there is decreasing marginal utility of income). The criterion implies that higher mean income can more than offset a loss of equality, which makes the SSD criterion less restrictive than the formerly common practice of ranking income distributions on the joint basis of their means and Lorenz curves. But the converse does not apply in that greater equality cannot compensate for a decrease in mean income, however small.

Foster and Shorrocks (1988) additionally link SSD with the income-gap poverty ratio, P(α=2,*z*), which is defined as the normalised sum of the income shortfalls of the population below any poverty line *z*:

$$P(\alpha = 2, z) = \int_{y_{min}}^{z} \left[\frac{z - u}{z}\right] dF(u)du = F(z)\left[\frac{z - \mu_z}{z}\right] \text{ for } y_{min} \leq z \leq y_{max} \quad (6)$$

where μ_z is the mean income of the poor. It follows that if distribution $\mathbf{y}^R$ stochastically dominates $\mathbf{y}^S$ in the second degree then income-gap poverty in $\mathbf{y}^R$ cannot exceed that in $\mathbf{y}^S$, regardless of the choice of poverty line *z*.

Figure 1 also serves to illustrate the concept of SSD. Because $\mathbf{y}^R$ (and $\mathbf{y}^T$) dominates $\mathbf{y}^S$ according to the FSD criterion, the same is true for the SSD criterion. However, the figure is drawn so that $\mathbf{y}^R$ also dominates $\mathbf{y}^T$ according to the SSD criterion, even though F_R and F_T cross, since the integral of F_R with respect to the horizontal axis (area $y_{min}\,z$A) is less than that of F_T (area $y_{min}\,z$B) for any arbitrary poverty line *z* and with respect to the vertical axis (area $0p$A) is greater than that of F_T (area $0p$C) for any arbitrary population proportion *p*. Thus income-gap poverty is lower for $\mathbf{y}^R$ than for either $\mathbf{y}^S$ or $\mathbf{y}^T$ at any given poverty line *z*.

Finally, as with FSD, it may still be possible to rank two distributions even if they can not be ordered using the SSD criterion. First, it may be possible to draw conclusions about income-gap poverty from an SSD ordering of truncated distributions providing the poverty line can reasonably be assumed to be below the truncation point. Second, one may also test for stochastic dominance of the third or higher degree although this path is not pursued further in the paper due to the informational limitations of the data set employed in the study. Third degree dominance further implies social preferences for progressive transfers at lower income levels and is associated with the distribution-sensitive index $P(\alpha=3,z)$ of Foster *et al.* (1984). In the limit, q-th degree dominance tends to the maximin criterion as q tends to infinity (see Lambert, 1993).

3. Estimation and statistical inference

Microdata on the incomes of farmers and their households is generally obtained from farm account surveys, household budget surveys or tax records. However simple comparison of income distributions constructed directly from such sample information may lead to erroneous inferences about differences in overall welfare or poverty levels because of sampling error, so the use of methods of statistical inference in relation to dominance criteria is advisable (Howes, 1996). Following the pioneering work of Beach and Davidson (1983), a range of non-parametric (distribution-free) asymptotic tests for overall welfare and poverty dominance has been developed. We adapt the procedures outlined in Kakwani (1993) and extended in Zheng *et al.* (1995), since our requirement is to compare income distributions at a given set of income thresholds or levels (i.e. income class boundaries) rather than at a given set of population quantiles (e.g. deciles or quintiles).

Suppose we have a random sample of m individual units whose incomes are given as y_1, y_2, ..., y_m then consistent estimators of the head-count ratio and income-gap poverty measures, $P(\alpha=1,z)$ and $P(\alpha=2,z)$ respectively, are given by:

$$\hat{P}(\alpha,z) = \frac{1}{m}\sum_{i=1}^{m} I_i\left[\frac{z - y_i}{z}\right]^{\alpha-1} \equiv \frac{1}{m}\sum_{i=1}^{m} M_i(\alpha,z) \text{ where } M_i(\alpha,z) = I_i\left[\frac{z - y_i}{z}\right]^{\alpha-1} \quad (7)$$

and I_i is an indicator variable which is set equal to one if $y_i \leq z$ and zero otherwise. Kakwani (1993) shows that $\sqrt{m}\,[\hat{P}(\alpha,z) - P(\alpha,z)]$ is asymptotically normally distributed with zero mean and variance $\sigma^2 = E\{[M_i(\alpha,z) - P(\alpha,z)]^2\}$ for which a consistent estimator is given as:

$$\hat{\sigma}^2 = \left\{ \frac{1}{m} \sum_{i=1}^{m} \{M_i(\alpha, z)\}^2 \right\} - \{\hat{P}(\alpha, z)\}^2 = \hat{P}(2\alpha - 1, z) - \{\hat{P}(\alpha, z)\}^2 \qquad (8)$$

and the estimated standard error of $\hat{P}(\alpha, z)$ is then simply $\hat{\sigma}/\sqrt{m}$. These findings provide the basis for a straightforward test for the equivalence of poverty levels between two income distributions, say, $\mathbf{y}^R$ and $\mathbf{y}^S$. Thus, given the poverty line or income threshold z, let $\hat{P}_R(\alpha, z)$ and $\hat{P}_S(\alpha, z)$ be the sample poverty indices estimated from randomly and independently drawn samples of sizes m_R and m_S respectively. Then under the null hypothesis H_0: $\hat{P}_R(\alpha, z) = \hat{P}_S(\alpha, z)$, the test statistic:

$$v = \left[\hat{P}_R(\alpha, z) - \hat{P}_S(\alpha, z)\right] \Big/ \left[\left(\hat{\sigma}_R^2 / m_R\right) + \left(\hat{\sigma}_S^2 / m_S\right)\right]^{1/2} \qquad (9)$$

has a standard normal distribution where $\hat{\sigma}_R^2$ and $\hat{\sigma}_S^2$ are the corresponding estimated variances. Hence, if v is significantly negative (positive) then $\mathbf{y}^R$ has a lower (higher) poverty level than $\mathbf{y}^S$ at the specified income level *z*.

Zheng *et al.* (1993) subsequently apply the test statistic v to the comparison of multiple poverty lines based on simultaneous inference procedures that require the use of the studentised maximum modulus (SMM) distribution.[2] Consider the multiple comparison of the two distributions $\mathbf{y}^R$ and $\mathbf{y}^S$ at a set of common income levels that partition the income range into K mutually exclusive and exhaustive classes. Let v_k (k=1,2,.. K) be the value of the test statistic evaluated at the upper boundary of the k'th class,[3] then the test procedure allows four possible outcomes. First, poverty dominance (and hence stochastic dominance of the corresponding degree) of $\mathbf{y}^R$ over $\mathbf{y}^S$ requires that no v_k is significantly positive and at least one of them is significantly negative. Second, dominance of $\mathbf{y}^S$ over $\mathbf{y}^R$ requires that no v_k is significantly negative and at least one of them is significantly positive, since the test is symmetric. Third, neither distribution is dominant if one or more v_k are significantly negative and one or more v_k are significantly positive. In this case, limiting the comparison to the first J (J<K) class boundaries may yield a conclusive ordering over the truncated distributions. Finally, the two distributions can not be distinguished if no v_k is significantly different from zero.

Turning to the particular cases of interest, the estimator of the head-count poverty ratio , $\hat{P}(1,z)$, is simply q_z/m, where q_z is the number of units in the sample with income less than *z*, and the corresponding variance estimator is given as $\{q_z/m\}(1-\{q_z/m\})$. Hence, inferences can be drawn about FSD and head-count poverty dominance so long as grouped frequency data are available by income class, which is generally the case in even the most minimal summary presentation of income survey results.

Second, the estimator of the income-gap poverty ratio, $\hat{P}(2,z)$, is given as $\{q_z/m\}(z-\bar{y}_z)/z$ where $\bar{y}_z$ is the cumulative sample mean (i.e. the mean income of those units with incomes less than z), and the corresponding variance estimator is given as $\{q_z/m\}[s_z^2+(1-\{q_z/m\})(z-\bar{y}_z)^2]/z^2$ where s_z^2 is the cumulative sample variance (i.e. the variance of those units with incomes less than *z*). Estimation of income-gap poverty is practicable given data on sample frequencies and mean income levels by income class for a known set of class boundaries, while knowledge of the sample variance of each income class is also required for statistical inference.[4] However, if sample variances are unknown then inferences may still be drawn given approximate estimates of these variances obtained using appropriate interpolation techniques, while Anderson (1996) proposes a general estimation and testing framework based on a linear interpolation methodology which is applicable in the absence of information on both sample means and variances.

In the case of the FADN survey data employed in this paper, results are presented in a standardised summary format which records sample frequencies and mean income levels by income class but gives no information either on the overall sample range or on sample variances. The sample variance of each income class was therefore approximated by means of the split-histogram interpolation technique recommended by Cowell and Mehta (1982) with the widths of the lowest and highest income classes specified as twice the (absolute) difference between the respective class mean and interior bound. The resultant SSD rankings proved to be relatively insensitive to the particular choices of interpolation technique and range assumption used to generate the sample variance estimates. By way of comparison, we note below that making allowance for sampling error through the use of the statistical test procedures generated far more conclusive rankings than simple numerical (zero variance) comparisons.

4. Empirical Analysis

The imprecise nature of the income objective of the CAP is reflected in a corresponding lack of well-specified operational goals either in terms of the targeted income variable or the intended recipients. Recent discussion has focused on the total income of agricultural households (TIAH) and has led to the development of a new range of economic indicators at the sectoral level (Hill, 1996a). However, no corresponding provision has been made at the farm or household level so that the annual FADN survey remains the only consistent source of microdata currently available on farming incomes in the member states of the Community of Twelve (EU12). This survey is widely recognised to provide a less than satisfactory basis for the analysis of the economic well-being of the agricultural community due to problems of coverage, scope and methodology. Nevertheless, Hill (1991) suggests in his authoritative review that FADN data on the distribution of farm family income per holding (FFI/holding) could provide 'an important guide to the existence and locations of holdings generating small amounts of income for their occupiers' (p.43) that may be of assistance in the continuing attempts to redistrubute income support among farmers (Commission of the European Communities, 1991; European Commission, 1997). The following analysis of FFI/holding by member state serves this particular objective, although it is more generally intended to illustrate the nature of the welfare and poverty comparisons that could be made if a micro-counterpart of the TIAH were to be established.

The FADN survey is based on a representative sample of some 58000 'commercial' farms which market the bulk of their production and have economically significant levels of agricultural activity. It excludes many small farms whose occupiers might generally be considered part of the agricultural community for policy purposes: only 50% of the holdings recorded in the 1993

Farm Structure Survey were covered by FADN. FFI/holding is currently the main FADN income indicator reported in official statistics and is a residual measure of farm business income which represents the return on the labour and owned capital (including land) of the farmer and family. ‘In practice it accords broadly with the notion of profit from farming’ (Hill, 1996b). However, FADN does not provide reliable estimates of per capita farming incomes given limitations in the concept and measurement of the unpaid labour of farmers and their families (see Hill, 1991, pp.43-4), nor, more generally, enable incomes to be adjusted to reflect the different needs of households of different size since data are not collected on the composition of farm households. Moreover, FADN does not provide information on the total income position of farm households since data are not collected on non-farm sources of income. Thus, no conclusions regarding the overall welfare of farm households or the extent of agricultural poverty can be drawn from our results.

The main analysis was based on the 1994/95 FADN survey summary of FFI/holding for six classes of income, with all monetary values converted from national currencies into ECU at prevailing exchange rates. Table 1 reports the estimates of the head-count and income-gap ratios calculated from these data, together with the associated asymptotic standard errors. The head-count ratios show that the Mediterranean countries typically have the largest proportion of farms with low incomes from farming, with more than 80% of farms in Portugal and 50% of farms in Italy generating incomes of less than 5000 ECU. Conversely, the Northern European states consistently have the highest proportion of farms with high farm incomes, with less than 80% of farms in Belgium, the Netherlands, Luxembourg and United Kingdom generating incomes below 50000 ECU. The income-gap ratios point to the so-called ‘negative income problem’ in the Northern European states which is associated with high levels of farm indebtedness (European Commission, 1995) and is particularly severe in Denmark (where the average loss of the 44% of farms found in the lowest income class was 8700 ECU) and the Netherlands (where the bottom 23% of farms lost 14000 ECU each on average). Nevertheless, overall mean incomes were generally higher in the Northern states than in the Mediterranean states and this is reflected in the lower estimates of the income-gap ratios at the 200000 ECU threshold.

The ranking exercise was conducted using the estimates presented in Table 1, though the number and spacing of the income thresholds are not ideally suited for this purpose. In particular, because the lowest income class accounts for a high proportion of the sample farms in some member states, the ordering generated by the FSD criterion proved unreliable with conclusive rankings obtained for some pairings of member states even though the income-gap ratios indicated a crossing of the two CDFs below the first income threshold of 5000 ECU. We therefore focus exclusively on the orderings generated by the SSD criterion as these seem likely to be more reliable given that the share of total farm income accounted for by the lowest income class is much lower (and is, in some cases, negative) than the proportion of farms.

The application of the SSD criterion to the full (non-truncated) income distributions resulted in conclusive rankings of 42 of the 66 possible pairings of member states using the statistical inference test procedure, with none of the pairs of the distributions being statistically indistinguishable. In contrast, simple numerical comparison would have generated a more partial ordering with only 33

Table 1. Head count and income-gap ratios by member state, 1994/95

Member state	Sample size	Mean income (‘000 ECU)	Head count ratio $\hat{P}(1,z)$						Income-gap ratio $\hat{P}(2,z)$					
			Income threshold z (‘000 ECU)						*Income threshold z (‘000 ECU)*					
			5	10	20	30	50	200	5	10	20	30	50	200
Belgium	1194	38.8	0.075	0.129	0.297	0.486	0.730	1.000	0.157	0.128	0.168	0.242	0.391	0.806
			0.008	*0.010*	*0.013*	*0.014*	*0.013*	*0.000*	*0.019*	*0.004*	*0.005*	*0.005*	*0.006*	*0.004*
Denmark	2111	13.2	0.439	0.542	0.693	0.805	0.922	1.000	1.201	0.846	0.733	0.740	0.792	0.934
			0.011	*0.011*	*0.010*	*0.009*	*0.006*	*0.000*	*0.037*	*0.012*	*0.008*	*0.007*	*0.007*	*0.003*
West Germany	5098	18.7	0.262	0.371	0.588	0.764	0.926	1.000	0.495	0.407	0.444	0.524	0.658	0.907
			0.006	*0.007*	*0.007*	*0.006*	*0.004*	*0.000*	*0.014*	*0.004*	*0.004*	*0.004*	*0.004*	*0.001*
Greece	5360	9.8	0.312	0.643	0.912	0.974	0.995	1.000	0.147	0.323	0.565	0.693	0.811	0.951
			0.006	*0.007*	*0.004*	*0.002*	*0.001*	*0.000*	*0.004*	*0.003*	*0.003*	*0.003*	*0.002*	*0.001*
Spain	6391	14.3	0.214	0.477	0.808	0.910	0.967	1.000	0.200	0.269	0.471	0.604	0.740	0.929
			0.005	*0.006*	*0.005*	*0.004*	*0.002*	*0.000*	*0.006*	*0.003*	*0.003*	*0.003*	*0.002*	*0.001*
France	7899	26.2	0.114	0.217	0.457	0.668	0.880	1.000	0.226	0.194	0.266	0.367	0.538	0.869
			0.004	*0.005*	*0.006*	*0.005*	*0.004*	*0.000*	*0.008*	*0.002*	*0.002*	*0.002*	*0.003*	*0.001*
Eire	1207	13.6	0.357	0.573	0.788	0.883	0.959	1.000	0.222	0.343	0.521	0.627	0.748	0.932
			0.014	*0.014*	*0.012*	*0.009*	*0.006*	*0.000*	*0.011*	*0.006*	*0.007*	*0.006*	*0.006*	*0.002*
Italy	17034	10.5	0.527	0.722	0.873	0.926	0.967	1.000	0.315	0.477	0.645	0.731	0.818	0.947
			0.004	*0.003*	*0.003*	*0.002*	*0.001*	*0.000*	*0.003*	*0.002*	*0.002*	*0.002*	*0.001*	*0.001*
Luxembourg	290	32.0	0.136	0.200	0.337	0.523	0.775	1.000	0.267	0.219	0.243	0.303	0.453	0.840
			0.020	*0.023*	*0.028*	*0.029*	*0.024*	*0.000*	*0.046*	*0.011*	*0.011*	*0.012*	*0.014*	*0.007*
Netherlands	1528	38.7	0.233	0.296	0.436	0.567	0.713	1.000	0.886	0.573	0.470	0.480	0.546	0.806
			0.011	*0.012*	*0.013*	*0.013*	*0.012*	*0.000*	*0.049*	*0.010*	*0.008*	*0.007*	*0.007*	*0.006*
Portugal	3289	2.9	0.818	0.932	0.976	0.991	0.996	1.000	0.707	0.794	0.877	0.913	0.945	0.985
			0.007	*0.004*	*0.003*	*0.002*	*0.001*	*0.000*	*0.010*	*0.005*	*0.003*	*0.003*	*0.002*	*0.001*
UK	3344	35.0	0.196	0.296	0.492	0.627	0.786	1.000	0.346	0.296	0.347	0.420	0.539	0.825
			0.007	*0.008*	*0.009*	*0.008*	*0.007*	*0.000*	*0.014*	*0.004*	*0.004*	*0.004*	*0.004*	*0.004*
EU12	54745	15.1	0.373	0.560	0.763	0.860	0.942	1.000	0.344	0.409	0.542	0.634	0.743	0.925
			0.002	*0.002*	*0.002*	*0.001*	*0.001*	*0.000*	*0.002*	*0.001*	*0.001*	*0.001*	*0.001*	*0.000*

Source: Authors’ estimates from the level 1 results by FFI/holding of the 1994/95 FADN survey, summarised in six income classes (in ‘000 ECU): <5;5-10;10-20;20-30;30-50; ≥50. Given that the highest class is unbounded, the upper income threshold of 200000 ECU has been chosen to lie above the upper limit of the income range implied for any member state by the interpolation procedure used to approximate the standard errors of the income-gap ratio.
The figures in italics are estimates of the asymptotic standard errors.

of the pairings proving conclusive. This difference in ranking ability is due to the number of apparent ‘crossings’ that are revealed by the inference tests to be insignificant once sampling errors are taken into account. The finding that inference-based dominance analysis leads to more complete orderings of distributions than numerical (zero-variance) comparisons is a standard result in the literature (see Bishop *et al.*, 1993).

Figure 2a presents the resultant ordering of member states in the form of a Hesse diagram in which dominance is indicated by a connected line flowing downwards from the higher-ranked member state. For example, Belgium dominates France which in turn dominates Italy. In general, the Northern European states have higher mean incomes and therefore tend to dominate the Mediterranean states under the SSD criterion. However, the combined income of the lowest income farms in some Northern states is smaller in absolute terms, given the severity of the negative income problem, than that of the corresponding farms in the Mediterranean states. Thus, the Northern states do not uniformly dominate the Mediterranean states in spite of the disparities in mean income levels. For example, the Netherlands does not dominate any of the Mediterranean states and the United Kingdom does not dominate either Spain or Greece.

The SSD criterion was also used to generate orderings of the member states with the distributions truncated above each of the specified income thresholds. The resultant orderings are more conclusive than that generated by application of the SSD criterion to the full distributions, with 46 conclusive rankings at a truncation point of 50000 ECU, 48 at 20000 ECU, and 60 at 5000 ECU. Figure 2b illustrates the ordering generated with the truncation point of 20000 ECU which is greater than the EU12 average FFI/holding of 15100 ECU in 1994/95 and may

Figure 2a. SSD ordering based on full distributions

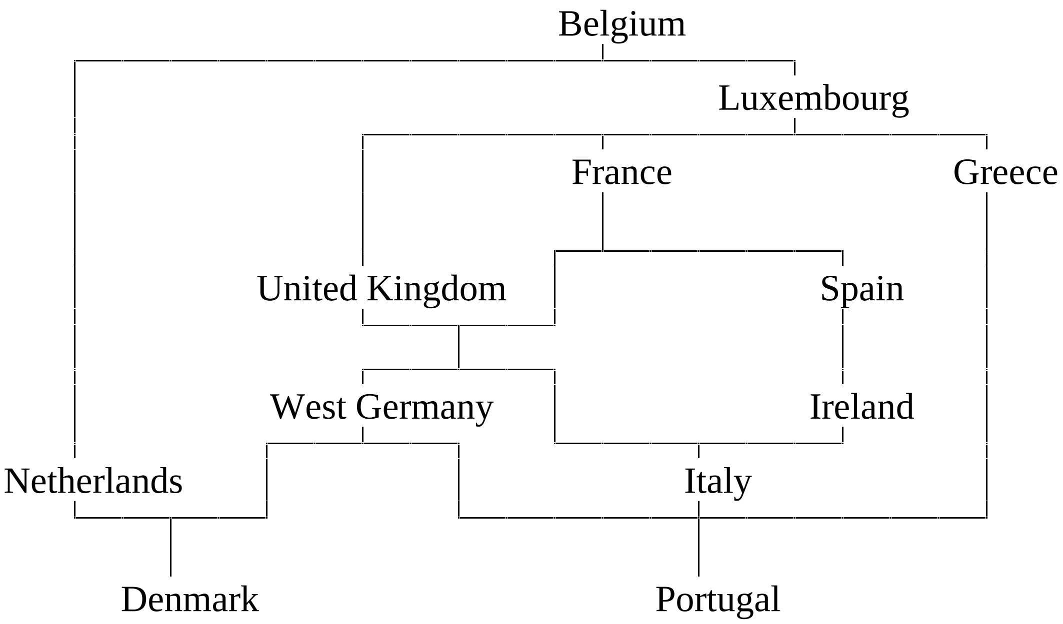
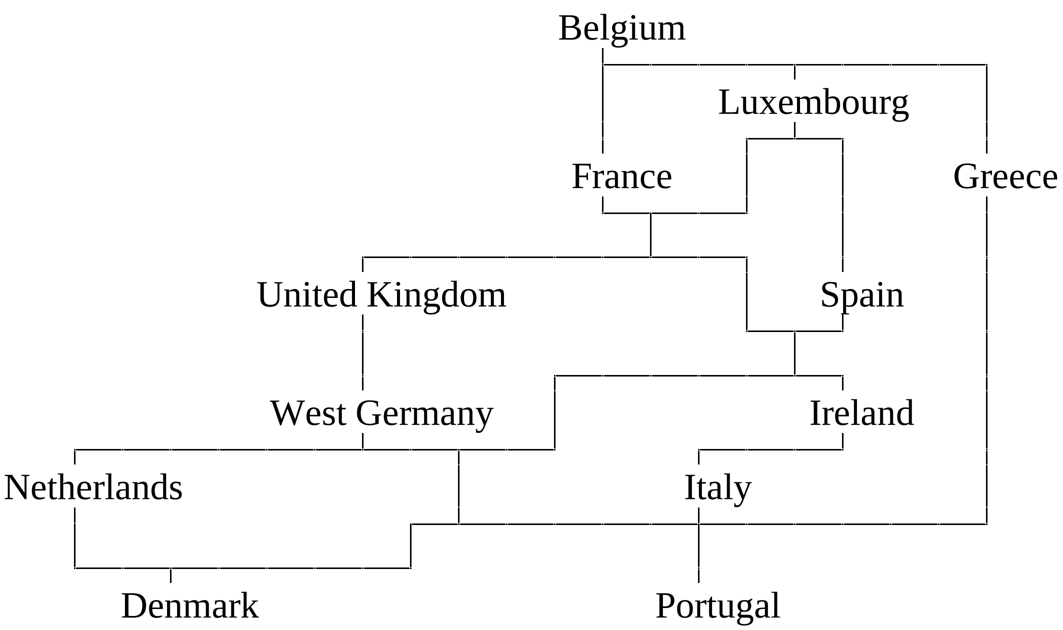


Figure 2b. SSD ordering based on distributions truncated above 20000 ECU.



Note: With infinite degrees of freedom, the 5% critical value of the SMM distribution for 6 multiple comparisons is 2.631, and for 3 multiple comparisons is 2.388 (Stoline and Ury, 1979).

be reasonably assumed to represent a more than adequate level of farm family income. The structure of the Hesse diagram is broadly similar to that for the ordering of the full distribution, but all of the Mediterranean states except Portugal now dominate Denmark while Spain dominates the Netherlands as well. The ordering of the truncated distribution thus provides a less clear-cut assessment of the standing of the Northern European states relative to Mediterranean states.

Finally, to examine the robustness of the orderings we repeated the analysis with FADN data for the years 1990/91 to 1993/94, with all monetary values expressed in 1995 ECU to eliminate the influence of both inflation and exchange rate movements.[5] The fine detail of the resultant orderings varies with the fluctuating fortunes of the individual member states (in particular, the relative positions of both Spain and the United Kingdom improve in the later years). However, the broad structure of all of these orderings is similar to those of 1994/95 given that the ranking of the member states by mean income was relatively stable over the period. For example, Belgium was invariably ranked above all other member states and Portugal was consistently dominated by all, or virtually all, other member states with the exception of Denmark. And it remains the case that the most prosperous Northern European states never uniformly dominate the Mediterranean states in spite of the disparities in mean income levels. In particular, the Netherlands, the United Kingdom and France were not found to dominate Greece in any year.

5. Conclusion

The paper has reported a set of operational rules for ranking income distributions which may be used to address a range of policy issues concerning the economic welfare of the agricultural community, the comparability of agricultural and non-agricultural incomes, and the extent and depth of poverty in farming. The rules are based on stochastic dominance procedures and may be derived from specific restrictions on the form of the social welfare function that imply preferences for higher incomes and a more equal distribution of income. However, two important advantages of these procedures are that they do not require that an exact set of distributional weights be specified in order to draw welfare conclusions, nor that a fixed poverty line be chosen in order to construct poverty orderings (Bishop *et al.*, 1993).

The application of the rules was illustrated by means of a comparative analysis of farming income levels across the member states of the EU12 using FADN data on farm family income per holding for the years 1990/91 through 1994/95. Rankings were obtained with the SSD criterion and suggest that the overall farm family income situation in the Northern European states was more favourable than in the Mediterranean states given the existence of wide disparities in mean income levels. However, because of the negative income problem, the Northern states do not uniformly dominate the Mediterranean states. Indeed, restricting the comparison to the bottom end of the income distribution, by excluding those farms that might reasonably be assumed to generate more than adequate levels of family income, revealed that the income shortfall was greater in the Netherlands than in Spain, and greater in Denmark than in any of the Mediterranean states except Portugal. The use of the SSD criterion therefore leads to a less clear-cut assessment than a simple comparison of mean income levels would suggest.

These findings may be of some help in guiding the continuing attempts to redistrubute income support among farmers (Commission of the European Communities, 1991; European Commission, 1997). For example, the Southern European states have long demanded additional measures to improve farm structures and thereby help to counter the perceived bias of the CAP in favour of ‘Northern’ commodities (see Bergmann, 1984; Soares, 1988). These claims are reasonable if the criterion for a member state’s eligibility for additional support is based on the level of average farm family income relative to the EU average. However, the ranking of the member states on the basis of the SSD criterion suggests that such aid would not be justified in terms of the farm family income of the lowest income groups. It might be more appropriate to tackle specific problems of farm indebtedness in Denmark (assuming the existence of suitable policy instruments) before trying more generally to raise mean farm family incomes in the Mediterranean states.

We would not wish though to over-emphasise the policy significance of our empirical findings given the limitations of FADN data for the analysis of the economic well-being of the agricultural community. Instead, we see the main value of the empirical study as being the demonstration of the potentially rich analysis of welfare and poverty issues that would be possible given a data source that provided information on the total income position of agricultural households and thereby enabled valid comparisons to be drawn with other socio-economic groups. Following Hill (1996a), we therefore conclude by urging the establishment of a microeconomic counterpart of the TIAH to complement the sectoral-level indicators that have been developed in recent years.

Notes

1. See Lambert (1993) for an overview. Note that we do not explore the use of so-called abbreviated welfare functions (which are expressed simply as a function of the mean income level and a summary inequality measure such as the Gini coefficient) to provide a basis for the comparative evaluation of income distributions. Nor do we analyse the contributions of different sources of income to the total inequality of incomes as in, for example, Ahearn *et al.* (1985).

2. See Miller (1981) and Stoline and Ury (1979) for a description of these test procedures, which have been widely applied to rank income distributions, and for tables of the SMM distribution.

3. If, as is usual, the final income class is unbounded then some arbitrary value may be chosen for the upper boundary of the K-th class that is greater than the assumed upper limit of the range.

4. Beach *et al.* (1994) give recursive formulae for converting data on sample means and variances by income class into the required cumulative estimates.

5. All FADN results have been calculated in 1995 money values in national currencies (using GDP implicit price indices as the deflators) and then converted to ECU using 1995 exchange rates

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