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# **Classical horizontal inequities in the provision of agricultural income support**

**Paul Allanson**

**Department of Economic Studies, University of Dundee, Dundee DD1 4HN, UK.**

**E-mail: [p.f.allanson@dundee.ac.uk](mailto:p.f.allanson@dundee.ac.uk)**



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# CLASSICAL HORIZONTAL INEQUITIES IN THE PROVISION OF AGRICULTURAL INCOME SUPPORT

*Abstract: This paper explores the redistributive effect of classical horizontal inequities induced by agricultural support policy. Within farm type horizontal inequity (HI) is associated with differences in the level of support received by farms of a given type and level of pre-support income, whereas between farm type HI arises from systematic differences in support levels between commodity regimes. The overall redistributive effect of HI in Scottish agriculture is shown to be substantial, though systematic discrimination between farm types proves not to be the major cause. The imperfect targeting of support revealed by the empirical findings has implications for the design of policy.*

*Keywords: Farm income support, Horizontal inequity.*

*JEL Classification: D63 I38 Q18*

## Introduction

One of the main objectives of the Common Agricultural Policy (CAP) is ‘to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture’ (European Union, 2002: Article 33). However, the provision of support through the CAP is not determined on a means-tested basis but is contingent instead on current and/or historical production choices.<sup>1</sup> The use of indicators other than farmers’ incomes to target support may well be justified in terms of the attainment of the other objectives of the CAP, most notably to increase agricultural productivity and assure the availability of supplies, or purely in terms of administrative convenience. But one likely consequence is the violation of the principle of horizontal equity, which states that equals should be treated equally.<sup>2</sup> In particular, horizontal inequities may arise from systematic differences in levels of support between commodities, such that farmers with identical levels of pre-support income receive different levels of support conditional on farm type. Moreover, even after controlling for both pre-support incomes and farm type, inequities may still arise from the heterogeneity of individual farms. The focus of this paper is on the measurement of these between and within farm type sources of classical horizontal inequity (HI).

The measurement of HI due to agricultural support programmes has received virtually no consideration in the agricultural economics literature in spite of the identification by Organisation for Economic Co-operation and Development (OECD) agricultural ministers (OECD, 1998) of equity and targeting as operational criteria for policy evaluation. In particular, OECD (2003) focuses on vertical rather than horizontal equity issues, concluding that farm support measures do not change ‘the income distribution in any significant way’ with the bulk of support going ‘to farm households who do not need it’ (pp.7-8). Variation in support levels across commodities in the European Union (EU) is reported to have ‘widened [average] income disparities between dairy and intensive livestock farms on the one hand and field crop and cattle farms on the other’ (p.30).

Allanson (2004) provides a characterisation of the overall redistributive effects of the CAP on Scottish farming incomes in terms of a vertical redistribution effect and a horizontal inequity component due to re-ranking. This re-ranking approach identifies HI with the procedural

unfairness manifest in changes in the ranking of farms between the pre-support and post-support income distributions, which provides a sufficient but not necessary condition for the unequal treatment of equals (Rodriguez et al., 2004). The adverse distributional effect of re-ranking is shown to have been of sufficient magnitude to more than offset the otherwise positive redistributive effect of the CAP in 1999/00. It is also reported that the re-ranking effect for the agricultural sector as a whole is not consistently larger than those for individual farm types, which is taken to imply the importance of HI sources other than variation in support levels across commodities. However the analytical framework employed in the study does not allow substantiation of this conjecture.

This paper draws on the work of Aronson et al. (1994) and Kakwani and Lambert (1999) on income taxation, to identify both the composition and overall level of classical HI in the provision of agricultural support. In particular, within farm type HI is identified with the dispersion of post-support incomes about a post-support income function estimated for each farm type as a non-parametric function of pre-support incomes. Between farm type HI is then captured by the deviations of these post-support income functions from a non-discriminatory function that is specified on the assumption that discrimination between farm types changes the distribution but not the average value of support at any given level of pre-support income. Finally, the overall level of classical HI is simply determined by the degree of dispersion of post-support incomes about the non-discriminatory function.

The structure of the paper is as follows. The next section outlines the approach that is used to identify classical horizontal inequity and considers the specification and estimation of both the post-support income functions for each farm type and the non-discriminatory support function. The third section presents an empirical illustration based on farm accounts data for Scottish agriculture in 1999/2000, the last full financial year before the foot-and-mouth outbreak. The final section offers a summary together with some brief concluding remarks on the policy implications of the empirical findings.

## **Identification of classical horizontal inequity**

The provision of support through the CAP is complex and cannot credibly be represented by a single schedule or model applicable to all farms. In particular, the CAP consists of a number of more or less distinct ‘common market organisations’ or commodity regimes, with the eligibility for benefits within each regime typically determined by some combination of current and/or historical levels of production and/or factors of production. This suggests that a better description of the level of support available through the CAP would consist of a number of separate commodity support schedules that apply specifically to producers of those commodities (e.g. cereal growers, milk producers etc.). However many farms produce more than one commodity and farm accounts data typically do not permit identification of the contribution of each to overall farming income due to the incomplete allocation of costs. Accordingly, separate models are defined not for each producer group but for distinct sub-populations of farms producing more or less similar combinations of commodities (e.g. specialist cereal farms, dairy farms etc.).

Consider a population of farms made up of an exhaustive set of  $K$  mutually exclusive farm types ( $k = 1, \dots, K$ ). Let  $y = (y_1, \dots, y_K)$ ,  $s = (s_1, \dots, s_K)$  and  $x = (x_1, \dots, x_K)$  be the vectors of observations on post-support income, support and pre-support incomes, where  $y_k$ ,  $s_k$ , and  $x_k$  are constituent sub-vectors of observations on farms of type  $k$  ( $k = 1, \dots, K$ ). Following the

approach taken in Aronson et al. (1994), assume that the level of support received by farms of type  $k$  is given by the model:

$$s_k = f_k(\mathbf{x}_k) + \varepsilon_k; \quad k = 1, \dots, K \quad (1)$$

such that their post-support incomes are determined by:

$$\mathbf{y}_k = \mathbf{x}_k + \mathbf{s}_k = \mathbf{x}_k + f_k(\mathbf{x}_k) + \varepsilon_k \equiv g_k(\mathbf{x}_k) + \varepsilon_k; \quad k = 1, \dots, K \quad (2)$$

where  $f_k$  and  $g_k$  are farm type specific functions of the pre-support income level, and the vector of ‘disturbance terms’  $\varepsilon_k$  is defined such that  $E[\varepsilon_k | \mathbf{x}_k] = 0$ .

The assumption of a systematic relationship between support and pre-support income is plausible given that the levels of both are determined by production choices. However the precise form of this relationship can not readily be specified given the nature and complexity of CAP commodity regimes. Accordingly,  $f_k$  and  $g_k$  are simply assumed to be continuous, smooth functions, yielding a non-parametric model with only very weak constraints on its structure. Furthermore, the relationship is unlikely to hold exactly as farms of type  $k$  with identical pre-support incomes may well differ in their eligibility for support as a result of differences in natural resource endowments, managerial ability and historical development. The disturbance term allows for this heterogeneity within type  $k$  farms.

The model of income support allows for the existence of two possible sources of classical horizontal inequity (HI). First farms of type  $k$  with identical pre-support incomes may have different post-support incomes due to the disturbance term, with the degree of dispersion of post-support incomes  $\mathbf{y}_k$  about  $g_k(\mathbf{x}_k)$  reflecting the extent of within farm type HI. Only if  $\varepsilon_k = \mathbf{0}$  will there be a one-to-one mapping from pre-support to post-support incomes for type  $k$  farms and hence no within farm type HI. Accordingly, the post-support income function  $g_k(\mathbf{x}_k)$  can be identified as the vector of post-support incomes that the sub-population of type  $k$  farms would receive in the absence of within farm type HI. Note that the distribution of  $g_k(\mathbf{x}_k) = E[\mathbf{y}_k | \mathbf{x}_k]$  will weakly Lorenz dominate that of  $\mathbf{y}_k$ , since the former may be obtained from the latter through a series of progressive, mean-preserving transfers. Moreover, if  $h(\mathbf{x}) = (g_1(\mathbf{x}_1), \dots, g_k(\mathbf{x}_k), \dots, g_K(\mathbf{x}_K))$  is defined as the vector of post-support incomes that the population of farms would receive in the absence of within-farm HI, then the distribution of  $h(\mathbf{x})$  will weakly Lorenz dominate that of  $\mathbf{y}$ . However these dominance relations may not necessarily hold exactly in any finite sample of farms drawn from the population.

The other potential source of classical HI is due to systematic discrimination between farm types. Different types of farm with identical pre-support incomes may have different expected post-support incomes as the post-support income functions  $g_k(\mathbf{x}_k)$  are farm type specific, with the scale of divergences between these functions reflecting the extent of between farm type HI. Only if  $g_k(\mathbf{x}_k) = g(\mathbf{x}_k) \forall k$ , and hence  $h(\mathbf{x}) = g(\mathbf{x})$ , will there be a one-to-one mapping from pre-support incomes to expected post-support incomes for all farms and hence no between farm type HI. The measurement of between farm type HI requires the identification of a post-support income function  $h^*(\mathbf{x})$  determining the post-support incomes that the whole population of farms could expect to receive in the absence of discrimination between farm types. There is, however, no established theory to guide the specification of this function.<sup>3</sup> One possible approach, in the manner of Kakwani and Lambert (1999), is to specify  $h^*(\mathbf{x})$  on the assumption that discrimination between farm types changes the distribution but not the average value of support at any given

level of pre-support income. The stipulation that the condition holds at each level of pre-support income serves to maintain the vertical stance of the overall support function if the proportions of each farm type are not independent of pre-support income. It follows that  $h^*(\mathbf{x})$  will be a weighted sum of the post-support income functions for the individual farm types:

$$h^*(\mathbf{x}) = \sum_{k=1}^K w_k(\mathbf{x}) g_k(\mathbf{x}); \quad \sum_{k=1}^K w_k(\mathbf{x}) = 1 \quad (3)$$

where the weights  $w_k(\mathbf{x})$  are locally determined by the relative frequencies of the farm types at any given pre-support income level, rather than being globally determined by the proportions of each farm type in the population. Note that the distribution of  $h^*(\mathbf{x})$  will (weakly) Lorenz dominate that of  $h(\mathbf{x})$  since  $h^*(\mathbf{x})$  is a weighted average of the  $g_k(\mathbf{x})$  functions.

Finally, the degree of dispersion of post-support incomes  $y$  about the non-discriminatory post-support income function  $h^*(\mathbf{x})$  will reflect the total extent of classical HI in the provision of agricultural support. Only if  $y = h^*(\mathbf{x})$  will there be a one-to-one mapping from pre-support incomes to post-support incomes for all farms and hence no HI. More generally, total classical HI will equal the sum of between and within farm type classical HI.

#### *Estimation of post-support income functions*

The first step in the estimation procedure is to estimate the post-support income functions in (2), from a sample consisting of  $n_k$  observations on pre-support and post-support incomes for each farm type. The estimation of these functions implicitly resolves the identification problem inherent in classical approaches to the measurement of HI in the absence of observations on exact pre-support income equals. The choice of a non-parametric technique for the purpose gets round the need to impose any parametric assumptions on the form of the  $g_k(\mathbf{x}_k)$  functions.

Rodriguez et al. (2004) advocate the use of bistochastic non-parametric estimators to estimate relationships of the nature of (2). This class of estimators yield estimates  $\hat{y}_k = \hat{g}_k(\mathbf{x}_k) = \mathbf{W} \mathbf{y}_k$  where  $\mathbf{W}$  is a bistochastic weight matrix<sup>4</sup> whose elements are solely determined by the pre-support income vector  $\mathbf{x}_k$ . A special case is the regressogram (Tukey, 1947), which is labelled the “close-equals” approach in Aronson et al. (1994; see also Lambert and Ramos, 1997; Kakwani and Lambert, 1999; van der Ven et al., 2001), where  $\hat{g}_k(\mathbf{x}_k)$  is given as the simple average of the values taken by  $y_k$  for which the corresponding values of  $\mathbf{x}_k$  fall into disjoint income classes. However this generates a discontinuous step function which may conceal features of the true function that are finer than the chosen width of the income classes. Rodriguez et al. (2004) propose instead a bistochastic smoothing estimator based on a modification of the classic Nadaraya-Watson (NW) kernel estimator (see Härdle, 1990). This entails a two-stage procedure in which the NW kernel estimator is first used to generate a smooth function whose value for each observation  $i$  in the sample is given as a weighted average of the values taken by  $y_k$  for which the corresponding values of  $\mathbf{x}_k$  lie in the neighbourhood of  $\mathbf{x}_{ki}$ . The final estimate  $\hat{g}_k(\mathbf{x}_k)$  is then derived by normalising the NW weights matrix so as to obtain a bistochastic matrix  $\mathbf{W}$ .

Rodriguez et al. (2004) claim that a major attraction of bistochastic estimators is that  $\hat{g}_k(\mathbf{x}_k)$  will weakly Lorenz dominate  $y_k$ , implying that the elimination of classical HI can not result in an increase in inequality as measured by any S-convex inequality measure. However the imposition of this restriction is inappropriate given that the Lorenz dominance of the classical HI-free distribution is only an asymptotic property of the model and need not necessarily hold exactly in

any particular sample. As a result, bistochastic non-parametric estimators will be biased in finite samples since they must satisfy:

$$\sum_{i=1}^j \hat{g}_k(x_{ki}) \geq \sum_{i=1}^j y_{ki}, \quad j=1, \dots, n_k; \quad k=1, \dots, K \quad (4)$$

where the observations are arranged in ascending order of post-support incomes and the equality holds for  $j=n_k$ . In particular, it can be seen that the predicted income of the farm with the lowest post-support income in the sample can not be less than the observed value.

More generally, the estimation of  $g_k(x_{ki}) = E[y_k | x_k = x_{ki}]$  as some local average of the observations on  $y_k$  in the neighbourhood of  $x_{ki}$  may be unduly restrictive. In particular, Hastie and Loader (1993) show that the NW kernel estimator will generate biased estimates if the slope of  $g_k(x_{ki})$  is non-zero and the spacing of sample observations on pre-support incomes is not uniform. Bias is also a problem at the boundary of the predictor space where the kernel neighbourhood is asymmetric. To overcome these problems, Hastie and Loader (1993) recommend the use of local regression techniques that fit a low-order polynomial rather than a constant to the data in the neighbourhood of any value of  $x_k$ , with the additional advantage of providing estimates of the derivatives of  $g_k(x_k)$  up to the specified order.

Accordingly, the variable span smoother of Sasieni (1998) is used to fit a local linear regression to the observations on  $y_k$  and  $x_k$  in the neighbourhood of each data point in the sample. The number of observations used to fit the model at each data point is determined by the variable span of the smoother, which is calculated by initially choosing the span at each data point that minimises the cross validated mean squared prediction error and then smoothing the resultant series of values. The smoother may be expected to provide a reasonable approximation to  $g_k(x_k)$  so long as the curvature of the unknown function is not excessive (Hastie and Loader, 1993). Like bistochastic estimators, the estimates  $\hat{g}_k(x_k)$  are a weighted sum of the observations on  $y_k$  but the weights need not be non-negative.

The second step in the estimation procedure is to estimate (3) to obtain the non-discriminatory post-support income function. One approach is to use equation (3) to calculate  $h^*(x)$  from the estimates  $\hat{g}_k(x_k)$  and kernel density estimates of the weight functions  $w_k(x_k)$  (see Kakwani and Lambert, 1999). However, reliable estimates of the weights functions could not be obtained given the limited number of observations on each farm type and the resultant sparseness of the data over the observed range of pre-support income levels. An alternative approach was therefore adopted in which  $h^*(x)$  was directly estimated using the same local regression technique as was used to estimate the  $g_k(x_k)$  functions in (2), but applied to the pooled sample of observations. Thus the predicted level of non-discriminatory post-support income at any given level of pre-support income will automatically reflect the farm type composition of the sample in the neighbourhood of that point.

### **Horizontal inequity in the provision of agricultural support in Scotland, 1999/00**

The method outlined in the preceding section is illustrated using population-weighted data on pre-support and post-support farming incomes constructed from the 498 individual farm records in the Scottish Farm Accounts Survey (FAS) for 1999/00. The FAS is a representative survey of full-time commercial farms carried out each year on behalf of the Scottish Executive (SEERAD,

2001).<sup>5</sup> It provides a wide range of physical and financial data, including detailed information on crop areas, livestock numbers, quotas, production, sales, revenues, subsidies and costs, which allows for the identification of policy benefits. Population weights are calculated using information from the June Agricultural Census on the distribution of agricultural holdings in Scotland by type of farming and size of business in 1999. Given a population of 15881 farms in the sampling frame, the sampling fraction for each farm size and type is approximately 3 per cent.

Farming income is measured by Family Farm Income (FFI), which is a measure of farm business income that represents the return to the farm's own capital and all unpaid labour (farmers and spouses, non-principal partners and directors and their spouses and family workers) based on the actual tenure and indebtedness of the farm business. The analysis is conducted at the farm level rather than per unit of unpaid labour because of doubts concerning the relevance and reliability of data on family labour input in the UK context (see Hill, 1991). The FAS does not provide sufficient information on either non-farm sources of farm household income or farm household composition to support a broader analysis of the distributional impact of the CAP on the overall welfare of the agricultural community.

Pre-support income is defined as (post-support) FFI less that part of gross policy transfers which is estimated to accrue to farm occupiers as owners of factors of agricultural production. This approach recognises that farm occupiers may not be the ultimate beneficiaries of farm support programmes (Floyd, 1965), which may also serve to benefit landlords, hired workers, manufactured and other input suppliers. Moreover, the effective incidence of support is allowed to vary depending on the way in which that support is provided (see OECD, 2003: Part II). The analysis thereby serves to identify the contribution of support to the inequality of post-support farming incomes, but it does not allow for the impact of agricultural policy on the distribution of pre-support incomes. To do so would require a model of the impact on individual farm incomes of adjustments in both farm production choices and the state of agricultural input and output markets in response to agricultural policy changes. However it seems unlikely that the results of such an equilibrium displacement modelling exercise would be robust given the magnitude of the changes that would be entailed by the complete abolition of support for agriculture (Gardner, 1987).

To calculate the gross value of transfers due to market price support, estimates are first taken from the OECD PSE database (OECD, 2001) of the gap between the EU domestic market and border prices for the main agricultural commodities, measured at the farmgate level. These estimates are then adjusted to reflect differences between United Kingdom (UK) and EU average producer prices, before being used to calculate the impact of market price support on both the value of observed output quantities and the cost of purchased feed and seed inputs. The value of payments to farm occupiers is explicitly recorded in the FAS and covers all grants and subsidies except for those in respect of permanent improvements. However the value of payments under the Arable Area Payments scheme (AAPS) is adjusted to take account of the implicit loss in revenues resulting from obligatory set-aside requirements.

The net economic benefit of these transfers to farm occupiers depends on the extent to which they result in increased returns to the farm-owned factors of production, including management, and hence in increased farming incomes. Following (OECD, 2003), the effect on farming income of a unit increase in output revenues, whether due to market price support, output payments or a reduction in set-aside requirements, is estimated as the combined cost share of the farm-owned factors of production, while that of a unit increase in payments based on areas planted, livestock

numbers or input use is simply calculated as the farm-owned share of those inputs. Estimates of factor cost shares are obtained on the assumption that Scottish agriculture may be characterised by an aggregate Cobb-Douglas production technology exhibiting constant returns to scale. Allowing for fixed farm-specific and year-specific effects, the parameters of the Cobb-Douglas production function are estimated from an unbalanced panel of observations formed from the FAS samples for 1995/96 through 1999/00 (Roberts et al., 2002).<sup>6</sup> This yields shares for total labour, land and buildings, livestock capital, and all other purchased inputs of 15.4%, 9.2%, 8.6%, and 41.5% respectively. With these attributable costs accounting for 74.8% of total revenue, the residual 25.2% is identified as the return to the farmer's (fixed) management input. Farm-owned shares of factors of production are derived for each farm in the FAS sample, with 80.7% of labour, 58.8% of land and buildings and 100% of livestock capital being supplied on average by farm occupiers in 1999/00. Hence the average net benefit to farmers of an extra £1 of market price support or output-related payments; payments based on areas planted; payments based on livestock numbers; and payments based on purchased input use would have been £0.517, £0.588, £1 and £0 respectively.

### *Empirical findings*

The first column of figures in Table 1 presents weighted summary statistics for Scottish agriculture in 1999/00. In that year, the average level of FFI per farm was just £12065 in spite of gross transfers due to market price support of £14335 and payments worth £26180. In practice farmers do not receive the full benefit of these transfers due to leakages to other owners of factors of production, so the total impact of agricultural support on average family farm income is predicted to have been £30373 rather than £40516. Even so, pre-support FFI would have been –£18308 on average with nearly 90 per cent of farms recording losses. These results highlight the chronic dependence of farming on state aid.

Table 1. Weighted summary statistics by farm type 1999/2000.

Farm Type	All	General		Specialist		Mixed	
		Cereals	Cropping	Dairy	Sheep	Cattle	Sheep & Mixed
Number of observations	498	26	59	71	62	107	105
% of raised sample		17.2%	12.4%	11.2%	10.1%	20.5%	16.4%
Farm business size (ESU/farm)	63.5	53.5	116.8	95.9	34.4	43.8	52.2
(Post-support) FFI (£/farm)	12065	16680	14340	16721	4575	9972	8955
% farms with post-support FFI<0	22.5%	19.7%	17.6%	20.2%	38.1%	24.7%	20.3%
Total transfers (£/farm)	40516	38954	40937	55127	26715	35564	41453
Of which due to:- Market price support	14335	12729	11934	46922	2291	8773	9035
Payments	26180	26225	29002	8206	24424	26792	32417
Net benefit to farmers (£/farm)	30373	26330	27532	32211	24444	30748	35104
Of which due to:- Market price support	7695	6782	6439	25010	1309	4838	4835
Payments	22738	19549	21095	7359	23181	25984	30368
As % of post-support FFI	251.7%	157.9%	192.0%	192.6%	534.3%	308.4%	392.0%
Pre-support FFI (£/farm)	-18308	-9650	-13192	-15490	-19869	-20776	-26149
% farms with pre-support FFI<0	87.2%	75.1%	69.2%	81.6%	97.0%	94.9%	96.1%

Source: Author's calculations

The remaining columns provide comparable information for each farm type, where seven distinct farm types have been identified on the basis of the distribution of standard gross margins across enterprises.<sup>7</sup> Post-support income levels were highest on dairy and cereals farms, and lowest on specialist grazing livestock farms which are typically smaller businesses located in Less

Favoured Areas. Payments provided the main source of support for all farm types other than dairy farms, with payments based on areas planted accounting for the bulk of support on arable farms and payments based on livestock numbers doing likewise on sheep and cattle farms. Total transfer and net benefit levels vary across farm types but not in such a way as to either consistently increase or decrease income disparities between farm types. On the one hand, dairy farms received both the largest transfers and above average net benefits in spite of above average pre-support income levels, while specialist sheep farms received the smallest transfers and net benefits in spite of the disadvantages of size and location faced by these holdings. On the other hand, cereal farms received below average transfers and benefits, while mixed farms did comparatively well from the support system with net benefits sufficient to generate above average levels of post-support income in spite of large pre-support losses. No clear picture therefore emerges with regard to farm type as to the vertical equity characteristics of the agricultural support system in Scotland.

Table 2 presents the main findings of the paper on the redistributive effect of horizontal inequities in the provision of agricultural support. Results are reported for a range of summary inequality measures so as to provide some indication of the robustness of the findings to the choice of measure.<sup>8</sup> The Gini coefficient, relative mean deviation and coefficient of variation are all measures of relative inequality, providing indices whose magnitudes are unaffected by equiproportionate changes in all incomes.<sup>9</sup> The absolute Gini is an absolute inequality measure that is invariant to equal additions to all incomes rather than to scalar changes.

Table 2. Redistributive effects of agricultural support.

<i>Inequality measure</i>	Gini Coefficient	Relative mean deviation	Coefficient of variation	Absolute Gini
<i>Income concept</i>				
Post-support income	0.907	1.230	1.802	10946
Expected post-support income	0.467	0.655	1.211	5758
Non-discriminatory post-support income	0.449	0.588	1.029	5576
Pre-support income	0.613	0.844	1.226	11214
<i>Redistributive effects of classical HI</i>				
Within farm type	0.440	0.575	0.591	5187
Between farm type	0.018	0.067	0.182	182
Overall	0.458	0.642	0.773	5370
<i>Net redistributive effect</i>	0.295	0.386	0.577	-268

Source: Author's calculations.

The first four rows report the degree of inequality in the distributions of post-support income  $y$ , expected post-support income conditional upon farm type  $\hat{h}(x) = (\hat{g}_1(x_1), \dots, \hat{g}_k(x_k), \dots, \hat{g}_K(x_K))$ , non-discriminatory post-support income  $\hat{h}^*(x)$  and pre-support income  $x$ , respectively. The redistributive effects reported in the remainder of the table are all derived from these inequality estimates. Thus the overall redistributive effect of classical HI is calculated for each measure as the difference in inequality between the distributions of  $y$  and  $\hat{h}^*(x)$ , and is composed of a within farm type effect equal to the difference in inequality between  $y$  and  $\hat{h}(x)$  and a between farm type effect equal to the difference in inequality between  $\hat{h}(x)$  and  $\hat{h}^*(x)$ . Finally, the net redistributive effect of support is calculated for each measure as the difference in inequality between the distributions of  $y$  and  $x$ .

The Table reveals two main points of interest. First, the estimates of the redistributive effects of HI are all positive, implying that the elimination of HI in the provision of support would make the distribution of post-support farming income less unequal. In particular, the results for the three relative measures of inequality all suggest that agricultural policy would have reduced rather than increased relative inequality was it not for the presence of HI, given that the overall HI effect is larger than the net redistributive effect for each measure. The results for the Absolute Gini suggest that agricultural policy had virtually no effect on absolute inequality, but it remains the case that the distribution of post-support income would have been less unequal in absolute terms but for HI. All four sets of results imply that the overall redistributive effect of horizontal inequities in the provision of support were substantial, accounting for roughly one half of measured inequality in the distribution of post-support farming incomes.

Second, for all the inequality measures, the redistributive effect of within farm type HI far exceeds that of between farm type HI. The former arises from the dispersion of post-support incomes about the post-support income functions  $\hat{g}_1(\mathbf{x}_1), \dots, \hat{g}_K(\mathbf{x}_K)$ , whereas the latter stems from systematic divergences between these functions and the common, non-discriminatory function  $\hat{h}^*(\mathbf{x})$ . The results therefore imply that factors other than farm type are dominant in determining differences in the levels of support received by individual farms with a particular level of pre-support income. Discrimination between farm types, due to the commodity organisation of agricultural support, is a comparatively minor source of horizontal inequities in the provision of agricultural support in spite of the observed disparities in average support levels across farm types.

## Conclusions

The use of indicators other than farmers' incomes to target agricultural support inevitably results in some degree of horizontal inequity (HI) due to the provision of different levels of support to farmers with identical pre-support incomes. The paper proposes a methodology for the identification of both the composition and overall level of HI in the provision of agricultural support and provides estimates of the resultant redistributive effects for Scottish agriculture in 1999/2000. The empirical analysis reveals that the main source of HI was the weakness of the relationship between support and pre-support income levels within each farm type, rather than systematic discrimination between farm types. The overall redistributive effect of HI is found to have been substantial in comparison to the degree of inequality in the distribution of post-support incomes.

The imperfect targeting of support revealed by the empirical findings has implications for both the past and future design of agricultural policy. Historically, the wide variation in support levels between farms with similar pre-support incomes suggests that policies designed to concentrate production-related payments on those farms capable of generating only low levels of farm income would have been largely ineffective. Moreover, there seems to have been little scope to improve targeting through the rebalancing of support across commodity regimes given that systematic discrimination between farm types appears to be only a minor source of horizontal inequities. Looking ahead, the decoupling of payments will break the link between current production choices and the receipt of subsidies, with farmers merely required to keep their land in good agricultural and environmental condition. In the case of Scotland, this is likely to further weaken the relationship between support and pre-support incomes because entitlements to the new decoupled payment will be "grandfathered" on the basis of historical payment receipts.

More generally, the impact of decoupling on the ability to target support in an efficient and effective manner will depend on the strength of the correlation between the indicator employed to allocate entitlements and (post-decoupling) pre-support income.

## Notes

1. See Agra Informa (2005) for a comprehensive guide to the CAP.
2. See Lambert (2001) for a discussion of this principle.
3. The problem is analogous to that encountered in the determination of wage discrimination using Oaxaca-Blinder decomposition techniques. See Neumark (1988) for discussion.
4. A bistochastic matrix is a square matrix in which all elements are non-negative, and all rows and all columns sum to one.
5. The sampling frame excludes very small farms (less than 8 Economic Size Units (ESU)), very large specialist livestock units (greater than 200 ESU), and certain minor farm types.
6. Further details of sample construction, variable definitions and estimation results are available from the author on request.
7. The cereals, general cropping, dairy and mixed farm types are identical to the eponymous UK robust types. The specialist sheep farm type corresponds to EC type 441, specialist cattle to EC types 421 and 422 combined, and mixed cattle & sheep types to EC types 431, 432, 442 and 444 (as implemented in the UK) combined. See MAFF (2001: Appendix B) for further description of the classification scheme.
8. See Cowell (1995) or Lambert (2001) for a general discussion of inequality measurement and the properties of the measures used in this study. The choice of measures is constrained by the fact that many standard measures are simply undefined for negative incomes (see Amiel et al., 1996).
9. Note that the sign of these measures is determined by the sign of average income (Amiel et al., 1996). As average pre-support income is negative, the absolute values of the indices are reported to allow direct comparability between results (see Allanson, 2004).

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