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Marginal analysis of income mobility effects by income source with an application to the agricultural policy mix

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Marginal analysis of income mobility effects by income source with an application to the agricultural policy mix

Abstract

The note proposes a novel decomposition of the Shorrocks mobility index by income components to identify the impact on farm income mobility of a marginal change in each component. An empirical application shows that a revenue-neutral change in the balance of agricultural protection between market-based support and direct payments would not have had the effect of reducing the variability of relative farm incomes in Scottish agriculture.

Keywords: farm income mobility; decomposition by income source; agricultural policy analysis

JEL classifications: D31, D63, Q18

1. Introduction

Income fluctuations are significantly larger at the farm than the sector level, leading to considerable movement of farms within the income distribution (Meuwissen *et al.*, 2008). One consequence of this income mobility is that longer-term inequality is less severe than would be inferred from cross-sectional estimates based on annual data. For example, Allanson *et al.* (2017) reports a 5.7% fall in the Gini coefficient for Scotland if income values are calculated as two-year individual farm averages, with this fall increasing to 12% as the length of the measurement period is extended to include more years. A further corollary is that agricultural policies that reduce idiosyncratic income volatility should also reduce such 'excess' short-term inequality. Finger and El Benni (2014) identify this effect as an additional benefit of risk management schemes such as the Income Stabilisation Tool introduced by the European Union (EU) in the 2013 Common Agricultural Policy (CAP) reform (European Commission, 2013).

In this note, we investigate the broader conjecture that the historical shift from market-based support towards direct payments in the CAP will have had a similar beneficial effect by insulating farmers from both price and production risk (Tangermann, 2011). Using the example

of Scottish agriculture, the main contribution is to provide the first estimates, to our knowledge, of the possible impact of such a change in the agricultural policy mix on farm income mobility. For this purpose, we propose a novel decomposition of the Shorrocks (1978) mobility index by income components to identify the impact of a marginal change in each component on 'excess' short-term inequality.

2. Methods

Let y_t denote annual income in year *t*, with mean $\overline{y}_t$, cumulative density function (cdf) $R_t = F_t(y) = P(y_t \le y)$ and Gini coefficient $G(y_t, R_t) = 2\mathrm{cov}(y_t, R_t)/\overline{y}_t$. The Shorrocks index measures the degree of equalisation if the measurement period is extended to T years:

$$M_T = 1 - \frac{G(y_A, R_A)}{\sum_{t=1}^{T} w_t G(y_t, R_t)}; \qquad T \ge 1 \tag{1}$$

where $G(y_A, R_A)$ is the Gini coefficient of average annual income over the *T*-year period $y_A = \sum_t y_t / T$, with mean $\overline{y}_A$ and relative ranks R_A; and the weights $w_t = \overline{y}_t / T\overline{y}_A$ sum to one by construction. M_T will be close to zero if there is little income mobility and to one if annual inequality is largely due to transitory idiosyncratic income shocks such that $G(y_A, R_A)$ is close to zero.

Further defining income as the sum of a set of components x_{kt} $(k = 1, \ldots, K)$, which will be positive for revenues and negative for costs, then some manipulation yields:

$$\begin{aligned} M_T &= \frac{2\sum_i \sum_t (y_{it} - \overline{y}_A)(R_{it} - R_{iA})}{NT\overline{y}_A \sum_t w_t G(y_t, R_t)} = \frac{\sum_i \sum_t (y_{it} - \overline{y}_A)(R_{it} - R_{iA})}{N\sum_t \mathrm{cov}(y_t, R_t)} = \frac{\sum_k \sum_i \sum_t (x_{kit} - \overline{x}_{kA})(R_{it} - R_{iA})}{N\sum_t \mathrm{cov}(y_t, R_t)} \\ &= \sum_{k=1}^{K} \left(\left(\frac{\sum_i \sum_t (x_{kit} - \overline{x}_{kA})(R_{it} - R_{iA})}{N\sum_t \mathrm{cov}(x_{kt}, R_t)} \right) \left(\frac{\sum_t \mathrm{cov}(x_{kt}, R_t)}{\sum_t \mathrm{cov}(y_t, R_t)} \right) \right) \equiv \sum_{k=1}^{K} M_{kT} v_{kT} \end{aligned} \tag{2}$$

where the first equality holds as $G(y_A, R_A) = \sum_t w_t G(y_t, R_t) - 2\sum_i \sum_t (y_{it} - \bar{y}_A)(R_{it} - R_{iA}) / NT\bar{y}_A$ from results in Jones and López Nicolás (2004); y_{it}, x_{kit}, R_{it} and R_{iA} denote observations on farm i ($i = 1,\ldots,N$); and $\bar{x}_{kA}$ is the *T*-year mean of x_k. Hence M_T is equal to a weighted sum of component-related income mobility indices $M_{kT} = 1 - \left(CI(x_{kA}, R_A) / \sum_t w_{kt} CI(x_{kt}, R_t) \right)$, where $CI(x_{kt}, R_t)$ and $CI(x_{kA}, R_A)$ are the concentration indices of component *k* over the year *t* and *T*-year income distributions respectively, and $w_{kt} = \bar{x}_{kt} / T\bar{x}_{kA}$.

$M_{kT} = 0$ if there is no linear association between the component and income mobility since the numerator $\sum_i \sum_t (x_{kit} - \bar{x}_{kA})(R_{it} - R_{iA})$ in (2) will equal zero in this case.[1] But, unlike M_T, M_{kT} can be either positive or negative. In particular, M_{kT} is likely negative for a time-invariant revenue component that is positively associated with income (i.e. similar to CAP direct payments) given that the cdf $R_t = F_t(y)$ of the typically unimodal farm income distribution will be convex below the mode and concave above it. It follows from Jensen's inequality that the average of the annual income ranks R_{it} of farms with low (high) average incomes will typically be above (below) their *T*-year income rank R_{iA}, which in combination with the positive association between revenue and income will result in a negative value of $\sum_i \sum_t (x_{kit} - \bar{x}_{kA})(R_{it} - R_{iA})$ and hence of M_{kT} (see Allanson *et al.* (2010) for further discussion). The weights ν_{kT} equal the shares of the total covariation between year-specific incomes and ranks that are due to each component. These sum to one, since $y_t = \sum_k x_{kt}$, and will typically be positive for revenues and negative for costs.

To investigate how changes in particular components affect mobility, we follow the approach in Lerman and Yitzhaki (1985) and consider a change in each farm's income due to

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[1] Note that $(R_{it} - R_{iA})$ captures income mobility as defined by Shorrocks, i.e. the deviation between a farm's rank in the period *t* and *T*-period distributions, with $\sum_i \sum_t (R_{it} - R_{iA}) = 0$ by definition.

a change in component *k* from x_{kit} to ex_{kit} in all years, where *e* is close to 1. The effect on mobility will approximately equal:

$$\frac{\partial M_T}{\partial e} = \partial \left\{ M_{kT} \frac{\sum_t \text{cov}(\text{e}\, x_{kt}, R_t)}{\sum_t \text{cov}(\text{e}\, x_{kt} + \sum_{j \neq k} x_{jt}, R_t)} + \sum_{j \neq k} M_{jT} \frac{\sum_t \text{cov}(x_{jt}, R_t)}{\sum_t \text{cov}(\text{e}\, x_{kt} + \sum_{j \neq k} x_{jt}, R_t)} \right\} \Big/ \partial e \qquad (3)$$

$$\approx M_{kT} v_{kT} (1 - v_{kT}) - v_{kT} \sum_{j \neq k} M_{jT} v_{jT} = (M_{kT} - M_T) v_{kT} = \left(\frac{G(y_A, R_A)}{\sum_t w_t G(y_t, R_t)} - \frac{CI(x_{kA}, R_A)}{\sum_t w_{kt} CI(\text{x}_{kt}, R_t)} \right) v_{kT}$$

where the derivation relies on the assumption that income ranks, and hence component-related mobility indices, will not be significantly affected by the change (see Yitzhaki and Schechtman, 2013). Hence whether an equiproportional change in the *k*'th component increases or reduces mobility, and hence 'excess' short-term inequality, will depend on the signs of both $(M_{kT} - M_T)$ and v_{kT}. $\sum_k (M_{kT} - M_T) v_{kT} = 0$ since multiplying all components by *e* leaves mobility unchanged.

3. Empirical application

The empirical analysis is based on an unbalanced panel of farms from the Scottish Farm Accounts Survey (FAS) covering the production years 1995 to 2009.[2] The FAS is an annual stratified sample survey of around 500 full-time farms, with farms chosen randomly to be representative of their economic size and type as enumerated in the June Agricultural Census (Scottish Government, 2012). Table 1 presents selected results as the measurement period is extended from the chosen base year of 1995, initially aggregating over the first 2 years for all farms present in both years, then the first 3 years and so on. Farms, once recruited, can stay in the survey for an unlimited length of time, with 172 of the 536 farms in the 1995 sample present

[2] See Allanson et al. (2017) for a full account of the construction of the data set employed in the study. Limiting the entire analysis to a balanced panel led to lower values of M_T for small *T*, though the estimate of M_T for *T* = 15 is identical to that in Table 1 by construction.

in all 15 waves. For each multi-year period, probability weights were re-calculated using Census farm numbers in the base year, thereby abstracting from the effects of structural change.[3] All standard errors were generated using a bootstrap procedure that reflects the panel design.

Farm income was defined as the difference between trading revenue and expenditure, with this measure of cash income representing the return to the group with an entrepreneurial interest in the farm for their manual and managerial labour and on their investment in the business (Scottish Government, 2012). Average annual income over the entire period was £34,260, with revenues of £117084 – £25960 in direct payments and £91124 in other 'market-based' revenues (including associated grants and subsidies) – and expenditure of –£82824.

Income mobility was 0.054 for $T=2$, meaning that averaging incomes over 1995 and 1996 reduced inequality by 5.4% compared to the weighted average of the Gini coefficients for the 2 years. Figure 1 shows that M_T tends to increase with T but approaches an upper limiting value of about 13% after about 10 years, with no further equalisation once relative incomes have approached their long-term values. Alternative base years produced broadly similar findings, with Figure 1 also displaying M_T values with 2000 and 2005 as base years, for which the maximum T values are 10 and 5 years respectively.

The reported values of the component-related mobility indices imply that income mobility was not significantly associated with market-based revenues over any time horizon, but was negatively related to both direct payments and trading expenditure. As expected, the covariation shares are positive for the two revenue components and negative for expenditure. In combination, these results might be taken to imply that the 'share' of income mobility due to the association with trading expenditures was slightly greater than one, being partially offset

[3] The results differ slightly from those reported in Allanson *et al.* (2017) due to this treatment of the weights.

by the stabilising effect of direct payments and with market-based revenues playing no significant role.

A more meaningful exercise for policy purposes is to examine the marginal effects. For T=2, an equiproportionate expansion in market-based revenue, direct payments or trading expenditure by an average absolute amount of £1000 per annum would have changed mobility by respectively –0.0010, –0.0011 and 0.0017 ceteris paribus. Hence, higher overall levels of support would have reduced mobility compared to what it would otherwise have been, unless offset by cost increases within agriculture. But a revenue-neutral change in the balance of support measures would have had very little effect on income mobility, with this also being the case for longer measurement periods. The elasticities of mobility with respect to the three components were –1.74%, –0.48% and 2.22% for T=2, with little change over alternative time horizons. The sensitivity of mobility to changes in market-based revenues and expenditure reflects the residual nature of farm income.

4. Discussion

Direct payments are generally held to have increased farm income stability in the EU (Tangermann, 2011), mainly because they are less variable than other income components (Severini *et al.*, 2016). However it does not follow that direct payments will have also reduced income mobility, which measures the movement of farms within the income distribution and therefore reflects the degree of idiosyncratic rather than overall income variability. This note proposes a novel decomposition of the Shorrocks index by income components, with the results of the marginal analysis implying that a revenue-neutral change in the balance between market-based support and direct payments would not have reduced the variability of relative incomes in Scottish agriculture. It also adds to the existing literature on the redistributive impact of agricultural support policy, which focuses on the effects on annual income inequality (Keeney,

2000, Allanson 2008; Deppermann *et al.*, 2014). In particular, higher overall levels of support would likely have reduced 'excess' short-term inequality due to farm income mobility. Further studies are required to explore whether these findings are more generally characteristic of the dynamic redistributive properties of the CAP throughout the EU.

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Table 1. Income mobility effects by income component with 1995 as base year.

Measurement period	1995 only	1995-1996	1995-1999	1995-2004	1995-2009
T	1	2	5	*10*	*15*
Sample size: *N*	536	498	385	*227*	*172*
Annual averages (£ per farm)					
Income	40789***	40744 ***	32533***	30686***	34260 ***
	1724	*1525*	*1437*	*2227*	*2776*
Market-based revenues	89202***	87438 ***	79197***	76497***	91124 ***
	2813	*2559*	*3521*	*8875*	*13097*
Direct payments	22230***	22615 ***	21596***	21971***	25960 ***
	675	*640*	*758*	*1446*	*2093*
Trading expenditure	–70944***	–69309 ***	–68260***	–67783***	–82824 ***
	2081	*2300*	*3590*	*9095*	*12955*
Average annual Gini: $\sum w_t G(y_t, R_t)$	0.505***	0.4677 ***	0.4982***	0.5072***	0.4815 ***
	0.017	*0.0147*	*0.0167*	*0.0326*	*0.0312*
T-Period Gini: $G(y_A, R_A)$	0.505***	0.4427 ***	0.4622***	0.4530***	0.4200 ***
	0.017	*0.0144*	*0.0174*	*0.0337*	*0.0329*
Shorrocks Mobility Index: M_T	0	0.0536 ***	0.0724***	0.1068***	0.1278 ***
	-	*0.0175*	*0.0084*	*0.0142*	*0.0190*
Component-related income mobility: M_{kT}					
Market based revenues	-	0.0008	–0.0040	–0.0029	–0.0383
		0.0110	*0.0176*	*0.0237*	*0.0454*
Direct payments	-	–0.0358 *	–0.0491*	–0.0662	–0.1103 **
		0.0213	*0.0277*	*0.0459*	*0.0499*
Trading expenditure	-	–0.0594 **	–0.0835**	–0.1214***	–0.2125 ***
		0.0255	*0.0333*	*0.0467*	*0.0600*
Share of total covariation: v_{kT}					
Market based revenues	-	1.7637 ***	1.8344***	1.7939***	1.7775 ***
		0.0861	*0.1585*	*0.3783*	*0.4164*
Direct payments	-	0.2901 ***	0.2968***	0.2825***	0.3001 ***
		0.0233	*0.0364*	*0.0608*	*0.0683*
Trading expenditure	-	–1.0538 ***	–1.1312***	–1.0765**	–1.0775 **
		0.0996	*0.1878*	*0.4279*	*0.4614*
Share of income mobility: $M_{kT} v_{kT} / M_T$					
Market based revenues	-	0.0260	–0.1025	–0.0487	–0.5335
		0.3363	*0.5040*	*0.6096*	*1.1056*
Direct payments	-	–0.1939 **	–0.2013	–0.1751	–0.2590
		0.0944	*0.1416*	*0.1716*	*0.1859*
Trading expenditure	-	1.1679 ***	1.3038**	1.2238*	1.7926
		0.4078	*0.6117*	*0.7405*	*1.2452*
Absolute marginal effect $\times 10^3$: $(M_{kT} - M_T) v_{kT} / \bar{x}_{kA}$					
Market based revenues	-	–0.0011 ***	–0.0018***	–0.0026***	–0.0032 **
		0.0003	*0.0006*	*0.0009*	*0.0015*
Direct payments	-	–0.0011 ***	–0.0017***	–0.0022***	–0.0028 **
		0.0004	*0.0005*	*0.0008*	*0.0011*
Trading expenditure	-	0.0017 ***	0.0026***	0.0036***	0.0044 **
		0.0005	*0.0008*	*0.0012*	*0.0018*
Relative marginal effect: $(M_{kT} - M_T) v_{kT} / M_T$					
Market based revenues	-	–1.7377 ***	–1.9369***	–1.8426**	–2.3110
		0.3725	*0.5911*	*0.9039*	*1.4937*
Direct payments	-	–0.4840 ***	–0.4982***	–0.4576**	–0.5591 **
		0.1000	*0.1646*	*0.2070*	*0.2421*
Trading expenditure	-	2.2217 ***	2.4350***	2.3002**	2.8701 *
		0.4450	*0.7222*	*1.0598*	*1.6746*

*Source: Authors' calculations. Each statistic is based the sample of farms that are present in all years of the relevant period. Bootstrapped standard errors in italics based on 1000 replications. Statistical significance at 1%, 5% and 10% levels are denoted by ***, ** and * respectively.*

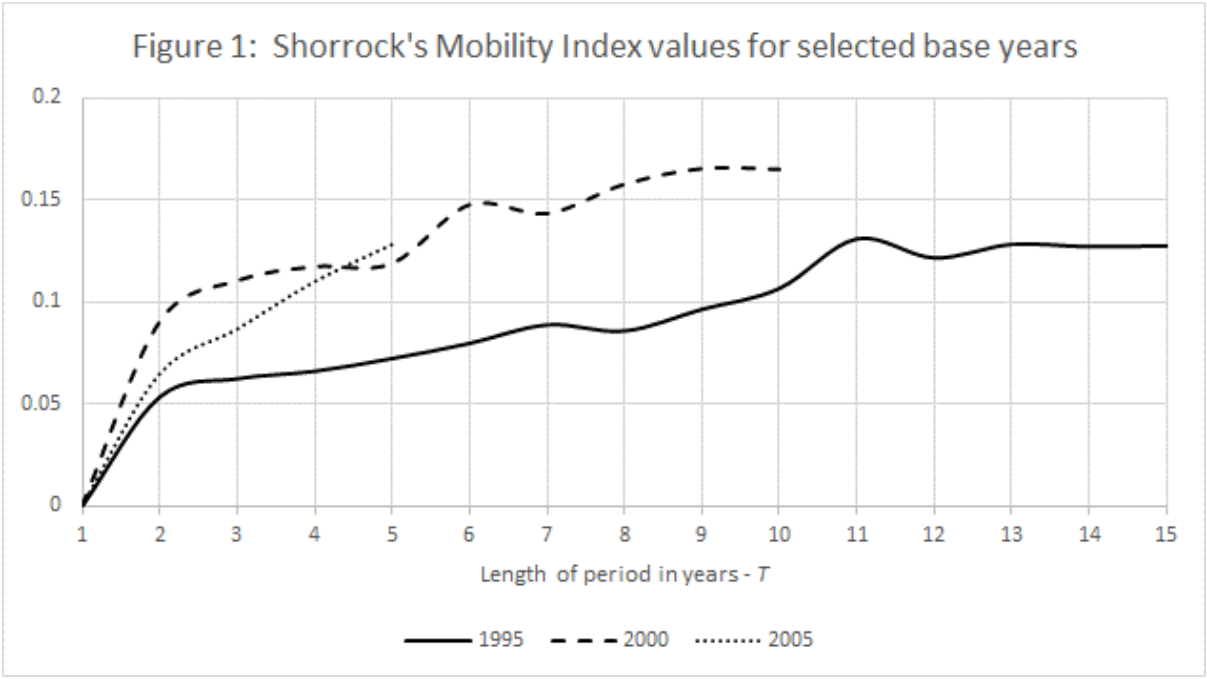
Figure 1: Shorrock's Mobility Index values for selected base years
0.2
0.15
0.1
0.05
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Length of period in years - T
1995
2000
2005