Land Heterogeneity, Agricultural Income Forgone and Environmental Benefit: An Assessment of Incentive Compatibility Problems in Environmental Stewardship Schemes

Rob Fraser

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Abstract

This paper examines the issue of incentive compatibility within environmental stewardship schemes, where incentive payments to farmers to provide environmental goods and services are based on foregone agricultural income. The particular focus of the paper is land heterogeneity, either of agricultural or environmental value, leading to divergence between the actual and socially optimal level of provision of environmental goods and services. Given land heterogeneity, such goods and services are likely to be systematically over- or under-provided in response to a flat rate payment for income foregone.

Keywords: land heterogeneity; agricultural income forgone; incentive compatibility; environmental stewardship.

JEL classifications: D82, L51, Q18, Q58.

1. Introduction

The European Union’s Common Agricultural Policy (CAP) has an established history of compensating farmers for policy changes which have reduced their production income. For example, the May 1992 CAP Reform introduced the concept of Direct Payments, which were designed to compensate farmers both for reduced price support and for foregone production income on set-aside land (see Fraser, 1993; Froud et al., 1996). More recently, agricultural policy developments in the European Union have encouraged farmers to provide environmental goods and

1 Professor of Agricultural Economics, University of Kent and Adjunct Professor of Agricultural and Resource Economics, University of Western Australia. E-mail: r.fraser@kent.ac.uk. I am particularly grateful to the Editor in Chief, as well as to two anonymous referees for their helpful comments on previous versions.

services. An example of this type of policy was the UK’s Countryside Stewardship Scheme, which has recently evolved into the Environmental Stewardship Scheme (DEFRA, 2007a).

A general problem for such schemes is that of asymmetric information (Fraser and Fraser, 2005), which can itself be broken into the specific components of adverse selection and moral hazard. A range of studies have analysed the implications for agri-environmental policy design (e.g. Wu and Babcock, 1996; Moxey et al., 1999; Fraser, 2002). However, a key difference between these two components is that moral hazard encourages illegal or extra-contractual behaviour by scheme participants, while adverse selection does not involve illegal behaviour, but is centred on incentive compatibility. DEFRA (2007a) states that the Environmental Stewardship Scheme ‘generate(s) financial incentives for farmers to provide the public goods they would not otherwise deliver’ (p. 6), where these ‘payments are based on income foregone’ (p. 13). In this case, scheme participation encourages farmers to participate based on income foregone, rather than on the benefits participation is supposed to deliver to the wider public. From the policy design perspective, this basis for payment to farmers raises the question of whether it properly corrects the market failure in relation to the provision of environmental goods and services, and in so doing delivers ‘the socially optimal level of those goods and services’ (p. 6). For example, Harvey (2003) points out that ‘the suppliers are not explicitly rewarded for their provision and hence cannot be expected to supply them in appropriate quantities’ (p. 714).

In this context Rygnestad and Fraser (1996) demonstrated a relevant problem of incentive compatibility in policy design as it related to the operation of the CAP’s set-aside policy in situations of heterogeneous land quality. In particular, with set-aside premiums established with reference to average levels of production income foregone, heterogeneous land quality means that it is in farmers’ best interests to set aside the lowest quality land in terms of production income, which results in policy ‘slippage’ in terms of output control. Other research which has identified heterogeneity of land as an important consideration in agri-environmental policy design includes Campbell (2007) and Hanley et al. (2007), who point out that ‘Supply prices would be expected to vary across farmers, because of differences in opportunity costs’ (p. 434), while ‘Willingness to pay for a given public good such as moorland landscapes could also be expected to vary spatially’ (p. 435).2

The aim of this paper is to show that the relationship between land heterogeneity and incentive compatibility is also a problem for the design of agri-environmental schemes, such as the UK’s Environmental Stewardship Scheme, where payments to farmers for providing environmental goods and services are based on average levels of agricultural income foregone, rather than on society’s willingness to pay for these environmental goods and services. In particular, it will be shown that, if land is heterogeneous, both in terms of agricultural value and in terms of environmental value, then foregone income payment leads to a systematic misallocation of

2 In this context of land heterogeneity Oñate et al. (2006) also found evidence of ‘differences in gross margins among modelled representative farms, related to the homogeneity of the area’ and affecting the consequences of implementing an agri-environmental scheme (p. 257). Johnston and Duke (2007) also found evidence of ‘significant preference heterogeneity’ in relation to land-related policy attributes among respondents surveyed about agricultural land preservation (p. 1108).
taxpayer funding, both within and between landscape regions. Note that we only consider income-foregone payments here. We do not consider other incentives, financial and otherwise, for farmers to adopt environmentally friendly practices (see, e.g. Pannell et al., 2006; Knowler and Bradshaw, 2007). This important point is considered in the section 4.

The structure of the paper is as follows. Section 2 examines the problem of ‘local’ land heterogeneity, demonstrating: (i) that a uniform incentive payment system based on average production income foregone within a region of similar environmental value and agricultural land-use results in actual levels of provision of environmental goods and services which are strongly sensitive to the levels of these payments; (ii) that such payments systematically encourage under- or over-provision of environmental goods and services between farms relative to the socially optimal levels within the region. Section 3 then examines the problem of land heterogeneity between regions, either in the level of agricultural income or in the size of environmental benefits. Once again it is shown that, with incentive payments based on agricultural income foregone, taxpayer funding will be systematically misallocated between regions. In particular, there will be:

(i) excess provision of environmental goods and services in regions of relatively high agricultural income and/or low environmental benefits from such goods and services;

(ii) inadequate provision of environmental goods and services in regions of relatively low agricultural income and/or high environmental benefits from such goods and services.

Moreover, such misallocation may be so extreme that the overall level of social benefit is less than the cost of taxpayer funding, resulting not only in a re-distribution of income, but also in a dead weight loss to society from the policy’s operation.

2. Local Land Heterogeneity

This section examines the problem for policy design of ‘local’ land heterogeneity, i.e. within a single region of similar environmental value and similar agricultural land use. From the policy perspective ‘local’ can also indicate a region where the payments for providing the same environmental goods and services are uniform across the region. However, even within such a region, land productivity will vary both within and between farms. For example, in the study of Danish cereal farms by Rygnestad and Fraser (1996), crop land was broadly characterized as being poor, average or good, with maximum yields varying in each case from 5.45 to 8.45 to 10.45 tonnes/ha. Moreover, each farm was characterised by the proportion of each of these land types which it comprised. As a consequence, each farmer would respond to the introduction of compulsory set-aside by setting aside their lowest quality land, whilst farms with an overall higher quality of land would experience the largest decreases in production income.

Given such land heterogeneity on-farm, the marginal cost of diverting land to environmental purposes increases as more land is diverted. This marginal cost is represented in Figure 1 by the line $MC^0(E)$ (assuming continuous variation in land productivity over the farm). In this situation, if the established incentive payment per hectare in the region for converting land from agricultural production to the
The socially optimal diverted area for this farm is defined by the social (willingness-to-pay) demand curve for environmental goods and services. This is represented by the line $D_S$ in Figure 2, which otherwise replicates Figure 1. Figure 2 is drawn to represent an ideal outcome, where the farmer’s actual choice of area to convert ($Q_A$) is exactly equal to the socially optimal area to convert ($Q_S$) — i.e. where the marginal social willingness to pay for conversion is exactly equal to the farmer’s marginal cost of conversion, and where both are equal to the established incentive payment for converting land. This situation is unique, demonstrating that payment based on income foregone is not necessarily inconsistent with a socially optimal outcome. More specifically, in this situation the combined value of consumer surplus:

$$\Box OQ_A CE$$

and producer surplus:

$$\triangle ABC$$

less the amount of government (taxpayer) funding to farmers to achieve the area converted:

$$OC_0$$

$$Q_0$$

$$Q_1$$

Hectares of land

Figure 1. Marginal cost of providing environmental goods and services

provision of environmental goods and services is given by $OC_0$, then the farmer will choose to convert the $Q_0$ hectares for which the marginal cost (agricultural income foregone) is less than (or equal to) this incentive payment. As can be readily seen from this representation, the lower the quality of the land on a farm, the lower the marginal (or opportunity) cost of diverting land to environmental purposes, and the greater the area of land which will be diverted for any given payment. On the other hand, the more homogenous is the land on the farm, the flatter is the marginal cost, and the more sensitive is diverted area to the level of payment.

3 My thanks go to an anonymous referee for pointing out this special case to me.
In particular, for smaller converted areas (than $Q_A = Q_S$) this net benefit is lower since the loss of combined consumer and producer surplus exceeds the savings in government spending, compared with the optimum, while for larger converted areas (than $Q_A = Q_S$) the gain in combined consumer and producer surplus is less than the amount of extra government spending.

However, this fortunate coincidence of a fixed income foregone payment and a socially optimal conversion of land will only happen if: (i) all farms in this region are identical in terms of their spread of land quality (i.e. all farms have the same $MC_E$ curve); (ii) the social demand for environmental provision is common to all land in the region; (iii) the uniform payment is established at exactly the appropriate level to balance the common marginal cost with the common social benefit. Otherwise, it is clear that land heterogeneity will result in any uniform payment delivering a socially sub-optimal provision of converted land on any particular farm in the region. This situation is represented in Figure 3, where both the incentive payment per hectare of converted land and the social demand curve for each hectare of converted land are unchanged from those in Figure 2 (i.e. $OC_0$ and $D_S$), but above-average and below-average marginal cost of conversion farms

4 Because existing agri-environmental policies such as the ESS are based on uniform incentive payments within regions, no consideration is given here to specific farm-based incentive payments. However, a scheme featuring specific farm-based payments would be worth investigating if the demand for environmental provision in a region could be substituted between farms, for example such that low-quality farm land specialised in this provision, thereby improving overall social benefit.
are represented by $MC_X^E$ and $MC_Y^E$, respectively. As is clear from Figure 3, between-farm land heterogeneity results in different levels of converted land being chosen by the two farmers (i.e. $Q_X^A$ compared with $Q_Y^A$). In addition, even though the social demand curve for converted land is the same for farms X and Y, their differing marginal costs of conversion implies a different socially optimal area of converted land on each farm, with area on farm Y exceeding that for farm X (i.e. $Q_Y^S > Q_X^S$) to reflect farm Y’s lower marginal cost of conversion. More importantly, a uniform conversion incentive payment per hectare for the two farms in this case results in under- or over-provision of environmental goods and services by farmers relative to the social optimum for their farm. Specifically, for farms in the region which have above-average quality of agricultural land for the region (such as X), farmers will systematically choose to convert less than the socially optimal area of converted land for their farms (i.e. the marginal social willingness to pay for land to be converted exceeds the marginal cost of doing so). The obverse applies to farmers with below-average quality of agricultural land for the region (such as Y). Even though the environmental value of land is the same across the region, a uniform payment means that the provision of environmental goods and services will be concentrated in parts of the region where the agricultural value of land is below average. Moreover, this intra-regional misallocation of funds will occur even when the total funding to the region for the provision of environmental goods and services within the region is similar to the socially desirable level.5

5 If environmental value was much higher than given by $D_S$, then at some level both types of farms would feature inadequate provision. Similarly, for environmental value much lower than $D_S$, at some level both types of farms would feature excess provision. Even so, the provision of environmental goods and services will be concentrated in parts of the region where the agricultural value of land is below average.
3. Land Heterogeneity Between Regions

A similar problem arises because of heterogeneity in the social value of environmental care, as is likely to be the case between two different regions. To begin, and to keep the analysis as simple as possible, consider two such regions, with different social valuations of the care provision, but with farms assumed to be identical as far as their opportunity costs of conservation, amenity, recreation and environmental (care) provision is concerned (albeit with heterogeneous land within the farm, and hence upward sloping MC curves).

3.1. Heterogeneity in environmental value

In this case the two regions are specified to be equivalent in terms of agricultural productivity, such that the incentive payment per hectare for converting land to the provision of environmental goods and services is identical for the two regions. However, the two regions are heterogeneous in terms of the marginal social value of their environmental landscape, with one region featuring greater marginal social willingness to pay for environmental goods and services per hectare than the other for each hectare of converted land. This situation is represented in Figure 4, showing that the actual proportion of land chosen to be converted to the provision of environmental goods and services is the same for both regions ($Q_A$), consistent with their identical agricultural productivity and incentive payments to convert land. However, it can also be seen that the environmental land heterogeneity between the two regions results in a systematic misallocation of the provision of environmental goods and services between the two regions. In particular, a flat rate payment results in excess provision of environmental goods and services in the region of low environmental value, and

![Figure 4. Two regions with different environmental value](image-url)
inadequate provision of environmental goods and services in the region of high environmental value.\(^6\)

3.2. Heterogeneity in agricultural value

At the other extreme, consider two regions with the same environmental value (demand for environmental care), but with different agricultural productivities (marginal costs of provision) (Figure 5). An example of this type of situation in the UK would be an arable region and a hill-farming region, where the agricultural income per hectare is higher in the arable region than in the hill-farming region, but where the total environmental value of the two regions is similar, perhaps because the hill-farming region features higher environmental value per individual user, but is more distant from a population centre than the arable region. In this case, payment rates established with reference to income foregone will result in different payments in each region, which may (or may not) result in the same amounts of land diverted (converted) to environmental provision. But the common demand (willingness to pay) for care means that the socially optimal amount of converted land in the region of low agricultural value exceeds that for the region of high agricultural value (i.e. \(Q_2^S > Q_1^S\)). In this case, an incentive payments scheme based on agricultural income foregone for environmental values which are identical, results in a systematic misallocation of the provision of environmental goods and services between the two regions, with a particular bias towards excess provision in the region of

\(^6\)Note as in the previous section that for extremely divergent levels of incentive payments and marginal social willingness-to-pay environmental goods and services could be under- or over-provided in both regions. However, the extent of under- or over-provision would still differ markedly between the two regions, and a bias remain towards under-provision in the region of higher environmental value and over-provision in the region of lower environmental value.
high agricultural value, and inadequate provision in the region of low agricultural value.

### 3.3. Heterogeneity in both agricultural and environmental value

In practice, both the opportunity costs of providing care and the social valuations of the environmental provision differ between and within regions. It is highly unlikely that the cost of provision is systematically reflective of the social value of environmental care. For example, Fraser and Rygnestad (1999) showed for Danish cereal growing that croppable land with relatively low agricultural productivity was also the land that offered the highest potential benefits from set-aside in terms of reduced nitrate leaching. Moreover, in the UK (and other EU countries), the so-called ‘less favoured areas’ in terms of agricultural income per hectare, are also increasingly being referred to as areas of ‘high nature value’ (European Environment Agency, EEA, 2004). As a consequence, the following numerical illustration is based on a negative correlation between agricultural and environmental value – low agricultural value being associated with high environmental value, and *vice versa*.

A numerical illustration allows quantification of both total government spending and total consumer and producer surplus generated by such spending on the operation of an incentive payment system for the conversion of agricultural land to the provision of environmental goods and services.

Based on the framework of the previous subsections, let the low agricultural/high environmental value region have the following specification (where this region is denoted by ‘H’):

\[
D_H = 120 - q \\
MC_H = 15 + 0.5q \\
OC_H = 30.
\]

While for the high agricultural/low environmental value region (denoted by ‘L’):

\[
D_L = 60 - q \\
MC_L = 50 + 0.25q \\
OC_L = 70.
\]

Table 1 shows the numerical results. As expected from the findings of sections 2.1 and 2.2, and given the specified negative correlation between agricultural and environmental value, there is excess provision of environmental goods and services in region L, and inadequate provision in region H. Moreover, given the chosen parameter values, there is larger governmental spending than is socially optimal, and the combined value of consumer and producer surplus is less than that achieved with the socially optimal provision of environmental goods and services. But the most significant quantitative finding is that, while the combined value of consumer and producer surplus exceeds governmental spending in the case of the socially optimal provision (a ratio of 1.95 : 1), the actual provision leads to a deadweight welfare loss with total governmental spending exceeding the combined gains in consumer and producer surplus (a ratio of 0.92 : 1). In this case, the operation of the incentive payments scheme based on agricultural income foregone results in an overall reduction in social welfare.
4. Conclusion

It is clear from this analysis that any flat rate payment scheme for environmental care will generate suboptimal provision when either or both the opportunity costs of provision and the social values of the environment are heterogeneous. Furthermore, the more different are the costs and values of environmental provision between different areas (within or between regions), the greater is the misallocation likely to be, to the extent that the total costs of any flat rate scheme can exceed the benefits. The focus here has been on payments based on income foregone (the opportunity costs of providing environmental care). In particular, such a system will encourage over-provision of environmental goods and services (relative to the socially optimal level) on farms with relatively low average quality of agricultural land (section 2). In addition (section 3) such a system will encourage:

(i) over-provision of environmental goods and services (relative to the socially optimal level) in regions of relatively high agricultural income and/or low environmental benefits from such goods and services;

(ii) under-provision of environmental goods and services (relative to the socially optimal level) in regions of relatively low agricultural income and/or high environmental benefits from such goods and services.

Moreover, in a situation where the regions involved feature a negative correlation between agricultural and environmental value, it was shown that the misallocation of funding for the provision of environmental goods and services between regions may be so great as to result in an overall reduction in social welfare from the operation of the scheme.

In essence, as argued by Harvey (2003), the policy design problem is to “properly” reflect the public or social values of the (environmental goods and services) back to the landowners’ because ‘only then can we expect market forces … to encourage land users to operate at the socially optimal level’ (p. 714).

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Region L</th>
<th>Region H</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area converted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>80</td>
<td>30</td>
<td>110</td>
</tr>
<tr>
<td>Optimal</td>
<td>8</td>
<td>70</td>
<td>78</td>
</tr>
<tr>
<td>Governmental spending</td>
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<td></td>
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</tr>
<tr>
<td>Actual</td>
<td>5600</td>
<td>900</td>
<td>6500</td>
</tr>
<tr>
<td>Optimal</td>
<td>416</td>
<td>3500</td>
<td>3916</td>
</tr>
<tr>
<td>Consumer surplus</td>
<td></td>
<td></td>
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<tr>
<td>Actual</td>
<td>1800</td>
<td>3150</td>
<td>4950</td>
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<tr>
<td>Optimal</td>
<td>448</td>
<td>5950</td>
<td>6398</td>
</tr>
<tr>
<td>Producer surplus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>800</td>
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<td>1025</td>
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<tr>
<td>Optimal</td>
<td>8</td>
<td>1225</td>
<td>1233</td>
</tr>
<tr>
<td>Consumer and producer surplus</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Actual</td>
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<td>3375</td>
<td>5975</td>
</tr>
<tr>
<td>Optimal</td>
<td>456</td>
<td>7175</td>
<td>7631</td>
</tr>
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In this context it is interesting to note that although the UK’s Environmental Stewardship Scheme states that it uses agricultural income foregone as the basis for determining incentive payments for the provision of environmental goods and services, that scheme does actually contain an exception to this ‘rule’. Specifically, within the component of this scheme called ‘higher level stewardship’ one of the identified environmental services is ‘educational access’, which provides ‘schools and colleges’ with the opportunity to visit farms and have farmers ‘explain the links between farming, conservation and food production’ (DEFRA, 2007b, p. 94). In this case, the incentive payments to farmers is ‘per visit’, and in applying to participate in the provision of ‘educational access’ farmers are ‘expected to provide evidence of this demand’ (DEFRA, 2007b, p. 94). Consequently, in making their decision regarding whether to provide this environmental service farmers must take account of the social benefit associated with its provision in so far as this will determine the ‘demand’ for ‘educational access’. Perhaps this approach might be made more common across the other environmental services?

However, as argued by Pannell et al. (2006) ‘adoption of conservation practices is complex and multifaceted’ (p. 1421) and as suggested by Knowler and Bradshaw (2007) ‘efforts to promote conservation agriculture will have to be tailored to reflect the particular conditions of individual locales’ (p. 25). Therefore, while dealing with the joint problems of land heterogeneity and incentive compatibility, agri-environmental policy design should also be sensitive to broader considerations of farmer participation where this participation is voluntary. On the other hand, the transactions and implementation costs associated with such ‘well-designed’ policy instruments delivered by government on our behalf might well exceed the benefits. If so, the appropriate conclusion is not necessarily that the current system of cost-based flat rate payments is second best, but rather that we should be seeking different processes to allow the beneficiaries of environmental care to connect more closely with those able to provide these services (Harvey, 2003).

References


