Utilising Equilibrium-Displacement Models to Evaluate the Market Effects of Countryside Stewardship Policies: Method and Application

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Utilising Equilibrium-Displacement Models to Evaluate the Market Effects of Countryside Stewardship Policies: Method and Application

Klaus Salhofer, Franz Sinabell*

Abstract:

As part of the so called accompanying-measures of the CAP reform Council Regulation (EEC) 2078/92 was established in 1992. The goals of this regulation are to reduce farm output and/or to reduce environmentally detrimental side effects of farm production and/or to support farm income. This paper demonstrates how to use equilibrium-displacement models to analyse market effects of programmes that were introduced according to this regulation. It is argued that CSPs affect the product output in two different ways: first, there is the output decreasing effect of the program restriction and second, there is an output increasing effect of direct payments. An empirical example of our method for one of these programmes in Austria shows that the overall output effect is ambiguous and that the final outcome is more likely to be positive. Hence this particular scheme is probably counter-productive in decreasing production volumes, a major goal of CR (EEC) 2078/92.

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1 Introduction

The central element of the reform of the Common Agricultural Policy (CAP) in 1992 was the shift from price supports to direct payments, aiming to combine control of agricultural markets with extensification of agricultural production. As part of the so called accompanying-measures of the CAP reform Council Regulation (CR) (EEC) 2078/92 was established in the same year. This regulation was instituted in order to make the CAP reform compatible with the goals of the 'Green Paper' *Perspectives for the CAP* (European Commission, 1985) in which the European Commission stated that environmental objectives must be integrated in agricultural policies. According to the reasoning of this regulation the role of farmers is not seen to be just producers of agricultural commodities, but also to be stewards of the environment and countryside.

Based on CR (EEC) 2078/92 Community aid programmes have been introduced in all EU Member States. The objectives of these programmes that are part-financed by the EAGGF (European Guidance and Guarantee Fund) are:

1. to accompany the changes to be introduced under the market organisation rules,
2. to contribute to the achievement of the Community's policy objectives regarding agriculture and the environment,
3. to contribute to providing an appropriate income for farmers.

Clearly, the goals of this regulation are to reduce farm output and/or reducing environmentally detrimental side effects of farm production and/or supporting farm income.

However, Member States do have considerable freedom to put more or less weight to the above policy goals, to choose among the particular targets, the instruments to reach them, and the amount of funds they are deeming appropriate to attract farmers to enrol. Any such programme may consist of several schemes which are offered either in the whole country or in particular regions only. In the remainder of this paper the heterogeneous set of aid programmes emanating from CR (EEC) 2078/92 will be subsumed under the term *countryside stewardship policies* (CSPs).

Since 1993 a total of 163 programmes have been notified for adoption by the Commission and 152 programmes have been adopted by the end of 1996 (Scheele, 1996). The volume of premiums paid to farmers over the same period is totalling 6.9 billion ECU (Deblitz, 1998). However, studies evaluating the effectiveness of these programmes are scarce.[1] Therefore the aim of this paper is to propose a method with which the effects of a wide number of CSPs can be evaluated. We argue that in most cases CSPs attempt an extensification by utilising standard instruments (e.g. input control, output control) and compensate farmers by direct payments. While the direct impact of these policies clearly is a reduction of output, the direct payments are creating additional input demand and hence weaken or even reverse the output effect of CSPs. Both effects can be evaluated using an equilibrium-displacement model (EDM), a tool frequently used in agricultural policy analysis (e.g. Gardner, 1987; Alston, Norton and Pardey, 1995, chapter 4; OECD, 1995).

In the following section CSPs are classified according to the instruments that are used. An EDM is developed in section 3 for a representative class of CSPs using input restrictions. For illustration purposes the theoretical results are applied for one scheme, the Austrian 'crop rotation scheme'. The results are discussed in the last section and conclusions are drawn how effective the analysed CSPs are with respect to reducing output, a major goal of CR (EEC) 2078/92. Finally, directions for further research are outlined.

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1 One exception is the study of Harrison-Mayfield, Dwyer, and Brookes (1998) who analyzed farm level and regional level effects of CSPs on income and on farm employment by combining survey data with an input-output model.

2 Classification of CSPs according to the instruments that are used

Van Huylenbroeck et al. (1998) who carried out a cross-country comparison of CSPs conclude that there is a high diversity in almost all aspects ranging from objectives, transfer vehicles, premiums, and the acceptance by farmers. CSP measures are voluntary, leaving it to the single farmer to participate in a given scheme or not which is virtually the only aspect that all programmes do have in common.

The general mechanisms of 2078/92 CSPs are:

1. the public is leasing property rights of farmers for some period (at least five, in some schemes up to 20 years),
2. the public is setting up markets for countryside stewardship goods and buying services that have the character of public goods.

Typical for category 1 are schemes aiming at reducing negative impacts of farming methods (like erosion, emission of minerals and other farm chemicals) and extensifying farm production (like reduction of the proportion of sheep and cattle per forage area). Schemes falling into category 2 are less important with respect to both, their number as well as their transfer volume. Under such schemes farmers are managing their land in a way to preserve habitats and enhance biological diversity. Both mechanisms are at work in schemes where farmers allow access to their land for recreational purposes and provide management and infrastructure.

The set of instruments on which CSPs in the EU are building are almost exclusively among the classical instruments of agricultural policy:

a) output control,
b) input control,
c) production premiums, and
d) various combinations of these instruments.

Pure output control measures generally do not play an important role in CSP programmes. Input control measures, on the contrary, are of major importance. They frequently restrict the use of

- land as a factor of production: like set aside schemes (mostly motivated by water protection concerns or for habitat development) and schemes aiming at converting arable land into grassland;
- purchased inputs: schemes limiting the use of mineral fertiliser and/or pesticides or banning it almost entirely like in the 'organic farming scheme' which is offered in all EU-Member States.

Production premiums are paid in schemes aiming at increasing the number of heads of local livestock breeds and schemes trying to motivate farmers to plant crops in danger of extinction. There are also schemes with premiums not directly linked to output but having rather similar effects, e.g. by paying premiums per head of livestock that is grazing on marginal land.

A typical example of combinations of both, output and input control measures, is the Austrian "elementary support" scheme (limiting the number of livestock per land and restricting fertiliser use). Among rather complex schemes, combining output and input control with production premiums is the French "Prime à l’herbe" scheme. Premiums are paid if stocking rates lie between specified minimum and maximum boundaries while simultaneously restricting the use of farm chemicals. Many of the schemes in the United Kingdom add further complexity by combining these instruments with requirements to open land for public access with the associated requirements to provide infrastructure and management.

Given its importance we will concentrate on the case of input controls. We first describe the method used and derive theoretical results on which market parameters the output effects depend upon and afterwards quantitatively illustrate the method for the 'crop rotation scheme' which accounts for 17.5% of premiums of the Austrian agri-environmental programme.

3 The method

3.1 Equilibrium-displacement models

The simplest model useful to analyse CSPs is one which represents one output market for the agricultural product as well as two input markets, one which is directly affected by the CSP, e.g. through an input restriction, and one which represents all other inputs. A common way to describe these three markets, in the tradition of Muth (1964), Floyd (1965), and Gardner (1987) based on Hicks (1932) and Allen (1938), is by the following system of six equations:[2]

(1) $Q = g(P)$,

(2) $Q = f(X_1,X_2)$,

(3) $W_1 = \frac{\partial f(\cdot)}{\partial X_1} P$,

(4) $W_2 = \frac{\partial f(\cdot)}{\partial X_2} P$,

(5) $X_1 = h_1(W_1,b_1)$,

(6) $X_2 = h_2(W_2,b_2)$.

The six endogenous variables in the model are the produced quantity of the agricultural commodity Q and its price P, as well as the two input factor quantities X_1, and X_2 and their prices W_1 and W_2. Equation (1) describes the demand for the agricultural product. Equation (2) is the agricultural production function. Equations (3) and (4) are the first order conditions of profit maximisation and state that the value of the marginal product of each factor ($\partial f(\cdot)/\partial X_i$) must be equal to its price. Equations (3) and (4) can also be seen as inverse conditional factor demand equations (conditional on the quantity of the other input factor).[3] Equations (5) and (6) are input factor supply equations with b_1 and b_2 being exogenous shift variables, where such an exogenous shift might be the result of government intervention.

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2 It is also possible to describe the three related markets solely by supply and demand functions rather than a starting from a production function (Buse, 1958; Piggott, 1992)

3 The derivation of equations (3) and (4) is given in the appendix.

Assumptions made in these kind of models include i) that all markets are competitive (though this assumption can be easily relaxed by introducing a conjectural variation model (see for example Maier (1993), or Salhofer, Hofreither and Sinabell (1998)); ii) producers maximise profits; iii) all firms are identical (which is equivalent to assuming they have the same technology), iv) constant returns to scale; and v) firms produce a single homogenous output. Assumption ii) can be replaced by assuming cost minimising behaviour instead. Therefore, instead of looking at the problem from the primal side, and hence specifying a production function, one can also use the dual approach by replacing equations (2) to (4) by[4]

(2') $P = c(W_1,W_2)$,

(3') $X_1 = c_1(W_1,W_2)Q$,

(4') $X_2 = c_2(W_1,W_2)Q$.

Equation (2') expresses the long-run condition that product price equals minimum average total cost. Equations (3') and (4') are derived from the cost function using Shepard's Lemma and are inverse conditional (output constant) factor demand functions.

The system of six equations (1), (2'), (3'), (4'), (5), and (6) are used below to describe the three markets, since it is the most convenient one to solve, especially for more than two input factors (Mullen, Wohlgenannt and Farris, 1988; Mullen, Alston and Wohlgenannt, 1989; Alston, Norton, and Pardey, 1995, chapter 4.3.4).

Since we are interested in changes in the system (implied by policy changes), we take the total differentials of this system of six equations and express the results in relative changes (i.e. $dX/X = d\ln X \equiv EX$) and elasticities:

(1'') $EQ = - \eta EP$

(2'') $EP = k_1EW_1 + k_2EW_2$

(3'') $EX_1 = -k_2\sigma EW_1 + k_2\sigma EW_2 + EQ$

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4 The derivation of equations (2') to (4') is given in the appendix.

(4’’) $EX_2 = k_1\sigma EW_1 – k_1\sigma EW_2 + EQ$

(5’’) $EX_1 = \varepsilon_1 EW_1 + \beta_1$

(6’’) $EX_2 = \varepsilon_2 EW_2 + \beta_2$ [5]

with η being the absolute value of the demand elasticity, k_1 and k_2 being cost shares of the two input factors (note that $k_1 + k_2 = 1$, because of the constant returns to scale assumption), σ being the elasticity of substitution between the two inputs, ε_1 and ε_2 being input supply elasticities, β_1 and β_2 being the relative shift in supply of factor one and two. So, the system of six equations (1’’) to (6’’) has six endogenous variables (the relative changes in prices and quantities), six parameters (η, k_1, k_2, σ, ε_1, and ε_2), and two exogenous shift variables (β_1 and β_2).

This system can be solved either by repeated substitution or by matrix algebra. Using the latter one for convenience reasons one may express equations (1’’) to (6’’) by

$$(7) \quad \underbrace{\begin{vmatrix} 1 & \eta & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & -k_1 & -k_2 \\ -1 & 0 & 1 & 0 & k_2\sigma & -k_2\sigma \\ -1 & 0 & 0 & 1 & -k_1\sigma & k_1\sigma \\ 0 & 0 & 1 & 0 & -\varepsilon_1 & 0 \\ 0 & 0 & 0 & 1 & 0 & -\varepsilon_2 \end{vmatrix}}_{\mathbf{A}} \underbrace{\begin{vmatrix} EQ \\ EP \\ EX_1 \\ EX_2 \\ EW_1 \\ EW_2 \end{vmatrix}}_{\mathbf{x}} = \underbrace{\begin{vmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \beta_1 \\ \beta_2 \end{vmatrix}}_{\mathbf{b}}$$

Using the system of equations (7) we can gain theoretical as well as quantitative insights on the market effects of CSPs.

3.2 The effect of the restriction requirement

As mentioned above most CSPs either directly restrict the use of input factors, usually land or chemical inputs, or make them more expensive. According to Figure 1b a restriction might cause the supply of the restricted factor to change from S to S’ implying displacements in all three markets. For example, a set aside requirement will cause the shadow price of land to increase from W_1 to W_1’, causing a leftward demand shift (in the case of gross complements)

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5 The derivation of equations (1’’) to (6’’) is given in the appendix..

in the market of all other inputs from D to D' and hence a decline in production from Q to Q' and so on.

Using equation (7), the relative change (compared to the initial level) of agricultural output (EQ) due to the relative change in the quantity of land used for production (β_1) is given by

$$(8)\quad EQ = \frac{\eta k_1(\sigma + \varepsilon_2)}{\sigma(\varepsilon_1 k_1 + \varepsilon_2 k_2 + \eta) + \eta(\varepsilon_2 k_1 + \varepsilon_1 k_2) + \varepsilon_1 \varepsilon_2}\beta_1 .$$

Equation (8) is derived using Cramer's rule by calculating EQ = det(B)/det(A). The term det(B) is the determinant of matrix **B**, which is identical with Matrix **A** (in equation 7) except that its first column is substituted by the right hand side vector **b** since EQ is the first element in vector **x**. Determinants of **A** and **B** can be derived by hand or using a mathematical software.

In the case of a shift in supply of input X_1, parameter β_2 in vector **b** is zero and β_1 is the ratio of hectares of land no longer available to produce output Q divided by the initially planted hectares (see Figure 1b):

$$(9)\quad \beta_1 = (X_1' - X_1)/X_1 .$$

Since the restriction on land not only shifts the input supply curve to the left, but also leads to an inelastic supply $\varepsilon_1 = 0$ then equation (8) simplifies to

$$(10)\quad EQ = \frac{\eta k_1(\sigma + \varepsilon_2)}{\sigma \varepsilon_2 k_2 + \eta(\sigma + \varepsilon_2 k_1)}\beta_1 .$$

If there is a floor price policy for the agricultural product (like for cereals in the EU) producers face a total elastic demand. Hence $\eta = \infty$ and equation (10) simplifies to

$$(11)\quad EQ = \frac{k_1(\sigma + \varepsilon_2)}{\sigma + k_1 \varepsilon_2}\beta_1 \le 0 .$$

Equation (11) clearly reveals first, the direction in which a set aside scheme pushes agricultural output, and second, on which particular parameters the market effects of CSPs depend.

Since under usual assumptions (k_1, k_2, ε_1, ε_2, σ, and $\eta \geq 0$)[6], all parameters are positive and β_1 is negative (since some land is taken out of production), a set aside programme will never increase agricultural output. The parameters influencing the magnitude of the market effects of the programme are: the cost share of land (in the case of constant returns to scale this is equal to the shadow value of land divided by total revenues), the elasticity of substitution between land and all other input factors, and the aggregate supply elasticity of these other input factors.

Further insights are gained by applying extreme values to equation (11). If we have for example a Leontief type production technology and therefore land can not be substituted by other input factors ($\sigma = 0$) the output decreases by the same percentage as does land ($EQ/\beta_1 = 1$). On the other hand if land is a perfect substitute ($\sigma = \infty$), output would only decrease by the cost share of land ($EQ/\beta_1 = k_1$). Hence, the set aside requirement is more effective in decreasing output the more inelastic is the elasticity of substitution. Similarly if the supply elasticity of all other inputs is perfectly inelastic $\varepsilon_2 = 0$, the output decreases by the ratio of the cost share ($EQ/\beta_1 = k_1$), while if $\varepsilon_2 = \infty$, output decreases by the same percentage as does land ($EQ/\beta_1 = 1$). Hence, the effectiveness of the set aside programme increases with increasing supply elasticity of all other inputs. Finally if $k_1 = 0$, i.e. land is not necessary to produce the agricultural output, then of course $EQ/\beta_1 = 0$, while if $k_1 = 1$, i.e. only land is necessary to produce the agricultural output, obviously $EQ/\beta_1 = 1$. Hence, the effectiveness of the set aside programme increases with increasing k_1.

Similar insights are gained by investigating how the change in output induced by a set aside requirement changes with a change of the forcing parameters and hence by differentiating EQ/β_1 with respect to the parameters :

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6 Remember that by definition η is the absolute value of the demand elasticity.

$$(12)\quad \frac{\partial(EQ/\beta_1)}{\partial\sigma} = \frac{k_1\varepsilon_2(k_1-1)}{(\sigma+k_1\varepsilon_2)^2} \le 0,$$

$$(13)\quad \frac{\partial(EQ/\beta_1)}{\partial k_1} = \frac{\sigma^2+\varepsilon_2\sigma}{(\sigma+k_1\varepsilon_2)^2} \ge 0,$$

$$(14)\quad \frac{\partial(EQ/\beta_1)}{\partial\varepsilon_2} = \frac{k_1\sigma(1-k_1)}{(\sigma+k_1\varepsilon_2)^2} \ge 0.$$

Equation (12) indicates that an increase in the elasticity of substitution will decrease the ratio EQ/β_1 and hence decrease the effects of a set aside programme on final output. An increase in k_1 or ε_1 will have the opposite market effect by increasing output.

3.3 The effect of the direct payments

All 2078/92 CSPs do have in common that farmers get direct payments as a compensation for the losses they incur when complying with the restrictions on property rights or production possibilities. As described in section 2 most of these payments are decoupled in a sense that they do not depend on the quantity produced. However, they implicitly might have an influence on the quantity produced if some share of these transfers is used to purchase additional quantities of the unrestricted inputs. So in our simple two input model a part of the direct payments received in exchange for idling land might be used to purchase additional quantities of the other inputs and hence stimulate production. The direct payments in fact subsidise the non-restricted inputs. This is depicted in Figure 1c by a rightward shift of supply curve S to S' in the market of all other inputs implying displacements in the other two markets.

The impact of this demand shift on final output again can be assessed by using equation (7) with now $\beta_1 = 0$ and

$$(15)\quad \beta_2 = (X_2' - X_2)/X_2.$$

the relative change in the quantity of input two used for production. Again assuming $\varepsilon_1 = 0$ and $\eta = \infty$ the relative change in output is given by

(16) $EQ = \frac{k_2\sigma}{\sigma + k_1\varepsilon_2}\beta_2 \geq 0$.

Therefore, final output will never decrease (but is very likely to increase) if some of the direct payments are used to purchase additional units of the non-restricted inputs. The market effect of the reinvested direct payments will be larger the higher are k_2 and σ and the smaller are k_1 and ε_2:

(17) $\frac{\partial(EQ/\beta_2)}{\partial\sigma} = \frac{k_1 k_2 \varepsilon_2}{(\sigma + k_1\varepsilon_2)^2} \geq 0$,

(18) $\frac{\partial(EQ/\beta_2)}{\partial k_1} = \frac{-k_2\varepsilon_2\sigma}{(\sigma + k_1\varepsilon_2)^2} \leq 0$,

(19) $\frac{\partial(EQ/\beta_2)}{\partial k_2} = \frac{\sigma(k_1\varepsilon_2 + \sigma)}{(\sigma + k_1\varepsilon_2)^2} \geq 0$,

(20) $\frac{\partial(EQ/\beta_2)}{\partial \varepsilon_2} = \frac{-k_1 k_2\sigma}{(\sigma + k_1\varepsilon_2)^2} \leq 0$.

Therefore, the overall effect of CSPs on agricultural output is ambiguous. While the restriction of input factors decreases final output, the possible reinvestment of the transfers will increase output. The conditions under which the negative effect of the restriction is larger than the positive effect of the direct payments can be investigated by utilising equations (11) and (16):

(21) $k_1(\sigma + \varepsilon_2)|\beta_1| > k_2\sigma\beta_2$.

No conclusion about the overall effect can be drawn in general and is left open to empirical investigations.

To derive quantitative results for the market effect due to the set aside requirement of a CSP one has to quantify β_1 and β_2 and assume values for the parameters k_1, k_2, σ and ε_2, which will be done in the next section.

4 Quantitative assessment of the Austrian 'crop rotation scheme'

4.1 Some facts about the 'crop rotation scheme'

In Austria CR (EEC) 2078/92 was implemented with the ÖPUL[7] programme in 1995, the year when Austria joined the European Union. This programme offers 25 schemes which cover all elements designated by CR (EEC) 2078/92 with the notable exception of the promotion of 'land management for public access and leisure activities'. The acceptance of this programme (measured as the number of farms enrolled) lies between 170,000 (almost 80% of all agricultural holdings are participating in the scheme 'elementary support') and 0 (the scheme 'reduction of livestock'). Only two schemes, 'elementary support', and 'crop rotation premium' are accounting for 38% of the transfers paid to farmers under this programme (BMLF, 1996a, 259).

The 'crop rotation scheme' was chosen for this case study because a significant volume of CSP-premiums (17% of all ÖPUL-premiums in 1995) is transferred to farmers participating in this scheme and because of its simple illustrative structure.

Farmers enrolling this scheme must comply with the following criteria:[8]

- a maximum of 75% of arable land may be used to produce cereals and maize, and
- a winter cover crop (covering at least 15% of arable land) must be planted before 1st of November and may not be ploughed under before 1st of December.

Premiums ranging from 900 to 1,900 ATS/ha (67 to 140 ECU/ha) are paid according to the acreage covered by winter cover crops. The average premiums were 1,100 ATS/ha in 1995 (BMLF, 1996a) which implies that at least approximately 20% of arable land was covered

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7 The acronym ÖPUL can be translated as "Austrian programme to promote agricultural practices which are ecologically sound, extensive and beneficial for the natural environment"

8 See BMLF (1996b) for the details of this scheme.

during the winter season. Some forage crops are defined to be winter cover crops, therefore many livestock producers automatically meet the second criterion.

The effects of the CSP requirements are

- a decrease in production of cereals and maize by restricting the farm owned factor land, and
- an increase of cost for those producers which have to plant winter cover crops because they need more purchased inputs (seed, energy, machinery) apart from having to increase labour input.

4.2 Parameters used for the quantitative assessment of the 'crop rotation scheme'

Parameter values are based on several sources: ranges of elasticities are taken from the literature, cost share parameters are based on the SPEL dataset (Eurostat, 1998, and Kniepert, 1998), and shift parameters are derived from official sources and using information from a farm survey. Table 1 gives an overview of the parameters that were used.

The actual amount of land taken out of cereal production because of the restriction on land through the 'crop rotation scheme' is difficult to derive for two reasons: first, because of the existence of a very similar program (and hence a similar restriction on land) since 1992 and second, because of the manifold exogenous policy changes in 1995 in Austria. Hence, the shift parameter β_1 (see equation (9)) is derived from the effects on land-use following the introduction of this very a similar scheme in 1992.[9] Official sources were used to single out the effect this measure had on land that was used for producing cereals and maize (BMLF, 1993, and ALFIS). Parameter β_1 ideally would be calculated by dividing land owned by CSP par-

9 In fact the 'crop rotation scheme' can be seen as a direct successor of the scheme introduced in 1992. The most important differences to the ÖPUL 'crop rotation scheme' are that not just grain producers could participate this scheme but all other producers as well, and that instead of planting winter cover crops farmers in 1992 had to idle a small percentage of land.

ticipants and used for cereal and maize production by land of CSP participants used for cereal and maize production prior to the implementation of the programme. Such detailed information is not available. Instead β_1 is approximated by reduction of land used to produce cereals and maize from 1991 to 1992 relative to this area in 1991 and is calculated to be -9 %.

The second shift parameter β_2 (additional input demand implied by direct payments; see equation (15)) is derived by using information on the share of direct payments farmers are spending to purchase farm inputs. The values are taken from a survey that was carried out in 1998 among farmers in Lower Austria, the province with the biggest share of cereal producers in Austria (Sinabell, 1998).

Although this survey was not representative (250 farmers were interviewed) we are basing our assumptions on these responses because figures from surveys in several other EU Member States (Bergström et al., 1998) indicate a relative stable range around the Austrian values. The survey indicates that 40% of direct payments are used to buy variable inputs and 25% are re-invested in durable equipment.[10]

The high survey figures may be rationalised by the facts that some of the respondents may not yet have adjusted their purchasing behaviour to the generally lower price levels on agricultural markets, and others may use a considerable share of transfers that are deemed to be income compensations to make new investments to adjust to the new business environment. On the other hand, it might be argued that the investments are in fact not output increasing but are made to substitute time that is either used for leisure or for conducting off farm activities (a considerable share of farms in Austria is run by part time farmers). In addition, it might be plausible that product revenues otherwise used to buy inputs are used for consumption and balanced with the revenues of direct payments. Considering these facts we adjust the survey

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10 The question asked in this survey was: "How are you distributing direct payments over the following categories: _% for consumption purposes, _% for variable inputs (like fertilizer, fuel), _% for investment goods for farm operation (like machinery, buildings), _% for investments in other business activities?"

figures downwards and assume that 30% to 50% of the direct payments are used to buy additional inputs.

The total of direct payments from the 'crop rotation scheme' (BMLF, 1996a) multiplied by these percentages, accounting for the additional cost for planting winter-cover crops, and dividing these numbers by the total cost of cereal and maize production, gives us a lower and upper bound of β_2 of 0.09 and 0.16, respectively.

Using the assumption of constant returns to scale and perfect competition cost share parameters k_1 and k_2 can be derived utilising standard farm account data.[11] Given both assumptions the total cost of production (including the shadow value of factors like land and labour which are owned by farmers) equal total revenues, $W_1X_1 + W_2X_2 = PQ$, and hence profits in the economic sense are zero. Let’s first assume that W_2X_2 is total cost of all purchased inputs (including overheads). Then W_1X_1 corresponds to the value added or the shadow value of inputs owned by farmers, in our application mainly land and labour. The cost share of purchased and owned inputs are $k_2 = W_2X_2/PQ$ and $k_1 = W_1X_1/PQ$. Utilising the SPEL data set (Eurostat, 1998) in the form processed by Kniepert (1998) to calculate gross margins and value added we derive these cost shares. In particular we calculate that the weighted average k_2 for maize, wheat, durum, barley, oats, and other cereals was 0.59 in 1995. However in our empirical application W_1X_1 includes only the shadow value of land but not labour. Hence, k_2 can be expected to be somewhat higher. Assuming that for cereal and maize production land has an significantly higher shadow value than labour in the computations we assume k_1 to be in the range of 0.35 and 0.2 and hence k_2 between 0.65 and 0.8.

Empirical studies on the supply elasticity of input factors are scarce. Combining single-equation structural-regression models with time-series analysis Salhofer (1997) derives supply elasticities for operating inputs (mainly chemicals) of 1.16, for durable investment goods

11 Note that both assumptions are already made from the beginning anyway.

(machinery and buildings) of 0.96, and for farm labour of 3.19. Using the same data set but slightly different estimation procedures Salhofer (1998) derives supply elasticities for operating inputs of 1.91, for durable investment goods of 1.49, and for farm labour of 1.2. Given that, a reasonable range of ε_2 is between 1 and 3. Much more empirical evidence exists in the case of substitution elasticities. A typical range may lie between 0.5 and 1.5.

4.3 Results of the quantitative assessment of the 'crop rotation scheme'

The results presented in Table 2 show that restricting land for the production of grains by 9% leads to a reduction of grains output spanning from -7 % to –2.6 %. The parameter of the reduction of land is set by policymakers to reach certain goals, whereas the other parameters leading to this result are based on market observations which finally reflect producer and consumer behaviour as well as technological relationships.

The effect of direct payments that are invested into the farm operation by the recipients is remarkable: the direct effect of the CSP-premiums may lead to an increase in output of grains by +11.34%. If our assumptions based on a farm survey hold, the minimum output increasing effect due the use of premiums to buy farm inputs is +1.95%.

Both effects together, reduction of land for the production of cereals and maize plus additional investments being funded by the CSP premiums rather likely lead to a positive production effect. Based on the parameters used in this study the range lies between a moderate output decrease (-5.1%) and a remarkable increase (+8.7 %).

5 Summary and conclusions

This paper demonstrates how to use equilibrium-displacement models (EDM) to analyse market effects of countryside stewardship policies (CSPs). Since this paper presents - to our knowledge - the first study on CSPs using this methodology a thorough treatment is given here. The choice for EDM comes from the fact that most of the CSPs use very traditional instruments to motivate farmers to provide stewardship goods and this kind of instruments can be conveniently analysed by this type of models.

While here we concentrate only on the effects of CSPs on the output of the agricultural product, this method can be easily extended to evaluate the effects on input market quantities and prices. For illustration purposes we use a very simple model (one output, two inputs) which can be extended in all directions. However, by becoming more complex an algebraic presentation like the one presented in section 3 might become intractable and only numerical solutions of the system of equations are useful. Therefore, there is a clear trade-off between abstracting from some complexities to obtain further insights and being more complete but working with a black box.

Here we argue that CSPs affect the product output in two different ways: first, there is the output decreasing effect of the program restriction (in our case on land) and second, there is an output increasing effect of direct payments. We analysed the 'crop rotation scheme' which is part of the Austrian agri-environmental programme that was established according to CR (EEC) 2078/92 in 1995. Participants of this scheme are allowed to allocate at most 75% of their land for the production of cereals and maize and in exchange receive direct payments. We proved analytically and empirically that the overall output effect is ambiguous and that the final outcome is more likely to be positive. Hence this particular scheme is probably counter-productive in decreasing production volumes, a major goal of CR (EEC) 2078/92. Empirical results from a regional partial equilibrium model are supporting this result. Röhm and Sinabell (1998), evaluating income and output effects of the Austrian agri-environmental programme, found that land that would otherwise be set aside is kept in production due to production stimulating premiums.

A positive effect on the income of farmers participating in such a voluntary scheme, another goal of CR (EEC) 2078/92, is very likely given the direct payments. However, according to farm survey data, only a minor part of these payments is actually used for consumption purposes, whereas the major part is used to buy operating inputs and investment goods. The model presented here can be adopted to analyse the effects on the distribution of income (welfare) of this and similar policies in more detail (Alston, Norton and Pardey, 1995).

According to the guidelines of the 'crop rotation scheme' there is no restriction on land that is no longer used for the production of cereals and maize. Assuming that this land is used for producing alternative crops which requires farm chemicals as inputs, and knowing that a significant share of the premiums is used to buy variable inputs (among them mineral fertilisers and pesticides) leads to the conclusion that it is not certain if the net effect of this scheme is a reduction or increase of potentially harming inputs. This conclusion rests on the assumption that the policy effect on farm chemicals use can serve as a proxy for environmental effects which may be disputed. Therefore, further efforts are necessary to evaluate the environmental effects of this scheme, the third goal of CR (EEC) 2078/92 under which the analysed policy was established. Gardner (1991) has demonstrated how to adopt the EDM modelling approach to explicitly take environmental benefits of a policy into account.

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Appendix:

Derivation of Equations (2') to (4'):

In the case of constant returns to scale the sector wide cost function is given by (Varian, 1994)

(A.1) $C = c(W_1,W_2)Q$.

From equation (A.1) one cane derive unit costs, $C/Q = c(W_1,W_2)$, which under perfect competition equal the product price P. Hence equation (A.1) can be rearranged to equation (2').

By applying Shepard's Lemma to the cost function (A.1) one can derive the conditional input demand functions (3') and (4').

Derivation of Equations (1''):

Total differentiating equation (1) yields

(A.2) $$dQ = \frac{\partial g(\cdot)}{\partial P} dP.$$

Dividing both sides by Q and expanding the right hand side by P/P leads to

(A.3) $$\frac{dQ}{Q} = \frac{\partial Q}{\partial P}\frac{dP}{Q}\frac{P}{P}.$$

Since $dQ/Q = EQ$, $dP/P = EP$, and $\partial QP/\partial PQ = -\eta$, with η being the absolute value of the own-price elasticity of demand, equation (A.3) can be rearranged to equation (1'').

Derivation of Equations (2''):

Total differentiating equation (2'), dividing both sides by P and expanding the right hand side by W_1/W_1 and W_2/W_2 yields

(A.4) $$\frac{dP}{P} = \frac{\partial c(\cdot)}{\partial W_1}\frac{dW_1}{P}\frac{W_1}{W_1} + \frac{\partial c(\cdot)}{\partial W_2}\frac{dW_2}{P}\frac{W_2}{W_2}.$$

Recall that $c(W_1,W_2) = C/Q$. Hence $\partial c(\cdot)/\partial W_i = (\partial C/\partial W_i)/Q = X_i/Q$. Since the input cost share $k_1 = W_1X_1/PQ$, and $k_2 = W_2X_2/PQ$ equation (A.4) can be rearranged to equation (2').

Derivation of Equations (3'') and (4''):

Total differentiating equation (2'), dividing both sides by X_1 and expanding the right hand side by W_1/W_1, W_2/W_2, and Q/Q yields

$$\text{(A.5)}\quad \frac{dX_1}{X_1} = \frac{\partial c_1(\cdot)}{\partial W_1} Q \frac{dW_1}{W_1}\frac{W_1}{X_1} + \frac{\partial c_2(\cdot)}{\partial W_2} Q \frac{dW_2}{W_2}\frac{W_2}{X_2} + \frac{c_1(\cdot)}{X_1}\frac{dQ}{Q} Q.$$

Since $c_1(W_1,W_2) = X_1/Q$, $\partial_1 c(\cdot)/\partial W_1 = (\partial X_1/\partial W_1)/Q$. When the output-constrained elasticity of demand for input X_1 with respect to the price j is denoted as $\nu_{1j} = \partial X_1/\partial W_j$ equation (A.5) can be rearranged to

$$\text{(A.6)}\quad EX_1 = \nu_{11}EW_1 + \nu_{12}EW_2 + EQ$$

By symmetry of the cost function $\nu_{ij} = \nu_{ji.}$ Imposing homogeneity of degree zero in prices on this demand function means that $\nu_{11} = -\nu_{12}$. Finally by Allen's definition of the elasticity of input substitution $\nu_{ij} = k_j\sigma_{ij}$. Hence equation (A.6) can be rearranged to equation (3''). The same arguments apply to equation (4'').

Derivation of Equations (5'') and (6''):

Total differentiating equation (5'), dividing both sides by X_1 and expanding the right hand side by W_1/W_1, and b_1/b_1 yields

$$\text{(A.7)}\quad \frac{dX_1}{X_1} = \frac{\partial h_1(\cdot)}{\partial W_1}\frac{W_1}{X_1}\frac{dW_1}{W_1} + \frac{\partial h_1(\cdot)}{\partial b_1}\frac{b_1}{X_1}\frac{db_1}{b_1}.$$

The own price elasticity of supply is given by $\partial h_1()W_1/\partial W_1X_1 = \varepsilon$, $\partial h_1()b_1/\partial b_1X_1 = 1$ since we are examining shifts in the quantity direction, and $db_1/b_1 = \beta_1$. Hence equation (A.7) can be rearranged to equation (5''). The same arguments apply for equation (6'').

Table 1: Parameters used for the quantitative assessment

Parameter	low	high
k_1	0.20	0.35
k_2	0.65	0.8
ε_2	1	3
σ	0.5	1.5
β_1	-0.09	-0.09
β_2	0.09	0.16
η	∞	∞

Table 2: Results of the equilibrium-displacement model

	lower estimate	upper estimate
grains output effect due to land restriction	-7.06%	-2.63%
output effect due to direct payments	+1.95%	+11.34%
overall effect on grains output	-5.11%	+8.71%

source: own calculations

Figure 1: Simple one output, two input model