

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

K. Salhofer and F. Sinabell

## Die Verwendung von Equilibrium-Displacement Modellen zur Beurteilung der Markteffekte von Landschaftspflegeprogrammen: Methode und Anwendung

### 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 objec-

tives 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

### Zusammenfassung

Im Rahmen der Reform der Gemeinsamen Agrarpolitik von 1992 wurde als ein Element der flankierenden Maßnahmen die VO (EWG) 2078/92 erlassen. Die Ziele dieser Verordnung sind, die Produktion zu beschränken, und/oder nachteilige Umwelteffekte der Agrarproduktion zu verringern, und/oder das Einkommen im Agrarbereich zu stützen. Dieser Beitrag zeigt, wie „Equilibrium-Displacement“ Modelle verwendet werden können, um die Markteffekte von Programmen zu beurteilen, die im Rahmen dieser Verordnung eingeführt wurden. Wir zeigen auf, daß solche Programme in zweierlei Weise wirken: Es kommt zu einem produktionsmindernden Effekt durch die Beschränkung von Produktionsfaktoren aber auch zu einem produktionssteigernden Effekt aufgrund von Direktzahlungen. Am Beispiel einer österreichischen Maßnahme wird gezeigt, daß der Gesamteffekt nicht eindeutig zu bestimmen ist, der produktionssteigernde Effekt möglicherweise jedoch überwiegt. Folglich trägt die untersuchte Maßnahme wahrscheinlich nicht zur Produktionsenkung, einem wichtigen Ziel der VO (EWG) 2078/92, bei.

**Schlagerworte:** Agrarpolitik, Agrar-Umweltprogramme, Equilibrium-Displacement Modelle.

### Summary

As part of the so called accompanying-measures of the reform of the Common Agricultural Policy 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 countryside stewardship policies affect the product output in two different ways: first, there is the output decreasing effect of the programme 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 Council Regulation (EEC) 2078/92.

**Keywords:** agricultural policy analysis, countryside stewardship policies, equilibrium-displacement models.

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.<sup>1</sup> In this first treatment of the subject we concentrate on the first of the three goals mentioned above, and propose a method that can be extended to the other two goals as well. 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 et al., 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.

## 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, nitrate emission 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 is 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:<sup>2</sup>

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

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

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

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

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

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

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).<sup>3</sup> 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.

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



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 ( $\beta_1$ ) is given by

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

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  $\beta_2$  in vector b is zero and  $\beta_1$  is the ratio of hectares of land no longer available to produce output Q divided by the initially planted hectares (see Figure 1b):

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

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

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

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

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

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 ( $k_1, k_2, \varepsilon_1, \varepsilon_2, \sigma$ , and  $\eta \geq 0$ )<sup>7</sup>, all parameters are positive and  $\beta_1$  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  $EQ/\beta_1$  with respect to the parameters :

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

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

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

Equation (12) indicates that an increase in the elasticity of substitution will decrease the ratio  $EQ/\beta_1$  and hence decrease the effects of a set aside programme on final output. An increase in  $k_1$  or  $\varepsilon_1$  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

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

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

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

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  $\sigma$  and the smaller are  $k_1$  and  $\varepsilon_2$ :

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

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

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

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

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):

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

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  $\beta_1$  and  $\beta_2$  and assume values for the parameters  $k_1$ ,  $k_2$ ,  $\sigma$  and  $\varepsilon_2$ , 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<sup>8</sup> 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:<sup>9</sup>

- 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 1<sup>st</sup> of November and may not be ploughed under before 1<sup>st</sup> 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 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; 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 programme (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  $\beta_1$  (see equation (9)) is derived from the effects on land-use following the introduction of this very a similar scheme in 1992.<sup>10</sup> 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  $\beta_1$  ideally would be calculated by dividing land owned by CSP participants 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  $\beta_1$  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  $\beta_2$  (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., 1999) 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 reinvested in durable equipment.<sup>11</sup>

The high survey figures may be rationalised by the facts

Table 1: Parameters used for the quantitative assessment  
Tabelle 1: Parameter für die quantitative Schätzung

Parameter	low	high
$k_1$	0.20	0.35
$k_2$	0.65	0.8
$\varepsilon_2$	1	3
$\sigma$	0.5	1.5
$\beta_1$	-0.09	-0.09
$\beta_2$	0.09	0.16
$\eta$	$\infty$	$\infty$

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 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  $\beta_2$  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.<sup>12</sup> 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 a 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 (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  $\epsilon_2$  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 policy makers 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

Table 2: Results of the equilibrium-displacement model  
Tabelle 2: Ergebnisse des Equilibrium-Displacement Modells

policy implications	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

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 programme 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 et al., 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.

## Endnotes

- <sup>1</sup> One exception is the study of HARRISON-MAYFIELD et al. (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.
- <sup>2</sup> It is also possible to describe the three related markets solely by supply and demand functions rather than starting from a production function (BUSE, 1958; PIGGOTT, 1992)
- <sup>3</sup> The derivation of equations (3) and (4) is given in the appendix.

<sup>4</sup> In the case of the agricultural markets the assumption of perfect competition may be justified by the large number of firms producing grains and by the fact that farmers take prices given by government. The fact that in reality not all firms are identical does not compromise the proposed method in general, but only suggests that one has to disaggregate participating farmers (e. g. depending on the size of the farm) into subgroups and analyse the effects for these groups separately. How disaggregated the analysis will be depends on the problem, the structure of the farm sector, as well as on the constraints given by data and time.

- <sup>5</sup> The derivation of equations (2') to (4') is given in the appendix.
- <sup>6</sup> The derivation of equations (1'') to (6'') is given in the appendix.
- <sup>7</sup> Remember that by definition  $\eta$  is the absolute value of the demand elasticity.
- <sup>8</sup> The acronym ÖPUL can be translated as "Austrian programme to promote agricultural practices which are ecologically sound, extensive and beneficial for the natural environment"
- <sup>9</sup> See BMLF (1996b) for the details of this scheme.
- <sup>10</sup> 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.
- <sup>11</sup> 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?"
- <sup>12</sup> Note that both assumptions are already made from the beginning anyway.

## Appendix

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

In the case of constant returns to scale the sector wide cost function is given by (VARIAN, 1992)

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

From equation (A.1) one can 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 Equation (1'')*:

Total differentiating equation (1) yields

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

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

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

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

*Derivation of Equation (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

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

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  $k_1 = W_1 X_1/PQ$ , and  $k_2 = W_2 X_2/PQ$  equation (A.4) can be rearranged to equation (2'').

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

Total differentiating equation (3'), 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

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

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

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

By symmetry of the cost function  $v_{ij} = v_{ji}$ . Imposing homogeneity of degree zero in prices on this demand function means that  $v_{11} = -v_{12}$ . Finally by Allen's definition of the elasticity of input substitution  $v_{ij} = k_j \sigma_{ij}$ . 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

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

The own price elasticity of supply is given by  $\partial h_1(\cdot)W_1/\partial W_1 X_1 = \epsilon$ ,  $\partial h_1(\cdot)b_1/\partial b_1 X_1 = 1$  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'').

**References**

ALFIS (1998): Farm Data Base. Federal Ministry of Agriculture and Forestry. Wien.  
 ALLEN, R. D. (1938): Mathematical Analysis for Economists. MacMillan, London.  
 ALSTON, J. M., G. W. NORTON and P. G. PARDEY (1995): Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting. Cornell University Press, Ithaca.  
 BERGSTRÖM, P., L. DRAKE and H. SVEDSÄTER (1999): Farmers' attitudes to EU Countryside Stewardship Policies. Research Document FAIR1/CT95-0709/C5/DFR-01, Department of Economics, Swedish University of Agricultural Sciences, Uppsala.  
 BMLF (BUNDESMINISTERIUM FÜR LAND- UND FORSTWIRTSCHAFT) (1993): Bericht über die Lage der österreichischen Landwirtschaft 1992. Wien.  
 BMLF (BUNDESMINISTERIUM FÜR LAND- UND FORSTWIRTSCHAFT) (1996a): Grüner Bericht 1995. Wien.  
 BMLF (BUNDESMINISTERIUM FÜR LAND- UND FORSTWIRTSCHAFT) (1996b): Sonderrichtlinie des Bundesministeriums für Land- und Forstwirtschaft für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft (ÖPUL): Zl. 25.022/39-II/B8/95 idF 25.014/220-II/B8/96. Wien.  
 BUSE, R. C. (1958): Total Elasticities – A Predictive Device. Journal of Farm Economics. Vol. 15, 881–891.  
 DEBLITZ, C. (1998): Vergleichende Analyse der Ausgestaltung und Inanspruchnahme der Programme zur Umsetzung der VO (EWG) 2078/92 in ausgewählten Mitgliedsstaaten der EU. Arbeitsbericht, Institut für Betriebswirtschaft der FAL Braunschweig.

- EUROPEAN COMMISSION (1985): Perspectives for the Common Agricultural Policy – The Green Paper of the Commission. Green Europe – News Flash, Brussels.
- EUROSTAT (1998): SPEL EU Data for Agriculture 1973–97. Office for Official Publications of the European Communities, Luxembourg.
- FLOYD, J. E. (1965): The Effects of Farm Price Supports on the Returns to Land and Labor in Agriculture. *Journal of Political Economy*, Vol. 73, 148–158.
- GARDNER, B. L. (1987): *The Economics of Agricultural Policies*. McGraw-Hill, New York.
- GARDNER B. L. (1991): Redistribution of Income Through Commodity and Resource Policies. In: JUST, R. E. and N. BOCKSTAEL (eds.): *Commodity and Resource Policies in Agricultural Systems*. Springer Verlag, Berlin, 129–142.
- HARRISON-MAYFIELD, L., L. DWYER and G. BROOKES (1998): The Socio-Economic Effects of the Countryside Stewardship Scheme. *Journal of Agricultural Economics*, Vol. 49, 157–170.
- HICKS, J. R. (1932): *The Theory of Wages*. MacMillan, London.
- KNIEPERT, M. (1998): Activity data sheets based on the SPEL data set. Computer software, Department of Economics, Politics, and Law, Universität für Bodenkultur Wien.
- MAIER, L. (1993): *The Costs and Benefits of U.S. Agricultural Policies with Imperfect Competition in Food Manufacturing*. Garland Publishing, New York.
- MULLEN, J. D., J. M. ALSTON and M. K. WOHLGENANNT (1989): The Impact of Farm and Processing Research on the Australian Wool Industry. *Australian Journal of Agricultural Economics*, Vol. 33, 32–47.
- MULLEN, J. D., M. K. WOHLGENANNT and D. E. FARRIS (1988): Input Substitution and the Distribution of Surplus Gains from Lower U.S. Beef-Processing Costs. *American Journal of Agricultural Economics*, Vol. 65, 245–254.
- MUTH, R. F. (1964): The Derived Demand Curve for a Productive Factor and the Industry Supply Curve. *Oxford Economic Papers*, Vol. 16, 221–234.
- OECD (1995): *Adjustment in OECD Agriculture*. Paris.
- PIGGOTT, R. R. (1992): Some Old Truths Revisited. *Australian Journal of Agricultural Economics*, Vol. 36, 117–140.
- RÖHM, O. and F. SINABELL (1998): Exploring Farm Level and Market Effects of Countryside Stewardship Policies: Results of the Quantitative Analysis for the Region Oberösterreich (Upper Austria): STEWPOL Discussion document FAIR1/CT95–0709/C2–C8/D-03, Department of Economics, Politics, and Law, Universität für Bodenkultur Wien.
- SALHOFER, K. (1997): *Efficiency of Income Redistribution through Agricultural Policy: A Welfare Economic Analysis*. Peter Lang, Frankfurt.
- SALHOFER, K. (1998): Gewinner, Verlierer und Verschwendung: Bewertung der österreichischen Agrarpolitik mit Hilfe eines vertikal gegliederten Modells. Diskussionspapier Nr. 73–W-98, Institut für Wirtschaft, Politik und Recht, Universität für Bodenkultur Wien.
- SALHOFER, K., M. F. HOFREITHER and F. SINABELL (1998): Promotion of the Agricultural Sector and Political Power in Austria. *Public Choice*, forthcoming.
- SCHEELE, M. (1996): The Agri-environmental Measures in the Context of the CAP-Reform. In: WHITBY, M. (ed.): *The European Environment and CAP Reform*, CAB International, Wallingford, Oxon, 3–7.
- SINABELL, F. (1998): Umwelteinstellung und Akzeptanz des ÖPUL – Ergebnisse einer Befragung von Bauern in Niederösterreich. Unpublished manuscript, Department of Economics, Politics and Law, Universität für Bodenkultur Wien.
- VAN HUYLENBROECK, G., E. GOEMAERE, A. COPPENS, P. GATTO and M. MERLO (1998): Preliminary Results of an Inventory of Countryside Stewardship Policies (CSPs) in Different EU-Member States. Unpublished manuscript, Department of Agricultural Economics, University of Gent.
- VARIAN, H. R. (1992): *Microeconomic Analysis*. 3<sup>rd</sup> edition. Norton, New York.

### Address of authors

Mag. Dr. Klaus Salhofer, Dipl. Ing. Franz Sinabell, Universität für Bodenkultur Wien (University of Agricultural Sciences Vienna), Department of Economics, Politics, and Law, Gregor Mendel-Strasse 33, A-1180 Vienna, Austria. e-mail: sinabell@edv1.boku.ac.at

Eingelangt am 22. Jänner 1999  
Angenommen am 2. März 1999