Analysis of Trade and Environmental Policy Options on the Basis of a National Agricultural Sector Model with Multifunctional Outputs

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Summary

Studies on liberalisation normally do not take into account the external benefits and costs of agriculture. Empirical studies on the valuation of externalities should be integrated into quantitative modelling. MULTSIM is a national supply model of agriculture. Besides commodity output the model depicts also external benefit linked to landscape preservation and external environmental costs of agriculture. Internalisation scenarios are defined showing that the reduction of commodity-linked support and the introduction of land subsidies and intermediate input taxes have differentiated impacts on the farm types' competitiveness. A comprehensive policy approach to multifunctional agriculture requires market feedbacks to be taken into account. Internalising externalities may lead to a strong reduction of commodity output quantities. This gives rise to expectations that commodity prices would increase, which in turn would dampen the production impacts. As a consequence MULTSIM should be regarded as a bridge tool that may be linked to microeconomic based multi market models and agricultural trade models. A further strain of model development is an improved consideration of multiple policy objectives.

Key words: environmental costs; multifunctional agriculture; policy analysis; agricultural sector modelling

Zusammenfassung

Liberalisierungsstudien berücksichtigen die externen Nutzen und Kosten der Landwirtschaft in der Regel nicht. Empirische Studien zur Bewertung von Externalitäten sollten in die quantitative Modellierung einbezogen werden. MULTSIM ist ein nationales Angebotsmodell des Agrarsektors. Neben dem Warenoutput umfasst das Modell auch die aus der Landschaftserhaltung resultierenden externen Nutzen sowie die externen Umweltkosten der Landwirtschaft. Es werden Internalisierungsszenarien definiert, die zeigen, dass der Abbau von Produktsubventionen und die Einführung von Flächensubventionen und Vorleistungssteuern die Wettbewerbsfähigkeit der verschiedenen Betriebstypen ganz unterschiedlich beeinflussen. Es wird auch deutlich, dass bei einem umfassenden Politikansatz für eine multifunktionale Landwirtschaft auch Rückkoppelungen durch die Marktmechanismen zu berücksichtigen sind. Die Internalisierung von Externalitäten kann zu einem starken Produktionsrückgang führen. Dies lässt Produktpreissteigerungen erwarten, die die Produktionseffekte abschwächen würden. Damit wird deutlich, dass MULTSIM als ein Bindeglied zu mikroökonomisch basierten Multi-Markt-Modellen und Agrarhandelsmodellen zu sehen ist. Eine weitere methodische Entwicklungsoption ist die verbesserte Berücksichtigung von Mehrfachzielsetzungen in der Politik.

Schlüsselwörter: Umweltkosten; multifunktionale Landwirtschaft; Politikanalyse; Agrarsektormodellierung

1 Introduction

The WTO round of Doha aims at liberalising agricultural markets and reducing domestic support. Some countries demand that non-trade concerns (NTCs) are also negotiated. These are policy objectives that are perceived as endangered by liberalisation. NTCs overlap with the multifunctionality concept, which means that agriculture produces non-commodity outputs like landscape amenities and natural environment jointly with commodity output. Since these outputs have characteristics of externalities and public goods, it is argued that farmers should not decide on factor allocation and output on the basis of world market prices only, but react to politically set incentives like subsidies and taxes that aim at internalising external benefits and costs.

There is disagreement on the design of efficient support measures. The necessity of production-linked support to achieve national policy goals is controversially discussed. Big agro-exporters like the US and the Cairns Group consider multifunctionality as a concept for disguised protectionism. Among trade economist it is argued that NTCs do not justify production and trade distorting measures (e.g. ANDERSON, 2000; PAARLBERG, BREHDAL und LEE, 2002). And in fact, measuring the value of external benefits of agriculture is subject to considerable empirical uncertainty.

Quantitative modelling should support policy makers in understanding goal conflicts. Agricultural sector models which depict external environmental effects focus on functional relationships between production processes and environmental indicators (e.g. for biodiversity and nitrate contamination of water) as well as on economic adjustment processes triggered by changes in farmers' behavioural incentives like prices, subsidies and taxes. They analyse the impacts of policy changes often at a detailed regional level (e.g. FLUR, GOTSCH and RIEDER, 2001; HECKELEI and BRITZ, 2001; MALITIUS, MACK and MORESINO, 2001). There exist many empirical studies valuing externalities from the demand side perspective. They are based on contingent valuation (e.g. CICIA and SCARPA, 2002; DRAKE, 1992; LOOMIS, 2002) and choice experiments (e.g. MÜLLER, 2002). However, transfers of benefits and benefit functions from study sites to policy sites can be subject to major errors (NAVRUD, 2002). This makes using the results of willingness-to-pay studies for policy advice and quantitative modelling at the national and supranational level a shaky undertaking.

Multi-market models (e.g. KIRSCHKE and JECHLITSCHKA, 2002; WAHL, WEBER and FROHBERG, 2000) and trade models (e.g. DIXIT and RONINGEN, 1986; VON LAMPE, 2001) merge supply and demand analysis, but in most cases do not consider externalities or public goods/bads when looking at the welfare impacts of policy options.

MULTSIM is an illustrative agricultural supply model differentiated by farm types. Non-commodity output is jointly produced with commodity output. Farm types have varied impacts on negative and positive externalities. Internalisation policy scenarios can be exogenously defined using subsidies and taxes linked to production factors or output. But it is also possible to calculate optimal values of internalisation variables based on prior assumptions on the social welfare function. MULTSIM shows impacts on farm income, taxpayers and overall welfare. It is designed as a bridge to more differentiated analysis and for later use linked with a standard multi-market model.

The remainder of the paper is organised as follows. Section 2 specifies the technological and behavioural assumptions and describes the policy interface of MULTSIM. In section 3 some policy scenarios calculated with the model are analysed. Since the valuation of externalities and the functional relationships determining their production is subject to considerable uncertainties, section 4 presents the results of sensitivity analyses. In section 5 conclusions for policy design, on the applicability of the model for policy analysis and for the further development of the model are presented.

2 National model of multifunctional agriculture

2.1 Technology

The agricultural sector produces the following outputs: commodity output *y* represented by the production value, non-commodity output *a* with external benefits from landscape maintenance (e.g. flood control, aesthetic value, variety of landscape, amenities), and environmental output *e* representing external costs (e.g. water, soil and air contamination). Production takes place in five farm types. These are specialised field crops, specialised grazing, specialised granivore, permanent cultures, and mixed agricultural production [F=(FIELD,GRAZ,GRAN,PERM,MIX)]. As production factors producers use intermediate input, land and other primary factors including labour and capital [L=(INT,LAND,OTHP)].

Non-allocable inputs and complementary output are sources of jointness between commodity output and non-commodity output (OECD, 2001, p. 30), but the model allows for variable proportions between these joint products.

Commodity production function

For each farm type a production function *YF* relates commodity output *yf* to input use *xf*:

$$(1)\ yf_f \le \mathrm{YF}_f(\mathbf{xf}_f) = a_f \prod_l xf_{fl}^{\alpha_{fl}} \text{ for all } f \in F;\ l \in L;\ a_f, \alpha_{fl} > 0;\ \sum_l \alpha_{fl} = 1 .$$

Total agricultural output is then defined by:

$$(2)\qquad y = \sum_f yf_f .$$

The production factors of a farm type are strictly essential in (1), whereas the single farm types are not strictly essential in (2). The technology is characterised by constant returns to scale, and the production functions are factor-wise separable with substitution elasticities equal to unity. The inherent assumptions of the Cobb-Douglas technology are restrictive, but reduce the number of parameters to be estimated.

Landscape benefit production function

Contrary to the commodity production function it is assumed that all farm types are strictly essential for producing landscape benefit:

$$a = \mathrm{A}(\mathbf{xl}, \mathbf{yf}) = b \prod_f xf_{f,LAND}^{\beta_f} \left(\frac{yf_f}{xf_{f,LAND}} \right)^{\gamma_f};$$
$$f \in F;\ \mathrm{b}, \beta_f > 0;\ \gamma_f \ge 0;\ \sum_f (\beta_f + \gamma_f) = 1 .$$

The above function relates landscape benefit to land use and commodity output per land unit, whereby land is assumed non-allocable to commodity output and landscape benefit. The marginal productivity of land also depends on commodity output. If the elasticities γ_f are positive, landscape benefit and commodity output are complementary.

Substituting (1) into the above function yields the following production function for landscape benefit:

$$(3)\qquad a = \mathrm{A}(\mathbf{xf}) = b \prod_f a_f^{\gamma_f} xf_{f,INT}^{\alpha_{f,INT}\gamma_f}\, xf_{f,LAND}^{\beta_f - \gamma_f (1-\alpha_{f,LAND})} xf_{f,OTHP}^{\alpha_{f,OTHP}\gamma_f};$$
$$f \in F;\ \mathrm{b}, \beta_f > 0;\ \gamma_f \ge 0;\ \sum_f (\beta_f + \gamma_f) = 1 .$$

(3) shows positive marginal productivities of land for $\beta_n > \gamma_n(1-\alpha_{n,LAND})$, i.e. for small γ-parameters relative to β-parameters. For $\beta_n < 1+\gamma_n(1-\alpha_{n,LAND})$ positive marginal productivity of land diminishes with increasing land use and for $\beta_n > \gamma_n(1-\alpha_{n,LAND})$ it increases with increasing use of the other production factors. If $\beta_n < \gamma_n(1-\alpha_{n,LAND})$, i.e. for relatively large γ-parameters, commodity output per land unit has a strong influence on landscape benefit and hence marginal productivity of land might be negative.

Environmental costs production function

The potential environmental costs per land unit *sef* in the farm types depend on intermediate input use per land unit:

$$sef_f = \mathrm{SEF}(sf_f) = c_f \left(\frac{xf_{f,INT}}{xf_{f,LAND}} \right)^{\kappa_f} \text{ for all } f \in F;\ \mathrm{c_f} > 0;\ \kappa_f > 1 .$$

Land is a sink-resource for toxic chemicals from intermediate input use. Increasing intermediate input use degrades soil and reduces the sink quality of land so that the potential environmental burden increases disproportionately. To calculate potential environmental costs *ef* caused by the farm types the above function is multiplied with land input by farm type, which yields:

$$(4)\qquad ef_f = \mathrm{EF}(xf_f) = c_f\, xf_{f,INT}^{\kappa_f}\, xf_{f,LAND}^{1-\kappa_f} \text{ for all } f \in F;\ \mathrm{c_f} > 0;\ \kappa_f > 1 .$$

In the above function marginal environmental costs of intermediate input use is positive, increasing in intermediate input use and decreasing in land use. It also follows that marginal environmental costs of land is negative, increasing in land use and decreasing in intermediate input use.

Finally, the potential environmental costs at the farm type level is aggregated to total sector environmental costs:

$$(5)\ e = \mathrm{E}(\mathbf{ef}) = d\sum_f ef_f \left(\frac{1}{xf_{f,LAND}}\right)^{\nu}\ ;\ f \in F;\ \mathrm{d} > 0;\ 0 \le \nu \le 1.$$

Depending on the parameter ν in (5) land of farm types with low environmental burden may serve as ecological compensation for farm types causing high environmental burden. With ν=0 there would be no such ecological dilution effect, whereas with ν=1 total sector environmental costs would equal average potential environmental costs per land unit over all farm types times constant factor *d*.

2.2 Allocation of production factors

Profit is defined as the sum of rents accruing to the farm sector from fixed production factors. In the scenarios and sensitivity analyses presented in sections 3 and 4 it is assumed that the land capacity (LAND) is given at the total sector level and that other primary factor input (OTHP) is fixed at the farm type level. Variable factors are intermediate input (INT) and land at the farm type level. Given prices and subsidies/taxes for commodity output (*pp* and *sp*) and production factors (*pw* and *sw*), the single farm types maximise their profits subject to production function (1):

$$(6)\ \max!:\ PF_f = yf_f\left(pp_f + sp_f\right) - \sum_l xf_{fl}\left(pw_{fl} + sw_{fl}\right)$$

for all $f \in F;\ l \in L$.

Land rent is maximised at the total sector level given prices for land use:

$$(7)\qquad \max!:\ R = \sum_f xf_{f,LAND}\, pw_{f,LAND};\quad f \in F.$$

Two further constraints balance the land transfers *xftran* between farm types with area allocation of the base year *AREAF* and total sector land capacity *AREA*:

$$(8)\ xf_{m,LAND} \le AREAF_m + \sum_n xftran_{nm} - \sum_m xftran_{mn}$$

for all $\mathrm{m};\ \mathrm{n,m} \in F;\ xftran_{nm} \ge 0$.

and

$$(9)\qquad \sum_m xf_{m,LAND} \le AREA;\ \mathrm{m} \in F.$$

The optimisation problems at farm type level and at total sector level are set up simultaneously. A system of Kuhn-Tucker conditions for non-linear optimisation with inequality constraints is programmed with the software GAMS (BROOKE et al., 1998). It comprises marginal conditions, non-negativity restrictions and complementary slackness equalities (i) at the farm type level for each of the decision variables *yf* and *xf* and the multipliers λ of the commodity production functions and (ii) at the total sector level for each of the decision variables $xf_{m,LAND}$, the multipliers *u* of the land transfer constraints and the multiplier *t* of the land capacity constraint. The solution contains the profit and land rent maximising factor inputs by farm type xf^*, land transfers $xftran^*$, commodity output yf^*, and the shadow price t^* for the land capacity. The production functions (2) and (3) determine landscape benefits *a* and environmental costs *e*. The system can be solved, however, only if the multipliers *u* are known[1]).

2.3 Data and model calibration

The model frame is filled with production and input value data of the German Farm Accountancy Data Network for the base year 1999/2000 (BMVEL, 2001). These data are made consistent with the Economic Accounts for Agriculture (EUROSTAT, 2000) at the total sector level.

Data for external landscape benefits and environmental costs are more uncertain. There is great variance in the results of willingness-to-pay studies for landscape amenities depending on the methodological design, attributes covered, site characteristics and socio-economic environment (e.g. CICIA and SCARPA, 2002; LOOMIS, 2002; BROUWER and SLANGEN, 1998). The calculations presented in section 3 are based on agricultural landscape benefit corresponding to 5 % of the commodity output value. But also the environmental costs are assumed to be relatively high amounting to 10 % of the commodity output value. It is to be noted that these values are not meant to reflect true external benefits and costs but are set for illustrative scenario building. Sensitivity analyses with respect to the valuation of the externalities are presented in section 4.1.

The complete elasticity set for the base version of MULTSIM is presented in table 1. The production elasticities in the commodity output production functions are estimated as input value shares in commodity output value. This implies that factor wages reflect marginal value productivities of production factors. It is assumed that the aggregate elasticity of landscape benefit with respect to land is unity ($\Sigma_f\beta_f$=1), whereas commodity output has no direct influence on landscape benefit (γ_f=0). The landscape benefit elasticities of the single farm types reflect shares in total agricultural land use. The environmental costs elasticities with respect to intermediate input are set to κ_f=1.5. There is no ecological dilution effect taken into account (ν=0). Sensitivity analyses with respect to landscape benefit elasticities are presented in section 4.2.

Table 1: **Production elasticities in the base version** (BAS)

		FIELD	GRAZ	GRAN	PERM	MIX
α	INTINP	0.591	0.567	0.778	0.294	0.788
	LANDINP	0.121	0.090	0.062	0.048	0.088
β		0.527	0.374	0.033	0.009	0.057
γ		0.000	0.000	0.000	0.000	0.000
κ		1.500	1.500	1.500	1.500	1.500

The constant factors of the production functions are calibrated in order to exactly reproduce the data for the base year. Also the multipliers *u* of the land transfer constraints are calibrated. The calibration procedure of MULTSIM assumes that the statistically observed factor inputs are also profit maximising inputs. Given prices, subsidies and taxes and all inputs fixed for the base year the Kuhn-Tucker system can be solved for the multiplier *t* of the land capacity constraint and multipliers *u* of the land transfer constraints.

1) The mathematical foundations of Kuhn-Tucker systems are explained for example in CHIANG (1984, pp. 722).

These two multipliers determine the prices for land use in the single farm types and ensure that land demand in the calibrated model exactly corresponds to land distribution in the base year. In the model simulations the calibrated values for *u* are kept unchanged.

2.4 Policy interface

The policy interface of the model comprises a spreadsheet to set subsidies and taxes linked to output and production factors, the calculation of welfare and distributional indicators and an optional optimisation procedure to determine values for subsidies and taxes based on prior assumption on the social welfare function.

The welfare and distributional indicators are the producer rents, the external benefits and costs and the taxpayers' net position vis-à-vis agriculture which is defined as expenditures on subsidies minus revenues from taxes. The consumer rent is not calculated since MULTSIM assumes that demand for commodity output is perfectly price elastic. Only after completing the model by price dependent demand functions the consumer rent may be computed. Overall social welfare is defined as the sum of the above indicators. Hence, in the overall social welfare function commodity output and factor inputs are valued at their prices net of subsidies and taxes but with external benefit and costs taken into account.

The existence of externalities makes it unlikely that profit maximising behaviour of farmers results in social welfare maximising factor input unless government intervention corrects the price signals of the markets (PEARCE und TURNER, 1990, pp. 84). Government intervention in the form of subsidies and taxes can be played through with the model by scenario analyses. The impacts on overall social welfare and single welfare indicators can be compared. A more normative procedure is to maximise overall social welfare or single welfare indicators or a vector of such indicators and to determine the corresponding allocation of production factors subject to the technological constraints. The task is then to find those values for subsidies and taxes that lead to that optimal allocation conditioned on profit maximising behaviour of farmers. Such normative policy analyses can be conducted if policy preferences are known. A disadvantage of the normative procedure is that policy preferences often become visible only after having discussed several policy options with their results. This in mind, it is in most cases more helpful to first analyse several alternative policy options with different levels of subsidies and taxes by conventional scenario setting. But additional normative analyses offer advantages: they create scenarios that serve as additional references with which policy options can be compared. In order to find "good" policy options it is important to have calculated scenarios that are already "optimal" at least with respect to one or several indicators.

Normative analyses in the above sense is therefore proposed by MULTSIM. The model is solved for the social welfare maximising subsidies and taxes conditioned on farmers that behave as profit maximising producers. The modelling-technique uses the Kuhn-Tucker conditions for profit maximisation as constraints to the social welfare optimisation problem.

3 Internalisation scenarios

3.1 Policy assumptions

In the base scenario (BA) all commodity subsidies are abolished. Policy instruments for internalising external costs and benefits are intermediate input taxes and land subsidies. These policy instruments are at their social welfare maximising levels in scenario 4 (SC4). In SC1 to SC3 and SC 5 to SC 7 intermediate input taxes are reduced and increased, respectively, by identical steps of 25 % of their levels in SC4. As in BA commodity subsidies are abolished throughout SC1 to SC7.

To determine the subsidies and taxes for SC4 a two-step optimisation procedure is run. The first step maximises overall social welfare subject to the technological and farmers' behavioural constraints as described in section 2. The second step minimises the taxpayers' net position[2]) subject to the same constraints but, in addition, with the result for overall social welfare from the first step fixed.

3.2 Results

Subsidies and taxes in the base year (BY) and in the different scenarios are presented in Table 2. In the full internalisation scenario (SC4) land subsidies for the farm types range from €103 to €191 per ha and intermediate input taxes cover 15.2 % to 17.4 % of the purchase prices. The highest land subsidies but also the lowest intermediate input taxes are calculated for mixed (MIX) and specialised granivore (GRAN) farm types.

Table 2: **Subsidies and taxes in base year, base scenario and internalisation scenarios**

	BY	BA	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Commodity subsidies[1]									
FIELD	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAZ	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAN	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MIX	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Intermediate input taxes[2]									
FIELD	0.0	0.0	4.3	8.5	12.8	17.1	21.4	25.6	29.9
GRAZ	0.0	0.0	4.0	8.1	12.1	16.2	20.2	24.3	28.3
GRAN	0.0	0.0	3.8	7.6	11.4	15.2	19.0	22.9	26.7
PERM	0.0	0.0	4.4	8.7	13.1	17.4	21.8	26.1	30.5
MIX	0.0	0.0	3.6	7.3	10.9	14.6	18.2	21.8	25.5
Land subsidies[3]									
FIELD	0	0	107	107	107	107	107	107	107
GRAZ	0	0	103	103	103	103	103	103	103
GRAN	0	0	191	191	191	191	191	191	191
PERM	0	0	150	150	150	150	150	150	150
MIX	0	0	155	155	155	155	155	155	155

1 In % of commodity price. – 2 In % of purchase price. – 3 In € per ha

Table 3 shows the impacts on intermediate input use, land use and commodity output. Abolishing commodity subsidies in the base scenario (BA) leads to a substantial fall in intermediate input use by 23 % for the total agricultural sector. The strongest reduction is calculated for the mixed

2) The sum of the squared net transfers (subsidies minus taxes) of the taxpayers to the farm types is minimised.

farm type for two reason: first, the commodity subsidies of the base year are very high in this farm type so that abolishing means a strong decline in the incentive price, and, second, the share of intermediate input in the production value is the highest among all farm types. With full internalisation of the external effects by land subsidies and intermediate input taxes (SC4) intermediate input use of the total sector is reduced by 48 %, again with the strongest impact for the mixed farm type.

When commodity subsidies are abolished (BA), the external environmental costs fall by €1.1 billion (see figure). With full internalisation (SC4) the environmental situation is improved by further €1.1 billion. The total effect of SC4 on environmental costs is a reduction of 63 % compared to the base year (BY). The external landscape benefits vary only slightly between the different scenarios. With total sector land capacity used at its limit the only potential source for increasing landscape benefit is reallocation of land between the different farm types.

The welfare position of producers and taxpayers and the external benefits and costs in the base year and the different scenarios are also shown in the figure. Abolishing commodity subsidies (BA) reduces the taxpayers' burden by €3.3 billion. The loss in producer rents amounts to €3.0 billion or 23 %. With full internalisation of externalities (SC4) there is a further reduction of producer rents by 5 % compared to BA, since land subsides are not sufficiently high to compensate farmers for losses from intermediate input taxes. The taxpayers' net position improves slightly thanks to the revenues from intermediate input taxes which are slightly higher than the expenditures for land subsidies.

Table 3: **Impacts on commodity output and factor input in base scenario and internalisation scenarios** (percentage change over base year)

	BA	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Commodity output								
Total sector	-14	-19	-24	-28	-32	-36	-39	-42
FIELD	-17	-22	-27	-31	-34	-38	-41	-43
GRAZ	-7	-12	-16	-20	-23	-26	-29	-32
GRAN	-24	-27	-38	-46	-54	-60	-65	-69
PERM	1	0	-2	-3	-5	-6	-7	-9
MIX	-41	-41	-50	-57	-64	-69	-73	-77
Intermediate input								
Total sector	-23	-30	-37	-43	-48	-53	-57	-61
FIELD	-26	-34	-40	-45	-50	-54	-58	-61
GRAZ	-13	-22	-28	-34	-39	-43	-47	-51
GRAN	-29	-34	-46	-55	-62	-68	-73	-77
PERM	1	-4	-10	-14	-19	-23	-27	-30
MIX	-47	-48	-58	-65	-71	-76	-80	-83
Land use								
Total sector	0	0	0	0	0	0	0	0
FIELD	-5	-7	-7	-7	-6	-6	-6	-6
GRAZ	13	9	11	12	14	15	17	18
GRAN	-17	16	4	-6	-15	-24	-31	-37
PERM	13	28	30	31	32	33	34	35
MIX	-33	-6	-14	-22	-29	-35	-40	-45

Overall social welfare improves by €2 billion when SC4 is compared to BY, whereby two thirds of that gain result from abolishing commodity subsidies and only one third from the introduction of the internalisation policy instruments.

4 Sensitivity analysis

There is considerable uncertainty about the value of external benefits and costs and on the production relationships in a multifunctional agriculture. The sensitivity analyses examine the consequences of different assumptions on the valuation of externalities and on the magnitude of landscape benefit elasticities.

4.1 Valuation of externalities

In model version V1 the base year's external environmental costs is only half of the value as assumed for the model's base version (BAS) that was used for the scenarios in section 3. In model version V2 the base year's external landscape benefit is twice as high as in BAS.

Table 4 shows the land subsidies and intermediate input taxes in the full internalisation scenario (SC4) for all three model versions. With halved environmental costs (V1) intermediate input taxes are about one third lower than in BAS and also the land subsidies are one-third lower. The parallelism in the impact on the two internalisation instruments is a direct consequence of the second objective criterion, i.e. the minimisation of the taxpayers' net position (see section 3.1). Doubling landscape benefit (V2) has only minor consequences on the optimal level of the internalisation instruments.

Together with the finding that the social welfare function is rather flat within a range of ±50 % of the optimal level of the intermediate input tax (SC2 to SC6) (see figure), the results of the sensitivity analyses cautiously suggest that the choice of the level of the internalisation instruments may be rather robust to different estimates of the value of externalities when overall social welfare is the dominant criterion.

Table 4: **Sensitivity of optimal subsidies and taxes to valuation of externalities** (percentage change over the base model BAS)

	V1[1]	V2[2]
Intermediate input taxes		
FIELD	-30.3	-0.2
GRAZ	-35.0	0.3
GRAN	-30.6	-1.1
PERM	-33.8	1.9
MIX	-29.5	-2.6
Land subsidies		
FIELD	-35.2	1.9
GRAZ	-38.2	-3.1
GRAN	-31.0	2.5
PERM	-37.8	-8.3
MIX	-30.1	4.2

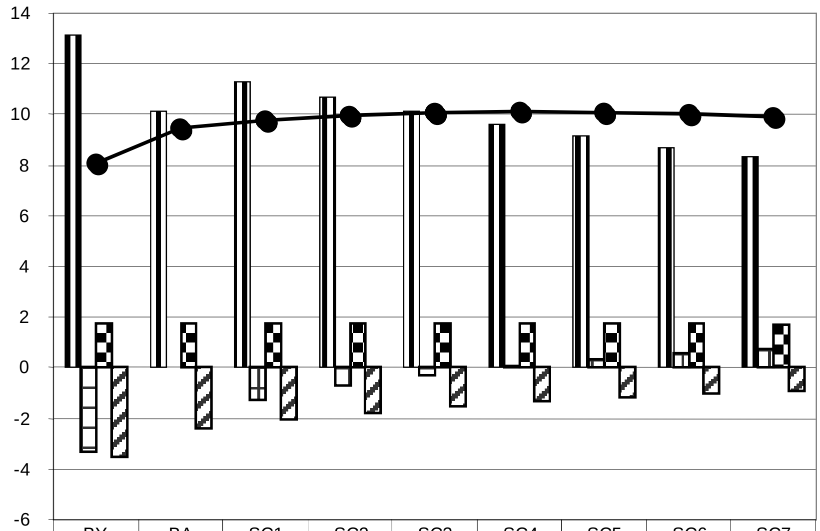
[1] External environmental costs in base year 50 % lower than in BAS. – [2] External landscape benefit in base year 100 % higher than in BAS.

4.2 Elasticities in the landscape benefit function

β-elasticities

In model version BET the elasticities in the landscape benefit function with respect to land, the β-elasticities, represent a higher influence of specialised grazing (GRAZ) and

Welfare indicators in the base year and scenarios (in billion €)



	BY	BA	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Producer surplus	13.143	10.104	11.306	10.680	10.114	9.602	9.135	8.709	8.317
Taxpayer	-3.308		-1.252	-0.713	-0.280	0.069	0.350	0.577	0.760
Landscape benefit	1.760	1.745	1.753	1.752	1.749	1.745	1.740	1.734	1.727
Environmental costs	-3.519	-2.396	-2.045	-1.752	-1.512	-1.313	-1.147	-1.008	-0.890
Overall social welfare	8.075	9.453	9.763	9.967	10.072	10.103	10.078	10.012	9.915

Figure

mixed (MIX) farm types than those in model version BAS. In order to safeguard the homogeneity of degree 1 of the landscape benefit function, the β-elasticities of the other farm types have lower values than in BAS. The elasticities in the different model versions are shown in table 5.

Table 5: **Landscape benefit elasticities in different model version**

	FIELD	GRAZ	GRAN	PERM	MIX
BAS					
β	0.527	0.374	0.033	0.009	0.057
γ	0.000	0.000	0.000	0.000	0.000
BET					
β	0.354	0.503	0.022	0.006	0.115
γ	0.000	0.000	0.000	0.000	0.000
GAM					
β	0.395	0.281	0.025	0.007	0.043
γ	0.104	0.098	0.021	0.010	0.017

For the full internalisation scenario (SC4) the results of the sensitivity analyses with respect to optimal land subsidies are presented in table 6. With a stronger dependence of landscape benefit on land use in specialised grazing and mixed farm types land subsidies for these farm types are 13.1 % and 17.5 %, respectively, higher than in BAS, whereas they are 5.8 % to 9.3 % lower for the other farm types. In model version BET full internalisation of externalities leads to an increase of land use in the mixed farm type by 15 %, whereas in BAS land use in this farm type is reduced. The stronger differentiation in farm types' land use impacts strengthens the potential of land reallocation for improving landscape benefits: whereas for model version BAS landscape benefit was slightly reduced in the full internalisation scenario (see figure), it increases by 5 % for model version BET. The impacts of different assumptions about the elasticity values on intermediate input taxes are also presented in table 6. For the mixed farm type the optimal tax level in model version BET is about 10 % lower than in BAS, whereas for other farm types small increases are calculated.

Table 6: **Sensitivity of optimal subsidies and taxes to landscape benefit elasticities** (percentage change over the base model BAS)

		BET	GAM
Intermediate input taxes	FIELD	0.0	-9.8
	GRAZ	2.6	-9.0
	GRAN	3.8	-10.1
	PERM	1.5	-3.4
	MIX	-10.2	-15.2
Land subsidies	FIELD	-9.3	-7.5
	GRAZ	13.1	-6.0
	GRAN	-5.8	-17.0
	PERM	-8.5	-27.5
	MIX	17.5	-13.9

γ–elasticities

In a second set of sensitivity analyses it is assumed that landscape benefit does not depend on land use only but on commodity output, too. The model version GAM represents an aggregate landscape benefit elasticity with respect to commodity output of 0.25. This value is distributed to farm types according to their shares in commodity output value.

The farm type specific elasticities with respect to commodity output, the γ–elasticities, are shown in table 5. In order to safeguard the homogeneity of degree 1 of the landscape benefit function the β-elasticities are smaller than in BAS.

In model version GAM optimal land subsidies are 6 % to 27.5 % lower and optimal intermediate input taxes are 3.4 % to 15.2 % lower than in BAS (see table 6). Again, the parallelism in the impact on the internalisation instruments is a direct consequence of the second objective criterion, i.e. the minimisation of the taxpayers' net position.

If landscape benefit depends on commodity output, there is a trade-off between reducing environmental costs and improving landscape benefits. The reduction of environmental costs due to full internalisation is smaller in model GAM than in model version BAS. But also the decline in landscape benefit is in GAM higher than in BAS.

5 Conclusions

5.1 National and international policy design

The implementation of policy measures often depends on the possibility to compensate for losses of certain social groups. Therefore a single welfare criterion is not sufficient to discriminate between policy options that aim at internalising external costs of agriculture and improving its multifunctional value.

The policy simulations show that abolishing commodity subsidies results in strong income losses for farmers of about 23 %. These losses could be avoided if taxpayers' transfers to agriculture would be redirected into direct payments that are decoupled from output and factor input. This is possible without additional burden on the taxpayer's net position. The net external costs of agriculture (environmental costs minus landscape benefit) would be substantially reduced so that there is a gain in overall social welfare.

Full internalisation of externalities by intermediate input taxes and land subsidies leads to an additional reduction of agriculture's net external costs that is higher than the additional loss in producer rents. The land subsidies do not fully compensate farmers for the income losses from the intermediate input taxes if minimisation of the taxpayers' net position is a secondary policy objective. Nearly full income compensation by additional decoupled payments to the farm sector could be granted within the limits of the taxpayers' net payments of the base year. However, this depends on the size of the environmental costs to be internalised. Additional sensitivity analysis with the same model shows that for very high external environmental costs (20 % of commodity output value) farm income compensation in the full internalisation scenario would need additional financial resources.

The modelling results also indicate that the policy objectives for a multifunctional agriculture must not necessarily result in conflicts with international trade policy. If a combination of different policy measures that aims at internalising positive as well as negative external effects of agriculture is implemented, the impact on commodity output quantity is unlikely to be positive. The Uruguay round of the GATT has made substantial improvements in categorizing agricultural support measures into allowed non production distorting and forbidden production distorting effects. Such a categorization, as helpful as it is for guidance in international agricultural policy, bears also the danger, that the choice for national agricultural policy-making is too heavily restricted. What is necessary in addition to the categorization of the policy measures, is an integrated valuation of the combined effects of policy measures implemented in a country. This should allow, for example, to exempt subsidies linked to land use from the obligation to abolish domestic support, if the country also employs measures to internalise external environmental costs that at the same time also reduce commodity output.

5.2 Applicability of the model

At the national and supranational level the framework for the design of national policies is set. At these policy sites goal conflicts between farm incomes, environment, multifunctionality, more market orientation and international trade are visible. The model MULTSIM can serve to bridge more detailed analyses of multifunctional and agro-environmental issues and market and trade analysis. The model does not allow to draw conclusion for specific policy design at the regional level. It therefore does not compete with regionally disaggregated models.

There is great uncertainty in measuring willingness-to-pay for environment and landscape benefit at the policy site (NAVRUD, 2002; RANDALL, 2002). In such a situation an economic model like MULTSIM that postulates relatively simple functional relationships between factor input, commodity output and externalities may be helpful. With data and parameter sensitivity analyses the potential impacts of alternative hypotheses on the functional relationships on optimal policy design can be tested. This just reflects the true world of policy-making which is characterised by uncertain knowledge about these relationships.

With MULTSIM the supply effects of environmental and multifunctional policy measures are modelled, but price feedbacks from markets on factor allocation and hence on external benefit and costs are not yet taken into account. If the supply effects in a country or a group of countries with similar policy objectives influence world market prices, the welfare indicators calculated by MULTSIM may be incomplete. The same counts for the case that domestically produced and imported goods are imperfect substitutes. Market and trade models that depict such market linkages normally do not consider impacts on externalities and public goods. For these reasons MULTSIM should be linked to a multi-market model or an agricultural trade model. This would allow to better represent the interactions between market and trade policy and environmental and multifunctionality policies. Cost-benefit analysis based on quantitative modelling could be improved. Good candidates for such a linkage are microeconomic multi-market models that are compatible with the behavioural assumptions in MULTSIM (e.g. WAHL, WEBER and FROHBERG, 2000).

Multifunctional agriculture has many policy objectives that compete with each other. Models for policy decision support should make visible goal conflicts but should also support the finding of solutions. However, there are drawbacks in normative policy analysis which are not easily to overcome. One of them is a-priori weighting of different objective criteria to arrive at one overall social welfare indicator, which bears the danger that important policy options may be ignored. The use of more flexible optimisation approaches for multiple policy goals like reference point optimisation (WIERZBICKI, 2000) should be tested.

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