# Modelling organic farming at sector level

# – an application to the reformed CAP in Austria

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**Abstract**

We analyse whether the 2003 CAP reform and the anticipated new program of rural development will lead to an expansion or a reduction of organic farming. An extended version of the Positive Mathematical Programming (PMP) method is developed in order to differentiate organic farming from conventional and other agri-environmental management practices in a sector model. Austria is chosen for the case study because 8 % of its farmland are managed organically, and detailed data on alternative management practices are available. The results suggest that the recent agricultural policy reforms will make organic farming more attractive for farmers, given the price premiums relative to conventional products will remain at observed levels.

*JEL classification: Q11, Q18, Q21*

*Keywords:* Organic farming; Common Agricultural Policy; Program for Rural Development, Agricultural sector modelling

## 1. Introduction

The Program for Rural Development – the second pillar of the Common Agricultural Policy (CAP) – aims at promoting environmentally production methods. Among the most successful programs is the promotion of organic farming. In EU-15, about 3.8 million hectares of agricultural land were used for organic production in the year 2000 (EUROSTAT, 2003). The Member States, where the percentage of the utilised agricultural area was higher than or equal to the EU-15 average (3%), were Austria and Italy (both 8%), Finland (7%), Denmark and Sweden (both 6%), and the United Kingdom (4%). For the promotion of organic farming, approximately EUR 700 mn were granted by EU and national funds in 2000 (CEC, 2003).

The 2003 reform of the CAP changed the policy framework of farming significantly. Thus, we expect that supply of organic products will be affected, because opportunity cost will change. Several studies have investigated the effects on farm incomes and farm outputs (FAPRI Ireland Partnership, 2003; OECD, 2004; LEI, IAP and IAM, 2003). But none of these studies looked at the consequences for organic farming, therefore, it is relatively unknown what effects the 2003 CAP reform will have on the supply of organic food.

According to our knowledge, only a few agricultural sector models differentiate conventional from organic production (Frandsen and Jacobsen, 1999 and Jacobsen , 2002). Jacobsen (2002) used an Applied General Equilibrium Model (AGE) to evaluate the consequences of different strategies to enhance the environmental effectiveness of farming practices. We propose an alternative approach, a modified version of the Positive Mathematical Programming (PMP) method.

PMP was initially developed by Howitt (1995) and since then extended and applied in many studies (e.g., Lee and Howitt, 1996; Paris and Arfini, 1995; Röhm and Dabbert, 2003). The advantage of this method over an AGE approach is, that we are able to evaluate regional supply responses of agri-environmental programs in a very detailed manner. Austria is chosen as a case study, because a considerable share of agricultural land is used for organic farming, and a broad collection of farm management data has been made available for such an analysis.

The topic of the paper is (i) to present an extended PMP method to model organic farming when other agri-environmental programs are present, (ii) to analyse whether the 2003 CAP reform will reduce or boost the acreage used for organic production in Austria, and how crop land acreage and the sizes of livestock herds are going to be affected, (iii) what implications are to be expected from financial reallocations due to the new program for rural development, which will likely be implemented in 2007.

## 3. The method and the model

### *3.1 An extension of the PMP method to model organic farming when other agri-environmental programs are present*

The PMP method uses observed crop allocations and average production cost to derive parameters for non-linear cost functions (Howitt, 1995). Thus marginal cost can be derived from linear programming (LP) models. Given non-linear objective functions, regional PMP production models adjust smoothly and in a more realistic manner than LP models. Röhm and Dabbert (2003) proposed an extension of this method to integrate agri-environmental programs into regional models. In the standard PMP method the variants of say wheat production are treated like separate crops. Their reasoning is, that it is easier to switch from management practice A (standard production with growth regulator) to practice B (without growth regulator) when producing wheat than to switch between wheat and rape. We build on these approaches and extend the method of PMP in two directions:

- First, we think that agri-environmental practices should be differentiated in models, in particular if we consider organic farming. It is relatively easy to switch from wheat to maize production, either on organic or conventional farms. However, it takes much more efforts to switch the farming system from conventional to organic farming.
- Our second extension is related to problem of solving large scale models. The fact that a single crop can be produced by many farming practices (organic, conventional, etc.), and that each practice can have additionally several management measures (e.g. winter cover crops) will result in a large number of choice variables. We therefore use variable separation techniques to approximate the non-linear cost curves of the standard PMP method by piecewise linear functions (Schmid and Sinabell, 2005).

Suppose, the objective is to maximize producer surplus (PS) from the production of $i$ crops, with $m$ farming systems (e.g. conventional and organic farming systems) using $v$ environmentally friendly management measures (winter cover crops, erosion control measures,

etc.). Observed activity levels on crops, farming systems, and management measures ($b_{i,m,v}$) are separated into a set of activity grids ($b^{g}_{i,m,v,s}$) ranging, for instance, between 10 and 200 percent of the observed levels. The design of the activity grids can be such that the deviations are smaller around the observed levels and get larger the further they get away from these points.

The set of exogenous parameters include indexed prices ($\rho_{i,m}$), outputs ($o_{i,m,v,s}$), approximated production cost shares ($\chi_{i,m,v,s}$), Leontief production technologies ($\mathrm{A}_{i,m,v}$), and a land resource endowment ($b_{i,m,v}$). The choice on crop, farming system, and management measure shares is obtained by building convex combinations ($\theta_{i,m,v,s}$) among the set of activity grids ($b^{g}_{i,m,v,s}$). The model is calibrated to observed activity levels ($b_{i,m,v}$) using the extended PMP method of variant production technologies developed by (Röhm and Dabbert, 2003).

$$\max_{\theta} PS = \sum_{i,m,v,s} \left[ \left( \rho_{i,m}\, o_{i,m,v,s} - \chi_{i,m,v,s} \right) \theta_{i,m,v,s} \right] \tag{1}$$

$$\text{s.t.} \qquad \sum_{i,m,v,s} \left( \mathrm{A}_{i,m,v}\, b^{g}_{i,m,v,s}\, \theta_{i,m,v,s} \right) \le \sum_{i,m,v} \left( b_{i,m,v} \right) \tag{2}$$

$$\sum_{s} \left( \theta_{i,m,v,s} \right) = 1 \qquad \text{for all i, m and v} \tag{3}$$

$$0 \le \theta_{i,m,v,s} \le 1 \tag{4}$$

where $\chi_{i,m,v,s} = \int_{0}^{b^{g}_{i,m,v,s}} \left( \alpha_{i,m,v} + 2\beta_{i,m,v} b^{g}_{i,m,v,s} + 2\varphi_{i,m,v} \sum_{v} \left( b^{g}_{i,m,v,s} \right) \right) db^{g}_{i,m,v,s}$ are approximated multi-variant production cost shares of quadratic shape. The coefficients of a linearly increasing multi-variant marginal cost curve are $\alpha_{i,m,v}$, $\beta_{i,m,v}$, and $\varphi_{i,m,v}$. The intercept coefficients of the indexed linear multi-variant cost curve are

$$\alpha_{i,m,v} = 1 - \frac{\left(\lambda_{i,m} + \lambda_{i,m,v}\right)}{VC_{i,m,v}}, \tag{5}$$

the slope coefficients of variant activity levels are

$$\beta_{i,m,v} = \frac{\lambda_{i,m,v}}{VC_{i,m,v}\, b_{i,m,v}}, \text{ and} \tag{6}$$

the slope coefficients of crop activity levels are

$$\varphi_{i,m,v} = \frac{\lambda_{i,m,v}}{VC_{i,m,v} \sum_{v} b_{i,m,v}}. \tag{7}$$

The λ are modified duals of the perturbed model. The variable costs (VC) of production activities are from the Austrian standard gross margin catalogue (BMLFUW, 2002).

By definition, the area beneath a linear marginal cost curve is the *variable* cost of production as expressed in $\chi_{i,m,v,s}$, or a point on the associated quadratic cost curve. The convexity and identity condition in equation (3) allows any weighed combination in the set of activity grids ($b^{g}_{i,m,v,s}$). The optimal crop, production system, and management measure shares in hectares are finally computed by $b^{g}_{i,m,v,s}\theta^{*}_{i,m,v,s}$. Similarly, total production output is the sum of $o_{i,m,v,s}\theta^{*}_{i,m,v,s}$, total revenue is the sum of $\rho_{i,m}o_{i,m,v,s}\theta^{*}_{i,m,v,s}$, and total production cost are the sum of $\chi_{i,m,v,s}\theta^{*}_{i,m,v,s}$.

It is important to note that environmentally friendly management measures are separately available for conventional and organic farming systems. This modified multi-variant production cost approach allows for an easier change between management variants (e.g. winter cover crops) than between crops and farming systems. These substitution schedules have considerable consequences in regional and sectoral modelling especially, when agronomic considerations, different farming systems, and agri-environmental policies play an important role in the decision process of farmers.

### *3.1 The Positive Agricultural Sector Model Austria - PASMA*

The Positive Agricultural Sector Model Austria (PASMA) is employed to estimate the impact of farm policy measures on the supply of organic farming in Austria. PASMA depicts the political, natural, and structural complexity of Austrian farming in detail. Data from the Integrated Administration and Control System (IACS), Economic Agricultural Account (EAA), Agricultural Structural Census (ASC), Farm Accountancy Data Network (FADN), the Standard Gross Margin Catalogue (BMLFUW, 2002), and the Standard Farm Labour Estimates (Greimel et al. 2003) provide necessary information on resource and production endowments for 40 regional and structural (i.e. alpine farming zones) production units in Austria. Consequently, PASMA is capable to estimate production, labour, income, and environmental responses for each single unit.

Apart from the model features described in the previous section, PASMA uses convex combinations of crop and feed mixes, expansion, reduction and conversion of livestock stands, and a transport matrix. Imports of feed and livestock are included to allow reasonable responses in production under various policy scenarios. Conventional and organic production systems (crop and livestock) have separate feed and fertilizer balances at regional and structural scales. Transfers between these two production systems are not allowed in the model, however, they compete for the same resources (i.e. land and labour).

The support program for farms in less-favoured areas (LFA) and the agri-environmental program are explicitly modelled with area payments that are stratified by region and structure. Thus the two most important components of the program for rural development (with a volume equivalent to 38 % of Austrian farm sector income in 2004) are modelled measure by measure. Product prices and other model assumptions are referenced in Schmid and Sinabell (2003). Most prices are exogenously given and based on OECD (2004 and 2005). Prices for organic products are based on Eder et al. (2002), and Freyer et al. (2001).

## 4. Policy reform, scenarios, and results

*4.1 The reform of the Common Agricultural Policy*

The objectives of the 2003 CAP reform are economic (increased competitiveness, stronger market orientation, and more efficient income support), social (more responsiveness to consumer demands, encouragement to improve food quality and safety), and environmental goals (development of environmental and animal welfare standards). In order to achieve these goals, the following measures were agreed upon in 2003 to:

- modify market regimes (reduction of administrative prices, special regulations for protein crops and durum wheat, prolongation of the milk quota system until 2014/15),
- the introduction of a single farm payment (direct payments will be decoupled from farm outputs), and
- introduce several accompanying measures (e.g. degression, modulation, enhancement of consumer trust, additional environmental and animal welfare standards).

Member states have got the freedom to fine tune CAP-instruments according to their specific policy goals. They may choose to introduce the single farm payment in full or they may opt to retain part of the premiums coupled to the output (this option was chosen in Austria). The funds saved by modulation will be used to reinforce the program for rural development. Via this new instruments, funds can be re-allocated among Member States (Austria will be among the beneficiaries).

*4.2 The model scenarios*

The **first scenario** analysed in this paper is a comparison between the situation in 2003 (with the Agenda 2000 in place) and the reformed CAP in 2008, when the introduction of a single farm payment will be fully implemented. In this scenario we analyse whether we can expect a stimulation or a weakening of organic farming after the recent CAP reform at national scales.

The **second scenario** is a comparison between a base-line towards 2008 with the Agenda 2000 in place and the reformed CAP in 2008. In the Agenda 2000 situation (no decoupling) a different set of prices is used (based on OECD, 2004) and direct payments are linked to outputs.

In **both scenarios**, we assume that the budget for agri-environmental measures will be reduced by about 10 % to allow some redistribution to other measures in the new program for rural development, to be introduced in 2007. Funds saved by the reduction of the volume of agri-environmental payments are assumed to remain in the farm sector (modelled as lump sum transfers).

In Austria, the premiums for suckler cows will remain coupled to production by 100 % and the slaughter premiums by 40 %. All other premiums apart from rural development payments will be decoupled. A moderate (exogenous) rate of technical progress and constant real input prices are further assumptions. We do not adopt exogenously given labour declines in order to isolate the policy effect on structural adjustment. As required by regulations, decoupled premiums must be matched by eligible hectares and land must be maintained in good agricultural and ecological condition. Thus, afforestation is effectively prevented unless maintenance costs of agricultural land exceed decoupled premiums. Per hectare premiums for organic farming are at the same nominal levels as in 2000, and other conditions (e.g. animal

welfare requirements and restrictions on feed components) do not change between the scenarios, either.

*4.3 Model results*

The model results reported in Table 1 show a comparison between the (modelled) situation in the 2003 and outcomes in 2008 when the CAP reform is fully implemented. A comparison between the base-line of the Agenda 2000 scenario in 2008 and the situation after the 2003 CAP reform is provided in the right column.

**Economic consequences**

- Farm welfare (producer surplus of agricultural activities including direct payments and other subsidies) is likely to increase at national level in nominal terms when the situation in 2003 is compared to 2008 (first scenario).
- It is assumed that premiums for organic farming will not change in the new program for rural development. But the total volume of payments will expand by 2.2 % (compared to 2003) or 1.2 % (compared to Agenda 2000 in 2008) because more farmland is brought into the program.

**Consequences for farm labour**

- After the 2003 CAP reform, the demand for farm labour will be lower by 1 %.
- Organic farming is more labour intensive, thus the decline of farm labour due to the CAP reform is cushioned.

**Consequences for land use and crop production**

- Total arable land will decline after the CAP 2003 reform, in particular conventional arable land. The acreage of organically managed arable land will be affected to a lesser extent.

- The conditions of the single farm payments guarantee that farm land is not turned into forest. Therefore the decline of arable land is mirrored by an increase of grassland, which is more extensively managed.
- The production of conventionally produced crops will almost evenly decline across all products. The results are mixed as far as organic crop production and protein crops are concerned.

*Table 1: Percentage change of economic, land use, and production indicators in 2008 compared to AGENDA 2000 in 2003 and 2008*

| | unit | level 2003 | % change of CAP reform versus Agenda 2000 scenario | |
|---|---|---|---|---|
| | | | baseline 2003 | baseline 2008 |
| economic indicators | | | | |
| farm welfare[1)] | bn EUR | 3.78 | + 0.7 | – 1.4 |
| volume of agri-environmental program [2)] | mn EUR | 628 | – 10.6 | – 10.5 |
| organic farming premiums | mn EUR | 86 | + 2.2 | + 1.2 |
| farm labour input | 1,000 AWU | 172 | – 1.0 | – 0.1 |
| land use | | | | |
| arable land | 1,000 ha | 1,380 | – 3.5 | – 1.5 |
| – conventional | 1,000 ha | 1,260 | – 3.7 | – 1.5 |
| – organic | 1,000 ha | 120 | + 0.1 | – 1.0 |
| grassland (without alpine grassland) | 1,000 ha | 1,101 | + 4.6 | + 3.7 |
| crop production conventional (acreage) | | | | |
| – cereals (without maize) | 1,000 ha | 561 | – 3.8 | – 1.3 |
| – protein crops | 1,000 ha | 36 | – 4.4 | + 1.2 |
| – oilseeds | 1,000 ha | 106 | – 4.6 | – 3.3 |
| crop production organic (acreage) | | | | |
| – cereals (without maize) | 1,000 ha | 52 | + 1.8 | – 0.5 |
| – protein crops | 1,000 ha | 11 | + 7.9 | + 1.1 |
| – oilseeds | 1,000 ha | 2 | – 0.4 | – 1.1 |
| heads of conventional livestock | | | | |
| cattle | 1,000 heads | 1,733 | + 1.4 | + 0.5 |
| male cattle | 1,000 heads | 480 | – 2.5 | – 5.5 |
| female cattle | 1,000 heads | 1,253 | + 2.3 | + 1.9 |
| pigs | 1,000 heads | 3,209 | + 0.3 | + 0.3 |
| heads of organic livestock | | | | |
| cattle | 1,000 heads | 319 | + 1.0 | + 0.9 |
| male cattle | 1,000 heads | 42 | – 2.1 | – 3.2 |
| female cattle | 1,000 heads | 277 | + 1.4 | + 1.5 |
| pigs | 1,000 heads | 36 | + 4.1 | + 3.4 |

Source: Own calculations based on price forecasts of OECD (2004). Note: 50,000 additional suckler cow premium entitlements are shared among owners of heifers. Additional funds for the program for rural development (17 million € annually from modulation) are not accounted for in total transfers.
[1)] Farm welfare is producer surplus from agricultural activities including single farm payments and other program payments. [2)] The assumption is made that the volume of Axis-2 measures is reduced by 10% in 2007 while premiums per hectare for organic farming remain at 2003 levels.

**Consequences for livestock production**

- Non-beef meat production will expand after the 2003 CAP reform. This is particularly true for organic pork production.
- We expect a larger herd of suckler cows and heifers after the reform and relative to Agenda 2000 because premiums remain coupled to production in Austria. Less bulls will be fattened, because bull premiums will no longer be linked to production.

## 5. Discussion and conclusions

We have analysed how output of organic farms might respond to changes after the 2003 CAP reform. Our model results capture the Austrian agricultural sector for which detailed farm data are available. The results suggest that organic farming will become more attractive to farmers after the 2003 CAP reform if specific support is maintained.

Organic farms are affected by the abolition of production linked premiums as other farms are. However, production adjustments are slightly different in organic farms than in conventional farms. The overall reform effect is that organic output declines to a lesser extent than conventional output. Thus, the 2003 CAP reform is likely to reach two goals, namely the reduction of outputs while simultaneously making farming less input intensive.

Our results are contingent upon the assumption that historically observed margins between conventional and organic crop and livestock outputs will be paid in future. This assumption seems to be justified by two reasons: (i) An Austrian and an EU action program for organic farming strive to boost demand for organic products. If demand side effects materialize then we expect prices at current levels. (ii) Organic products are free of GMOs. Thus consumers get an additional attribute *for free* when they buy organic food. This is likely to stimulate demand among consumers concerned about GMO food. However, at the current state we cannot base our reasoning on model results, because the demand side is not included yet.

Therefore, in future efforts will be necessary to account for consumer choices and feedbacks from the market within the modelling approach we developed.

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