TESTING FOR EFFICIENCY: A POLICY ANALYSIS WITH PROBABILITY DISTRIBUTIONS

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ABSTRACT

The study evaluates the efficiency of government intervention using a vertical structured model including imperfectly competitive agricultural input markets, the bread grain market, and the imperfectly competitive food industry. To test for policy efficiency the actually observed bread grain policy is compared to a hypothetical efficient policy. To account for the sensitivity of the results in regard to the model parameter values computer-intensive simulation procedures and surface response functions are utilized.

Keywords: agricultural policy, efficient combination of policy instruments, statistical policy analysis

INTRODUCTION

As a rule, governments defend their policy as efficiently meeting stated objectives. The aim of this study is to take this to an empirical test. In particular, it is analyzed if the market interventions into the Austrian bread grain market before the EU accession were designed to efficiently meet the main stated objectives. To do so, the actually observed policy is compared to a hypothetical optimal policy using the same instruments, but at optimal levels.

In the next section, the official objectives relevant to the past bread gain policy in Austria and the policy instruments are reviewed. In Section 3 a vertically-structured model including imperfectly competitive agricultural input markets, the bread grain market, and the imperfectly competitive food industry is developed. Since the results crucially depend on the model parameters a range rather than (one or a few) specific values are derived for each model parameter. In Section 4 the simulation model and assumed parameter ranges are used to test for the efficiency of the bread grain policy under uncertainty. Section 5 provides a sensitivity analysis of the results. Section 6 gives a summary and discussion.

OBJECTIVES AND INSTRUMENTS OF BREAD GRAIN POLICY

Thus, official objectives of farm policy as stated in national agricultural legislation are manifold there also appears to be a high degree of unanimity about the goals of agricultural policy among developed countries. Following Winters (1990) in analyzing the objectives of agricultural support in OECD countries one may identify four categories of farm policy goals: i) support and stabilization of farm income; ii) self-sufficiency with agricultural (food) products; iii) regional, community and family farm aspects; iv) the environment. There is not much doubt among agricultural policy analysts that farm income support has been the most important goal over the last decades (Josling, 1974; Gardner, 1992).

In general, Austrian agricultural legislation is not different from other developed countries. The overall goals of agricultural policy are stated in paragraph 1 of the "Landwirtschaftsgesetz" (Agricultural Status) and perfectly fit in the four categories mentioned above.

The particular objectives of bread grain market interventions are stated in the "Marktordnungsgesetz" and can be summarized as: i) safeguarding domestic production, ii) stabilizing flour and bread prices; and iii) securing a sufficient supply and quality of bread grain, bread grain products and animal feedstuffs.

Utilized policy instruments to meet stated policy objectives can be illustrated by means of Figure 1 with D_{fo} being the domestic demand for bread grain for food production and D being the total domestic demand for bread grain including demand for feeding purposes. Initial domestic supply is represented by S and supply including a fertilizer tax by S_t. World market price is assumed to be perfectly elastic at P_w. Farmers obtain a high floor price (P_D) for a specific contracted quantity (or quota) Q_Q. Since farmers have to pay a co-responsibility levy (CL_{PD}) the net producer price is P_D - CL_{PD}. Quantities, which exceed the quota can be delivered at a reduced price P_E. Again, farmers' net floor price is P_E - CL_{PE}, with CL_{PE} being the co-responsibility levy for bread grain beyond the quota. Food processors have to buy bread grain at the high price P_D, while the price of bread grain for feeding purposes is P_E. Therefore, domestic demand for bread grain in food production is Q_D, domestic demand for feeding purposes is $Q_E - Q_D$, total domestic demand is Q_E, and exports are $Q_X = Q_S - Q_E$.

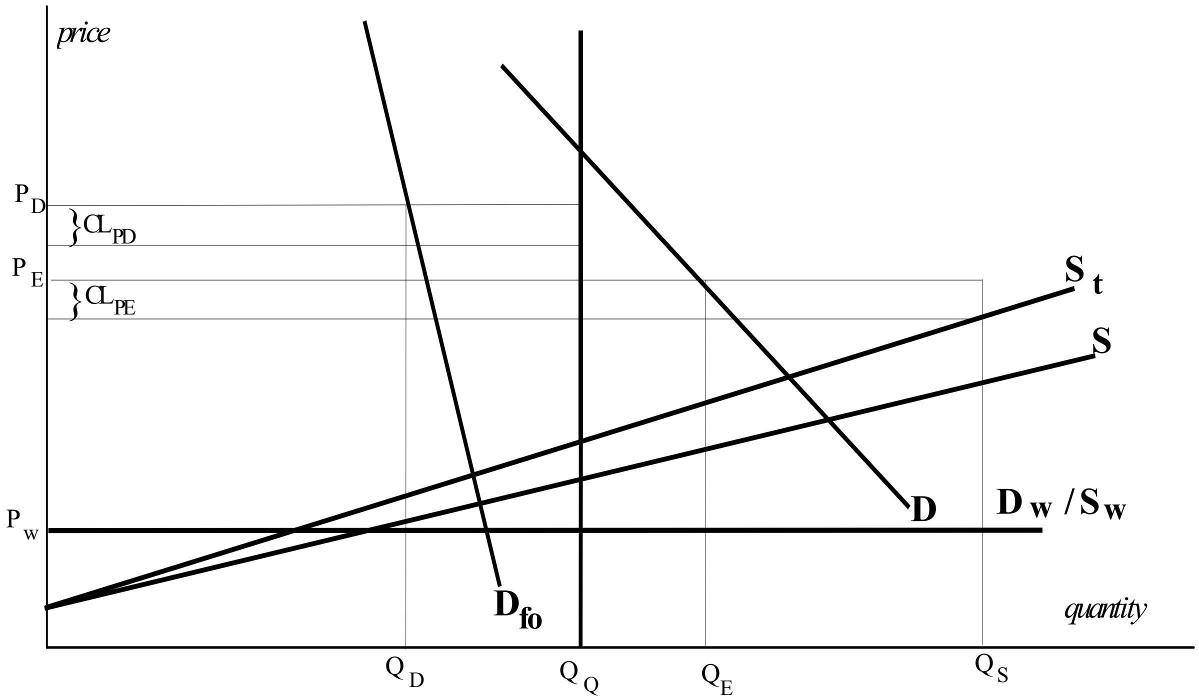

Figure 1. Bread grain market and policy

THE MODEL

As illustrated in Figure 2, the Austrian agribusiness of bread grains is modelled by a log-linear, three-stage vertically-structured model (A full description of the model is given in *Name Withheld,* 2002). The first stage includes markets of agricultural input factors used for bread grains production. Since 95% of farmland is owned by farmers and 86% of labour in the agricultural sector is self-employed, these two resources are assumed to be offered solely by farmers. On the contrary, investment goods (mainly machinery and buildings), and operating inputs (mainly fertiliser, pesticides, and seed) are produced by industries. Export and import of input factors is not considered. Hence, it is assumed that domestic consumption of input factors equals domestic production. This is certainly correct for land and agricultural labour but might not be exactly accurate for industrially produced input factors. However, in both cases a big share of domestic consumption was produced domestically

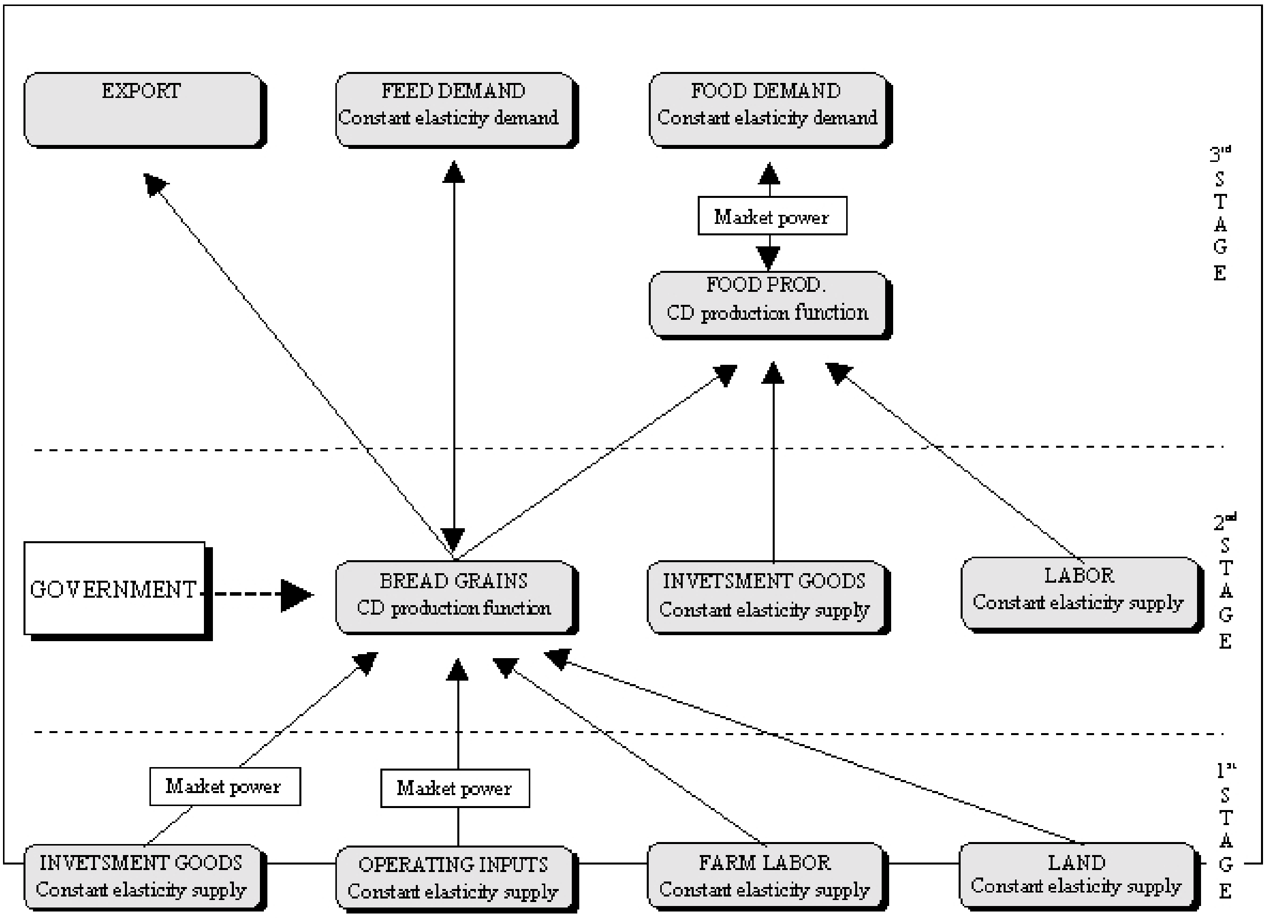

Figure 2. Model structure.

At the second stage, input factors of the first stage are used to produce bread grains assuming a Cobb-Douglas technology. The first and the second stage are linked by the assumption that agricultural firms maximise their profits.

At the third stage the produced quantities of bread grains are used for food production, animal feed, and exports. Firms, which process food combine bread grains with other input factors of investment goods, and industrial labour assuming a Cobb-Douglas technology. Again, the second and the third stage are linked by the assumption that food industry firms maximise their profits. Import and export of processed bread grains do not play an important role. Hence, it is assumed that domestic demand of processed bread grains equals domestic supply. Quantities of bread grains which are neither used for food production nor for animal feed are exported.

The farm sector is assumed to be competitive. This assumption is justified by the large number of firms producing bread grains and by the fact that farmers take prices given by government. Input industries and food industry as defined in the model are conglomerates of separate industries. Investment goods include all kind of agricultural machinery as well as agricultural buildings. Operating inputs include fertiliser, pesticides, seeds, fuel, lubricants, etc. The food sector comprises wholesale buyers, mills, as well as the bread, noodle and baker's ware industries. For this reason, the market structure of these aggregations of industries is hard to define. To account for this, the model includes a conjectural variation parameter. Varying this parameter imitates different market structures and different levels of market power ranging from perfect competition to monopoly (e.g. Maier, 1993).

To run the model 32 parameter values are necessary. While 13 values of these 32 parameters are endogenously derived in the calibration process, 19 specific parameter values have to be assumed. In contrast to most empirical studies of this kind we do not assume one (or a few) specific value(s) for each parameter, but rather assume each parameter to be in a plausible range.

The upper (a) and lower (b) bounds of these ranges are based on extensive literature and data analysis (described in detail in *Name Withheld*, 2001)).

Two alternative distributions are assumed between the upper and lower bounds: i) a uniform distribution $U(a, b)$; and ii) a symmetric normal distribution $N(\mu, \sigma,)$ with $\mu = (a+b)/2$ and $\sigma = (\mu - a)/1.96$, which is truncated at a and b.

On the base of these parameter ranges, 10,000 independent draws are taken for every single parameter and each alternative distribution. Hence, we derive 10,000 parameter sets including 19 elements for each alternative distribution, separately. These parameter sets are used to derive 10.000 simulation (and optimization) results for each alternative parameter distribution.

EMPIRICAL ANALYSIS

As discussed above, the main objective of agricultural policy in Austria, as in most developed countries, was to support farm income. Beside income redistribution, securing a sufficient supply and quality of bread grain products and animal feedstuffs was the most important goal of Austria's bread grain policy in particular. Given this, we may simplify government's decision problem as trying to maximize social welfare given a socially demanded level of farmer's welfare and self-sufficiency. (Note, that equally one could describe government's decision problem as minimizing social cost, given a certain amount of wealth transfers to farmers and self-sufficiency.) Assuming that the socially demanded transfer level is reflected in the actually observed transfer level, that self-sufficiency is given when domestic supply is greater or equal domestic demand, and that the policy instruments available to government are the actually used instruments, government's decision problem can be formalized as:

$$\max_{P_{QD}, P_E, CL_{PQD}, CL_{PE}, QQ} W, \quad \text{s.t.} \quad U_{BF} \geq U_{BF}^{A} \quad \text{and} \quad Q_X \geq 0 \qquad (1)$$

where W is social welfare (measured as the sum of welfare of all domestic social groups affected by the policy including upstream and downstream industries, bread grains farmers, consumers, taxpayers and buyers of bread grains for feeding purposes), U_{BF} is the welfare level of bread grain farmers, U_{BF}^{A} is the actually observed welfare level of bread grain farmers, and Q_x are bread grain exports.

The official goal of introducing a tax on fertilizer was soil protection and hence environmentally motivated. For simplicity, it is assumed that this environmental goal is separable from other goals and optimally met by the current level of fertilizer tax. Hence, government can freely choose the levels of five policy instruments (P_E, CL_{PE}, P_{QD}, CL_{PQD}, Q_Q) to maximize welfare under given constraints.

Utilizing the described simulation model, assumed distributions of parameter values, and welfare measures, the nonlinear optimization problem (1) is solved numerically for 2 times 10,000 alternative parameter sets utilizing GAMS software (Brooke et al. 1988). As a result two alternative distributions of the optimal welfare levels as well as the optimal policy instrument levels and combinations are derived.

Utilizing the same model, parameter sets, and welfare measures, but taking the world market price of bread grain one can simulate a hypothetical nonintervention scenarios. Thus, the social cost of the optimal policy are measured as $SC^* = W^* - W^W$ where W^* and W^W are the welfare level in the optimal situation and in the world market price situation, respectively. Similarly, assuming plugging in the actually observed prices into the simulation model one could calculate the social cost of the actual observed policy $SC^A = W^A - W^W$ where W^A is the actual welfare level. Finally, the relative social cost (RSC) give the share by which the social cost could have been reduced, if the government would have used an optimal combination and levels of policy instruments RSC = $(SC^A - SC^*)/SC^A$. This gives a measure of how close the actual policy is to the optimal policy.

The empirical results for the assumption of normally distributed parameters are summarized in Table 1.

At the mean the social cost of the actually policy are measured to be € 159 million (about 42% of the value of bread grain production) with a standard deviation of € 23 million. In 95% (9,500 cases) of our 10,000 simulations the social cost are in a range of € 116 million to € 206 million. The 75% probability interval is between € 131 million € 188 million.

Table 1. Social cost of actual and optimal policy given a normal distribution of parameter values.

				95% Probability interval		75% Probability interval	
	Mean	Median	Std. Dev.	from	to	from	to
Social cost of actual policy	159.3	158.6	23.2	116.3	206.2	131.4	188.4
Social cost of optimal policy	91.2	91.1	24.0	45.0	138.7	61.7	120.9
Percentage improvement	0.44	0.42	0.08	0.32	0.63	0.35	0.53

In the case of the optimal policy the social cost are significantly smaller with a mean of € 91 million, a standard deviation of € 24 million, a 95% probability interval between € 45 million and € 139 million, and a 75% interval between € 62 million and € 121 million. Therefore, by using the same instruments at different levels government could have reduced the social cost on average by € 68 million, about 44% of the actual social cost, and with a 95% (75%) probability between 32% (35%) and 63% (53%).

Assuming a uniform distribution of the parameter values between the upper and lower boundary does not change the mean and median significantly (Table 2), but certainly causes higher standard deviations and hence wider probability intervals.

Table 2. Social cost of actual and optimal policy given a uniform distribution of parameter values.

				95% Probability interval		75% Probability interval	
	Mean	Median	Std. Dev.	from	to	from	to
Social cost of actual policy	158.9	157.2	30.4	104.3	221.5	122.2	197.5
Social cost of optimal policy	90.2	89.3	31.6	31.4	152.8	51.5	129.7
Percentage improvement	0.45	0.43	0.11	0.30	0.72	0.33	0.59

SENSITIVITY ANALYSIS

To analyze the sensitivity of the RSC with respect to the model parameters, surface response functions are utilized (Zhao et al. 2000). The nonlinear relationships between RSC and model parameters are described by its second order approximation, i.e. a quadratic polynomial, comprising a constant, the 19 parameters par_i, and the permutations $par_i\ par_j$ of the products of all 19 parameters.

$$RSC = c_0 + \sum_{i=1}^{19} c_i par_i + \sum_{i=1}^{19} \sum_{j=1}^{i} d_{ij} par_i par_j + e, \qquad (2)$$

with c_0, c_i, and d_{ij} being regression coefficients, and e an error term.

Equation (2) is estimated using the 10,000 parameter sets drawn from the uniform distributions and the implied RSC-values. However, to exclude extreme parameter combinations the lowest and highest 2.5% of RSC-values are omitted, leaving 9,500 observations.

OLS-estimation of the response function exhibits an extremely good fit (R^2 = 0.993) as well as medium to high levels of significance for a majority of coefficients. About 57% of the coefficients are significant at the 99% level, 3% at the 95% level, and 12% at the 90% level.

Table 3. Sensitivity Analysis.

	Monte Carlo-results (n=9500)					**Evaluation at parameter means**			
Par.	**Mean**	**Median**	**S.E.**	**Min**	**Max**	**Avg.**	**RSC_{min}**	**RSC_{max}**	**Δ(RSC)**
α_A	-0.007	-0.005	0.018	-0.092	0.055	-0.006	0.418	0.417	-0.001
α_B	-0.035	-0.033	0.055	-0.245	0.168	-0.036	0.420	0.415	-0.004
α_G	-0.001	-0.002	0.018	-0.064	0.087	-0.002	0.418	0.417	0.000
α_J	0.015	0.015	0.021	-0.059	0.105	0.015	0.417	0.419	0.002
λ	-1.106^{***}	-1.187	0.277	-1.588	0.118	-1.232	0.494	0.364	-0.130
ε_A	0.000	0.000	0.005	-0.028	0.027	0.000	0.418	0.417	0.000
ε_B	-0.016	-0.012	0.032	-0.153	0.094	-0.015	0.419	0.411	-0.008
ε_G	-0.019	-0.023	0.015	-0.049	0.059	-0.029	0.431	0.415	-0.016
ε_H	-0.054	-0.064	0.034	-0.129	0.136	-0.078	0.453	0.409	-0.044
ε_K	-0.016	-0.018	0.024	-0.080	0.102	-0.023	0.428	0.415	-0.013
ε_J	-0.011	-0.011	0.014	-0.061	0.055	-0.015	0.424	0.415	-0.009
η_F	-0.109	-0.098	0.078	-0.366	0.225	-0.132	0.388	0.466	0.079
η_E	-0.176	-0.158	0.108	-0.539	0.076	-0.177	0.374	0.448	0.074
σ_S	0.005	0.005	0.012	-0.069	0.073	0.007	0.414	0.419	0.005
σ_F	-0.538^{***}	-0.543	0.138	-1.028	0.123	-0.644	0.603	0.332	-0.271
L_F	-1.023^{**}	-1.058	0.417	-2.116	0.604	-1.124	0.478	0.372	-0.106
L_G	-0.007	-0.012	0.032	-0.088	0.125	-0.013	0.419	0.417	-0.001
L_H	-0.019	-0.029	0.074	-0.225	0.317	-0.031	0.420	0.417	-0.003
MCF	0.107^{**}	0.101	0.054	-0.068	0.287	0.118	0.389	0.448	0.059

*, **, *** indicate a significance level of 90%, 95%, and 99%, respectively.
Legend: ε_A, ε_B, ε_G, and ε_H are supply elasticities of inputs used in bread grain production (A = land, B = labor, G = investment goods; H = operating inputs); α_A, α_B, and α_G are factor shares of land labor and investment goods in bread grain production; ε_K, ε_J, are supply elasticities of inputs used in food production (J = labor, K = capital); α_j, is the factor share of labor in food production; σ_S, and σ_S are elasticities of substitution between input factors in bread grain and food production respectively; η_F, and η_F, are elasticities of demand for food and feed respectively; L_F, L_G, and L_H are Lerner indices for the food industry, investment good industry and operating inputs industry respectively; λ is the agricultural share of expenditures for bread grain products; MCF are marginal cost of public funds.

The elasticity of the Relative Social Costs with respect to the 19 parameters was calculated performing the following Monte Carlo experiment: First, the 9,500 parameter sets and the estimated response function were used to calculate 9,500 RSC "base"-values. Second, the parameter sets were slightly changed by increasing all 9,500 values of the first parameter, e.g. α_A, by 1% and calculating 9,500 RSC "new"-values. Third, subtracting the 9,500 new RSC values from the 9,500 base-values and dividing the difference by the base values lead to 9,500 elasticity values, i.e. the percentage change of the RSC with respect to a 1% change in the first parameter. The left block of Table 3 reveals that at the mean (median) of all 9,500 calculated elasticity values a 1% change in the parameter α_A (factor share of land in the production of bread grains) decreases the RSC by 0.007% (0.005%) with a standard deviation of 1.8%, a maximum value of 0.055% and a minimum value of –0.092%. The same procedures lead to elasticities for all other parameters. The fact that the minimum elasticities are negative and the maximum elasticities are positive for all parameters reveals how the effect of a change in one parameter depends on the levels of all other parameters. Only four elasticities are significant different from zero at the 90% level or higher: the agricultural share of expenditures for bread grain products (λ), the Lerner index of the downstream industry (L_F), the elasticity of substitution at the food industry level (σ_F), and the marginal cost of public funds (MCF).

Alternatively to the mean value in the left block of Table 3, the first column represents the percentage change in RSC, when one parameter is changed by 1% and all other parameters are kept unchanged at their mean values. The results in the first columns of the left and the right block do not differ significantly from each other. The second and third columns of the right block, RSC_{min} and RSC_{max}, do not denote percentage changes, but the values of Relative Social Cost, when one parameter is set respectively at the lower and upper bound of its associated range, and all other parameters are set at their mean values. The last column, $\Delta(RSC)$, simply indicates the difference in the absolute Relative Social Costs ($\Delta(RSC) = RSC_{max} - RSC_{min}$). This can be interpreted as the „imprecision" in RSC due to the fact that in the model, the parameters used are range estimates rather than point estimates. The higher the absolute value of this last column, the greater the gain in the precision of the estimated RSC associated with a narrower parameter range.

The parameters λ, σ_F and L_F exhibit the widest ranges. Hence, additional information on their actual values would be most beneficiary to the simulation model.

SUMMARY

As a rule, governments defend their policy as efficient in common political statements. Utilizing a three-stage vertically structured model including upstream and downstream industries it was shown over a wide range of possible model parameter values that the Austrian bread grain policy was quite inefficient in meeting its two main objectives, namely supporting farm income and self-sufficiency. In fact, the social cost could on average have been reduced by more than 40% by using the same policy instruments, but at efficient levels.

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