Least Cost Efficiency of Agricultural Programs: An Empirical Investigation

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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 grains market, and the imperfectly competitive food industry. The actually observed policy is compared to a hypothetical optimal policy of the same policy instruments to test for policy efficiency.

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Introduction

It is commonly accepted among agricultural economists that supporting farm income is the central purpose of most government interventions in agricultural markets (Gardner, 1992). For Austria this objective is stated directly and indirectly several times in paragraph 1 of the "Landwirtschaftsgesetz" (Agricultural Status). The study intends to make a contribution by evaluating the efficiency of government intervention using a more complex model than previous studies. In particular, a three-stage vertically-structured model including imperfectly competitive agricultural input markets, the bread grains market, and the imperfectly competitive food industry is set up. This simulation model is applied to investigate if the utilized bread grains policy was least cost efficient. In particular, the actual policy is compared to the most efficient combination of currently employed policy instruments given that government intends to support farm income at lowest possible cost to society. Since the results crucially depend on the model parameters a range of possible parameters values utilizing information from a comprehensive literature review is assumed instead of point estimates. Parameter values within this range are randomly chosen and the above described simulations are conducted. By repeating this procedure 1000 times one can derive a distribution of potential welfare outcomes rather than a point estimate. The bread grains sector in Austria before the accession to the EC serves as the empirical basis for this study.

2. Modelling the Austrian Bread Grains Sector Including Agribusiness

The Model

The Austrian bread grains sector including agribusiness (agricultural input suppliers as well as food industry) is modeled by a log-linear, three-stage vertically-structured model. 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 labor in the agricultural sector is self-employed, these two resources are assumed to be offered solely by farmers. On the contrary, durable goods (mainly machinery and buildings), and operating inputs (mainly fertilizer, pesticides, and seed) are produced by industries. It is assumed that domestic consumption of input factors equals domestic production. This is certainly correct for land and agricultural labor but might not be exactly accurate for industrially produced input factors. However, in both cases the major share of domestic consumption was produced domestically.

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 maximize 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 durable goods and industrial labor assuming a Cobb-Douglas technology. Again, the second and the third stage are linked by the assumption that food industry firms maximize 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. Bread grains which are neither used for food production nor for animal feed are exported.

Firms in the farm sector are assumed to have no market power. 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 the food industry as defined in the model are conglomerates of separate industries. Durable goods include agricultural machinery as well as agricultural buildings. Operating inputs include fertilizer, pesticides, seeds, fuel, lubricants, etc. Wholesale buyers, mills, as well as the bread, noodle and baker's ware industries comprise the food sector. For this reason, the market structure of these aggregations of industries is hard to define and therefore modeled by a variable oligopoly. Since the model is log-linear, oligopoly-pricing behavior can be described by a mark-up over marginal cost. The mark-up coefficient ψ is defined by a conjectural variation model,

$\psi = 1+(1+\lambda)/(M\eta)$, where λ is the conjectural variation term describing expectations about competitors' behavior, M is the number of identical firms in the industry, and η is the elasticity of demand (Maier, 1993). Different λ's correspond to different oligopoly theories. Assuming $\lambda = 0$ corresponds to the Cournot conjecture, $\lambda = -1$ corresponds to the Bertrand conjecture, and if $\lambda = M-1$, the outcome is collusion. The mark-up coefficient ψ is a number between zero and one. If for example $\psi = 0.5$, the price for a unit of food is twice as high as the marginal cost of producing this unit.

Model Parameters

Given the assumed Cobb-Douglas technology production elasticities equal input cost shares. Cost shares of bread grains production in Austria are investigated utilizing the official gross margin calculations of the Ministry of Agricultural and Forestry as well as gross margin and value added calculations based on SPEL (production and income model for the agricultural sector of the European Community) data (Kniepert). The observed cost shares do not differ significantly from the one reported in the literature for other Western European countries (e.g. Heshmati and Kumbharkar) and the assumed ranges are reported in Table 1. The same procedure is used in the case of food production utilizing Austrian industry statistics.

Supply of inputs used at the farm as well as at the food industry level certainly get more elastic in the long run. However, given the observation that governments are more or less frequently changing intervention levels or policy instruments we are more interested in the short and medium run effects of the policy.

Supply of land for bread grains production is assumed to be perfectly inelastic for two reasons. First, production of bread grains in an appropriate quality is only possible in certain climatically favorable areas. Second, though it is certain that the amount of land under bread grains is sensitive to the level of returns in the long run, here in this short to medium run analysis a long time lag for adjustment is assumed.

All other elasticities are derived from an extensive literature review. A few studies have estimated farm labor supply elasticities at the household level. Lopez reports an on-farm labor supply elasticity of 0.12 at the sample mean for Canada. Thijssen estimates an elasticity of 0.17 for Dutch farmers. However, the aggregate sectoral supply elasticity is usually assumed to be higher since one has to take into account that labor force might move in or out of the sector. Most of the studies on aggregate farm labor supply in developed countries date back to the sixties and seventies using simple estimation procedures.[1] Estimated elasticities are in a wide range between 0.03 and 2.84 with a tendency of being larger in the long run and for hired labor. Given the high percentage of family labor in Austria and the medium run orientation of our analysis the supply elasticity of farm labor is assumed to lie in the wide range of 0.1 to 1.5.

Labor supply elasticities for non-farm sectors or whole economies are also found to be quite inelastic based on household data. For example Hansson and Stuart (1985) surveyed about 40 studies and calculated a median uncompensated supply elasticity of 0.1 and a compensated supply elasticity of 0.25. In an comparable effort Fullerton derived a supply elasticity of 0.15. Again, aggregated labor supply studies estimate much higher elasticities. For example Kimmel and Knieser find that a 1 % change in wage rates will reduce the hours worked by each employee by 0.5 %, but will also reduce the number of employees by 1.5 %. While the first number is comparable to the elasticity estimated in most cross section analyses as reviewed by Hansson and Stuart or Fullerton, the second number refers to the aggregated effect of a wage change. Using aggregated data of 22 OECD countries Hansson and Stuart (1993) derive aggregated uncompensated labor supply elasticities between 0.2 and 1.4, and compensated supply elasticities between 0.96 and 2. For Austria they report an

[1] Eleven different studies were reviewed.

uncompensated elasticity of 0.76 and an compensated elasticity of 1.5. Therefore, it is assumed that the food industry labor supply elasticity is somewhere in the wide range of 0.1 to 1.5.

Estimations of supply elasticities for durable goods and operating inputs are more or less absent from the literature. To our knowledge the only exception is an estimate of the supply elasticity of farm machinery for milk production in the UK by Dryburgh and Doyle of 1.88. While some studies from a theoretical point of view assume that supply of these goods is perfectly elastic (at least in the long run), others assume values typically in a range between 1 and 3 (e.g. Gardner, 1987; Maier, 1993). We follow the latter and assume a range between 1 and 3.

In accordance with a recent elaborated study for Austria (Wüger), as well as multiple studies for other European countries, the demand elasticity of bread grains products is assumed to be in the range of – 0.1 to – 0.6 (Table 1). Neunteufel and Ortner estimate own-price elasticities for feed wheat and feed rye of – 0.932 and – 1.427, respectively. Since the ratio of feed wheat to feed bread grains is 78 %, the elasticity of bread grains for feeding purposes is assumed to be – 0.932*0.78 + 1.427*0.32 = 1.041. This value is about in the middle of reviewed values which range from – 0.3 to – 2.

According to Sexton and Lavoie most empirical studies on market power in food processing find relatively small departures from competition. There has been little detailed study of industries that supply manufactured inputs to agriculture. According to McCorriston the actual observed behavior of input industries (fertilizer, tractor) in the UK was significantly more competitive than the Cournot outcome. Given this we assume a moderate mark-up behavior of food industry as well as input industries with $0.7 \leq \psi \leq 1$.

Table 1 summarizes the parameters derived from estimations and taken from the literature. Using these elasticities the model is calibrated, in order to match the three year averages of the prices and quantities over the period 1991 - 1993.

Bread Grains Policy

Government intervention in Austria's bread grains market is illustrated in Figure 1; D_{fo} is the domestic demand for bread grains for food production, D is the total domestic demand for bread grains including demand for feeding purposes, S is the domestic supply, S_t is the domestic supply given the fertilizer tax, and D_w/S_w is the foreign demand/supply line, both perfectly elastic at the prevailing world-market price because of the small-country assumption. Since 1988 farmers obtain a high floor price (P_{QD}) only for a specific quota Q_Q rather than the whole production. However, since farmers have to pay a co-responsibility levy (CL_{PQD}) the net producer price is $P_{QD} – CL_{PQD}$. Quantities, which exceed the quota, can be delivered at a reduced net floor price $P_E – CL_{PE}$. Food processors have to buy bread grains at the high price P_{QD}, while the price of bread grains for feeding purposes is P_E. Therefore, domestic demand for bread grains for food production is Q_D, domestic demand for feeding purposes is Q_E and exports are $Q_X = Q_S – Q_D – Q_E$.

3. Empirical Results

To test how efficient the Austrian bread grains policy was in supporting farm income a method developed by Bullock and Salhofer is utilized. In particular it is assumed that government tries to maximize welfare of nonfarmers (U_{NF}) given a socially demanded level of farmers welfare.[2] Assuming that this socially demanded welfare level of farmers (U_F) is reflected in the actually observed level (U_F^A), and that the policy instruments available to government are the actually used instruments, government’s decision problem can be formalized as:

(1) $$\max_{(P_{QD},P_E,CL_{PQD},CL_{PE},Q_Q)} U_{NF} \qquad \text{s.t. } U_F = U_F^A .$$

[2] Note that equally one could describe government’s optimization problem as maximizing social welfare (or minimizing social cost), given a certain amount of farmer’s welfare.

Beside supporting farm income, "securing a sufficient supply and quality of bread grains products and animal feedstuffs" was an important explicit goal of Austria's bread grains policy. In accordance with this objective a self-sufficiency constraint is introduced which requires that total domestic demand never be greater than domestic supply. Since the official goal of introducing a tax on fertilizer was soil protection rather than income redistribution, this policy instrument is kept at the current intervention level. Hence, government can freely choose the levels of five policy instruments (P_E, CL_{PE}, P_{QD}, CL_{PQD}, Q_Q) to redistribute income at the lowest possible social cost.

Comparing the welfare level of nonfarmers derived in this optimization problem (U_{NF}^*) to their actual welfare level (U_{NF}^A) measures the social cost of suboptimal combination of policy instruments (SCSC) or reveals the potential welfare gains to nonfamers from using the same instruments at alternative levels:

(2) $SCSC = U_{NF}^* - U_{NF}^A$.

The higher these social cost are the less efficient the actual policy turns out to be.

Optimization problem (1) is solved numerically for 1000 different random draws of parameters values within the ranges discussed above using the model described in the previous section, standard welfare measures and GAMS software (Brooke et al.). By doing so, we are able to derive a distribution of possible SCSC rather than a point estimate.[3] As depicted in Figure 2 at the mean the government could have improved social welfare by ATS 2,002 million. As implied by a skewness of 0.02 and a kurtosis of 3.09 the distribution of these potential welfare improvements is close to a normal. Hence, given a standard deviation of ATS 196 million in about 950 of the 1000 simulations the potential welfare improvements lie between ATS 1,666 and ATS 2,341 million. These numbers

[3] Similar methods to derive a distribution of welfare measures rather than point estimates are discussed in more detail in Zhao et al. .

are quite high if one considers that the welfare of bread grains farmers is estimated to be between ATS 817 million and ATS 2,043 million, with a mean of ATS 1,358 million.

To get some idea how parameters influences the results the parameter values of the 1000 simulations are regressed against the SCSC. Taking logarithms allows an interpretation in percentage changes. It turns out that the most important parameter is the factor share of the agricultural product in producing food. A ten percentage increase in factor share, e.g. from 0.32 to 0.352 would increase the potential welfare improvements at the average by ATS 165 million what is a little bit less than one standard deviation. Other important factors are the mark-up coefficients. For example a ten percentage decrease of the mark-up coefficient for food industry, e.g. from 1 to 0.9 would decrease the SCSC by ATS 93 million.

4 Summary and Conclusions

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 grains policy was quite inefficient in supporting farm income. In fact, the potential welfare gains from using the same policy instruments, but at efficient levels, are estimated to be significant larger than the estimated welfare of the supported group. Observing that government was very inefficient in achieving the explicitly stated objectives of agricultural policy stimulates the discussion about implicit policy objectives.

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Table 1   Summary of Derived Parameters

Parameter	Value	Parameter	Value
Production Elasticity of Farm Labour	0.32 - 0.37	Supply Elasticity of Agricultural Labour	0.1 - 1.5
Production Elasticity of Land	0.05 - 0.10	Supply Elasticity of Land	0
Production Elast. of Durable Goods in Agriculture	0.12 - 0.17	Supply Elasticity of Durable Goods in Agriculture	1 - 3
Production Elasticity of Operating Inputs	0.41 - 0.46	Supply Elasticity of Operating Inputs	1 - 3
Production Elast. of Food Industry Durable Goods	0.40 - 0.45	Supply Elasticity of Food Industry Durable Goods	1 - 3
Production Elasticity of Food Industry Labour	0.30 - 0.35	Supply Elasticity of Food Industry Labour	0.1 - 1.5
Production Elasticity of Bread Grains	0.20 - 0.30	Mark-up Coefficient of Operating Inputs Industry	0.7 - 1
Demand Elasticity of Food	–0.1 - –0.6	Mark-up Coefficient of Durable Goods Industry	0.7 - 1
Demand Elasticity of Feed	–0.6 - –1.5	Mark-up Coefficient of Food Industry	0.7 - 1

Table 2: Sensitivity Analysis

Dependent Variable: logarithm of SCSC

Independent Variables In Logarithms	Coefficient	Std. Error	t-Statistic	Prob.
Constant	9.119144	0.060138	151.6362	0.0000
Factor share land	-0.003395	0.002768	-1.226561	0.2203
Factor share agr. Durable goods.	0.085335	0.005497	15.52335	0.0000
Factor share labor	0.049709	0.013217	3.761098	0.0002
Factor share operating inputs	0.209993	0.016380	12.81973	0.0000
Factor share food industr. labor	-0.025154	0.028506	-0.882424	0.3778
Factor share bread grains	0.823972	0.012810	64.32244	0.0000
Supply elast. agr. durable goods	-0.042709	0.001769	-24.13611	0.0000
Supply elast. agr. labor	0.017378	0.000801	21.70742	0.0000
Supply elast. operating inputs	-0.124841	0.001810	-68.96104	0.0000
Sup. elast. food industr. durable goods	-0.002105	0.001791	-1.175333	0.2401
Supply elast. food industr. Labor	-0.001488	0.000819	-1.817657	0.0694
Demand elast. of feed[a]	0.001637	0.002061	0.794332	0.4272
Demand elast. of food[a]	0.061019	0.001123	54.31747	0.0000
Mark-up coeff. food industr.	0.462210	0.005233	88.32007	0.0000
Mark-up coeff. durable goods industr.	0.028349	0.002867	9.886364	0.0000
Mark-up coeff. operating inputs industr.	0.211476	0.005325	39.71573	0.0000
R-squared	0.959805	Mean dependent var		7.598963
Adjusted R-squared	0.959151	S.D. dependent var		0.084974
S.E. of regression	0.017174	Akaike info criterion		-5.273962
Sum squared resid	0.289939	Schwarz criterion		-5.190530
Log likelihood	2653.981	F-statistic		1467.058
Durbin-Watson stat	2.077752	Prob(F-statistic)		0.000000

a) Demand elasticities are in logarithms of absolute values.

Figure 1 Austrian Bread grains policy

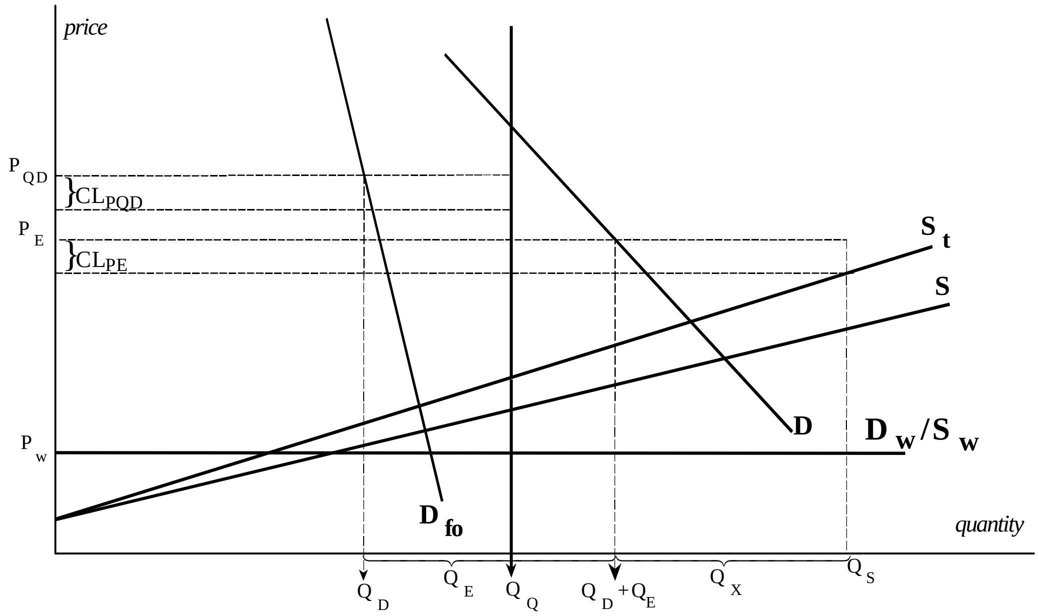

Figure 2 Distribution of Welfare Gains from an Optimal Policy