COMPARING SUPPLY SYSTEMS DERIVED FROM A SYMMETRIC GENERALIZED MCFADDEN PROFIT FUNCTION TO ISOELASTIC SUPPLY SYSTEMS: COSTS AND BENEFITS

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Abstract

A major drawback of constant elasticity supply and demand systems, which are widely used in simulation models for applied policy analysis, is that they can't be restricted to globally comply with certain conditions implied by economic theory. This paper compares constant elasticity systems to supply and demand systems derived from second order flexible functional forms (FFFs). Furthermore, supply systems in the model CEEC-ASIM, which are derived from a specific FFF, the Symmetric Generalized McFadden (SGMF) profit function, are assessed and compared to constant elasticity supply specifications which exhibit the same supply elasticities at the point of calibration.

1 Introduction

Second order flexible functional forms (FFFs) have been widely used since the 1980s for econometric estimation of agricultural and food product supply and demand systems. They have, however, been used to only a limited extent in applied agricultural sector models. The Central and Eastern European Countries Agricultural Simulation Model (CEEC-ASIM, Wahl et al. 2000; Frohberg and Winter, 2004) is a modelling framework with independent country modules used in applied agricultural policy analysis with supply and demand systems derived from second order flexible profit functions (Symmetric Generalized McFadden) and expenditure functions (Normalised Quadratic, and, more recently, the Normalised Quadratic-Quadratic Expenditure System; Frohberg and Winter, 2004). In CAPSIM (Witzke and Zintl, 2003) and CAPRI (Britz, 2004), supply and demand systems are also derived from FFFs, i.e. from a Normalized Quadratic profit function and a Generalized Leontief expenditure function, respectively. Yet most large-scale behavioural agricultural sector models rely on constant elasticity supply and demand systems, which cannot be derived from a profit or expenditure function without losing flexibility and being restricted in parameters to implausible values. Examples are the OECD Aglink model (OECD, year unknown), the Iowa State FAPRI model, the FAO World Food Model (FAO, 2001), the University of Göttingen/Humboldt-University of Berlin/USDA/European Commission European Simulation model (ESIM) (Banse, Grethe and Nolte, 2005; Münch 2002), the Penn State Trade Model (Stout and Abler, 2003) and many others. A major drawback of constant elasticity supply and demand systems is that they cannot be restricted to globally comply with certain conditions implied by economic theory. Why are they still so widely used?

This paper deals with this question using two approaches. Section 2 reviews the advantages and drawbacks of supply and demand systems derived from FFFs compared to constant elasticity systems from a theoretical and pragmatic point of view. Second, the supply systems in the model CEEC-ASIM, which are derived from one specific FFF, the Symmetric Generalized McFadden (SGMF) profit function, are assessed and compared to constant elasticity supply specifications. To this purpose, a constant elasticity version of CEEC-ASIM is set up in which sets of elasticities correspond exactly to the supply response of the SGMF version at the point of departure. The SGMF in CEEC-ASIM is calibrated to fulfil the convexity in prices property (curvature) globally in order to be consistent with profit maximising behaviour. Using the corresponding sets of elasticities in the constant elasticity version means that this version of CEEC-ASIM guarantees fulfilment of curvature properties and symmetry of cross effects only locally. Section 3 of this paper describes the CEEC-ASIM model as well as the SGMF function and its properties in some detail. In Section 4, resulting supply response to changing producer prices and the development of supply elasticities along supply functions are then compared under systematic price variation. Furthermore, different specifications of the SGMF which result in different curvature properties of the derived netput functions are compared. Finally, some conclusions are drawn and an overview of further development of the topic is given in Section 5.

2 Theoretical and Pragmatic Discussion of Behavioural Systems Derived from FFF Compared to Constant Elasticity Systems

Supply and demand systems derived from second order FFF typically have the same number of free parameters that can take independent values that are restricted only by economic theory as constant elasticity supply and demand systems. In that sense, it is misleading to consider FFF systems more flexible than constant elasticity systems (Feger, 2000). A real gain in flexibility, in contrast, would be a higher order function which would have free parameters to depict alternative courses of elasticity development. The major drawback, instead, of constant elasticity systems, is their lack of global consistency with economic theory which results from the fact that they cannot be derived from any profit/expenditure function without implausible restrictions on elasticities and loss of flexibility. As a result, constant elasticity systems can only be locally restricted to fulfil the symmetry of cross price effects as well as the adding up and curvature conditions. But only homogeneity can be fulfilled globally, other restrictions are violated if one departs from the point of calibration.

The main benefit of applying FFFs, in contrast, is that they meet the symmetry condition intrinsically and can be restricted to meet other conditions locally and, to a different extent, globally. Symmetry of cross effects is ensured by definition if supply functions are derived from an underlying profit function, as second order derivatives of any twice differentiable function are symmetric. Linear homogeneity of the profit function in prices, which directly follows from profit-maximising rational behaviour, can easily be ensured by parametric restrictions or by normalisation, in which case all second order terms are divided by a price, the numéraire. Curvature requirements, i.e. convexity in case of a profit function, can be implemented by restricting the Hessian matrix to positive semi-definiteness. The method of choice for restricting the Hessian to semi-definiteness is the Cholesky factorisation, which allows for the restriction of any second order flexible functional form to meet curvature requirements locally. For some flexible functional forms such restricted curvature properties hold globally, for others the definiteness of the Hessian varies with changes in exogenous variables. Monotonicity, which is at the supply side a profit function which is nonincreasing in input prices and nondecreasing in output prices, cannot be restricted globally without losing flexibility. Lau's incompatibility theorem (Lau, 1986) shows that for a unit cost function there cannot be a linear-in-parameters functional form which can be restricted to fulfil all conditions following from economic theory and at the same time keep flexibility.

Furthermore, using FFF systems yields unambiguous welfare measures, whereas welfare measures calculated based on constant elasticity systems are dependent on the path of integration under the respective supply and demand functions in case of multiple simultaneous price changes due to the missing global symmetry property. Grethe (2004: 120) carries out a sensitivity analysis for the calculation of the compensating variation and changes in producers surplus in a constant elasticity agricultural sector model with respect to the path of integration. Under significant nonsystematic sector-wide price variations, maximal differences in the total compensating variation and the change in producer surplus resulting from a change in the path of integration are found to be 0.4%. The resulting net welfare change differs up to 2.7% with respect to the path of integration. This, however, is no more than the observation of a single, specific case which does not allow for generalisation.

In addition to benefits, some costs are involved in using supply and demand systems derived from FFF. First, the potentially higher complexity of supply and demand functions puts higher requirements on the soft- and hardware used to solve the respective model. Whether this is a real drawback in a situation with exponentially increasing computational capacity available on PCs is an open question. Large scale models CAPRI and CAPSIM run with supply and demand systems derived from Normalized Quadratic profit functions and Generalized Leontief expenditure functions, respectively. These specific FFFs yield linear supply and input demand functions and relatively simple household demand functions which save on computational capacity compared to more complex functions, for example those derived from a SGMF function.

Second, the course of behavioural functions differs: elasticities calculated from FFF systems develop in the course of the function instead of being constant. The non-constancy of elasticities property may be considered a cost or a benefit from a simulation modeler's point of view, depending on whether the development of elasticities implied by the second order FFF at hand over the domain of intended simulations is considered more or less consistent with a priori assumptions regarding consumer and producer behaviour than the constant elasticity assumption.

Third, while it is straightforward to separate a yield and an area allocation component in constant elasticity supply systems, supply systems derived from FFFs usually do not differentiate between yield and area effects. This, however, is not a principal drawback of FFF systems, but rather a missing modelling effort. For example in CAPSIM, area allocation functions are derived from an area restricted Normalized Quadratic profit function. Dual values of the area restriction, in turn, are deducted from revenues, and the resulting net revenues are explaining variables of the profit function. Yield is exogenously determined (Witzke and Zintl, 2003).

And finally, a constant elasticity model is easier to interpret, and less easy to explain to non-modellers. Explanations like "the own price has fallen by 30% and the feed cost index has increased by 20%; in the light of an own price elasticity of 0.8 and a feed cost elasticity of -0.3 the projected decrease of beef production by about 30% seems…." become more complicated in any model with non-constant elasticities. It may be possible to roughly keep in mind the most important elasticites in large scale models, but less so their course in cases of non-constancy. The results of FFF models are therefore often less easy to track than constant elasticity specifications.

3 Empirical Evaluation: The Model Framework

3.1 Model Description CEEC-ASIM

For the empirical evaluation of different model specifications with respect to functional form of supply, the Poland component of CEEC-ASIM is used. CEEC-ASIM is a system of 14 individual country modules, covering the supply of 12 agricultural products, 5 intermediate inputs, and labour. The supply and input demand equations of CEEC-ASIM are derived from a Symmetric Generalised McFadden profit function, which belongs to the class of functional forms that are flexible up to the second order derivatives with respect to prices. Also consumer demand functions are derived from an FFF, the Normalised Quadratic expenditure function. Price transmission equations provide links between border, farm gate, and retail prices. Due to the small-country assumption, border prices are exogenous to the model. A detailed description of CEEC-ASIM in the version applied in this study is provided in Wahl et al. (2000).

The parameters of the supply and demand system of CEEC-ASIM are not econometrically estimated but are calibrated, as is the case for most applied agricultural sector models. Calibration means that the model can reproduce the base year quantities at base year prices while meeting the conditions of homogeneity, symmetry, adding up, and curvature that are necessary to represent profit and utility maximising behaviour. For the calibration of the profit and expenditure functions, initial sets of supply/input demand elasticities and demand elasticities are determined based on expert knowledge. The initial elasticity sets need not be consistent with microeconomic theory but should give some indication of the magnitude of the supply and input demand reaction to changing prices and of the food demand reaction to changing prices and income. The calibration procedures adjust the initial uncalibrated elasticities in order to make them comply with microeconomic theory. This means that the matrix of the second order derivatives of the profit function with respect to the prices (Hessian Matrix) is symmetric and positive semidefinite, and that the supply and input demand functions are homogenous of degree zero in prices. On the demand side, compliance with microeconomic theory means that the matrix of the second order derivatives of the expenditure function with respect to prices is symmetric and negative semidefinite, the uncompensated (or Marshallian) demand functions are homogenous of degree zero in prices and income, and the expenditure shares for the commodities add up to one.

All these constraints are implemented within a non-linear programming approach, which seeks to minimise the deviations of the final calibrated elasticity sets from the initial uncalibrated ones. A more detailed description of this calibration procedure is given in Wahl et al. (2000). Table 1 presents selected own and cross price elasticities of supply in the Poland module of CEEC-ASIM. Polish supply elasticities in CEEC-ASIM are set at relatively low levels for most products, especially for animal products. Supply responses are compared among supply systems based on these elasticities and the respective parameters of a SGMF supply system which meets these elasticities in the base situation in a later section.

Table 1: Selected Own and Cross Price Elasticities of Supply of the Poland Module of CEEC-ASIM

Product	Own price elasticity of supply	Most significant cross price elasticity
Wheat	0.40	-0.20 (coarse grains)
Coarse Grains	0.11	-0.13 (wheat)
Potatoes	0.15	-0.08 (pork)
Oilseeds	0.15	-0.12 (vegetables)
Sugar	0.41	-0.38 (wheat)
Milk	0.28	-0.08 (pork)
Beef	0.19	0.07 (milk)
Pork, eggs, poultry meat	0.23 - 0.32	-0.06 - (-0.13) (milk)

3.2 The Symmetric Generalized McFadden Profit Function

The Symmetric Generalized McFadden Function has been introduced by Diewert and Wales (1987) for the example of a cost function. As a profit function, the SGMF takes the following form:

$$(1)\quad \pi(P)=\sum_s \beta_s P_s + \frac{1}{2}\frac{\sum_s\sum_t \zeta_{s,t} P_s P_t}{\sum_s \alpha_s P_s}$$

where

π = profit

P = price

α, β, ζ = parameters. (In parameter notation we follow Wahl et al., 2000, instead of Diewert and Wales, 1987.)

s, t = index for outputs and inputs = 1,…,N; with N being the number of outputs and inputs.

The SGMF profit function is linear homogeneous in input and output prices. Convexity can be imposed by restricting the ζ -matrix to positive semidefiniteness e.g. by using the Cholesky decomposition and holds globally. First order derivatives with respect to input and output prices yield input demand and supply functions, respectively, which take the form:

$$\text{(2)}\quad \frac{\partial \pi(P)}{\partial P_s} = Q_s(P) = \beta_s + \frac{\sum_t \zeta_{s,t} P_t}{SAP} - \frac{1}{2}\frac{\alpha_s \sum_s \sum_t \zeta_{s,t} P_s P_t}{SAP^2}$$

with SAP (Sum (α •Price)) $=\sum_s \alpha_s P_s > 0$; $\zeta_{s,t} = \zeta_{t,s}$; $\alpha_s \geq 0$; and $\sum_t \zeta_{s,t} P_t = 0.$,

and Q = supply quantity (if Q > 0) or input demand quantity (if Q < 0).

The resulting netput functions are homogeneous of degree zero in prices and first order derivatives are symmetric. Each netput function Q_s has one level parameter β_s, N gradients $\zeta_{s,t}$ and one parameter α_s. (with also all α in the normalization term, which is equal for all Q_s). With respect to the α_s parameters, Diewert and Wales (1987: 54) state that they "may be selected by the investigator" and "should be measured in units of input . . .in order to ensure invariant elasticity estimates". They elaborate that the modeller should "e.g., choose $[\alpha_i] = \overline{x}_i$, the average amount of input i utilised over the sample period" (in a cost function as well as econometric context). Based on this statement, the α_s in CEEC-ASIM are set at the base quantity of the respective netput to which the model is calibrated:

$\alpha_{output} = Q_{output}$; $\alpha_{input} = -Q_{input}$.

Price elasticities of supply and input demand derived from (2) are:

$$\text{(3)}\quad \frac{\partial Q_s(P)}{\partial P_t}\frac{P_t}{Q_s} = \left(\frac{\zeta_{s,t}}{SAP} - \frac{\alpha_s \sum_t \zeta_{s,t} P_t - \alpha_t \sum_s \zeta_{t,s} P_s}{SAP^2} + \frac{\alpha_s \alpha_t \sum_s \left(\left(\sum_t \zeta_{s,t} P_t \right) P_s \right)}{SAP^3} \right) \frac{P_t}{Q_s}$$

Supply and input demand functions of the constant elasticity specification which we employ, take the form:

$$\text{(4)}\quad Q_s(P) = \chi_s \prod_t P_t^{\delta_{s,t}},$$

with $\delta_{s,t}$ being the supply elasticities of netput s with respect to the price of netput t. Each netput function Q_s has one level parameter χ_s, and N elasticites, and, therefore, one parameter less than the respective netput function derived from a SGMF profit function.

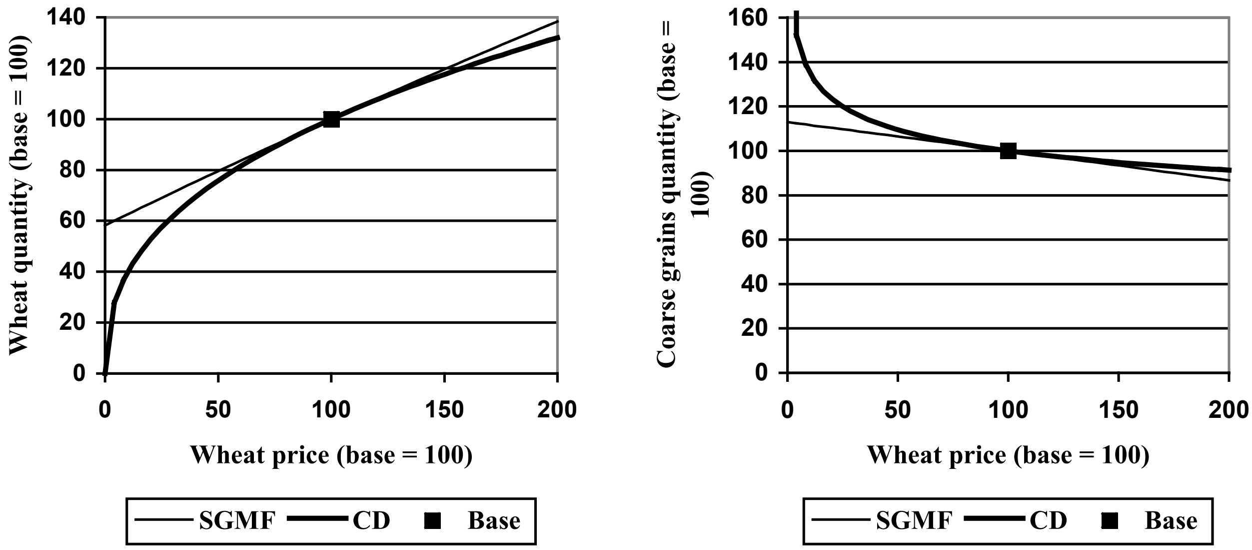
4 Results: Supply Systems Derived from a SGMF Profit Function Compared to Isoelastic Supply Systems in CEEC-ASIM

4.1 Course of Functions and Elasticities for CEEC-ASIM Base Elasticities

For the comparison of both supply specifications, supply functions in the CEEC-ASIM module for Poland are calibrated to the same set of elasticities and base data at the point of departure in order to limit differences to those resulting from functional form and minimise differences which would be simply due to different base parameters. An alternative approach for a comparison of the two supply systems would be to estimate supply systems of both functional forms based on the same data set. This is, however, beyond the scope of this article and may require supply and price data from a non-transformation country, which may allow for longer time series.

Graphs 1 and 2 below depict supply functions in CEEC-ASIM for wheat and coarse grains with respect to the wheat price derived from the SGMF profit function as well as the respective constant elasticity specifications.

Graphs 1 and 2: Supply Response of Wheat and Coarse Grains to Wheat Price Changes

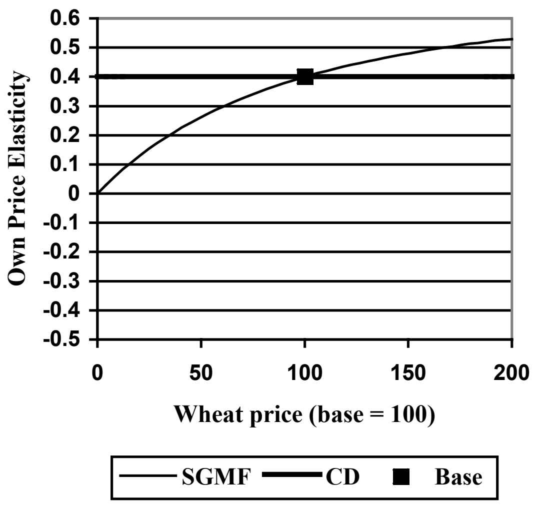


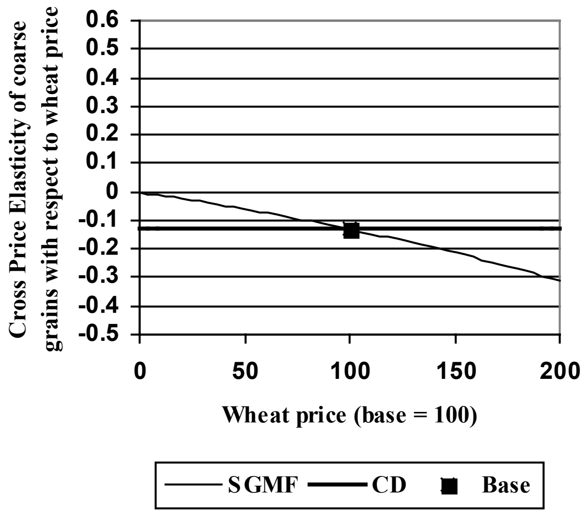
Graphs 1 and 2 show that the SGMF yields supply functions which are almost linear in prices. Deviations of supply between the SGMF and the constant elasticity pendant (refered to as "CD", for Cobb-Douglas) supply system are small for price variations between 50 and 150% of the base price. Systematic isolated variation of prices for all products which are included in CEEC-ASIM by +/-20% lead to deviations in supply response compared to the base situation between 0.46 and -0.92 percentage points under the SGMF system compared to the constant elasticity system.

At a first glance, the own price reaction implied by the CD supply function is more consistent with a priori plausibility considerations: the supply curve is getting flatter with increasing own price, which would reflect wheat production getting more constrained by physical limits. On the other hand, the supply function is very steep with low prices: below a certain price level wheat production is no longer profitable and production falls heavily. A supply level of 60% of the base situation in a situation with a price of zero, as implied by the supply function derived from the SGMF, seems implausible. On the other hand, the empirical foundation of behavioural parameters far outside the range of historically observed price-quantity combinations is extremely limited. Therefore simulation models based on behavioural equations are less than suitable for simulating within that domain.

Graphs 3 and 4 below show the course of supply elasticities derived from the SGMF in CEEC-ASIM and constant supply elasticities of the respective CD function.

Graphs 3 and 4: Own and Cross Price Supply Elasticities with Respect to the Wheat Price



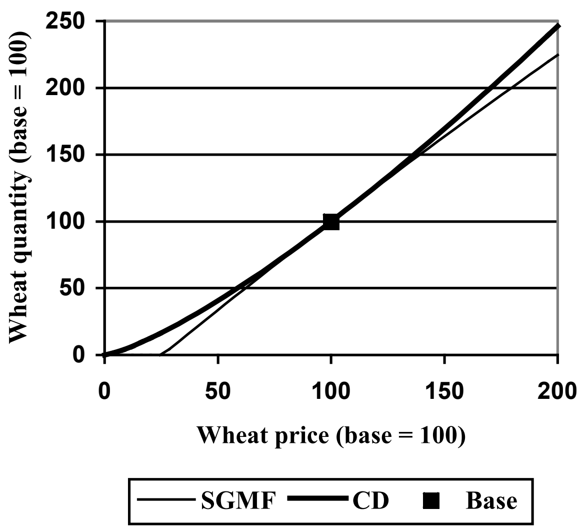


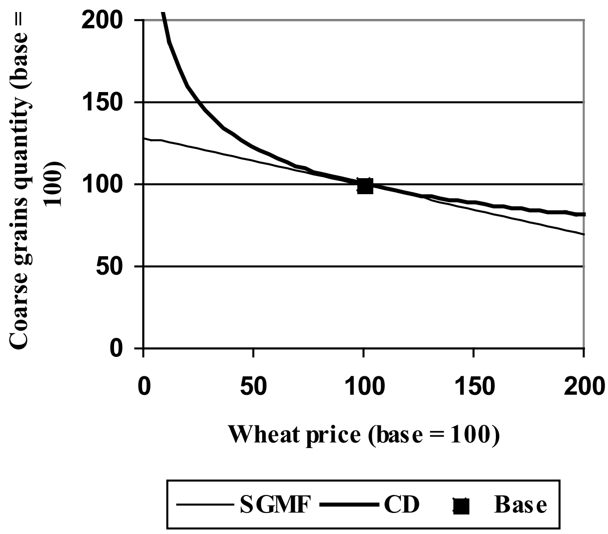
Graphs 3 and 4 simply reflect the development of elasticities along linear curves. In Graph 3, for an (almost) linear increasing SGMF supply curve (Graph 1) with a positive intercept on the y-axis, the elasticity starts at zero and approaches 1 if price $\rightarrow \infty$. In Graph 4, for an (almost) linear decreasing SGMF supply curve (Graph 2), the price elasticity starts at zero and approaches $-\infty$ for price $\rightarrow \infty$. The own price elasticity of supply of wheat is 0.4 in the base situation, 0.26 at 50% of that price level, and 0.54 at 200% of the base price. The cross price elasticity of coarse grain supply with respect to the wheat price is -0.13 in the base situation, -0.06 at 50% of that price level and –0.31 at 200% of the base price.

4.2 Course of Function and Development of Elasticities for Higher Base Elasticities

As described above, supply elasticities used to calibrate CEEC-ASIM are rather low, especially for animal products. In order to get a feeling for how the level of elasticities influences the differences between CD and SGMF specifications, the matrix of initial supply elasticities is multiplied by a factor three, calibrated again to theoretical consistency, and translated into SGMF parameters. Graphs 5 and 6 depict supply functions for wheat and coarse grains with respect to the wheat price derived from the SGMF profit function as well as well as the respective constant elasticity specifications.

Graphs 5 and 6: Supply Response of Wheat and Coarse Grains to Wheat Price Changes, CEEC-ASIM Base Elasticities Multiplied by 3



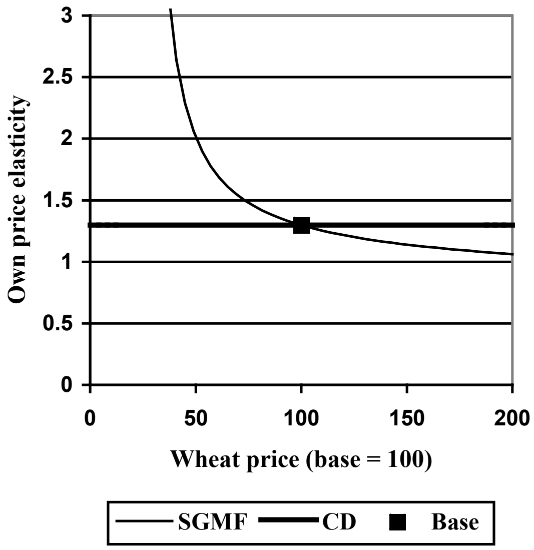


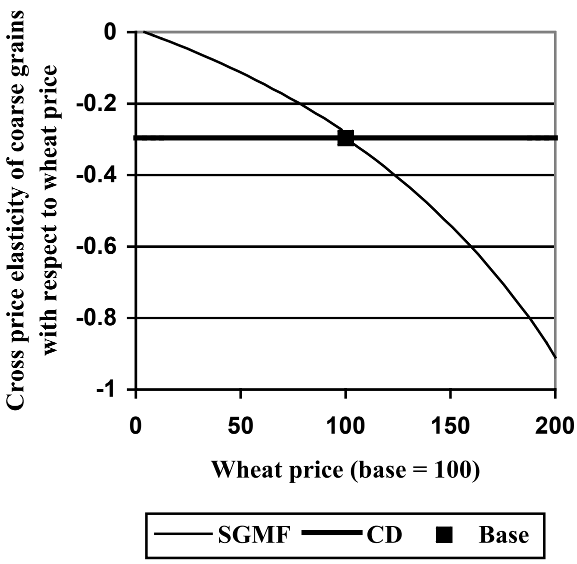
Graph 5 shows that deviations of supply are small for variations between 50 and 200% of the base price. This is because the own price elasticity for wheat is 1.2 which yields a rather linear constant elasticity supply function which meets the supply function derived from the SGMF (between 50 and 200% of the base price) quite well. In the lower part of the function, however, deviations are stronger as the supply function derived from the SGMF has a negative intercept on the y-axis and therefore no production takes place at a price below 25% of the base level. Graph 6 shows that deviations of coarse grain supply responses to a changing wheat price are small, between 50 and 150%, but significant outside this range, especially at extremely low wheat prices.

Systematic isolated variation of prices for products included in CEEC-ASIM of between -20 and +20% lead to deviations in supply between 0.5 and -5 percentage points between the two specifications with respect to functional form compared to the base situation. Maximum deviations are thus significantly higher than for lower supply elasticities; whether this holds generally is considered below.

Graphs 7 and 8 below show the course of supply elasticities derived from the SGMF in CEEC-ASIM and constant supply elasticities of the respective CD function in the version with higher base elasticities.

Graphs 7 and 8: Own and Cross Price Supply Elasticities with Respect to the Wheat Price, CEEC-ASIM Base Elasticities Multiplied by 3





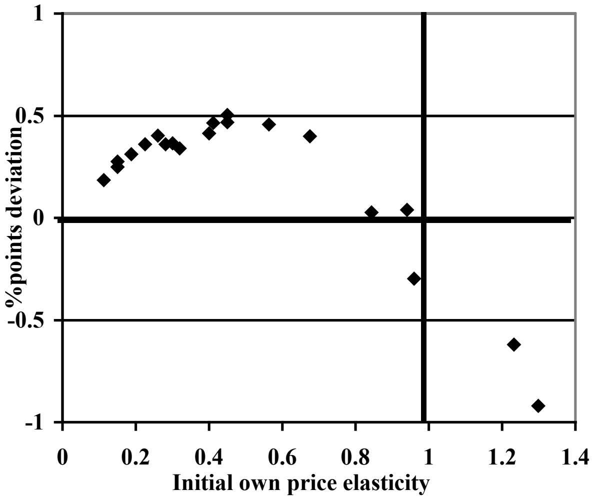
Graphs 7 and 8 again reflect the development of elasticities along linear curves. In Graph 7, for an increasing (almost) linear SGMF supply function with a negative y-intercept, the supply elasticity is ∞ at a price of zero and approaches 1 if price → ∞. The development of the supply elasticity in the course of the SGMF supply function in Graph 8 equals that in Graph 4. Relative deviations from the base elasticity of -0.29 are stronger than in case of the lower initial elasticity presented in Graph 4.

4.3 Relationship between Size of Elasticities and Deviation of Supply Response

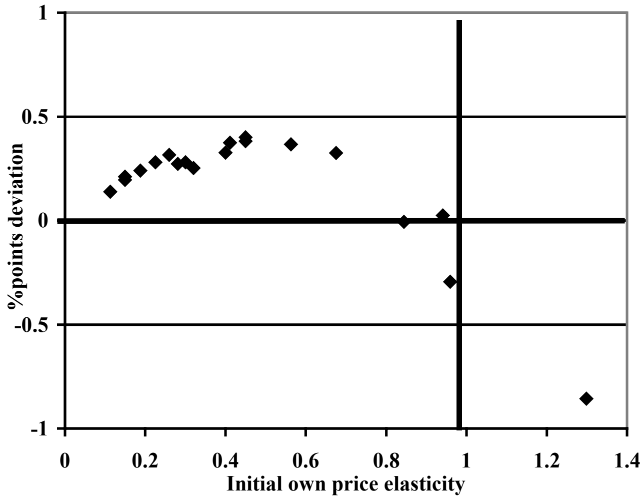
In order to look at the general relationship between the size of deviations in supply response between the two specifications and the size of initial elasticities prices for all products covered by CEEC-ASIM are varied separately by +/-20%. The percentage points of deviation in own price response under these price variations is graphed in Graphs 9a and 9b against the size of initial own price elasticities.

Graphs 9a and 9b: Percentage Points of Deviation in Own Price Response in Relation to Initial Own Price Elasticity

a) Decreasing own price



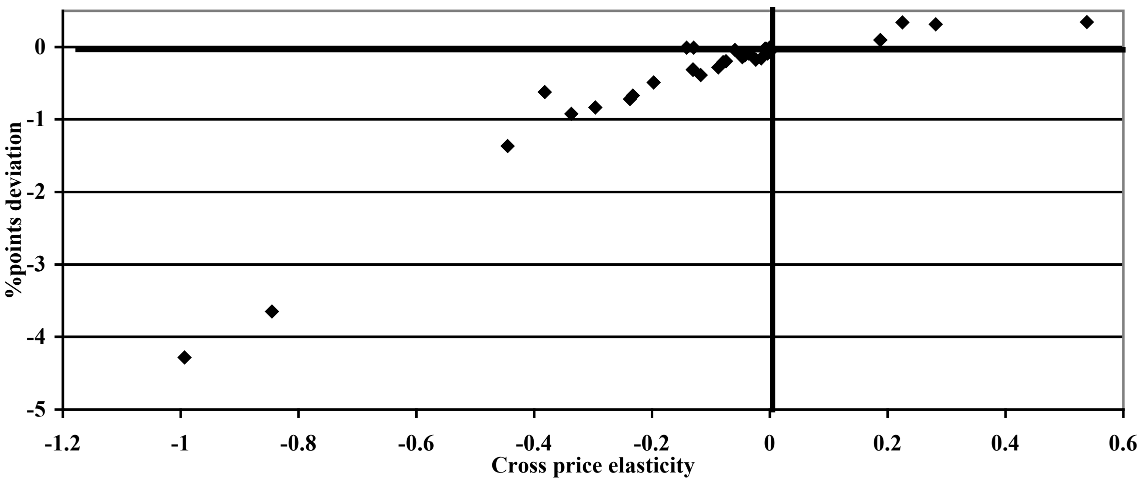
b) Increasing own price



Graphs 9a and 9b show that supply functions derived from the SGMF yield higher supply quantities of about 0.1 to 0.5 percentage points than the CD functions for initial own price elasticities below 1. This reflects the course of the two specifications as depicted in Graph 1 above. Deviations are increasing up to an initial own price elasticity of about 0.5. From there on, deviations are decreasing and for elasticities above one, supply quantities under the SGMF are smaller than under the CD specification, which reflects the course of the two specifications in Graph 5. Graphs 9a and 9b also show that deviations are slightly smaller in case of a price increase by 20% than a price decrease by 20%.

Graph 10 depicts percentage points of deviation in cross price response under the SGMF and the constant elasticity specification in relation to the size of the initial cross price elasticities. Deviations are shown for prices decreasing by 20%. Deviations with increasing prices are slightly smaller but similar and are therefore not reported here.

Graph 10: Percentage Points of Deviation in Cross Price Response in Relation to Initial Cross Price Elasticity



Graph 10 shows that for gross complements (positive cross price elasticities, beef and milk only) the deviation in the supply response under the SGMF compared to the CD specification is positive. For all substitutes, however, the deviation is negative, i.e. the supply response under the

SGMF yields higher supply quantities, which reflects the course of the respective functions as depicted in Graphs 2 and 6. In addition, the observation made above that a higher level of cross price elasticities yields a higher deviation of supply quantities (compare Graphs 2 and 6) seems to hold generally: Graph 10 shows a clear correlation between the level of the cross price elasticity and the deviation of the supply response in percentage points.

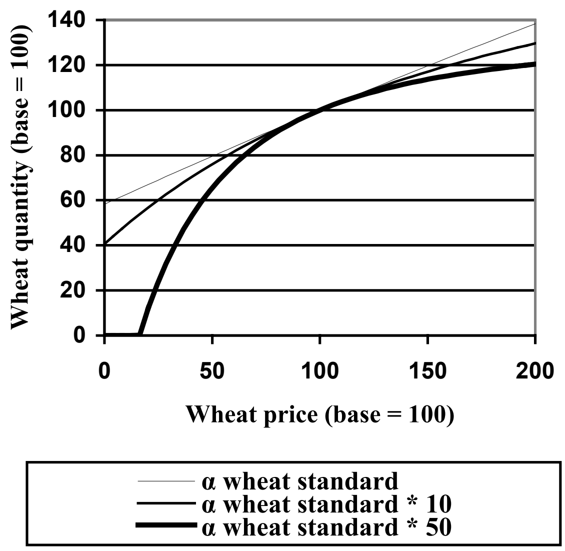
4.4 Course of Supply Functions Derived from the SGMF under Variation of the Normalisation Parameter

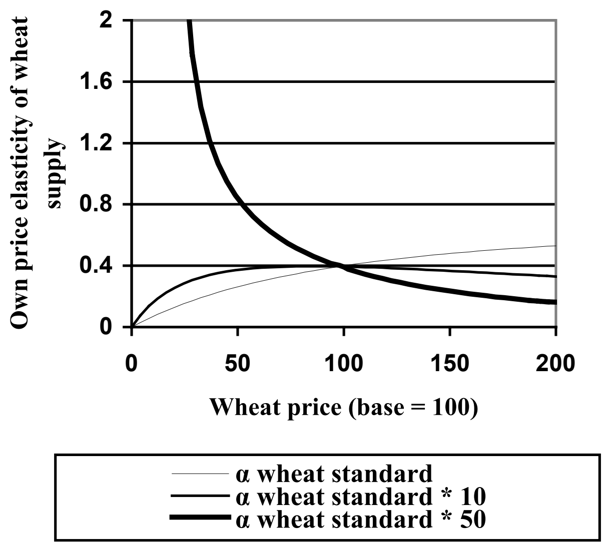
As shown above, the standard specification of the SGMF in CEEC-ASIM yields almost linear supply functions, which may be considered a disadvantage, especially in light of a large domain of simulations, which occurs when models are used for simulating effects of major policy changes, for example a reform of EU sugar market policies.

Therefore, the calibration of the SGMF system to the set of base elasticities is repeated under variation of the α_S parameters. As discussed above, Diewert and Wales (1987: 54) chose the α_S at the level of the base quantities, but considered this only an example, not a requirement. The CEEC-ASIM calibration mechanism meets the base elasticities and yields parameters for a SGMF profit function without problems if, instead of setting $\alpha_{output} = Q_{output}$ and $\alpha_{input} = -Q_{input}$, the α_S are set at higher levels, which results in supply functions being concave in their own price response. In order to depict this effect, two additional specifications for the supply function of wheat in CEEC-ASIM are compared to the original version: α_{wheat} multiplied by 10 and α_{wheat} multiplied by 50. For each specification the complete supply system is recalibrated.

Graphs 11 and 12 show results for the course of the wheat supply function and the development of elasticities along these functions with respect to the wheat price under these three variations.

Graphs 11 and 12: Wheat Supply Function and Development of Supply Elasticities under Different α_{wheat}

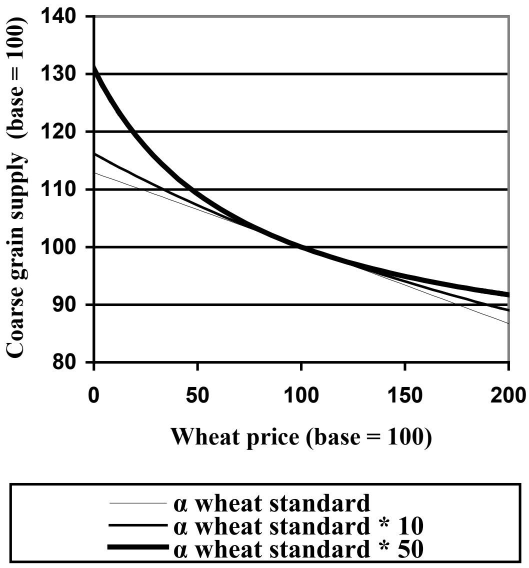


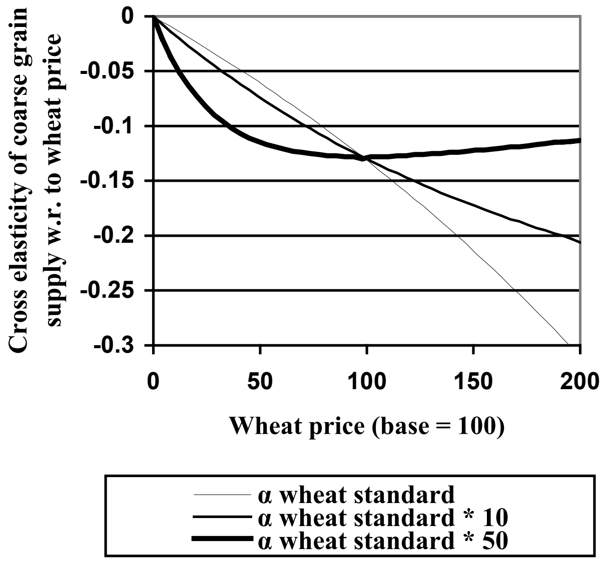


Graph 11 shows that the wheat supply curve can be calibrated to a wide range of curvatures by varying the α_{wheat} while meeting the calibrated base elasticity. In particular, a negative intercept on the quantity axis can be generated, implying that no production occurs below a certain base price, which may be consistent with a priori assumptions. Graph 12 shows the development of elasticities under the three curves.

There is however only one parameter α per netput function. So a changing curvature of the supply function in the own price for one product must also affect cross relationships of the respective product. And due to the symmetry of cross effects, this must also change the supply response of other products with respect to the price of the product, for which the α is changed. Graphs 13 and 14 depict this effect for coarse grains with a changing α_{wheat}.

Graphs 13 and 14: Coarse Grain Supply Functions with Respect to the Wheat Price and Development of Supply Elasticities under Different α_{wheat}





Graph 13 shows the supply response of coarse grains with respect to the wheat price. With an increasing α, the supply curve becomes more convex to the origin. Differences are relatively small up to a price variation of 50% from the base price. Graph 14 shows the development of the cross price elasticity of coarse grain supply with respect to the wheat price. Whereas the supply elasticity under higher α_{wheat} is closer to zero at prices above the base price, it is larger in absolute terms at prices below the base price. This must necessarily be the case due to the homogeneity condition, which requires the sum of all input and output price elasticities for one product to add up to zero. As Graph 12 shows, a higher α_{wheat} leads to a higher own price elasticity for wheat at prices below the base price. This also requires cross price elasticities of substitutes to be higher in absolute terms in order to fulfil homogeneity. Therefore, the symmetric cross price elasticities must be higher, which is the case for the cross price elasticity for coarse grains with respect to the wheat price, as shown in Graph 14.

The arbitrary variation of α_S, also described by Brosig (2000: 47) in an econometric context, seems an interesting option for including more a priori knowledge in the calibration process of the SGMF parameters than only including a set of elasticities. To a certain extent, additional information on the development of elasticites along the supply curve might be incorporated.

4.5 To What Degree Does the CD Approach Conflict with Theory?

The homogeneity requirement holds globally if it is locally implemented for the isoelastic supply systems. The concept of curvature does not fit isoelastic systems, as no integral can be found, which could fulfil the concavity requirement of the profit function. The symmetry condition is necessarily compromised under any price changes, as cross price elasticities are constant. Symmetry requires:

$$(5)\quad \frac{\partial q_i}{\partial p_j} = \frac{\partial q_j}{\partial p_i},$$

which can be ensured locally in a constant elasticity supply system by setting the cross price supply elasticity $\varepsilon_{j,i}$:

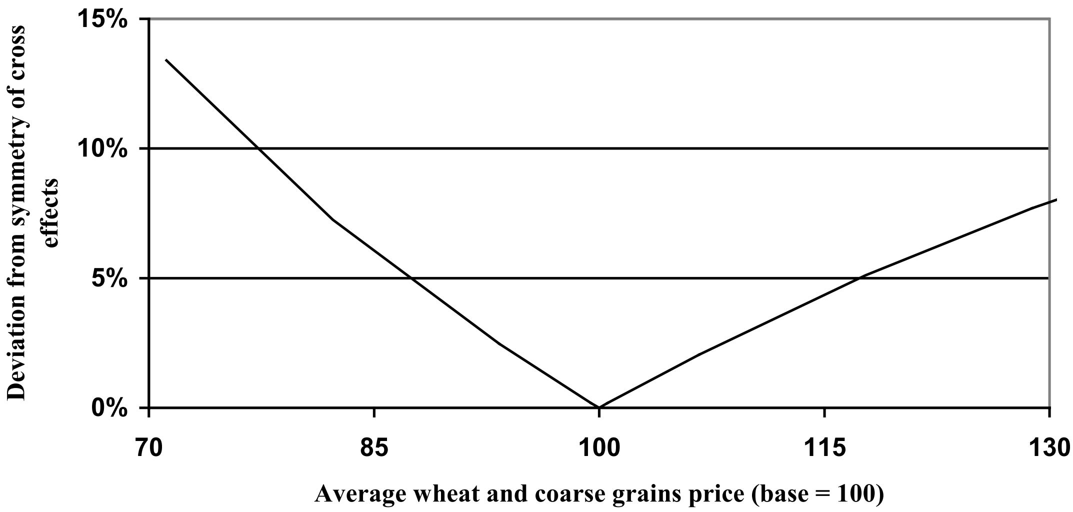
$$(6)\quad \varepsilon_{j,i} = \varepsilon_{i,j}\,\frac{p_i q_i}{p_j q_j}.$$

If $p_i\, q_i/p_j\, q_j$ changes during simulations, (5) not longer holds. Therefore, with changing price quantity combinations cross effects cannot be symmetric. To check to what extent the symmetry condition is hurt, we calculated the deviations of cross effects in absolute terms relative to the total price response under stepwise price variation by departing from the calibration point in 10% steps:

$$(7)\quad \left|\frac{dq_{wh}}{dp_{cg}} - \frac{dq_{cg}}{dp_{wh}}\right| \Big/ \frac{dq_{wh} + dq_{cg}}{2}.$$

Graph 15 displays these deviations at varying prices relative to the calibration point.

Graph 15: Deviation from Symmetry of Cross Price Effects between Wheat and Coarse Grains in CEEC-ASIM (Constant Elasticity Specification, Standard Elasticities)



Graph 15 shows that the absolute deviation from symmetry expressed relative to the total supply response increases almost linearly in the deviation from the base price situation in which symmetry holds locally. Deviations are considerable over the simulated domain of a change of +/- 30% in base prices. This hints at potentially significant deviations of welfare measures depending on the path of integration, because the path independency depends on the symmetry of cross effects.

5 Conclusions and Outlook

The above comparisons show that deviations in the supply response between supply systems derived from a SGMF profit function and constant elasticity systems are generally low for a domain for which most simulation models are typically used, say price variations of +/- 50% compared to the base situation. In addition, most simulation models usually apply mechanisms to ensure that total area used for crops stays constant compared to the base situation (Balkhausen et al., 2005), which further reduces any differences resulting from functional form. Nonetheless with high price variations deviations can become significant. For cross effects, deviations in supply response are higher, the higher the base elasticities for the respective products are in absolute terms. For own price effects, base supply elasticities below one tend to yield higher supply quantities under the SGMF with a varying price whereas the supply quantities are lower in case of base elasticities greater than one.

The standard specification of a SGMF supply system with the α_s set at the base quantities of the respective netputs yields supply functions which are almost linear in output prices. This may be considered a disadvantage, especially in light of a large domain of simulations, which occurs when models are used for simulating effects of major policy changes, for example a reform of EU sugar market policies. The variation of α_S therefore seems an interesting option to include more a priori knowledge in the calibration process of the SGMF parameters than including only a set of base elasticities. To a certain extent, additional information on the development of elasticities along the supply curve can be incorporated. For example, for the own price response a positive intercept with the price axis can be fixed as a second point through which the respective function would need to pass in addition to the calibration point, at which the slope must reflect the base elasticity. One must keep in mind, however, that such additional information also effects on cross price responsiveness.

Further work to shed light on the pros and cons of SGMF supply systems compared to constant elasticity supply systems is needed in several areas, including checking the technical practicability of SGMF systems in large scale models, comparing the size of respective welfare measures, and comparing results under "typical" policy simulation scenarios.

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