Substitutability of Energy in Austrian Agriculture.

Ulrich B. Morawetz and Martin Kniepert _
University of Natural Resources and Applied Live Science Vienna

1 Introduction

Firms can alleviate costs which are induced by climate policy in two major ways: first, they can adopt to changes in price relations by investing in new technologies and from learning by doing. Second, they can change the composition of their outputs and substitute inputs to adopt to new price relations. Both effects are crucial in general equilibrium climate modeling, but, as discussed in van der Werf (2007), quantitative, empirically based, measures have been rarely used. Never the less, the controversy on the substitutability of energy with other input factors has been going on at least since the energy crisis in the early 1970's (Berndt and Wood, 1975; Apostolakis, 1990) and has lead to many highly differing results. The differences can be explained by differing time horizons of various studies (Apostolakis, 1990) as well as the cost shares of energy which also depend on the model specification (Frondel and Schmidt, 2002). And, of course, for sector wise estimated production functions, the derived elasticity of substitution will also depend on the characteristics of the respective sector. The difficulties to derive empirically based elasticities of substitutions might have put off model builders from using them in their models. If climate policy costs for the Austrian agricultural sector were to be estimated in model similar to the bread grain policy model presented in Salhofer et al. (2006), empirical estimates for energy substitutability are needed. Yet, the number of empirically based estimations of elasticity of substitution for energy in Austrian agriculture are limited. We are only aware of the figures published in Neunteufel (1992) where only the substitutability of other inputs for energy is published.

2 Research Question

The purpose of this paper is to derive how well labor, capital, land and intermediate inputs can substitute energy in agriculture. Apart from being an interesting end in itself, it also is valuable input for climate policy models..

3 Methodological Framework

Austrian agriculture is dominated by small scale farms with the majority of work done by family members on land owned by the family or leased from other farmers. Consequently, no farm specific prices are observed for labor and land. Further, the extensive EU agriculture programs and the high share of part time farmers lead to non agricultural incomes which partly subsidize agricultural activities. These two circumstances make it hard to argue how cost or profit functions can be estimated since they assume cost minimization or profit maximization, respectively. Therefore, in this paper we directly estimate a production function instead. As such, the derived function is about the observed relation of inputs to outputs and does not need any assumptions about economic behavior.

As functional form for the production function the flexible translog is chosen,

$$(1) \qquad y = exp\left(\beta_0 + \sum_{n=1}^{5}\beta_n ln(x_n) + \frac{1}{2}\sum_{n=1}^{5}\sum_{m=1}^{5}\beta_{nm} ln(x_n) ln(x_m)\right)$$

where y is the output, and $x_1, \ldots, x_5$ are the input factors. The function will be statistically tested for structural properties such as homotheticity, homogeneity and separability of the inputs and, if appropriate, respective simplifications will be applied. To capture the panel structure of the data, the model will be extended by fixed or random effects. Based on the arguments of Stern (2004), the Allen Elasticity of Substitution is chosen as measure for substitutability.

4 Study Area and Data

The analysis is done with book keeping farm level panel data for approximately 2000 stratified Austrian farms from the years 1998-2006. Output is defined as revenue in Euro and input variables are land in ha, labor in average work force, capital as depreciation of the capital stock and intermediate inputs and energy use in Euros.

5 Expected Results

The results include the specification of the functional form of the production function for the Austrian agricultural sector as well as the derived marginal productivities, output elasticities and the determination of the substitutability (complimentarity) of the inputs. The main discussion in the paper will focus on the role of energy.

Literatur

Bobby E. Apostolakis. Energy–capital substitutability/complementarity : The dichotomy. *Energy Economics*, 12(1):48–58, January 1990.

Ernst R. Berndt and David O. Wood. Technology, prices, and the derived demand for energy. *The Review of Economics and Statistics*, 57(3):259–268–398, August 1975.

Manuel Frondel and Christoph M. Schmidt. The capital-energy controversy: An artifact of cost shares? *The Energy Journal*, 23(3):53–79, June 2002.

Marta G. Neunteufel. Faktornachfrage und technischer fortschritt im ¨osterreichischen agrarsektor. *Der F¨orderungsdienst*, 40(10):273–277, 1992.

Klaus Salhofer, Erwin Schmid, and Gerhard Streicher. Testing for the efficiency of a policy intended to meet objectives: General model and application. *Journal of Agricultural and Resource Economics*, 31(2):151–172, 2006.

David I. Stern. Elasticities of substitution and complementarity. Rensselaer, Working Papers in Economics 0403, Rensselaer Polytechnic Institute, Department of Economics, February 2004.

Edwin van der Werf. Production functions for climate policy modeling: An empirical analysis. Working paper 1316, Kiel Institute for theWorld Economy, March 2007.