Analysing stochastic dominance of soybean and maize production in Austria

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***Abstract* - Cultivation of legumes is expected to increase in the next years not only due to their agronomic and ecological advantages but also due to supportive policy measures of the Common Agricultural Policy (CAP). We apply a stochastic dominance analysis on gross margins of soybean and maize production in order to analyse the relative profitability in regional context. Field data from several hundred soybean and maize producers as well as statistical data on commodity prices are used for the analysis. Our approach allows us to assess and compare the profitability and risks of soybean and maize production in Austria and thus provide a decision support for farmers and outreach.**

Introduction and Outline

The European food and feed industry depends heavily on soybean and soymeal imports from the USA, Argentina and Brazil. According to FAOSTAT, the EU self-sufficiency ratio for soybeans amounted to a mere of 9% in 2011 (FAOSTAT, 2011). The latest CAP reform in 2013 has introduced policy measures that allow farmers to produce legumes on land that was previously set aside. These measures aim at increasing domestic soybean production and thus decreasing the European protein deficit (Bues et al., 2013; Europäische Kommission, 2013; Martinez, 2013). Details on the national implementation of the CAP reform are not agreed upon, yet.

Cultivating soybeans leads to an improvement of soil quality via nitrogen fixation, multifaceted crop rotation systems, and to a reduction of greenhouse gas emissions due to low fertilizer inputs.

The latest policy measures shall incentivize European farmers to increase domestic soybean production. In addition, effective risk management is one of the most important challenges farmers are concurrently facing. In recent years, an increasing degree of instability on global agricultural markets as well as expected changes in weather and climate conditions have drawn considerable scholarly attention to the exploration of risks farmers are exposed to. For example, different sources of income volatility in Austrian agriculture have been analysed in Strauss et al. (2012). The question arises whether soybean production with its known ecological advantages also meets the economic requirements farmers are taking into account when planning their production portfolios.

Our study aims at assessing the relative profitability of soybean production in comparison to maize production by contrasting the variability of gross margins by means of a stochastic dominance analysis. More than 5000 field data from several hundred soybean and maize producers are used in this analysis.

Similar risk analysis comparing six different crops have already been conducted by Eder et al. (1993) showing that the results of the first-degree stochastic dominance analysis depends on the level of coupled direct payments for certain crops. Archer et al. (2003) examined different sources of risk, i.e. production risk, timeline risk and institutional risk, and discussed options, among them government payments, to mitigate risks in agricultural production. Unlike in this work, they included correlations between each of the uncertain variables into the sampling procedure.

Data

We use two major data sets for our analysis. The first one includes observed data on crop yields, variable production costs and commodity prices for soybean and maize on field and farm level, which are provided by the working groups 'Agriculture' that are managed by the Austrian Federal Chambers of Agriculture from Upper Austria, Lower Austria, Burgenland, Carinthia and Styria. Data availability (e.g. number of observed farms) differ by working group and year. In total, a sample of about 1,155 soybean and 4,451 maize data entries collected between 2009 and 2013 are available. Data corrections have been undertaken in order to affirm their plausibility and comparability.

In addition, data on commodity prices has been derived from the Austrian Statistical Office for the time period 1998 to 2013. The price data is used in the bootstrapping procedure of calculating gross margins.

Results of the descriptive statistical analysis for soybean and maize production in humid and semi-arid regions are shown in Table 1. The data is analysed to detect changes over time and regional characteristics as well as to discuss single farm performance and crop management strategies.

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Table 1. Statistical analysis of crop yields and variable costs for maize and soybean production in humid and semi-arid regions in Austria.

			quartiles				
variable	mean	sd	min.	25%	50%	75%	max.
maize in humid regions 2009-2012							
yield (t/ha)	11,5	2,05	4,0	10,6	11,7	13,1	15,0
var.costs	763	195	167	622	728	886	2386
maize in semi-arid regions 2009-2012							
yield (t/ha)	10,2	2,09	4,2	9,0	10,1	11,8	15,1
var.costs	669	175	335	555	642	767	1715
soybean in humid regions 2009-2013							
yield (t/ha)	2,9	0,64	1,0	2,5	2,9	3,3	6,5
var.costs	521	94	240	454	514	568	983
soybean in semi-arid regions 2009-2013							
yield (t/ha)	2,2	0,80	1,1	1,8	2,2	2,6	5,4
var.costs	648	89	482	589	651	711	797

Note: own calculation using the statistical software package R.

Table 1 shows statistics on yields and variable costs for maize and soybean production in humid and semi-arid regions in Austria. Both crops perform markedly better in humid regions, i.e. mean and median values of the crop yields are considerably higher. Additionally, the variable costs for soybean production in humid regions are lower than in semi-arid regions. However, variable costs for maize production are higher in humid regions.

METHOD

A stochastic dominance analysis is conducted in order to compare the frequency distributions of gross margins of soybean and maize production. The observed data for crop yields and variable costs are used to derive the underlying distribution function. We apply Monte-Carlo simulation to derive a large number of random samples for crop yields and variable costs. Based on the price data provided by the Austrian Statistical Office, prices for the analysis are determined by a bootstrapping procedure and matched randomly with the sample of crop yields and variable costs. The results of soybean and maize gross margins are used to calculate the cumulative density functions (CDF). The two continuous CDFs for soybean and maize are defined within the range [a, b] representing the maximum and minimum levels of possible gross margins. For instance, soybean (S) is related to its probability density function PDF f(x) by

$$S(R) = \int_a^R f(x)\, dx \tag{1}$$

Consequently soybean (S) is said to dominate maize in the sense of first-degree stochastic dominance (FSD) if $S(R) \leq M(R)$ for all possible R in the range [a, b] with at least one strong inequality, i.e. the $<$ holds for at least one value of R. Graphically illustrated, the dominant curve always must be located to the right of the dominated curve (Anderson et al., 1980).

ANTICIPATED RESULTS

The results of the stochastic dominance analysis will enable us to analyse the relative profitability of both crops by contrasting the crop and region specific probability density functions of gross margins. In particular, the stochastic dominance analysis will be carried out for humid and semi-arid regions in Austria and will reveal whether farm management practices can compensate for different weather and climate conditions. Our research will provide a decision support for farm risk management with regard to crop management in regional context.

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