Climate change impacts on crop supply balances in Austria

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***Abstract* - We investigate climate change impacts on level and volatility of crop supply balances in Austria. The supply balance data is merged with simulated annual crop yields of two periods (1975-2005 and 2010-2040) by accounting for regional climate change. A comparative impact analysis enables to single out the effects of crop output changes on self-sufficiency ratios and trade balances. The analysis shows that the high current self-sufficiency ratio of grains is likely to decrease slightly until 2040 if historical climate trends and variabilities continue. Regional climate change affects both level and variability of crop yields implying new challenges for domestic food supply balance management.**

INTRODUCTION

Climate change is likely to impact regional, national, and global food and feed production (Misselhorn et al. 2012) as well as regional disparities in food and feed availability (Ziervogel and Ericksen 2010). The level and volatility of food and feed production mainly depends on biophysical parameters (e.g. soil, elevation, slopes), weather and climate parameters (e.g. temperature, precipitation, solar radiation), and farm management and techniques (e.g. crop rotation, fertilization, irrigation, tillage), whereas food availability also includes food distribution and exchange (Gregory et al. 2005). In Europe, an increasing variability of inter-annual crop yields is expected because of changes in agro-meteorological conditions, and in magnitude and frequency of extreme weather events (Battisti and Naylor 2009). Consequently, more volatile crop yields and thus supply balances are expected, which require additional measures and management tools.

A recent survey on established agricultural economic models considering climate change concluded that most of the models account for changing average crop yields and prices but practically none is well-suited to include yield and price volatility (Bojar and Verbrug 2012). This is mainly due to the structure of most economic models which use relative changes of crop yields and prices for further calculations. In most economic models agricultural supply and feed balances represent the average flow of commodities between the crop and the livestock sector. Therefore, we analyze the effects of crop yield variability on national crop supply balances in order to emphasize the importance in agricultural policy analysis and identify options to improve existing agricultural economic models.

DATA AND METHOD

Two major data sources are used for the analysis. The first data set is derived from the reported agricultural supply and feed balances provided by the Austrian Statistical Office. Supply balances summarize production, domestic use (e.g. human consumption, seeds, animal feed, industrial uses), storage, and net imports and exports of a given commodity. Consequently, keeping domestic use constant, changing production will affect storage, net imports and exports.

The second data set is derived from climate change impact simulations with the bio-physical process model EPIC (Environmental Policy Integrated Climate; Williams 1995). EPIC was applied on 1 km² cropland pixels to simulate inter alia annual dry matter crop yields. EPIC interlinks information on weather, soil, topography, and crop management to simulate bio-physical processes such as respiration, mineralization, nitrification, evapotranspiration, runoff, and erosion. Relevant input data are derived from (i) the digital soil map of Austria, (ii) the digital elevation map, (iii) the Integrated Administration and Control System, (iv) expert knowledge, and (v) a statistical climate change model for Austria (Strauss et al. 2013). The EPIC simulations have been performed for a 30-year reference period (1975-2005) and for four climate change scenarios covering the period 2010-2040. The average temperature is predicted to rise by ~0.05 °C per year. The uncertainty in precipitation is captured by scenario assumptions on annual precipitation sums and seasonal patterns. We use climate change scenario sc01 to present some results, which assumes similar mean annual precipitation sums as in the period 1975-2005.

In the crop supply balance analysis, land use and crop management data are kept constant to isolate the climate change impacts on crop yields. In addition, the quantity structure of the 2008-2010 agricultural supply balances is used for analysing impacts of crop yield changes on self-sufficiency ratios and trade balances.

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Results

Table 1 shows self-sufficiency ratios and trade balances as well as climate change impacts on average crop yields and standard deviations (stdev) for major crops in Austria.

Table 1. Self-sufficiency ratios (SSR) and trade balances for the period 2008-2010 as well as simulated crop yield changes between the periods 1975-2005 and 2010-2040 (climate change scenario sc01) in per cent.

	SSR	balance	mean	stdev
	2008-2010		change	
	%	1000 t	%	%
barley	94	-64	0,34	-15,8
maize	89	-272	-1,90	13,2
durum wheat[1]	103	-2.0	-3,86	0,2
oats	95	-5.2	-0,98	15,3
potatoes	92	-64.9	17,06	-4,7
soybeans	58	-51.6	4,00	17,0
sunflower	65	-44.7	-1,80	30,1
triticale	99	-3.1	1,63	14,6
winter rape	45	-201	7,53	-20,2
rye	85	-35.5	0,67	15,5
winter wheat	107	+95.6	1,29	-13,1

Note: A positive balance implies a surplus of exports. [1]Negative trade balance and SSR greater 100% are due to storage. Source: own results.

Table 1 shows that the self-sufficiency ratios in the period 2008-2010 ranged between 45% and 65% for winter rape, sunflower, and soybean and exceeded 85% for grains and potatoes. Winter wheat and durum wheat even reached self-sufficiency ratios above 100%. Compared to the period 1975-2005, climate change scenario sc01 shows a relatively little impact on mean annual crop yields except for potatoes (+17%) and winter rape (+7.5%). Consequently, only minor changes in self-sufficiency ratios are expected.

Figure 1 presents the impact of climate change scenario sc01 on the self-sufficiency ratio of grains in comparison to the period 1975-2005. Assuming unchanged land use, domestic use, and storage, the aggregation of grains shows that grain output and thus self-sufficiency is likely to decrease slightly in the next three decades if current climate trends and variabilities prevail (as assumed in climate change scenario sc01). The shape of the distribution indicates that lower self-sufficiency ratios are likely to occur more frequently.

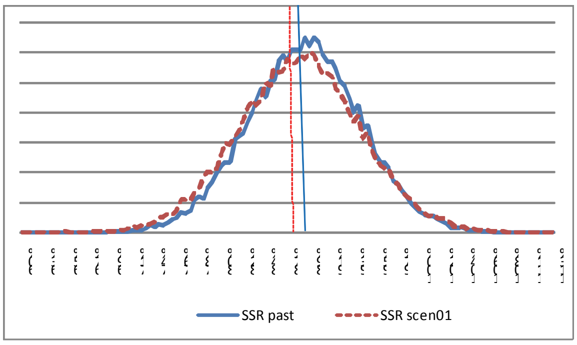

Figure 1. Calculated self-sufficiency ratios of grains based on simulated crop yields of the past period (SSR past) and the future period (SSR sc01). Source: own results.

Preliminary conclusions and outlook

The analysis indicates that both level and variability and thus agricultural production risk are likely to change in the future. Potential effects of climate change on self-sufficiency ratios of crop commodities are shown for Austria assuming that land use, domestic use and storage are held constant. Although such an assumption is not realistic because of changes in consumption as well as international markets and thus trade flows, the applied approach allows us to analyse the impacts of climate change on crop yields and self-sufficiency ratios.

Assuming inelastic demand, higher crop yield volatility is likely to induce higher price volatility as well. Such a development will increase agricultural production risks, which emphasizes the importance of further investigations on domestic crop yield and supply volatility as well as the roles of storage and trade.

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