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Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz

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Crop portfolio composition under shifting output price relations - Analyzed for selected locations in Canada and Germany -

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Abbreviations

€	Euro
$CAN	Canadian Dollar
AAEA	American Agricultural Economics Association
AAFC	Agriculture and Agri-Food Canada
AFPC	Agricultural & Food Policy Center, Texas A&M University
APF	Agricultural Policy Framework
APP	Advance Payments Program
ATC	Average total cost
AVC	Average variable cost
BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, German Federal Ministry for Food, Agriculture and Consumer Protection
BOPI	Bio-fuels Opportunities for Producers Initiative
CAD	Canadian Dollar
CAIS	Canadian Agricultural Income Stabilization program
CANSIM	Canadian Socio-economic Information Management System
CAP	Common Agricultural Policy of the EU
CAR	Cost and Return
CCN	Cash Crop Network of Agri Benchmark
CMO	Common Market Organization
COP	Cost of production
CV	Coefficient of variation
CWAD	Canadian Western Amber Durum wheat
CWB	Canadian Wheat Board
CWRS	Canadian Western Red Spring wheat
CWRW	Canadian Western Red Winter wheat
DLG	Deutsche Landwirtschaftsgesellschaft, German Agricultural Society
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
EAGGF	European Agricultural Guarantee and Guidance Fund
ecoABC	EcoAGRICULTURE Bio-fuels Capital Initiative
EDF	European Dairy Farmers
EEG	Erneuerbare-Energien-Gesetz, Renewable Energy Act
EMZ	Ertragsmesszahl, Indicator for natural productivity of a location
EPV	Estimated Processed Value
EU	European Union
EUR	Euro
FADN	Farm Accountancy Data Network of the EU

FAL	Bundesforschungsanstalt für Landwirtschaft, German Federal Agricultural Research Center
FAO	Food and Agriculture Organization oft he United Nations
FAS	Foreign Agricultural Service oft he USDA
FIMCLA	Farm Improvement and Marketing Cooperatives Loans Act
FLIPSIM	Farm Level Impact Simulation model
FNR	Fachagentur für Nachwachsende Rohstoffe, Agency for Renewable Resources
GATT	General Agreement on Tariffs and Trade
GMO	Genetically Modified Organism
IFCN	International Farm Comparison Network
L	Liter
LP	Linear Programming
M	Million
MC	Marginal cost
MR	Marginal revenue
MRT	Marginal rate of transformation
MVP	Marginal value product
OECD	Organization for Economic Cooperation and Development
PPP	Price Pooling Program
PSRMP	Private Sector Risk Management Partnership
RDR	Rural Development Regulation
RE	Rapeseed equivalent
SOP	Standard Operating Procedure within Agri Benchmark
SPS	Single Payment Scheme
SWSW	Soft White Spring Wheat
t	Metric ton
TIPI-CAL	Technology Impact Policy Impact Calculation model
toe	Tonnes oil equivalent
US, USA	United States of America
USD, US$	US-Dollar
USDA	United States Department of Agriculture
VAT	Value Added Tax
vTI	Johann Heinrich von Thünen-Institute, German Federal Research Institute for Rural Areas, Forestry and Fisheries
WTO	World Trade Organization

1 Introduction

1.1 Issue

Global markets for agricultural commodities have undergone major changes in the past two decades. Ongoing globalization and changing supply and demand patterns for agricultural commodities are key drivers for increasing dynamics in global agriculture.

Trade liberalization in the context of WTO-agreements is leading to a reduction of market protection and policy interference in agricultural sectors. Further, global population growth results in increasing demand for agricultural commodities as a source for human food. Growing welfare of emerging developing and transition countries leads to increasing consumption of value-added foods like meat and dairy products resulting in rising demand for agricultural commodities as a source for livestock feed. Recently high energy cost levels driven by crude oil prices accelerated disposition of biomass as a source for bio-energy (bio-fuel), creating new and further demand for agricultural commodities. Growing demand is accompanied by slow and limited expansion of production. Further, increasing climate variability affects the levels of production output leading to increasing variability in the supply of agricultural commodities.

The changing situation on markets for agricultural commodities is reflected in the development of output prices. Prices for agricultural commodities are rising as a result of increasing demand which is outpacing supply. Price volatility is increasing reflecting rising variability of supply from year to year. Overall, price relations between different agricultural commodities are shifting and might shift further in the future due to changing supply and demand patterns between different agricultural commodities. For example, oilseeds and corn are important feedstock for the growing bio-fuel industry, resulting in increased demand compared to other agricultural commodities. Price relations might thus shift in favor to these commodities, affecting production decisions of agricultural producers. Changes in production decisions, and thus production patterns and land use are important for farmers, policy makers, input suppliers and output processors since they affect whole supply chains and agricultural sectors world-wide.

Global cash crop production is analyzed within the *agri benchmark* Cash Crop Network which comprises farmers, advisors and researchers from different countries around the world. *agri benchmark* Cash Crop aims to provide information and research for stakeholders in agricultural supply chains and policy makers about current and future developments of global production of cash crops. Until recently, the research of *agri benchmark* Cash Crop has been driven by ongoing trade liberalization and resulting increased competition between whole supply chains of agricultural commodities. Fears that agricultural production in certain regions will decline due to lacking competitiveness seem to have expired in the context of the recent increase in world market prices for agricultural commodities. The perspective on competitiveness may thus change. In the future, competitiveness may be seen as the ability of the different agricultural commodities and products to compete for the limited resources needed for their production. This is especially true for land. A guideline for future *agri benchmark* research may thus be how production systems and farming structures as well as production output will change in this new context.

The potential for expansion of cash crop production is limited in developed agricultural sectors like in Canada and Germany since most farmland is already used in production. In these countries, production of major cash crops mostly takes place in multi-product farms under joint production systems and crop rotations, resulting in the fact that acreage expansion of one crop will reduce acreage allocated to other crops. In crop portfolios of multi-product farms, technical interdependencies exist between crops, leading to an interrelated efficiency, profitability and competitiveness of crops. Farm level production decisions in multi-product farms are thus not only based on single crop profitability but on profitability of whole crop rotations and crop portfolios. Changes in output prices for a single crops thus do not only affect production (acreage and output) of a single crop but also affect crop rotations and crop portfolio composition as a whole. The extent of changes in crop rotations and crop portfolio composition under shifting output price relations is thus determined by the characteristics of the different (technical) interdependencies between crops. Determinants of crop portfolio composition and rotation choice have thus to be identified in order to analyze the influence of changing output prices on crop portfolio composition.

Cash crop farms in Canada and Germany produce mostly the same crops like cereals and oilseeds. In both countries diversified crop rotations and crop portfolios with different production systems prevail which differ between countries and to some extent within each country. Determinants of crop rotation choice and crop portfolio composition do thus differ between and within these countries. Different determinants should therefore have a different influence on crop portfolio composition and rotation choice under changing output price relations.

1.2 Objective

Given the background of potential changing crop output price relations this thesis aims to analyze the influence of changing output price relations on crop portfolio composition and rotation choice for selected cash crop farms in Canada and Germany.

As a necessary precondition for this analysis, factors which determine crop portfolio composition and rotation choice have to be identified, assessed and compared between farms and countries.

Further, since this thesis is embedded in the research concept of *agri benchmark*, a methodology set for analyzing crop portfolio composition and rotation choice has to be developed which is feasible and applicable for analysis of cash crop farms within the world-wide *agri benchmark* Cash Crop Network.

1.3 Procedure

Chapter 2 contains an overview of framework conditions for cash crop production in Canada and Germany to provide necessary background information for crop portfolio composition and crop rotation choice. First, the role of both countries on global markets for major cash crops is described followed by a presentation of the respective agricultural policy framework and natural framework conditions for cash crop production. Further, production, prices and regional distribution of cash crops are illustrated.

In Chapter 3, the research concept of *agri benchmark* is presented providing background information about motivation and procedure of this thesis. The concept of typical farms and farm level data collection based on the “panel-approach” are of particular relevance for the methodological approach within this thesis. Data and information will be collected using the panel-approach to build four representative farms. Finally, a cost of production comparison for major oilseeds and the development of the *agri benchmark* Cash Crop Network are presented to demonstrate research work of *agri benchmark* conducted so far.

Chapter 4 provides the theoretical and methodological background for analysis of crop portfolio composition and rotation choice. General enterprise relationships in multi-product farms and sources for jointness of production are explained followed by a description of factors which influence crop selection and rotation choice.

Further, methodology for analyzing crop portfolio composition is evaluated and developed focusing on *agri benchmark* cost of production methodology and linear programming. Both approaches bear limitations for analyzing crop portfolio composition in the context of this thesis. Thus, the panel-approach applied within *agri benchmark* is advanced and extended to provide a methodology for analysis of crop portfolio composition and rotation choice. At Stage one of the extended panel-approach, data and information about physical, technical and financial resources of the representative farms are collected. Stage two identifies factors which determine crop portfolio composition and rotation choice for the representative farm. At Stage three, the impact of output price changes on crop portfolio composition is analyzed.

Results of Stages one and two of the extended panel-approach are presented in Chapter 5 for a total of four representative farms from Canada and Germany. Within each country, two representative farms are modeled and are described in terms of their resource endowment. Further, production systems prevailing at the different representative farms are described, forming a starting point for analysis of crop portfolio composition. Finally, factors determining crop portfolio composition and rotation choice are presented and discussed.

Results of Stage three of the extended panel-approach are presented in Chapter 6. Stage three is only applied to one of the four representative farms due to limited prospects for adjustments in crop portfolios and rotations under changing output price relations for the other farms.

Conclusions about crop portfolio composition under shifting output price relations and about application of the *agri benchmark* panel approach are drawn and presented in Chapter 7.

A summary of this thesis is provided in Chapter 8.

2 Overview of cash crop production in Canada and Germany

This chapter provides an overview of the general framework of cash crop production in Canada and Germany. The role of Canada and Germany on global markets for agricultural commodities is illustrated in Chapter 2.1, followed by a description of the agricultural policy framework in Chapter 2.2, the prevailing natural framework conditions in Chapter 2.3 and the production, prices and regional distribution of cash crop production in Chapter 2.4.

Cash crop production in Canada and Germany is diversified and takes place under different framework conditions. Legal and economic framework conditions, especially agricultural policies, are different in both countries. Natural conditions represented by climate and soils vary as well between both countries as within these countries, leading to distinctive regional structures and distributions of cash crop production. The different framework conditions in Canada and Germany are explained and illustrated to provide background information about cash crop production in both countries. This information are a prerequisite to identify and understand factors that determine production of cash crops and furthermore, choice of crop rotations and crop portfolio composition in both countries.

Canada and Germany are chosen for this analysis since both countries play an important role in global production and trade of major agricultural commodities. Additionally both countries grow mostly the same crops like cereals and oilseeds and thus compete in the same world markets. Selection of regions within both countries for this analysis is based on relevance of the respective region in cash crop production, not focusing on a particular crop but cash crop production in general. For Canada, regions selected are Alberta and Saskatchewan. North Rhine-Westphalia and Saxony-Anhalt are the respective regions for Germany.

In Canada and Germany cereals are the major category of crops produced followed by oilseeds. Wheat is the leading crop for both nations and further cereals grown are barley, corn, oats, rye and triticale. Also, oilseeds play an important role with rapeseed (canola)[1] being the major crop in this group. Further oilseeds grown are soybeans, sunflowers and flax (linseed) whereas from this category only sunflowers have some minor relevance in Germany. The production of sugar from sugar beets is more important in Germany than in Canada. The opposite holds for production of pulse crops like peas, lentils and beans,

1 The term „canola“ refers to the Canadian denomination for 00-rapeseed varieties (*Brassica napus* L. and *B. rapa* L.) which are low in erucic acid and glucosinolate content. This term will thus be used for denominating Canadian rapeseed in this thesis. Further information on canola is found in DOWNEY (1988).

which is important in Canadian cash crop production and only field peas are of minor relevance in Germany.

Total production of cereals and oilseeds is quite similar in Canada and Germany, but production of pulses and sugar is different (Table 2.1). Production of cereals ranges from around 35 million tonnes to more than 50 million tonnes in both countries while Canadian cereal production ranges mostly around 50 million tonnes and therefore is above German cereal production. Production of oilseeds shows an increasing trend in Germany from around 3 million tonnes to more than 5 million tonnes. Canadian oilseed production is twice as big as German oilseed output and ranges from around 6 million tonnes to more than 14 million tonnes. In terms of pulse crop and sugar production, both countries differ markedly. German sugar production ranges at around 4 million tonnes over the period shown, whereas sugar production in Canada ranges around only 100 thousand tonnes. The opposite holds for production of pulse crops. Here, Canadian production shows an increasing trend from little under 1 million tonnes to more than 4 million tonnes over the period shown. Pulse crop production in Germany is of little relevance with output varying from 150 thousand tonnes to around 700 thousand tonnes.

Table 2.1: Production (‘000 t) of major agricultural commodity groups in Canada and Germany from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Canada ('000 t)															
Cereals Total	53,857	49,648	51,483	46,617	49,344	58,494	49,557	50,993	54,078	51,038	43,391	36,303	50,174	52,684	53,086
Oil crops Total	6,575	5,863	8,253	10,881	10,147	8,369	10,336	11,813	12,946	10,930	7,579	7,736	10,173	11,656	14,197
Pulses Total	897	991	1,456	2,070	2,097	1,718	2,320	3,066	3,454	4,443	3,366	2,292	3,065	4,580	4,810
Sugars Total	160	118	113	182	164	157	105	93	122	121	86	55	96	118	103
Germany ('000 t)															
Cereals Total	39,268	34,758	35,549	36,336	39,863	42,136	45,486	44,575	44,461	45,271	49,686	43,391	39,426	51,097	45,980
Oil crops Total	3,124	2,862	3,104	3,245	3,271	2,158	3,079	3,676	4,536	3,746	4,254	3,918	3,729	5,377	5,154
Sugars Total	4,251	4,401	4,359	3,992	4,159	4,569	4,397	4,388	4,784	4,765	4,066	4,395	4,120	4,729	4,032
Pulses Total	242	152	225	246	304	380	492	683	706	471	641	478	453	528	406

Source: FAOSTAT (2008).

Corn and soybean production in Canada is concentrated in Eastern Canada, in Ontario and Quebec provinces. Production of wheat, barley and other cereals, as well as canola and pulse crops is concentrated in Western Canada, especially in the three “Prairie Provinces” Alberta, Saskatchewan and Manitoba (see Figure A1 in Appendix). Since cash crop production is more diversified and distinctive crop rotations prevail in the Prairie Provinces, Canadian farms and locations analyzed in this thesis are located in this area. Thus, description of Canadian cash crop production and the according framework conditions will focus on the Prairie Provinces, particularly on Alberta and Saskatchewan.

2.1 Canada and Germany on global markets for agricultural commodities

Canada and Germany are major producers and exporters of major agricultural commodities and thus play an important role on the global markets for these commodities. Both countries are among the global top ten producers of wheat and rapeseed in the period from 2003 to 2005 (Table 2.2 and Table 2.3).

Table 2.2: Wheat production and export (‘000 t) of major global producing and exporting countries from 2003 to 2005

Production ('000 tonnes)					Exports ('000 tonnes)				
Country	Rank (2005)	Year 2003	2004	2005	Country	Rank (2005)	Year 2003	2004	2005
China	1	86,492	91,956	97,449	USA	1	26,404	31,792	27,487
India	2	65,761	72,156	68,637	France	2	16,375	14,906	16,023
USA	3	63,814	58,738	58,740	Canada	3	11,704	15,134	13,978
Russian Federation	4	34,104	45,413	47,698	Australia	4	9,503	18,486	13,915
France	5	30,475	39,693	36,886	Argentina	5	6,169	9,977	10,425
Canada	6	23,552	25,860	26,775	Russian Federation	6	7,588	4,672	10,333
Germany	7	19,260	25,427	23,693	Ukraine	7	904	2,554	6,009
Pakistan	8	19,183	19,500	21,612	Germany	8	4,481	3,927	4,628
Turkey	9	19,008	21,000	21,500	United Kingdom	9	3,658	2,529	2,495
United Kingdom	10	14,288	15,473	14,863	Hungary	10	1,228	955	1,642
Iran, Islamic Rep	11	13,440	14,568	14,308	Czech Republic	11	760	159	1,468
Argentina	12	14,563	15,960	12,574	Kazakhstan	12	5,195	2,398	1,357
Ukraine	13	3,599	17,520	18,699	Bulgaria	13	313	710	1,124
Kazakhstan	14	11,537	9,937	11,066	Belgium	14	695	895	801
Australia	15	26,132	21,905	25,090	Austria	15	592	417	800
EU (27)	(1)	111,671	149,395	135,420	EU (27)	(1)	32,833	27,205	33,238

Source: FAOSTAT (2008).

For wheat, Canada ranked 6th in production and 3rd in exports for the year 2005, while Germany ranked 7th and 8th respectively (Table 2.2). Wheat production in Canada increased from about 23.5 million tonnes in 2003 to more than 26.5 million tonnes in 2005, while exports moved from more than 11.5 million tonnes in 2003 to more than 15 million tonnes in 2004, and about 14 million tonnes in 2005. German wheat production moved from more than 19 million tonnes in 2003 to about 25.5 million tonnes in 2004, and to more than 23.5 million tonnes in 2005. Wheat exports of Germany were about 4.5 million tonnes in 2003, about 4 million tonnes in 2004 and more than 4.5 million tonnes in 2005.

For rapeseed, Canada ranked 2nd in production and 1st in exports for the year 2005, while Germany ranked 4th and 5th respectively (Table 2.3). Rapeseed production in Canada increased from more than 6.5 million tonnes to more than 9.5 million tonnes in the 2003 to 2005 period. Canadian rapeseed exports increased from more than 3 million tonnes to 4 million tonnes in the same period. German rapeseed production increased from more than 3.5 million tonnes to about 5 million tonnes while exports moved from about 0.4 million tonnes in 2003 to more than 0.5 million tonnes in 2004 and less than 0.3 million tonnes in 2005.

Table 2.3: Rapeseed production and export (‘000 t) of major global producing and exporting countries from 2003 to 2005

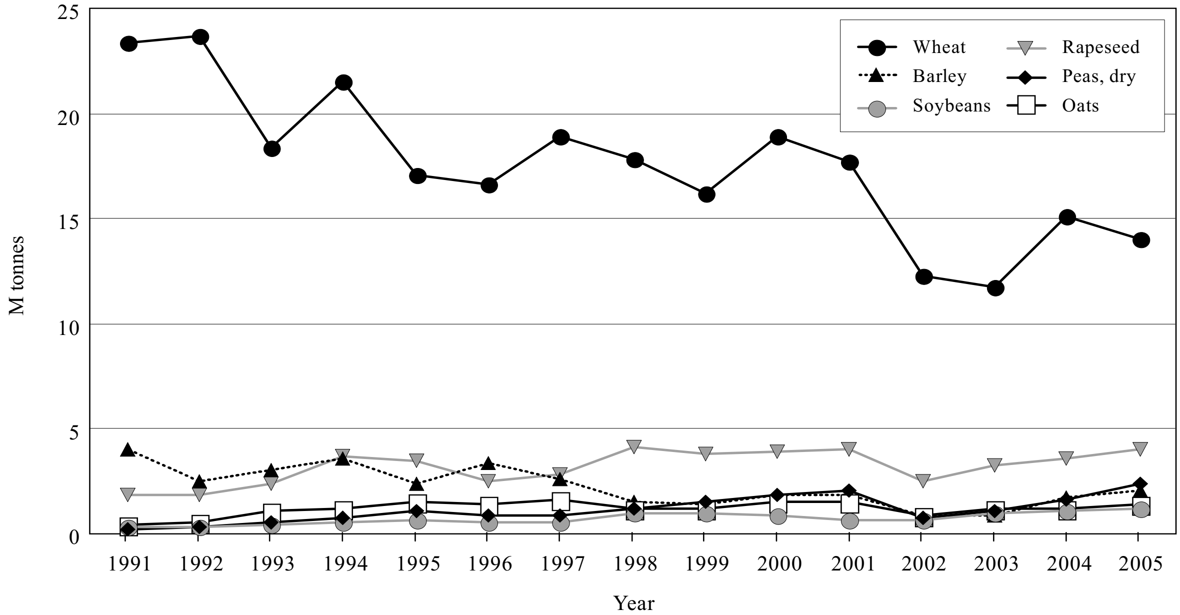
Production ('000 tonnes)					Exports ('000 tonnes)				
Country	Rank (2005)	2003	Year 2004	2005	Country	Rank (2005)	2003	Year 2004	2005
China	1	11,420	13,182	13,052	Canada	1	3,244	3,588	4,001
Canada	2	6,771	7,728	9,660	France	2	1,717	1,629	1,370
India	3	3,880	6,291	7,593	Australia	3	625	1,198	843
Germany	4	3,634	5,277	5,052	Hungary	4	59	136	309
France	5	3,361	3,993	4,533	Germany	5	389	538	255
United Kingdom	6	1,771	1,609	1,902	Czech Republic	6	48	79	239
Poland	7	793	1,633	1,450	Lithuania	7	104	102	212
Czech Republic	8	388	935	769	Poland	8	6	281	184
USA	9	686	608	717	Ukraine	9	26	81	183
Russian Federation	10	192	276	303	USA	10	283	373	177
Australia	11	1,703	1,542	1,441	United Kingdom	11	272	101	171
Denmark	12	354	468	342	Latvia	12	12	40	128
Pakistan	13	353	401	347	Romania	13	3	37	112
Hungary	14	108	291	283	Belgium	14	56	73	90
Slovakia	15	53	263	235	Russian Federation	15	26	60	64
EU (27)	(1)	11,061	15,462	15,649	EU (27)	(2)	2,884	3,190	3,330

Source: FAOSTAT (2008).

Canada and Germany are important producers and exporters in other markets for major agricultural commodities. The position of both countries in the global markets for barley, corn, soybeans and sugar is therefore displayed in Table A1 to Table A4 in the Appendix. Total production of major commodities in Canada is displayed in Table A5 and Figure A2 and for Germany in Table A10 and Figure A4 in the Appendix.

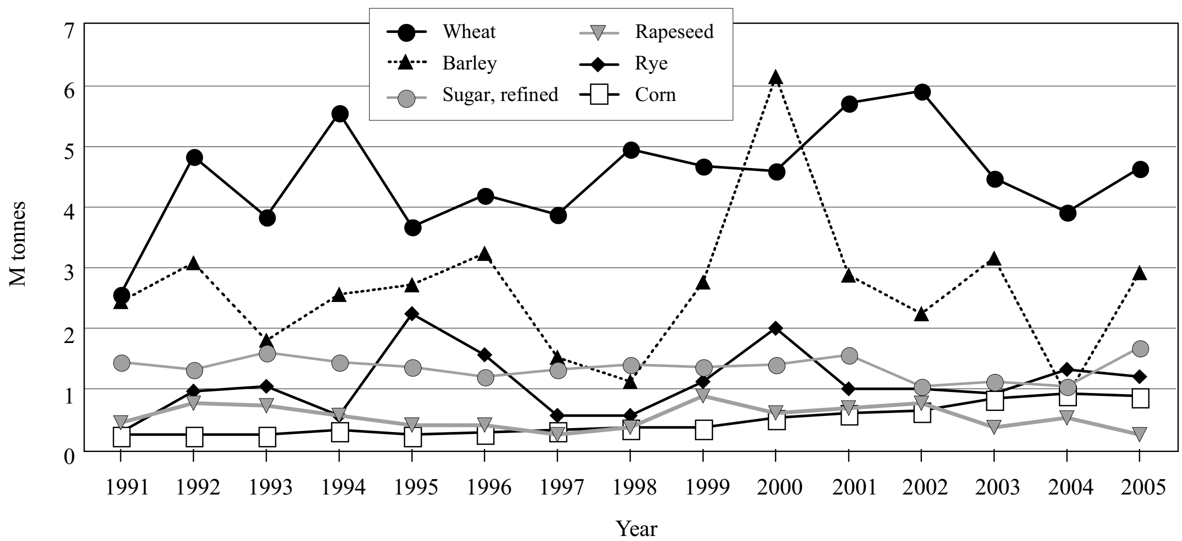
As was described so far, a huge variety of different crops is produced in Canada and Germany though only some of them are relevant for international trade. In terms of exports, wheat is again the most important crop for both countries (Figure 2.1 and Figure 2.2).

Figure 2.1: Exports (M tonnes) of major agricultural commodities of Canada from 1991 to 2005



Source: FAOSTAT (2008), own illustration.

Figure 2.2: Exports (M tonnes) of major agricultural commodities of Germany from 1991 to 2005



Source: FAOSTAT (2008), own illustration.

Canadian wheat exports declined from more than 20 million tonnes to less than 15 million tonnes in the 1991 to 2005 period (Figure 2.1). Exports of barley declined from about 4 million tonnes to about 2 million tonnes. Exports of rapeseed (canola) increased to about 4 million tonnes, thus showing the second highest exports after wheat. Exports of dry peas, soybeans and oats show a slight increase to around 2 million tonnes.

For Germany, wheat exports are highest followed by barley (Figure 2.2). Wheat exports range between about 4 million tonnes and 6 million tonnes and barley exports move from 1 million tonnes to about 3 million tonnes except for the year 2000. Exports of rye range from about 1 million tonnes to 2 million tonnes and have stabilized since 2001. Exports of sugar and corn are mostly stable; sugar exports in a range from 1 million tonnes to about 2 million tonnes and corn below 1 million tonnes. Exports of rapeseed are below 1 million tonnes and have declined to less than half a million tonnes.

As was shown in Figure 2.1 and Figure 2.2, exports for Canada and Germany differ in export volumes and types of commodity traded. Further, both countries differ in their trade balance for major agricultural commodities, which is illustrated for the year 2005 (Table 2.4). Besides substantial exports for wheat, barley, sugar, and rye, Germany is also a substantial importer for soybeans, corn, rapeseed and wheat. Canada shows only substantial imports for corn in 2005, which is used in the livestock industry. For Germany, imports are required for the feed and livestock sector as well, especially soybeans and partly corn and wheat. Further, different types and qualities of cereals which are not locally available but are needed for human consumption are imported. A special situation arises for rapeseed, where additional imports are needed besides local production to feed the demand from the growing bio-diesel sector.

Table 2.4: Production, exports and imports (‘000 t) of major agricultural commodities for Canada and Germany in 2005

Commodity	2005					
	Canada			Germany		
	Production	Exports ('000 tonnes)	Imports	Production	Exports ('000 tonnes)	Imports
Barley	12.481	2.021	67	11.614	2.929	656
Corn	9.461	269	2.154	4.083	882	1.718
Oats	3.432	1.354	19	964	82	98
Peas, dry	3.100	2.367	84	346	77	26
Rapeseed	9.660	4.001	102	5.052	255	1.461
Rye	359	108	0	2.794	1.196	145
Soybeans	3.161	1.181	390	1	29	3.884
Sugar, refined [1)]	103	31	59	4.032	1.702	473
Wheat	26.775	13.978	18	23.693	4.628	1.441

1) Production refers to beet sugar, raw.
Source: FAOSTAT (2008), own illustration.

Detailed export and import figures of agricultural commodities for Canada and Germany are found in Table A6 to Table A9 and Table A11 to Table A14 and Figure A3 and Figure A5 in the Appendix.

2.2 Agricultural policy

The legal framework for cash crop production in Canada and Germany is mainly shaped by the agricultural policy framework. Since this framework consists of many different regulations and programs in both countries, description will focus on those which mainly affect producers of cash crops.

2.2.1 Agricultural Policy Framework (APF) in Canada

Agricultural policy in Canada is shaped by the Agricultural Policy Framework (APF). It consists of five pillars – Business Risk Management, Environment, Food Safety and Quality, Renewal, and Science and Innovation.[2] For producers and thus cash crop farmers, programs belonging to the Business Risk Management Chapter are most important since they provide direct support. Description will thus focus on the Business Risk Management suite. Information about the remaining pillars of the Agricultural Policy Framework can be found at Agriculture and Agri-Food Canada's website.[3] Government expenditures in support for the agri-food sector in Canada are displayed in Table A15 in the Appendix.

2.2.1.1 Business Risk Management Suite

The Business Risk Management Suite provides programs and regulations to support producers in managing risks, including adverse weather, disease, insects or changes in commodity prices, input costs and production yields, that affect the viability and profitability of their business. This suite consists of the Canadian Agricultural Income Stabilization (CAIS) program, the Farm Improvement and Marketing Cooperatives Loans Act (FIMCLA), Production Insurance (Crop Insurance), Advance Payments Program (APP), Price Pooling Program (PPP), and the Private Sector Risk Management Partnerships (PSRMP). The most important programs for cash crop farmers are CAIS, APP and Production Insurance.

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2 AGRICULTURE AND AGRI-FOOD CANADA (2008).

3 Http://www.agr.gc.ca (as of March 6th, 2008), AGRICULTURE AND AGRI-FOOD CANADA (2005).

The *Canadian Agricultural Income Stabilization (CAIS)* program is a joint federal and provincial/territorial program to protect against large and small drops in farm income in a given year. Participating farmers choose between three different coverage levels, providing 56 %, 66.5 % and up to 70 % coverage of the total decline in their margin in relation to a reference margin. The Reference Margin (allowable income minus allowable expenses) is based on an average margin of the previous five years, with the highest and lowest margin years dropped (Olympic average). Adjustments to the margin can be made to reflect structural change and inventory changes for the respective farm. Income decline is determined by comparing the Reference Margin to the Production Margin (current year margin).[4]

In order to participate in the CAIS program, a fee has to be paid by farmers depending on the chosen level of coverage. For every $1,000 of Reference Margin protected the fee is $4.5 at the 70 % coverage level and $3.825 and $3.15 for the 66.5 % and 50 % coverage level respectively.[5]

CAIS payments are triggered when the Production Margin declines below the Reference Margin. The amount of payments is determined by the extent of the margin decline which is measured using three tiers, with Tier 1 representing the smallest and Tier 3 the largest decline. The following example is based on a Reference Margin of $100,000 and Production Margin that has declined to $35,000 (Table 2.5). The coverage level is 70 % and thus, the farmer can receive 70 % of the margin decline which is $65,000 ($100,000 – $35,000) in this example.

Table 2.5: Example for CAIS payments at 70 % coverage level

Tier	Portion of Decline Covered	Government Funds
Tier 1 Government Funds Paid for 50 % of decline	$100,000 to $85,000 = $15,000 x 50 %	$7,500
Tier 2 Government Funds Paid for 70 % of decline	$85,000 to $70,000 = $15,000 x 70 %	$10,500
Tier 3 Government Funds Paid for 80 % of decline	$70,000 to $35,000 = $35,000 x 80 %	$28,000
Tier 1 + Tier 2 + Tier 3 Capped at 70 % of Margin Decline	Calculated Benefit Maximum Benefit	$46,000 $45,500

Source: CAIS program handbook, Agriculture and Agri-Food Canada (2008a).

4 AGRICULTURE AND AGRI-FOOD CANADA (2008a).

5 All monetary values refer to Canadian Dollars.

Negative margins (both for reference and production) are included in the program as well. In case of negative margins, these are compensated for up to 60 % of the margin decline that is below zero. The maximum payments a farmer can receive under the CAIS program are capped, or limited to, either $3 million or 70 % of the margin decline, whichever is lower. Any amount over this limit will be deducted from the negative margin payment. In order to be eligible for a negative margin payment, the following criteria must be met:

– 2 of 3 production margins used to calculate the reference margin must be positive;
– Sound management practices must have been followed; and
– The negative margin must have occurred because of reasons beyond the farmer's control.

The following example illustrates CAIS payment calculation for negative Production Margin and negative Reference Margin (Table 2.6).

Table 2.6: Example for CAIS payments for negative margins

Program Year Allowable Income	**Program Year Allowable Expenses**	**Negative Margin**
$100,000	$160,000	-$60,000
		x 60 %
	= Negative Margin Benefit	$36,000
Negative Reference Margin	**Negative Program Year Margin**	**Margin Decline**
-$5,000	-$8,000	$3,000
		x 60 %
	= Negative Margin Benefit	$1,800

Source: CAIS program handbook, Agriculture and Agri-Food Canada (2008a).

The *Advanced Payments Program (APP)* provides producers with a cash advance on the value of their agricultural products during a specified period and thus improving the cash-flow situation throughout the year. The repayment of the cash advance is guaranteed by Agriculture and Agri-Food Canada (AAFC), the program itself is administered by various eligible producer organizations. This guarantee helps producer organizations to take loans from financial institutions at lower interest rates and issue a cash advantage on the anticipated value of the farmer's product that is being produced or stored or both. The cash advance rate is limited to 50 % of the average market price for the respective agricultural product in that area. Further, the maximum cash advantage is $400,000 and interest payments for the first $100,000 are covered by the federal government. Maximum period for repayment is 18 months. Emergency cash advances may be issued in case of, for example, unusual production conditions (bad weather, natural disaster etc.), but the amount is limited as well.[6]

Production Insurance (the former crop insurance) is a federal-provincial-producer cost-shared program that stabilizes a producer's income by minimizing the economic effects of production losses caused by natural hazards. Production Insurance is a provincially delivered program to which the federal government contributes a portion of total premiums and administrative costs. The federal government also provides a reinsurance arrangement (deficit financing) to provinces.

Production Insurance is a multi-peril insurance providing production risk protection. Most crops grown in Canada can be insured against losses caused by natural hazards like drought, flood, hail, frost, wind, excessive moisture and insect infestations. Payments are triggered when yield levels drop below a farm's average historical yield due to any of the risks covered.

Coverage and payments are based on two elements which are yield coverage and insured price. Yield coverage is based on the long-term individual yield of a farmer and long-term area yields. The insured price is based on expected prices and is set by the provincial insurance corporation. Producers are able to select coverage at 50, 60, 70 or 80 per cent of their average yield. In case of a yield loss, the indemnity payment is calculated based on the difference between the historic average and current yield level, the insured price and the coverage level. The final indemnity payment is calculated by multiplying the monetary value of the yield loss (physical yield loss times insured price) with the selected coverage level.

Insurance premiums are dependent on regional risk areas, selected coverage level, insured prices and the farmer's personal experience. Farmers may choose further features and benefits which increase premiums. Finally, costs for the premiums are shared at 40 % by producers and 60 % by both provincial and federal governments. In order to provide low cost minimum insurance, premium payments for the 50 % coverage level are shared at 10 % by the producer and 90 % by the governments.

Table 2.7 shows the share of insured acreage by coverage level in Saskatchewan for the 1997 to 2006 period. Most of the acreage, though declining over time, is insured at a 70 % coverage level. Share of the 50 % coverage level has increased from the year 2000 onwards since the lower premium rates provide an entry to minimum insurance.

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6 AGRICULTURE AND AGRI-FOOD CANADA (2008).

Table 2.7: Share of insured acreage by coverage level in Saskatchewan from 1997 to 2006

Year	Coverage Level				Weighted Average Coverage
	50%	60%	70%	80%	
1997	28%	11%	50%	11%	65%
1998	18%	9%	58%	15%	67%
1999	19%	9%	59%	14%	67%
2000	13%	7%	66%	14%	68%
2001	12%	6%	68%	14%	69%
2002	8%	4%	35%	53%	73%
2003	12%	8%	41%	39%	71%
2004	14%	10%	43%	33%	70%
2005	17%	11%	44%	28%	68%
2006	19%	11%	44%	26%	68%

Source: Saskatchewan Crop Insurance Corporation (2007).

Insured area in the crop insurance program has declined in Saskatchewan from 2002 to 2006, but has remained stable in Alberta (Table 2.8). The average indemnity-to-premium ratio is 85 for Saskatchewan and 94 in Alberta, meaning that on average every dollar spent by farmers and the governments is paid back to affected farmers with 85 cents (Saskatchewan) and 94 cents (Alberta). Further, the effect of the drought of 2002 can clearly be seen since indemnities were more than four times as high as premium payments in that year.

The *Farm Improvement and Marketing Cooperatives Loans Act (FIMCLA)* program is designed to increase the availability of loans for improvement and development of farms and the processing, distribution or marketing of farm products by co-operative associations. *Private Sector Risk Management Partnerships (PSRMP)* provides time-limited financial and technical assistance to approved risk management projects. The intention of the program is to support establishment of relationships between producer organizations and private sector financial services agencies. The *Price Pooling Program (PPP)* intends to improve marketing of agricultural products via marketing agencies (co-operatives). A price guarantee for products delivered by farmers via marketing agencies is given based on a percentage of the average wholesale price. An initial payment is made to cover eligible storing, processing, carrying and selling costs.[7]

[7] AGRICULTURE AND AGRI-FOOD CANADA (2008).

Table 2.8: Crop insurance participation and payments in Alberta and Saskatchewan from 2002 to 2006

Crop Year	Insured area ha	Ratio insured to seeded area %	Insured contracts	Premiums ($CAN '000)	Indemnities ($CAN '000)	Ratio indemnity to premium %
				Saskatchewan		
2002	10,317,300	74	34,783	248,600	1,070,000	430
2003	10,479,140	74	33,918	348,600	345,000	99
2004	10,115,000	70	32,087	291,500	392,100	135
2005	10,034,080	70	30,413	277,200	75,900	27
2006	8,941,660	66	28,220	211,400	125,800	60
Average	9,977,436	71	32,800	275,500	234,700	85
				Alberta		
2002	4,491,060	-	15,082	155,968	667,882	428
2003	4,947,853	-	16,826	207,040	93,352	45
2004	5,011,780	-	16,443	215,760	52,654	24
2005	4,688,909	-	14,575	186,013	35,608	19
2006	4,705,093	-	13,487	183,481	38,877	21
Average	4,768,939	-	15,282	189,652	177,674	94

Source: Saskatchewan Crop Insurance Corporation (2007), AFSC (2006 and 2007).

Fuel tax exemption

Canadian farmers benefit from fuel tax exemption. In Saskatchewan the current rate is set at 12 cent per liter and total farm consumption of diesel and gasoline is eligible. A 9 cent per liter discount is granted for propane used in farming.. In Alberta, the tax exemption is 9 cents per liter for gasoline and diesel. In addition to the tax exemption, farmers can buy diesel fuel at costs reduced by 6 cents per liter. Use of propane for farming is exempted from the fuel tax.[8]

2.2.1.2 Canadian Wheat Board

A particularity in the Canadian agri-food sector is the Canadian Wheat Board (CWB), which is a marketing agency for about 85,000 farmers who grow wheat, durum and barley in Western Canada. The structure of the Canadian Wheat Board is based on three pillars: single-desk selling, pooling and the government guarantee.[9]

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8 GOVERNMENT OF SASKATCHEWAN (2008) and ALBERTA AGRICULTURE AND FOOD (2008).

9 CANADIAN WHEAT BOARD (2007).

The Canadian Wheat Board Act gives the CWB sole export marketing authority for wheat and barley and domestic marketing authority for wheat and barley grown in the western Canadian provinces (*single-desk selling*). Wheat and barley grown for domestic livestock feed or industrial uses (like ethanol) need not be sold through the CWB. The Canadian Wheat Board markets wheat and barley both domestically and internationally and sales revenue, less marketing costs, is passed back to the delivering farmers. All CWB sales are deposited into one of four pool accounts (*pooling*): wheat; durum wheat; feed barley; and designated (malting) barley. This ensures that all farmers delivering the same grade of wheat or barley receive the same return at the end of the crop year regardless of when their grain is sold during the crop year (August 1 to July 31). Upon delivery, farmers receive an initial payment which is guaranteed by the government (*government guarantee*). As sales are made throughout the crop year, further payments can be issued and a final payment is made when returns to the pool exceed the sum of these total payments. CWB prices are based on world market prices and the CWB is not empowered to maintain artificial domestic support levels to subsidize Western Canadian farmers. Further, borrowings of the CWB to finance its operations are guaranteed by the government, resulting in lower interest rates and thus savings for Western Canadian producers.

With annual sales revenue ranging from four to six billion Canadian dollars, the CWB is one of the biggest exporters of Canada and one of the largest grain marketing organizations of the world. In the marketing year 2006-2007, CWB achieved combined revenues of more than 4.9 billion $CAN with more than 21.5 million tonnes of grain delivered. Wheat deliveries (about 15.51 million tonnes) ranked first, followed by durum (about 3.98 million tonnes) and designated (malting) barley (about 1.85 million tonnes).[10]

Farmers may benefit from the single-desk selling of their grain, though on the other side CWB's requirements in terms of timing and quantities for delivery may impose restrictions for production of wheat, durum and barley on farms. In case market niches and better marketing opportunities are available, these cannot be pursued by farmers due to marketing monopoly for wheat and barley of the CWB.

2.2.2 EU Common Agricultural Policy (CAP) in Germany

The agricultural policy framework in Germany is mainly shaped by the Common Agricultural Policy (CAP) of the European Union (EU). The CAP provides the general agricultural policy framework for all EU member countries, while implementation of

[10] CANADIAN WHEAT BOARD (2007, p. 1).

regulations at the national level may differ to some extent between member countries. Explanation of the CAP will focus on those regulations and measures related to cash crop production on the one hand and to Germany on the other. Additional and detailed information about all aspects of the CAP can be found at the website of the Directorate General for Agriculture of the European Commission.[11]

The EU Common Agricultural Policy comprises two principal forms of budgetary expenditure. The market support scheme known as Pillar One consists of various Common Market Organizations (CMOs) and further includes the Single Payment Scheme (SPS). Export subsidies and support for intervention buying and storage are defined by the CMOs for different agricultural products. The SPS provides direct area and livestock related payments available to nearly all farmers in the EU which are mainly decoupled from production. Measures and support under Pillar One are fully financed from EU resources through the European Agricultural Guarantee Fund[12] (EAGF). The Rural Development Regulation (RDR) known as Pillar Two consists of a range of selective payments for rural development measures and environmental programs. Measures under Pillar Two are financed from the European Agricultural Fund for Rural Development (EAFRD) and have to be co-financed by national or regional public funds. Pillar One measures are developed and administered at the EU level while Pillar Two measures can be chosen from at the member state level.[13]

An overview of budget expenditures of the (former) European Agricultural Guarantee and Guidance Fund can be found in Table A16 in the Appendix. The federal agricultural budget of Germany is displayed in Table A17. Expenditures of the total agricultural budget of the EU, as well as expenses related to Germany, are shown in Table A18 in the Appendix.

2.2.2.1 Common Market Organizations and Single Payment Scheme

For cash crop production in the EU and Germany, *Common Market Organizations (CMOs)* for cereals and sugar are the most important. No CMOs exists for oilseeds and protein crops although supplementary direct aid is available for growing energy crops and pulses. The CMOs provide price support and market intervention by intervention prices,

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11 Http://europa.eu/scadplus/leg/en/s04000.htm and http://ec.europa.eu/agriculture (as of March 9th, 2008).

12 Until the end of 2006, the European Agricultural Guarantee and Guidance Fund (EAGGF) provided financing to policy measures. Financing of Pillar One was provided by subsection “Guarantee” while resources for Pillar Two came from both subsections “Guarantee” and “Guidance”. See, for example, GAY et al. (2005, pp. 5-8) for more details.

13 OECD (2007, p. 105).

tariffs, tariff rate quotas and export refunds. The CMO regime for cereals includes all major cereals and some processed cereal products and provides price support by an intervention price which is set at 101.31 EUR per tonne. Intervention of rye was ceased in 2004 and the same will apply to corn from 2009 onwards. Market support via tariffs and export refunds are of minor relevance compared to those for other agricultural products (beef, dairy, sugar).[14]

Table 2.9: Intervention price for white sugar and minimum price for quota beet (EUR/t) from 2006 to 2010

Marketing Year		2006-2007	2007-2008	2008-2009	2009-2010
White Sugar	EUR/t	631.90	631.90	541.50	404.40
Quota Beet	EUR/t	32.86	29.78	27.83	26.29

Source: European Union (2008).

The CMO for sugar provides the same instruments as for cereals but further includes a production allowance (sugar quota) limiting total sugar production to 17.44 million tonnes in EU-25. The sugar quota is distributed among the member states and sugar producing companies within the member states. These sugar companies allocate quota to the different farmers (sugar beet producers) which serves as a limit for on-farm sugar beet production. Minimum prices for sugar beets have to be paid by the sugar companies as shown in Table 2.9.

The sugar regime of the EU is currently undergoing major reforms. The intervention price for sugar will be cut to 404.4 EUR per tonne in 2009, while the minimum price for quota beet declines to 26.29 EUR per tonne (Table 2.9). Intervention for sugar will cease in 2010 and is replaced by support for a private storage system. Further, a cut in sugar quota is to be achieved by voluntary return of quota by sugar producing companies of the member countries. Mandatory quota reduction from 2010 onwards will come into effect in case voluntary returns are not sufficient. Sugar production above total quota ceiling can either be used in manufacturing certain industrial products, especially bio-ethanol, or carried forward to the next marketing year. Exports of surplus sugar are only allowed to a maximum ceiling provided by international trade (WTO) agreements.[15]

Direct payment aid to farmers under the *Single Payment Scheme (SPS)* is a key element of the CAP. Decoupled payments under the SPS were introduced with the CAP reform of

[14] OECD (2007, p. 105 et seq.).

[15] OECD (2007, p. 107 et seq.).

2003 and have been implemented in the member states since 2005. Direct payments were introduced by the 1992 CAP reform and adjusted over time as a compensation measure for reductions in intervention prices and support schemes for the different agricultural products. With decoupling of direct payments, farmers can receive payments without a requirement to produce crops or livestock. Meanwhile direct payments are an important means of income support for farmers across the EU.

The Single Payment Scheme is based on payment entitlements which were allotted to farmers (one per hectare) based on historic payments during the reference period of years 2000 to 2002. In order to collect direct payments, entitlements are activated annually by matching them with a corresponding number of eligible hectares. Eligible hectares normally include all types of agricultural land except land used for permanent crops and forestry. Farmers may produce all crops on these acreages with the exception of permanent crops, fruit and vegetables and food potatoes.[16]

The total amount of direct payments per farmer is calculated by the number of entitlements, the farm acreage available for activation and the payment amount per entitlement (reference amount). Member states can choose from three options to calculate the reference amount per entitlement and thus implement the SPS in different ways. The reference amount in the "basic (historic) approach" is calculated based on historic individual farm payments during the reference period. In the "regional (flat rate) approach", historic payments received by all farmers for a defined region during the reference period form the basis for calculating the reference amount. Further, mixed approaches between the basic and regional approach (hybrid models) are possible allowing, e. g., for transit from the basic to the regional approach.[17]

Though full decoupling of direct payments is the general principle from 2005 onwards, member states may maintain some product-specific direct aids alongside the SPS. For the arable sector, a maximum of 25 % of the arable component of the SPS direct payments may be retained to continue coupled per hectare payments. An additional payment is granted for growing energy crops used for producing bio-fuels, electric or thermal energy (e. g., rapeseed for biodiesel production) which is EUR 45 per hectare. These payments are limited to two million hectares in the EU-27. In case this area ceiling is exceeded, payments are reduced. For protein crops (e. g., peas for feed) the payment amounts to 55.57 EUR per hectare and the ceiling is set at 1.6 million hectares.[18]

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[16] European Commission (2008).

[17] European Commission (2008).

[18] European Commission (2008a).

With the introduction of decoupled direct payments, a mechanism of financial discipline is established to control agricultural budget spending. Fixed ceilings for the agricultural budget exist and payments are reduced in case these ceilings are exceeded. This mechanism is accompanied by an instrument called “modulation” which enables transfer of CAP funds from Pillar One (market measures) to Pillar Two (rural development). Direct payments (SPS and other direct aids) are reduced by 3 % in 2005, 4 % in 2006 and 5 % from 2007 onwards until 2012 and shifted to Pillar Two to finance measures for rural development.

In order to qualify for direct payments, farmers have to fulfill certain requirements. A defined share of farm acreage has to be set aside which is controlled by set aside payment entitlements which can only be activated with set aside land. The level of mandatory set aside is defined by the member states and ranged around 8 per cent for Germany in the past. For the crop year 2007/2008, the mandatory set aside level was set to zero due to tight supply situations in major agricultural commodity markets. This regulation is likely to continue in the future as long as the supply situation remains tight. Furthermore, farmers have to comply with standards and regulations in managing their farm operation in sustainable ways, which is called “cross-compliance.” Regulations for compliance are set at the EU or member state level and include environmental rules, protection of public, animal and plant health, animal welfare, and the maintenance of all agricultural land in good agricultural and environmental condition. In case farmers do not follow cross-compliance regulations, direct payments may be reduced.[19]

2.2.2.2 Agricultural policy in Germany

The Single Payment Scheme of the EU is implemented in Germany with full decoupling of direct payments by a hybrid model based on the regional (flat-rate) approach. In order to provide a smooth transition to the future payment framework, certain parts of direct payments are granted for the individual farm (basic historic approach). The remainder is allocated at the regional level (regional approach) resulting in a regional flat rate payment amount. Regions in Germany are equal to the area of the “Bundeslaender” (e. g., North Rhine-Westphalia and Saxony-Anhalt).

During the transition period from 2005 to 2013, the farm individual payment amounts are reduced from year to year and shifted to the regional level resulting in increasing regional flat rate payment amounts (compare Table 2.10). Furthermore, regional payment amounts are differentiated between arable and permanent pasture land. Former farm individual

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[19] EUROPEAN COMMISSION (2008a).

livestock related payments are mostly transferred to the pasture land payment amount. With the reform of the CMO for sugar, farmers growing sugar beets were granted individual decoupled direct payments to compensate for price cuts. These payments will be reduced and transferred to increase the arable land payment amount. At the end of the transition period in 2013, payment amounts per hectare for both arable and pasture land will be equal (Table 2.10).[20]

Table 2.10: Decoupled direct payment amounts (EUR/ha) for North Rhine-Westphalia and Saxony-Anhalt by land type in 2005 and 2013

Agricultural Land Type		2005	2013[1)]
		North Rhine-Westphalia	
Arable Land	EUR/ha	267	359
Permanent Pasture Land	EUR/ha	105	359
		Saxony-Anhalt	
Arable Land	EUR/ha	317	355
Permanent Pasture Land	EUR/ha	97	355

1) Expected values.
Source: BMELV (2006a) and (2007a).

At the federal and regional (Laender) level, several programs exist to support farmers. These programs mainly consist of support for investments by subsidized interest rates. Furthermore, programs financed through the Rural Development Regulation of the CAP (Pillar Two) provide payments for following certain management behaviors like using reduced inputs and conservation tillage systems.

Fuel tax exemption

Like in Canada, farmers in Germany are eligible for a tax reduction on diesel fuel used for farming. In 2007, the fuel tax rebate was 0.21 EUR per liter but limited to a maximum of 10,000 liters. Fuel tax rebate is thus limited to 1.798 EUR per farm since further deductions arise from administering the tax exemption regime.[21]

20 BMELV (2006a).

21 BMF (2008).

2.2.3 Strategies for bio-energy in Canada and Germany

2.2.3.1 Bio-fuel strategy in Canada

The Canadian government launched a comprehensive national strategy on renewable fuels in late 2006 to achieve a reduction of greenhouse gas emissions. Currently, a mandate is being developed for an annual renewable content of five percent in the gasoline pool by 2010, and a two percent requirement for renewable fuel in diesel content by 2012 to increase demand for renewable fuels.[22]

In March 2007, the federal tax excise tax incentive for ethanol consumption was replaced by producer incentive payments to increase Canadian renewable fuel production capacity. The excise tax exemption of $0.10 per liter for ethanol and $0.04 per liter for bio-diesel was eliminated and replaced with production incentive rates of up to $0.10/L for renewable alternatives to gasoline and $0.20/L for renewable alternatives to diesel for the first three years, declining in the six years following (see Table 2.11).

Table 2.11: Maximum payable incentive rate for Canadian bio fuels (CAD/L)

Fiscal Year		2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Renewable Alternatives										
to Gasoline	$/L	0.10	0.10	0.10	0.08	0.07	0.06	0.05	0.04	0.04
to Diesel	$/L	0.20	0.20	0.20	0.16	0.14	0.12	0.10	0.08	0.06

Source: Natural Resources Canada (2008).

The payment of incentives is part of the “ecoENERGY for Bio-fuels” program which provides $CAN 1.5 billion from the federal budget to support the Canadian bio fuel sector from 2008 to 2017.[23]

Besides reducing greenhouse gas emissions, the renewable fuel mandate also aims to facilitate rural development and improve farm income. This is to be achieved by two major programs encouraging direct producer participation in bio fuels and the bio-economy. The *Bio-fuels Opportunities for Producers Initiative (BOPI)* assists in developing business proposals to support the creation and expansion of bio-fuels production capacity with significant ownership by agricultural producers. Federal

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22 USDA – FOREIGN AGRICULTURAL SERVICE (2007).

23 NATURAL RESOURCES CANADA (2008).

spending totals $CAN 20 million until end of fiscal year 2007-2008 for this program. The *ecoAGRICULTURE Bio-fuels Capital Initiative (ecoABC)* is the second program and is designed to encourage producer equity and ownership in bio-fuel facilities running on agricultural feedstock. The program provides a total of $CAN 200 million of repayable contributions of up to $CAN 25 million per project until 2011. This support helps farmers overcome the challenges of raising the necessary capital for construction or expansion of bio-fuel production facilities.[24]

Besides federal programs and regulations for the bio fuel sector, different programs and regulations exist on the provincial and territorial level.[25]

A minimum of 1.9 billion liters of renewable fuel is needed for gasoline to meet the five percent content mandate which would require to double current production capacity of 700 million liters in Canada. The 2 % bio-diesel mandate will require 520 million liters of bio-diesel. To meet this mandate through Canadian produced bio-diesel, Canadian production capacity would have to increase five-fold from current bio-diesel production capacity.[26]

Wheat (bio-ethanol) and canola (bio-diesel) are two major crops of the Canadian Prairies which serve as a feed stock for renewable fuel production. Given the background of the national strategy for bio-fuels, demand for both crops and their substitutes will increase to feed renewable fuel production. Increases in demand will thus likely result in higher crop output prices and thus affect crop choice and crop portfolio composition on cash crop farms in the Canadian Prairies.

2.2.3.2 Strategies for bio-fuels and bio-energy in the EU and Germany

The EU is supporting bio-fuels with the aim of reducing greenhouse gas emissions, diversifying fuel supply sources, offering new income opportunities in rural areas and developing long-term replacements for fossil fuel.[27] Therefore, the European Commission set a goal of 5.75 % market share for bio-fuels in the overall transport fuel supply by 2010 (Table 2.12) and adopted a strategy for bio-fuels in 2006. In March 2007, the EU Council agreed upon a target for bio-fuels of 10 % for the overall fuel supply by 2020. Besides the

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[24] USDA-FAS (2007).

[25] Details for programs at the provincial level are found in USDA-FAS (2007, pp. 10-13).

[26] USDA-FAS (2007).

[27] An overview of the EU and German bio-fuels and renewable energy perspective is found in USDA-FAS (2006) and (2007a).

promotion of bio-fuels, EU supports renewable energy in general as part of its energy policy and the minimum target of renewable energies in total energy consumption of the EU is set at 20 % by 2020. Production of biomass for bio-fuels or other renewable energy (biogas, electricity, heat etc.) is thus of particular relevance to the arable farming sector in the EU.[28]

Table 2.12: EU targets for renewable energy and bio-fuels

Year	Status	Renewable Energy %	Bio-fuels %
2005	Achieved	6.50	1.00
2010	Indicative objective	12.00	5.75
2020	Proposed binding objective	20.00	10.00

Source: USDA-FAS (2007a), European Commission.

According to European Commission Research, production of biodiesel in the EU will have to increase from the current level of 6 million tonnes to about 19 million tonnes oil equivalent (toe) in 2020 to meet the 10 % mandate. Production of bio-ethanol in the EU will have to grow from about 2 million tonnes to more than 15.5 million tonnes oil equivalent during the same period.[29]

Table 2.13: Compulsory blending rates for bio-fuels in Germany

Year	Overall mandate %	Biodiesel %	Ethanol %
2007		4.4	1.2
2008		4.4	2.0
2009	6.25	4.4	2.8
2010	6.75	4.4	3.6
2011	7.00	4.4	3.6
2012	7.25	4.4	3.6
2013	7.50	4.4	3.6
2014	7.75	4.4	3.6
2015	8.00	4.4	3.6

Source: USDA-FAS (2007a), European Commission.

28 EUROPEAN COMMISSION (2006) and WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK (2007).

29 EUROPEAN COMMISSION (2007b).

A framework of measures to reach EU targets for bio-fuels and renewable energy are set by the EU for the member states which mainly consist of tax exemptions and blending obligations.[30] Pure bio-fuels in Germany (bio-diesel and bio-ethanol) have been either marginally taxed or exempted from mineral oil tax in the past. This incentive heavily increased production of bio-fuels, especially bio-diesel from rapeseed. The resulting increase in tax shortfalls from bio-fuels led to a reversal of the tax exemption and introduction of increasing tax rates in 2006. Promotion and support of bio-fuels was then replaced by compulsory blending rates for bio-fuels in regular fuels which will increase to 8 % bio-fuels of total fuel consumption by 2015 (Table 2.13).[31]

Renewable energies in Germany are further supported by the Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG). This act promotes generation of electricity and heat based on renewable resources (e. g., biomass) by providing guaranteed sale prices over 20 years.[32]

The EU strategy on renewable energies and its implementation in Germany is of major relevance to the German arable sector. Rapeseed is used as feedstock for biodiesel production while bio-ethanol is produced from wheat, rye and sugar beets in Germany. Corn silage and other biomass are a major feedstock for producing electricity from biogas. The area devoted to renewable resources from agriculture has increased nearly five-fold from 1997 to 2007, where it doubled from 1 million hectares in 2004 to more than 2 million hectares in 2007.[33] Given the background of the EU and national targets for renewable energy and bio-fuels, demand for biomass and thus crops will increase to feed renewable energy and fuel production. As in Canada, increase in demand will likely result in higher crop output prices and thus affect crop choice and crop portfolio composition on cash crop farms in the EU and Germany.

2.3 Natural framework conditions for cash crop farming

Natural framework conditions for cash crop production are characterized by natural factors that influence crop growth and output (yield) like climate and soils. Major factors in this sense are soils (type and quality), precipitation (amount of rainfall and its distribution) and temperature (vegetation period and temperature extremes).

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[30] EUROPEAN COMMISSION (2006a).

[31] USDA-FAS (2007a, p. 9).

[32] WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK (2007, pp. 59 -61).

[33] FNR (2008).

2.3.1 Soil climatic zones in Western Canada

As was mentioned in Chapter 2 so far, diversified cash crop production in Canada prevails in the three Prairie Provinces of Alberta, Saskatchewan and Manitoba (Figure A1 in Appendix). Thus, the description of natural framework conditions focuses on this region.

2.3.1.1 Climate

The Canadian Prairies are part of the Great Plains of North America and slope eastward from about 1,300 m above sea level in the foothills of the Rocky Mountains to under 300 m in Manitoba. These plains extend to the Arctic Ocean in the north with no mountain range to impede air movement, especially movement of arctic cold air masses to the south and warm air masses from the United States to the north. This results in extreme temperature and weather fluctuations in the region. As an example, lowest temperature recorded in Regina was minus 48° C and highest plus 43° C. Frost depth can be as much as 3 m.[34]

Since the prairies are separated from the Pacific by the Rocky Mountains, the air is usually too dry to give much precipitation. However, local showers and thundershowers are frequent in the summer, especially in Manitoba. Most of the precipitation falls in the summer. Further, Chinook winds and blizzards are well known in the prairies. Especially in the foothills of Alberta, temperatures can rise from below zero °C to well above freezing in a few hours. Overall, the Prairie Provinces have short, warm summers and very cold, long winters. Droughts are likely to occur, especially in the south and southeast.

Total precipitation increases from south to north and from west to east. Precipitation averages about 300 mm per year in the south (Cypress Hills area) and increases to 450 mm per year in the northwest (near Edmonton). Precipitation levels increase in the eastern prairie with over 500 mm near Winnipeg and over 650 mm at the Ontario border. In June and July an average of ten to twelve days have measurable precipitation, but April and September have only six to eight.[35]

About 50 % of the annual precipitation falls from May to September, with about 30 % falling as snow during the winter months. Snow acts as an important source of soil moisture, insulates the soil and protects against erosion and drying.[36]

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[34] CHAPMAN and BROWN (1978).

[35] CHAPMAN and BROWN (1978).

[36] CAMPBELL et al. (1990, p.4).

Precipitation on the prairies can be highly variable with a moisture deficit commonly occurring. The high winds and warm days of the prairie summer result in a high evapo-transpiration rate so that soil moisture is depleted, resulting in a moisture deficit. Crop growth and yields are negatively affected by this deficit since most of it occurs during the vegetation period. The moisture deficit is largest in the south and declines when moving northward and eastward over the prairies.

Throughout the arable part of the prairies, January is the coldest month and July the warmest. Temperatures fluctuate widely, daily and seasonally. Differences between the warmest and coldest months are above 30° C. Mean annual temperatures, frost-free days (> 0° C) and annual growing-degree days above 5° C increase from north to south. Eastward from the foothills of Alberta, winters are usually colder and summers are warmer. Thus, growing-degree days and frost-free days generally increase from west to east whereas the mean annual temperature decreases slightly. Mean annual temperatures vary from about 0° C in the northern arable part of Saskatchewan to about 5° C in Southern Alberta. Frost-free days range from about 115 in Southern Alberta and about 90 in the northern arable part of Saskatchewan.[37]

2.3.1.2 Soil zones

The arable part of the Canadian prairies is characterized by distinctive soil zones – the Brown, Dark Brown, Black and Grey Wooded soil zones. Brown and Dark Brown soil zones are mainly located in Southwestern Saskatchewan and Southeastern Alberta. Black and Grey Wooded soil zones descend from the Dark Brown soil zone in Alberta to the west and north and northwards and eastwards in Saskatchewan. The arable part of Manitoba consists mostly of Black and Grey Wooded soil zones (see Figure 2.3). Detailed soil zone maps for Alberta and Saskatchewan are found in Figure A6 and Figure A7 in the Appendix.

Each type of soil has different characteristics and fertility levels. Soil textures in the *Brown and Dark Brown soil zones* range from sands through loams and clays, and all combinations of the three. Low precipitation and high evapo-transpiration seriously restrict crop production; the moisture deficit is highest in these soil zones. In the Brown soil zone, only the more drought resistant soil types are arable without irrigation while much of this soil zone is suitable only for ranching. There are about 7 million hectares of arable land in the Brown soil zone and about 7.7 million hectares in the Dark Brown soil zone. These two soils zones account for about 49 % of the arable land in Western Canada.[38] Organic matter content is relatively low and ranges between 1.5 to 3.0 % for the

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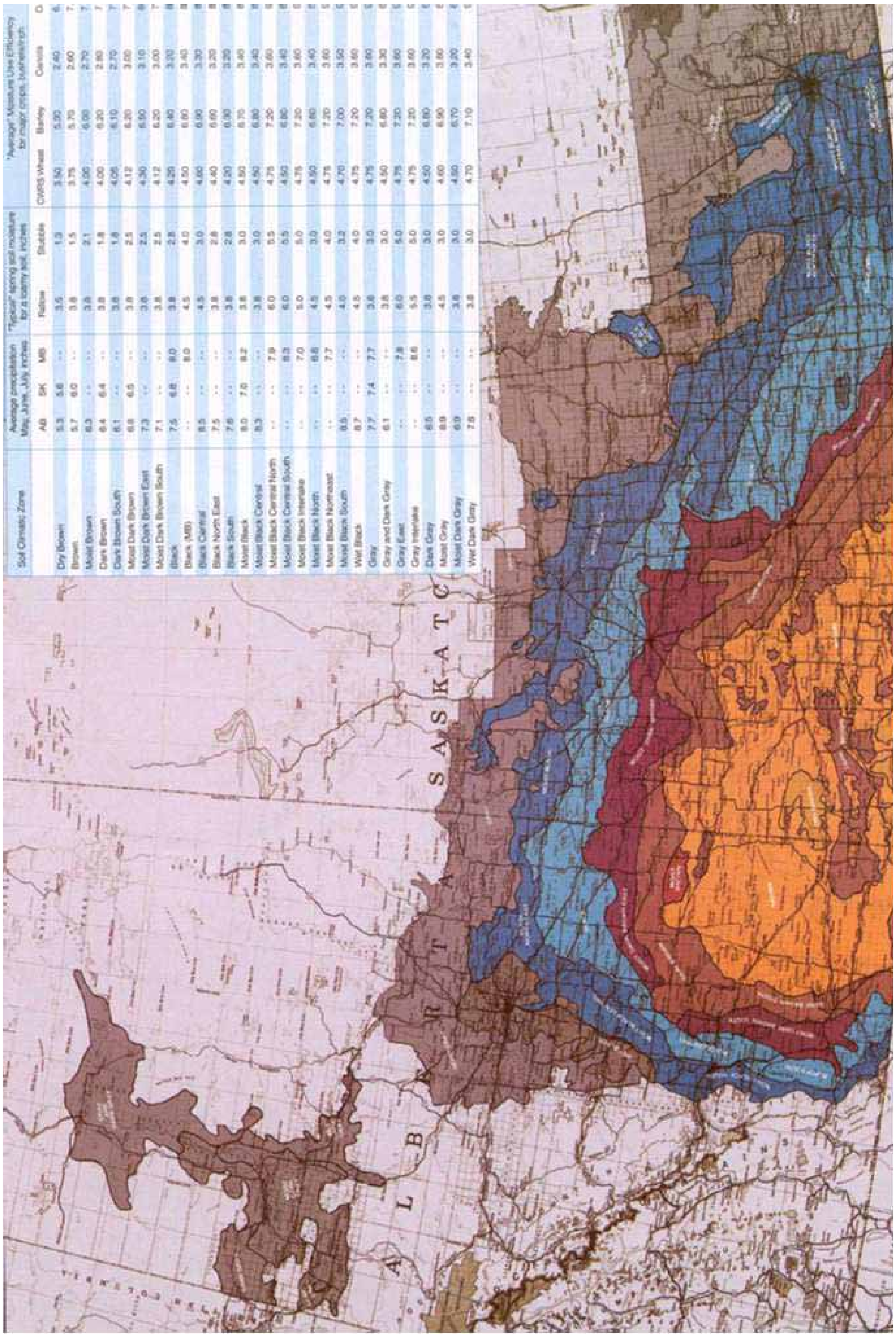
[37] CAMPBELL et al. (1990, p.4 et seq.).

[38] DEPAUW et. al. (1986).

Brown soils and around 4 % for Dark Brown soils. Topography varies from nearly level to very hilly in the Brown soil zone and plain in the Dark Brown zone.

Figure 2.3: Soil zones of the Canadian Prairie Provinces



Source: Agricultural Service Laboratories (1996).

The *Black soil zone* covers 16.8 million hectares, of which 78 % are potentially arable.[39] These soils usually receive more precipitation than other zones, averaging more than 400 mm annually in Saskatchewan and Alberta and 500 mm in Manitoba. Moisture deficits can still occur but not as frequently as in the Brown soil zone. The soil is mostly medium textured and the land is mainly level to gently rolling. Soil texture and a relatively high organic matter content of 8.7 % provide a high water holding capacity with good moisture supply resulting in higher yield levels than in the other soil zones.[40]

Less than 20 % of the *Grey Wooded soil zone* is considered suitable for arable production. This soil zone covers about 60 million hectares and is found between the Black soil zone and the boreal forests.[41] The climate of this zone is colder compared to the Black soil zone with fewer frost-free days which leads farmers to choose early maturing crops. The soil has a thin layer of dark colored humus over a layer of gray colored soil. The organic matter of this grayish layer is generally low but can be quite variable ranging from as low as 1 to 10 %. With sufficient applications of fertilizers these soils have good productivity. 1.2 million hectares of this soil zone are located in Manitoba.[42]

A special agricultural region in the Canadian Prairies is the Peace-River-Region, which stretches from northwestern Alberta into British Columbia along the Peace River. It is located north of the latitude of the arable area of the central plains in Alberta, Saskatchewan and Manitoba. The prevailing micro-climate allows for extensive, low input crop production and cattle farming.

2.3.1.3 Influence on cash crop production

The different climatic and soil zones of the Canadian Prairies have led to a regional differentiation of cash crop production with production systems adapted to the prevailing conditions. The short growing season and low number of frost-free days limit the viability of crops grown. Winter crops are limited to small areas only while summer crops dominate in the Canadian prairies. Moisture deficits as well as low and variable precipitation limit crop yields. Thus, production systems and especially tillage systems, aim to conserve moisture (no-till or minimum tillage seeding systems). Production systems for cash crops on the Canadian Prairies can generally be characterized as extensive, but land and capital intensive.

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[39] PUTNAM AND PUTNAM (1970).

[40] EVANS (1986).

[41] PUTNAM AND PUTNAM (1970).

[42] EVANS (1986).

2.3.2 Diverse climates and soils in Germany

Natural conditions for cash crop production in Germany are diverse and differ between regions. In comparison to Western Canada, climate and soils in Germany can not be characterized by a distinctive major zone or region. Agricultural area in Germany amounts to about 17 million hectares, of which 11.9 million hectares are used for crop production.[43]

Germany is divided into four distinct topographic regions – the Northern German Lowlands, the Central Uplands, the Alpine Foreland and the Alps. From the lowlands in the north, a plain with lakes, rivers, moors, marshes and heaths reaches inland from the sea, becoming a landscape of hills with streams, rivers, valleys, plateaus and extensive woodland areas. Hill and mountain ranges in the Central Uplands are up to 1,500 m high in altitude. The mountain ranges of the Alps form the southern border of Germany and reach up to 3,000 m in elevation.[44]

2.3.2.1 Climate

Germany has a temperate climate which is influenced by the North Atlantic Current with frequent weather changes (no sustained periods of cold or heat) and well-distributed precipitation in all seasons. Seasonal weather is subject to great variations from year to year. Winters may be unusually cold or prolonged, particularly in the higher elevations in the south, or mild, with the temperatures moving only two or three degrees above or below the freezing point. Spring may arrive early and extend through a hot, rainless summer to a warm, dry autumn with the threat of drought. In other years, spring may arrive so late as to be imperceptible and be followed by a cool, rainy summer.[45]

Despite the generally temperate climate there are specific regional climate patterns. Coastal areas and Northwestern Germany have a maritime climate which is dominated by warm westerly winds causing warm summers and mild winters with mean annual precipitation from 600 to 900 mm. From west to east and north to south, the climate becomes increasingly continental, showing more daily and seasonal variations with warmer summers and colder winters. Precipitation levels in most parts of Eastern Germany are lowest and range from below 500 mm to 600 mm per year, while Central and Southern Germany receive from 500 mm to 900 mm. The alpine regions in the south

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[43] BMELV(2006).

[44] Library of Congress (2005).

[45] Encyclopedia Britannica (2008).

and higher elevations in the Central Uplands have a so-called mountain climate. Due to higher elevation, temperatures are lower and precipitation is greater, since air is moisture-laden when moving across higher terrain. Precipitation in these regions may reach 1,500 mm and even 2,000 mm in the Alps.[46]

The mean annual temperature in Germany is 9° C. January is the coldest month with average temperatures ranging from 1.5° C to minus 0.5° C in the lowlands and can drop below minus 6° C in the mountains depending on elevation. July is the warmest month and situation reverses as it is cooler in the north than in the south with average temperatures about 16 to 18° C in the north and slightly higher in the south with about 19° C.[47]

During the year, more than four month show an average temperature above 10° C resulting in a growing period of more than 120 days.[48]

2.3.2.2 Soils

Most of Germany has temperate brown and deep brown soils. Finest soils are developed on the loess of the northern flank of the Central Uplands, the Magdeburg Plain, the Thuringian Basin and adjoining areas, the Rhine valley, and the Alpine Foreland. They range from black to extremely fertile brown soil types and most of them are arable land under cultivation.

In the northern plains soil types are sand, loam, and brown podzols, which are heavily leached of mineral and organic matter and thus are of poorer quality. Along the North Sea littoral in the northwest there are some extensive areas of sand, marsh, and mudflats that are covered with rich soil suitable for grazing and growing crops. The till (ground moraine) of the North German Lowlands and Alpine Foreland has heavy but fertile soil. Other productive soils include those based on fluvial deposits in river valleys (e. g., the Rhine valley in Western Germany). Brown soil covers much of the Central Uplands and is used for agriculture and grazing. With increasing elevation, soils are suitable only for grazing or forestation. Because of the preponderance of mountainous and forested areas, the remainder of German soil types range from sand to loam, from loam to clay, and from clay to rocky outcrops.[49]

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[46] KLOHN and WINDHORST (1998).

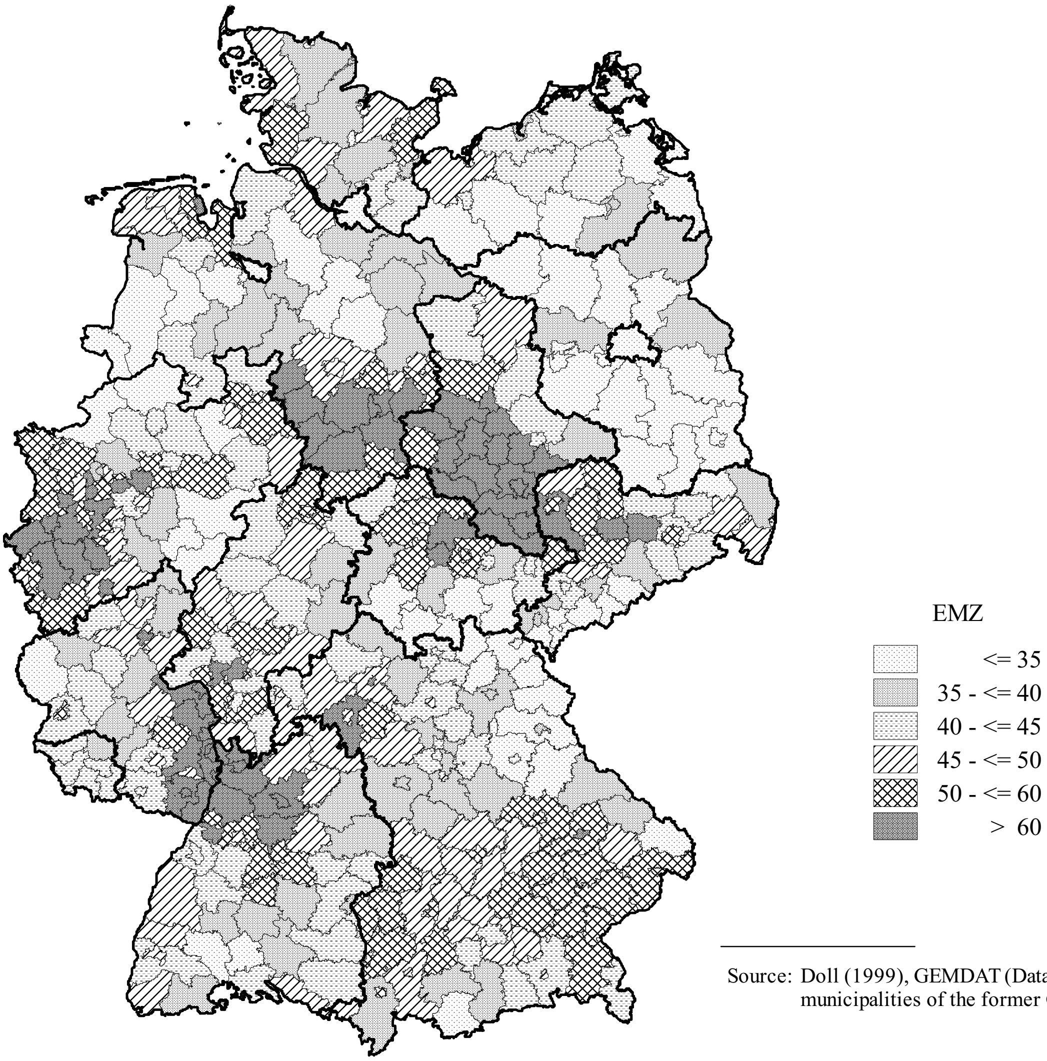
[47] HUBER (2000) and LIBRARY OF CONGRESS (2005).

[48] KLOHN and WINDHORST (1998).

[49] ENCYCLOPEDIA BRITANNICA (2008).

The combined effects of climate and soils for crop production in Germany are expressed by the “Ertragsmesszahl, EMZ”. EMZ is an indicator for yield potential or natural productivity of a location ranging from zero (poorest productivity) to 100 (best productivity). The EMZs for the different rural districts in Germany are displayed in Figure 2.4. Locations with highest natural productivity (yield levels) are found in the “Börde” landscapes around Hildesheim, Brunswick and Magdeburg located north and east of the Harz Mountains in Central and Eastern Germany. Locations in the Rhineland in Western Germany and the Rhine valley in Southwestern Germany also show high natural productivity.

Figure 2.4: Average EMZ (Ertragsmesszahl) for natural productivity by rural districts in Germany



Source: Doll (1999), GEMDAT (Data file for rural municipalities of the former GDR).

2.3.2.3 Influence on cash crop production

Climate and soils in Germany provide natural framework conditions for cash crop production with relatively high and stable yields for most arable regions of Germany. Major crops like cereals and rapeseed are mostly grown as winter varieties. Most of broad acre crop production like cereal and oilseed production are found in Northern and Eastern Germany (northern lowlands). Lower precipitation and higher temperatures during the growing season often negatively affect yield levels in Eastern Germany. This also holds for some regions of Southern Germany. Special crops like fruits, vegetables and wine are produced in the warmer climate of Southern and Southwestern Germany.

2.4 Production, prices and regional distribution of major cash crops

Agricultural policy and natural framework conditions lead to regional differentiation of cash crop production. In Canada, the Prairie Provinces and Alberta and Saskatchewan in particular dominate in production as well as in acreage of major cash crops (Table 2.14). Wheat is a major crop in both provinces, with Alberta having a share of about 33 % in Canadian production and 30 % in total acreage. Saskatchewan has slightly higher shares with about 38 % in production and 47 % in acreage. Further, canola is an important crop as well. Alberta accounts for 37 % of total Canadian canola output and about 32 % of canola acreage while Saskatchewan contributes more than 44 % to production and more than 47 % to acreage. Durum wheat is a special crop to the hot and dry zones of the Canadian prairies (Brown Soil Zone) and Alberta and Saskatchewan mostly make up all durum production of Canada. The same can be observed for pulse crops like lentils and peas though both crops are found in all zones or regions across the provinces. It has to be noted that nearly all (about 98 %) of Canadian production of lentils takes place in Saskatchewan.

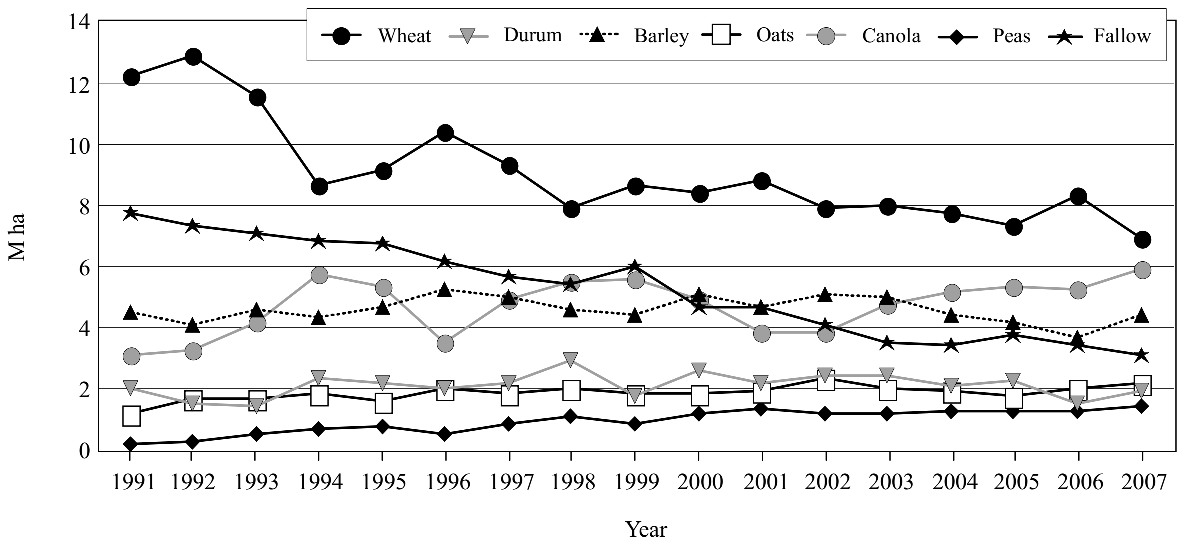
Table 2.14: Production and acreage of selected major cash crops in Alberta, Saskatchewan and Canada (Average 2005-2007)

	Average 2005 - 2007									
	Alberta				Saskatchewan				Canada	
Crop	Production ('000 t)	Share in Total Production (%)	Acreage (ha)	Share in Total Acreage (%)	Production ('000 t)	Share in Total Production (%)	Acreage (ha)	Share in Total Acreage (%)	Production ('000 t)	Acreage (ha)
Wheat (excl. Durum)	6,534,333	33.7	2,255,800	30.0	7,518,600	38.8	3,534,233	47.0	19,375,100	7,521,433
Durum	782,633	18.1	296,200	15.3	3,526,233	81.7	1,632,200	84.6	4,314,067	1,930,433
Barley	4,916,933	45.8	1,776,533	43.6	4,103,400	38.2	1,669,000	40.9	10,744,867	4,076,433
Oats	721,133	18.3	481,467	24.0	1,891,767	48.0	939,800	46.8	3,943,733	2,006,600
Canola	3,356,567	37.0	1,794,100	32.4	4,033,933	44.4	2,634,133	47.6	9,078,100	5,537,567
Peas	565,867	20.1	236,333	17.6	2,161,500	76.8	1,066,400	79.3	2,816,100	1,344,167
Lentils	13,033	1.6	8,900	1.4	817,867	98.4	616,533	98.6	830,900	625,433
Flaxseed	35,300	4.1	22,967	3.3	687,933	79.0	549,000	78.7	870,967	697,867

Source: CANSIM (Canadian Socio-economic Information Management System).

The development of acreage of major crops in Canada shows two major trends (Figure 2.5). Total wheat acreage (excluding durum) as well as the area of summer fallow has declined substantially to more than a half from 1991 to 2007. On the other side, acreage of canola and peas has increased significantly. In the 1991 to 2007 period, canola acreage nearly doubled while acreage of peas increased seven-fold. Reduction of wheat and fallow acreage and the increase in pulse crop acreage is due to a shift from the "traditional" wheat-wheat-fallow rotation to more sophisticated crop rotations. The wheat-wheat-fallow rotation dominated in prairie cash crop production until the mid 1990s and lost its importance with the abolishment of transportation subsidies in 1996[50] and the emergence of new production technologies (direct or no-till seeding) and new crops like peas and lentils. The expansion of canola acreage was further influenced by the increase in demand for canola or rapeseed oil mainly driven by bio-diesel production. The according development of yields for major cash crops in Canada is displayed in Figure A8 in the Appendix.

Figure 2.5: Acreage (M ha) of major cash crops and summer fallow in Canada from 1991 to 2007



Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

Growth in pea acreage was part of a general expansion of pulse crops in the past, especially in the Canadian Prairies. In addition to peas, which are the most important pulse crop, lentils, chick peas and beans are grown in the Prairie Provinces. Acreage

50 The Western Grain Transportation Act (WGTA) regulated and subsidized freight rates and costs for prairie farmers. Though freight rates are still controlled by the government, abolishment of the WGTA in 1996 led to a significant increase in transportation costs for most farmers in the prairies.

devoted to pulse crops increased from 0.53 million hectares in 1991 to 2.34 million hectares in 2007.[51] Reasons for this expansion are manifold. Technical progress like availability of new herbicides and the development of new varieties, well-adapted to the Canadian climate and growing conditions, and low prices for cereals helped expansion of pulse production. At the same time changes in production systems like reduced fallow, extended crop rotations and direct seeding occurred. The agronomic benefits of pulses like nitrogen-fixing ability and improved disease and weed control through diversified rotations contributed to the increase in acreage of pulses in the Canadian prairies. Today, Canada is an important player on the global market for pulses and is the leader in exports of peas, lentils and chickpeas.[52]

Table 2.15: Production and acreage of selected major cash crops in North-Rhine Westphalia, Saxony-Anhalt and Germany (Average 2005-2007)

Crop	Average 2005 - 2007									
	North Rhine - Westphalia				Saxony - Anhalt				Germany	
	Production ('000 t)	Share in Total Production (%)	Acreage (ha)	Share in Total Acreage (%)	Production ('000 t)	Share in Total Production (%)	Acreage (ha)	Share in Total Acreage (%)	Total Production ('000 t)	Total Acreage (ha)
Wheat	2,180,304	9.2	278,198	8.8	2,329,240	9.8	332,133	10.5	23,702,826	3,162,600
Barley	1,256,056	10.8	195,722	10.1	739,908	6.4	119,433	6.1	11,622,396	1,946,800
Rye	111,495	4.0	18,688	3.4	294,985	10.6	70,133	12.8	2,794,919	549,100
Corn	808,097	19.7	85,778	19.4	140,619	3.4	17,000	3.8	4,107,537	443,100
Rapeseed	248,398	5.0	67,162	5.1	577,267	11.5	162,580	12.3	5,001,318	1,323,100
Sugar Beets	3,755,090	14.9	60,607	14.4	2,468,867	9.8	45,173	10.8	25,281,618	420,100
Peas	7,869	2.3	2,105	1.9	47,641	13.8	17,655	16.0	346,342	110,300

Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

In Germany, production and acreage of major cash crops is more evenly distributed between regions than in Canada. North Rhine-Westphalia and Saxony-Anhalt do not dominate in any of the major cash crops (Table 2.15). Except for wheat, both regions differ in production and acreage of crops. Share of both regions in wheat production and acreage is mostly at the same level, ranging from more than 8 % to more than 10 %. Barley production and acreage is higher in North Rhine-Westphalia than in Saxony-Anhalt due to high demand from the feed and livestock sector located in this region. The same holds for production and acreage of corn. Production and acreage of rye and peas is higher in Saxony-Anhalt than in North Rhine-Westphalia due to different climate, soils and alternative crops. Rye is suited for poor soils and dry climate which prevail in Northern Saxony-Anhalt, peas are adapted to warm and dry climate which prevails in

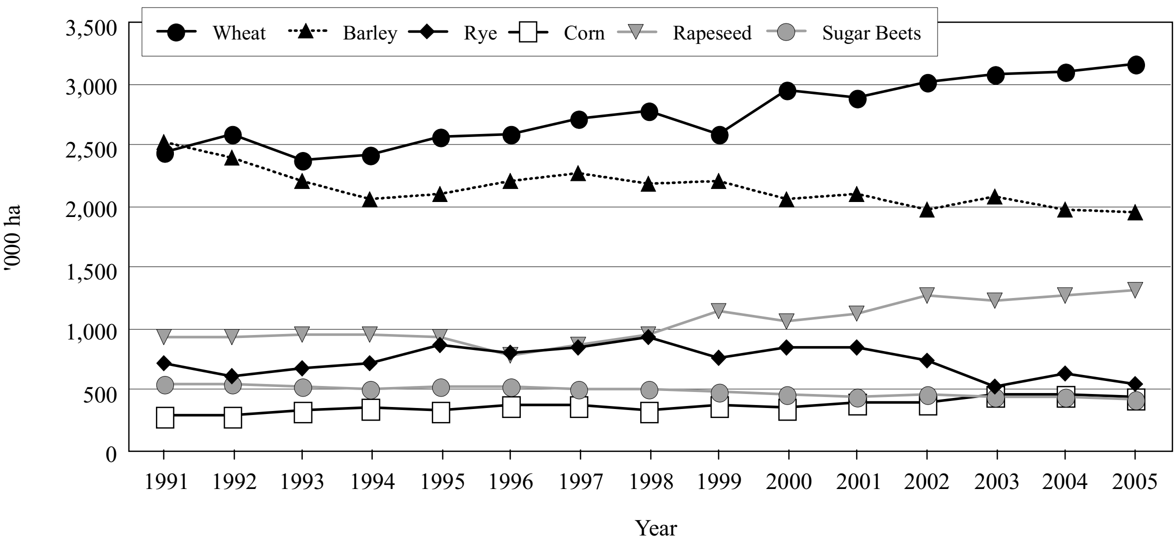
51 CANSIM (2008).

52 PULSE CANADA (2008).

Central and Southern Saxony-Anhalt. Rapeseed and sugar beets are the most important broad-leaf crops in both regions with both crops sum up to about 20 % share in production and acreage though share of both crops in both regions is different. While Saxony-Anhalt has a higher share in production and acreage of rapeseed and a lower share in sugar beets, the opposite holds for North Rhine-Westphalia. Production and acreage of sugar beets is mostly determined by the EU sugar quota regime (compare Chapter 2.2.2).

Development of acreage devoted to major cash crops in Germany reveals two general trends (Figure 2.6). Acreage of wheat and rapeseed increased while acreage of barley and rye decreased over the 1991 to 2005 period. Increase in acreage of wheat and rapeseed paralleled and also the decrease in barley and rye, especially during the 1999 to 2005 period. Increase in wheat and rapeseed was due to better market conditions and demand especially for rapeseed as a feedstock for bio-diesel production led to increased rapeseed acreage. Reduction in rye acreage was caused by reduction in EU intervention price and abolishment of rye intervention in 2004 (compare Chapter 2.2.2). According development of yields for major cash crops in Germany can be found in Figure A9 in the Appendix.

Figure 2.6: Acreage (‘000 ha) of major cash crops in Germany from 1991 to 2005

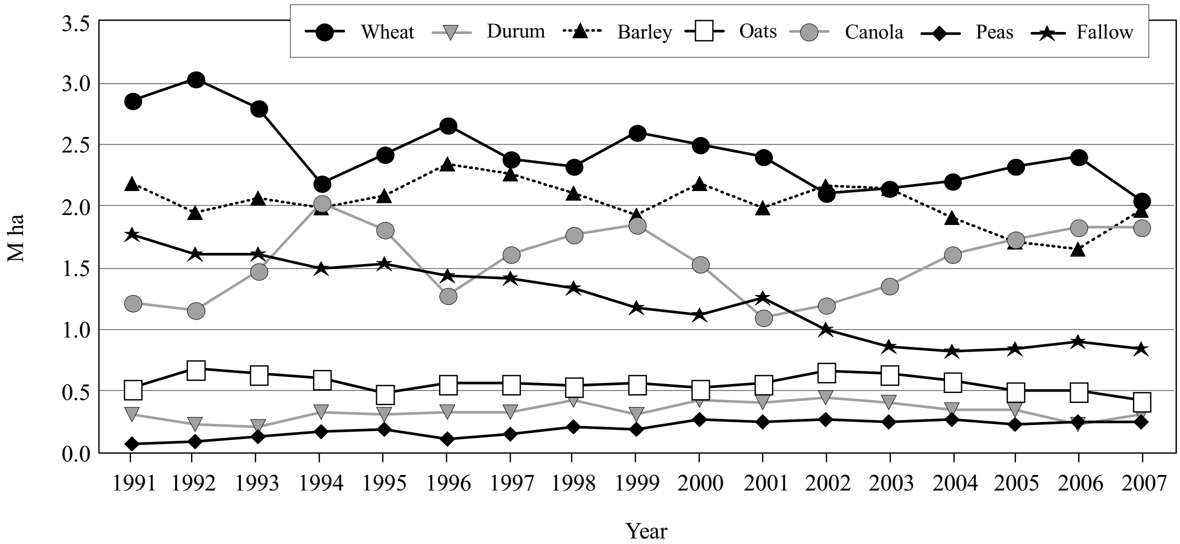


Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

2.4.1 Acreage, yields and prices of major cash crops in Canada

Over the period from 1991 to 2007, wheat acreage was highest in Alberta followed by barley and canola (Figure 2.7). In 2007, wheat, barley and canola reached nearly the same level in acreage at about 2 million hectares. Acreage devoted to fallow decreased from more than 1.5 million hectares in 1991 to less than 1 million hectares in 2007. Fallow is used during a rotation to restore soil moisture and control for weeds since no crop is grown.

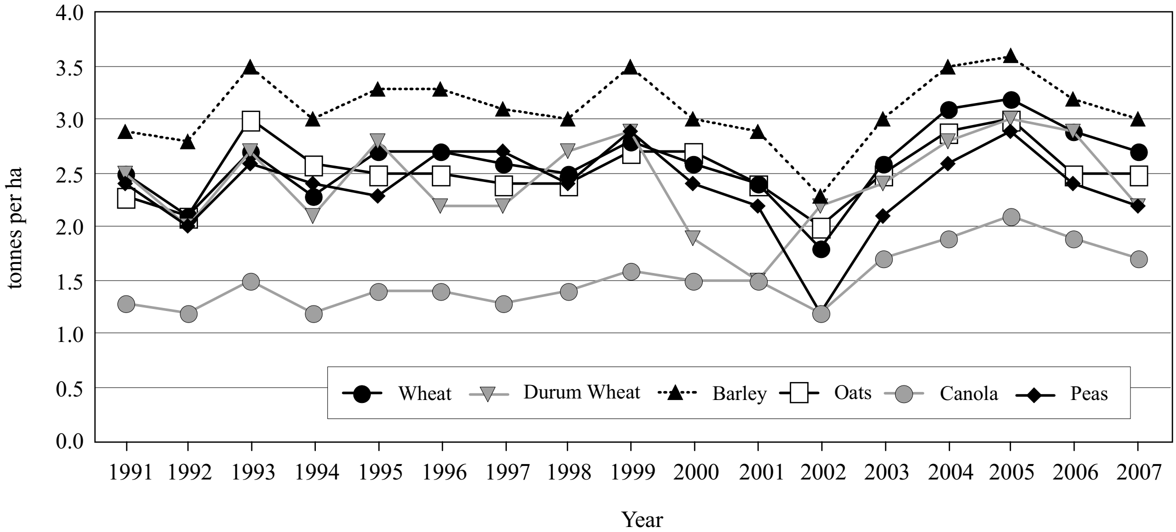
Figure 2.7: Acreage (M ha) of major cash crops in Alberta from 1991 to 2007



Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

Yield levels in Alberta reflect prevailing natural framework conditions of short growing seasons and low precipitation levels (see Chapter 2.3.1). Yield levels for most crops in Alberta range mostly around the same level of about 1.2 to 3.2 tonnes per hectare except for barley with higher yield levels around 2.3 to 3.6 tonnes per hectare and canola with lower yield levels between 1.2 and 2.1 tonnes per hectare (Figure 2.8). The impact of the major drought in 2001/2002 on yield levels can easily be revealed. Also, yield levels in Alberta are quite volatile with a coefficient of variation ranging from 0.16 for oats to 0.29 for durum and peas in the decade from 1997 to 2007.

Figure 2.8: Yields (t/ha) of major cash crops in Alberta from 1991 to 2007



Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

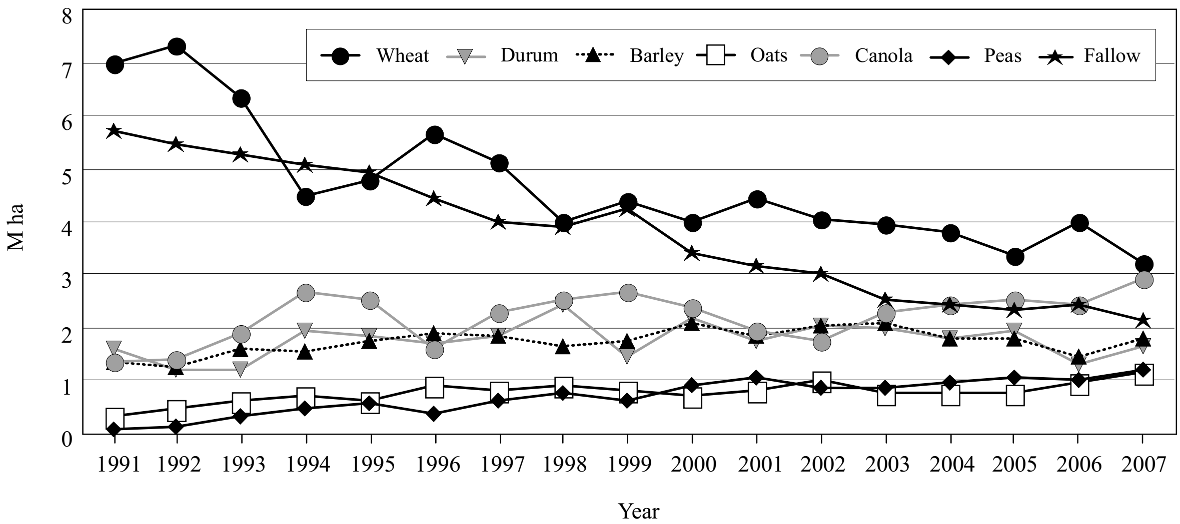
	Wheat	Durum	Barley	Oats	Canola	Peas
2007	2.7	2.2	3.0	2.5	1.7	2.2
Ø 1997 - 2007	2.7	2.4	3.1	2.5	1.6	2.4
Max[1)]	3.2	3.0	3.6	3.0	2.1	2.9
Min[1)]	1.8	1.5	2.3	2.0	1.2	1.2
CV[2)]	0.13	0.19	0.11	0.10	0.16	0.19

[1)] Maximum and minimum yields in the observed period.
[2)] Coefficient of variation.

The development of production of major cash crops in Alberta is illustrated in Figure A10 in the Appendix.

Wheat acreage in Saskatchewan dropped by more than half from about 7 million hectares in 1991 to about 3 million hectares in 2007 (Figure 2.9). The same decrease holds for acreage devoted to summer fallow, which dropped from more than 5.5 million hectares to about 2.0 million hectares over the same period. Acreage of peas and canola show a significant increase, from 0.05 million hectares in 1991 to more than 1.1 million hectares in 2007 for peas, and from 1.1 million hectares to 3.0 million hectares for canola in the same period.

Figure 2.9: Acreage (M ha) of major cash crops in Saskatchewan from 1991 to 2007

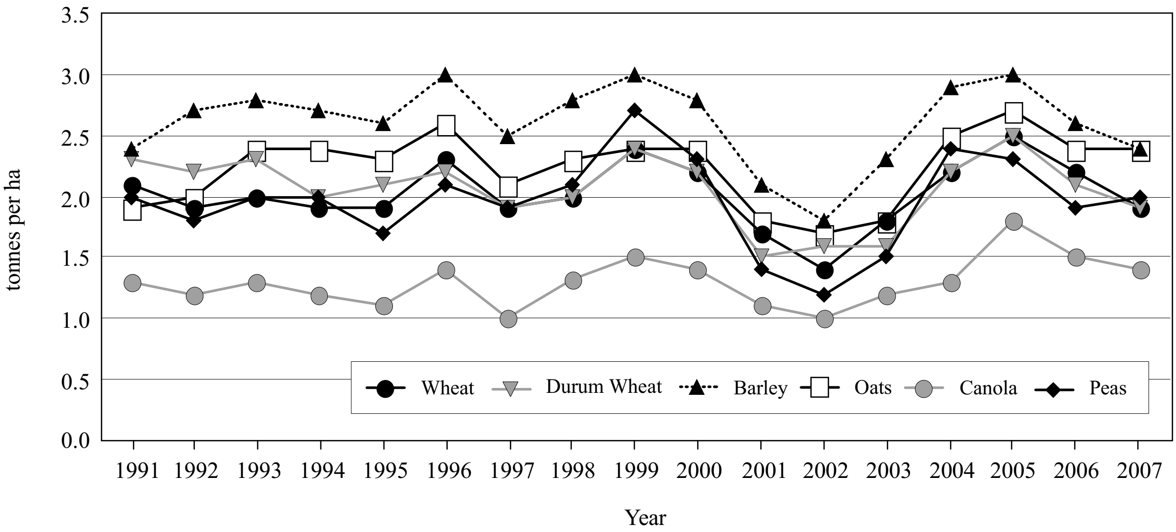


Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

Yields of crops in Saskatchewan show a similar pattern to those in Alberta though yield levels are lower on average in Saskatchewan than in Alberta and thus reflect the prevailing natural framework conditions of high moisture deficits. Yield levels range from 1.0 to 3.0 tonnes per hectare in Saskatchewan and 1.2 to 3.6 tonnes per hectare in Alberta (Figure 2.10). Yield levels for most crops move again close together, ranging from about 1.3 to about 2.7 tonnes per hectare. Yields of barley are higher, ranging from about 1.7 to 3.0 tonnes per hectare and yields for canola are lower, ranging from about 1.0 to 1.8 tonnes per hectare. As for yields in Alberta the impact of the drought in 2001 and 2002 can clearly be observed though yields in Saskatchewan were below average for three consecutive years compared to only one year in Alberta. Furthermore, yields of crops in Saskatchewan are more volatile than in Alberta. The coefficient of variation ranges from 0.20 for canola to 0.31 for peas in the 1997 to 2007 period.

The development of production of major cash crops in Saskatchewan is illustrated in Figure A11 in the Appendix.

Figure 2.10: Yields (t/ha) of major cash crops in Saskatchewan from 1991 to 2007



Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

	Wheat	Durum	Barley	Oats	Canola	Peas
2007	1.9	1.9	2.4	2.4	1.4	2.0
Ø 1997 - 2007	2.0	2.0	2.6	2.2	1.3	2.0
Max[1)]	2.5	2.5	3.0	2.7	1.8	2.7
Min[1)]	1.4	1.5	1.8	1.7	1.0	1.2
CV[2)]	0.15	0.16	0.14	0.14	0.17	0.22

[1)] Maximum and minimum yields in the observed period.

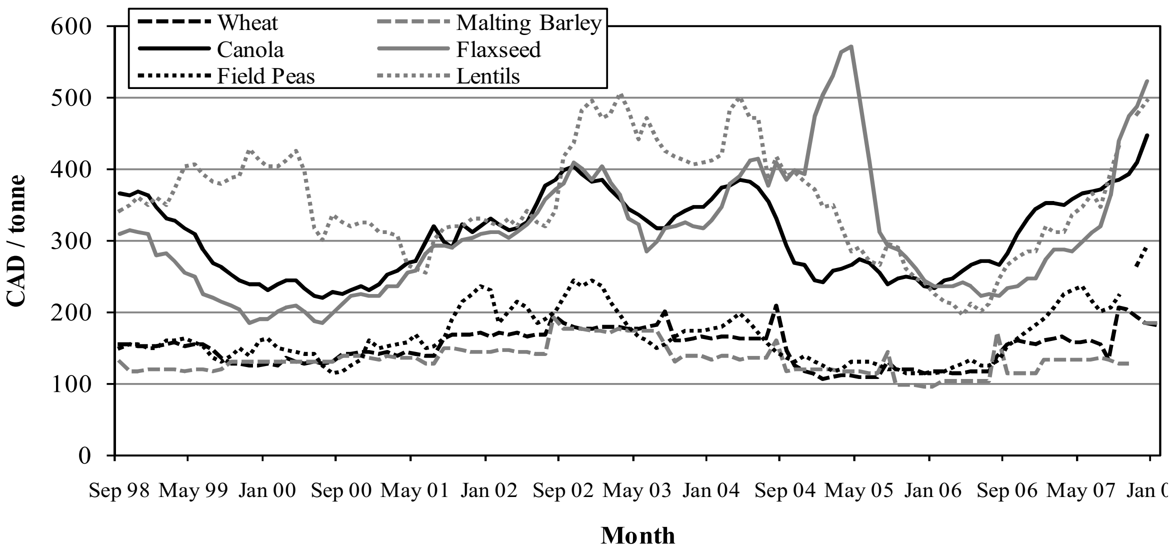
[2)] Coefficient of variation.

Development of crop output prices for major cash crops in Canada is illustrated based on prices for producers in Saskatchewan (Figure 2.11). Prices for wheat, malting barley and field peas range from about 100 to 250 $CAN per tonne in the 1998 to 2008 period. Prices for canola, flaxseed and lentils range from about 200 to more than 570 $CAN per tonne for the same period.

Prices of wheat, barley and field peas are less volatile than prices for canola, flaxseed and lentils. Coefficient of variation is below 0.20 for the first group of crops and higher than 0.20 for the latter group.

As can be seen from Figure 2.11, crop output prices have been comparably low since harvest of 2004, reaching lowest levels after harvest of 2006. Since then, prices for all crops show a strong increase reflecting the tight supply situation on world markets.

Figure 2.11: Crop output prices (CAD/t) of major cash crops in Saskatchewan from 1998 to 2008



Crop	Sep. 2007	Ø 1998 - 2008	Max[1)]	Min[1)]	CV[2)]
Wheat	206	150	208	106	0.16
Malting Barley	128	134	193	96	0.16
Canola	384	308	447	221	0.18
Flaxseed	438	308	570	184	0.29
Field Peas	223	166	292	115	0.23
Lentils	430	353	505	195	0.21

[1)] Maximum and minimum ratios in the observed period.

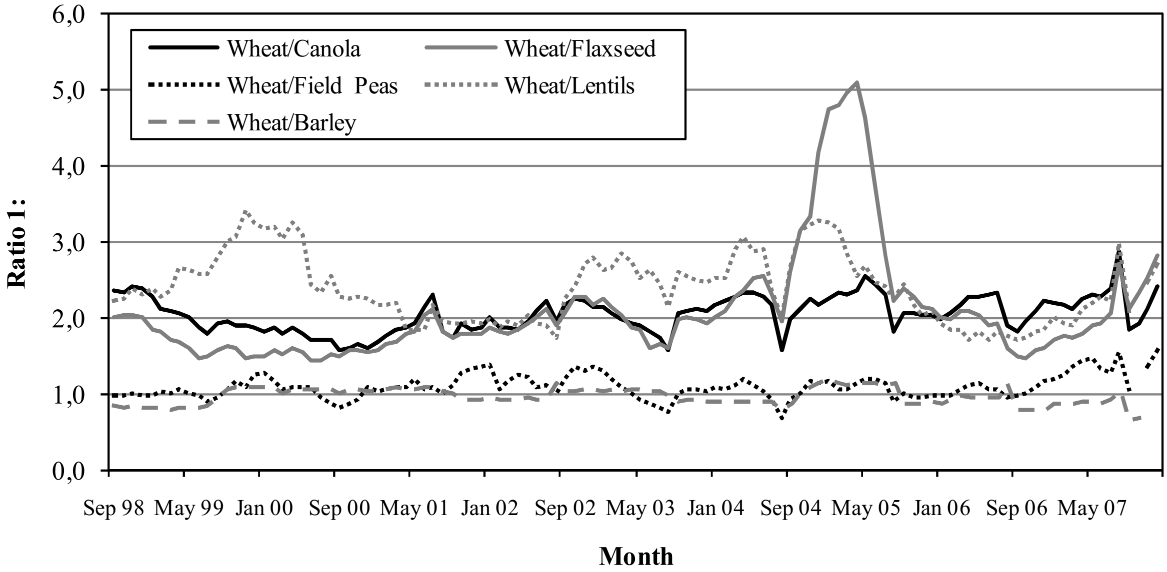
[2)] Coefficient of variation.

Source: Own illustration based on CANSIM.

Price ratios between wheat and other crops have been calculated to demonstrate relative price changes over time (Figure 2.12). Price ratios for wheat and barley as well as for wheat and field peas mostly range around the same level of 0.7 to 1.6 in the 1998 to 2008. Further, these price ratios are relatively stable with a CV of 0.11 and 0.14 respectively. The same holds for prices ratios between wheat and canola with a CV of 0.11. These price ratios range from 1.6 to 2.9 in the observed period.

Looking at the price increase since the harvest of 2006, price ratios have increased for all crops except barley and thus discriminating wheat and barley and providing a price advantage for oilseeds and pulses.

Figure 2.12: Crop output price ratios of wheat and major cash crops in Saskatchewan from 1998 to 2008



Price Ratio	May 2007	Ø 1998 - 2008	Max[1)]	Min[1)]	CV[2)]
Wheat/Canola	2.3	2.1	2.9	1.6	0.11
Wheat/Field Peas	1.5	1.1	1.6	0.7	0.14
Wheat/Lentils	2.2	2.4	3.4	1.7	0.19
Wheat/Flaxseed	1.9	2.1	5.1	1.4	0.36
Wheat/Barley	0.9	1.0	1.2	0.7	0.11

[1)] Maximum and minimum ratios in the observed period.

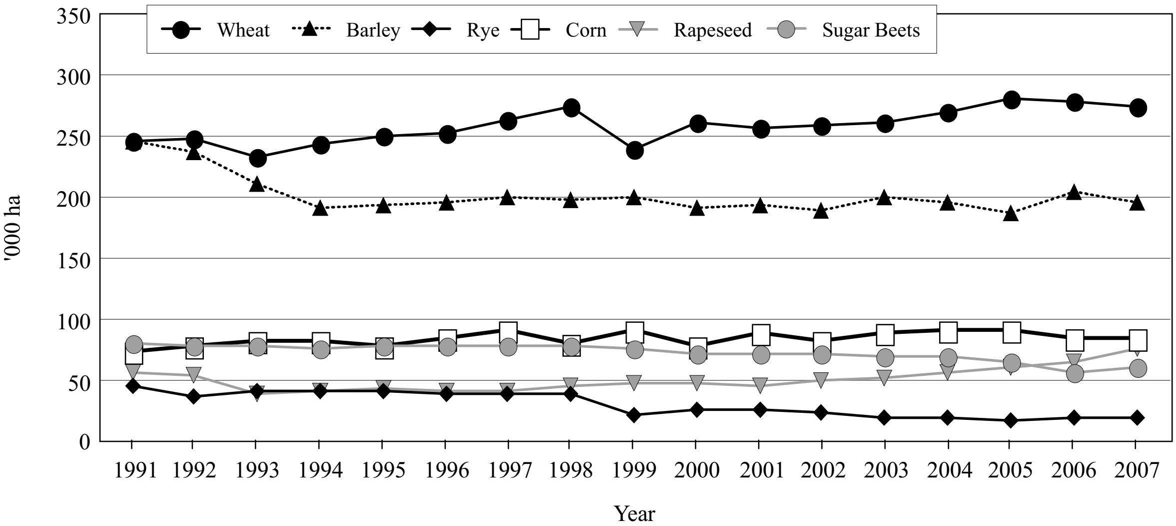
[2)] Coefficient of variation.

Source: Own calculations based on CANSIM.

2.4.2 Acreage, yields and prices of major cash crops in Germany

Acreage of major cash crops in North Rhine-Westphalia was relatively constant over the 1991 to 2007 period (Figure 2.13). Wheat acreage increased slightly from about 250,000 hectares in 1991 to 275,000 hectares in 2007. Acreage of rapeseed expanded from about 50,000 hectares to 75,000 hectares in the same period. Acreage of rye and sugar beets declined slightly while acreage of barley declined from about 250,000 hectares in 1991 to below 200,000 hectares in 1994 and ranged around this level from this point on. The situation of relatively constant acreage for major cash crops is due to the importance of other competing crops, mainly grown for feed or local consumption like corn for silage and potatoes.

Figure 2.13: Acreage ('000 ha) of major cash crops in North Rhine-Westphalia from 1991 to 2007



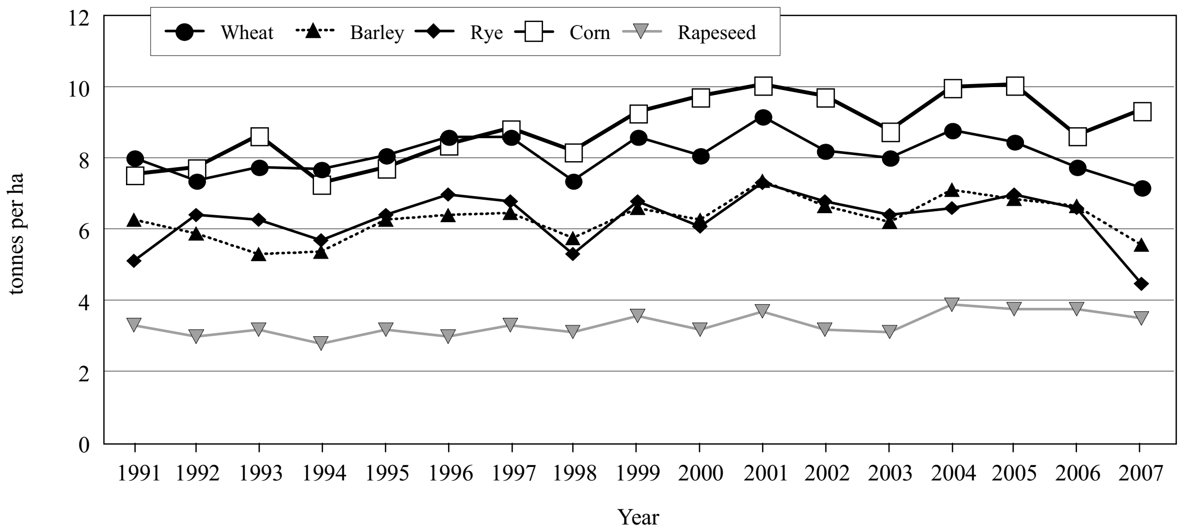
Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

Yield levels for major cash crops in North Rhine-Westphalia are higher and more stable than in the Canadian prairies (Figure 2.14). Coefficients of variation range from 0.06 for corn to 0.12 for rye for the 1997 to 2007 period. Yield levels thus reflect the prevailing natural framework conditions of a mild climate and sufficient rainfall. Yield levels are also higher since most crops are grown as winter varieties.

Three groups of yield levels can be identified with wheat and corn yields being the highest, barley and rye yields are in the medium range and rapeseed yields are lowest. Corn yields are highest ranging from 7.3 to 10.1 tonnes per hectare from 1991 to 2007 and averaging 9.4 tonnes per hectare in the 1997 to 2007 period. Wheat yields in North Rhine-Westphalia are nearly 3 to 4 times higher than in the Canadian prairies and average 8.2 tonnes per hectare in the 1997 to 2007 period. Yield levels of barley and rye are quite similar, ranging from 5.3 to 7.4 tonnes per hectare and 4.5 to 7.3 tonnes per hectare respectively. Yield levels of rapeseed range from 2.8 to 3.9 tonnes per hectare and average 3.5 tonnes per hectare in the 1997 to 2007 period.

The development of production of major cash crops in North Rhine-Westphalia is illustrated in Figure A12 in the Appendix.

Figure 2.14: Yields (t/ha) of major cash crops in North Rhine-Westphalia from 1991 to 2007



Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

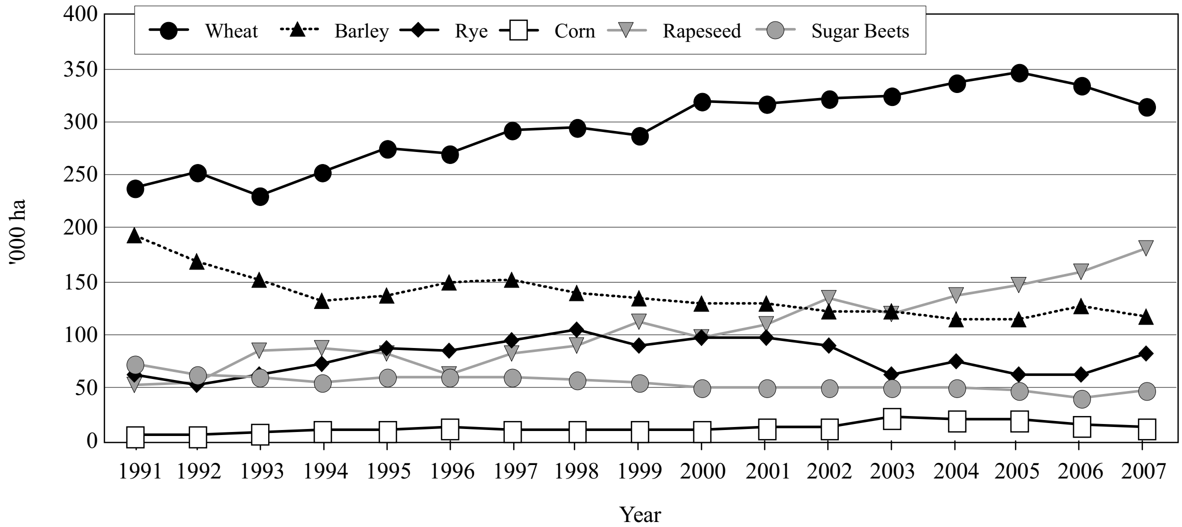
	Wheat	Barley	Rye	Corn	Rapeseed
2007	7.2	5.6	4.5	9.4	3.5
Ø 1997 - 2007	8.2	6.5	6.4	9.4	3.5
Max[1)]	9.2	7.4	7.3	10.1	3.9
Min[1)]	7.2	5.3	4.5	7.3	2.8
CV[2)]	0.07	0.08	0.12	0.06	0.09

[1)] Maximum and minimum yields in the observed period.

[2)] Coefficient of variation.

Development of wheat and rapeseed acreage in Saxony-Anhalt shows strong increases over the 1991 to 2007 period (Figure 2.15). Wheat acreage increased from about 240,000 hectares to about 310,000 hectares while rapeseed acreage nearly quadrupled to about 180,000 hectares in the same period. Acreage of barley dropped from about 190,000 hectares in 1991 to about 130,000 hectares in 1994 and remained relatively constant at around 120,000 hectares from that point on. Rye acreage peaked in 1998 at around 100,000 hectares but declined to about 60,000 hectares in 2006.

Figure 2.15: Acreage ('000 ha) of major cash crops in Saxony-Anhalt from 1991 to 2007

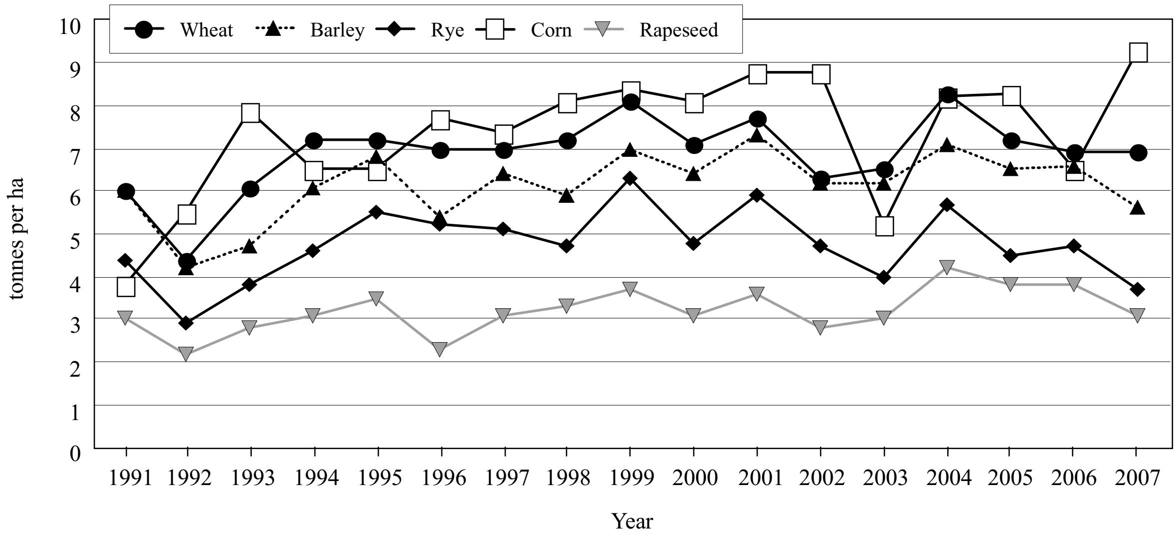


Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

Development of yield levels in Saxony-Anhalt is displayed in Figure 2.16. Yield levels of corn are highest (7.9 tonnes per hectare on average in the 1997 to 2007 period), followed by wheat (7.2 tonnes per hectare) and barley (6.5 tonnes per hectare). Yield levels of rye are lowest of all cereals since production prevails on poor soils with low rainfalls. Rapeseed yields are lowest ranging from 2.2 to 4.2 tonnes per hectare in the 1991 to 2007 period.

The development of production of major cash crops in Saxony-Anhalt is illustrated in Figure A13 in the Appendix.

Figure 2.16: Yields (t/ha) of major cash crops in Saxony-Anhalt from 1991 to 2007



Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

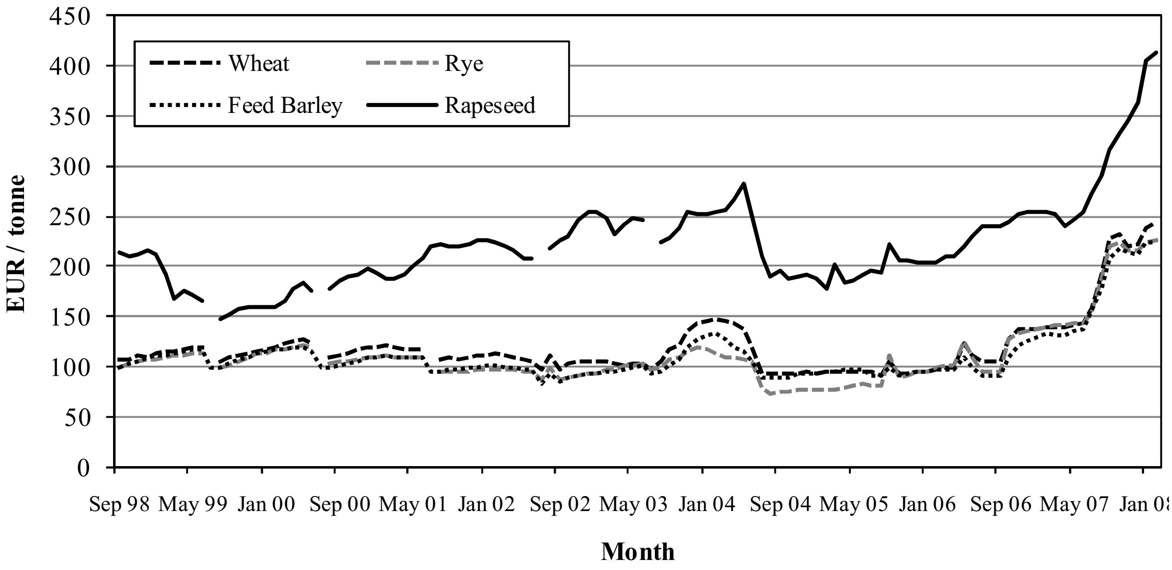
	Wheat	Barley	Rye	Corn	Rapeseed
2007	6.9	5.6	3.7	9.3	3.1
Ø 1997 - 2007	7.2	6.5	4.9	7.9	3.4
Max[1)]	8.3	7.3	6.3	9.3	4.2
Min[1)]	4.4	4.2	2.9	3.8	2.2
CV[2)]	0.08	0.08	0.15	0.14	0.12

[1)] Maximum and minimum yields in the observed period.
[2)] Coefficient of variation.

Crop output prices for cereals in Germany have been stable for most of the 1998 to 2008 period since prices have been dominated by the intervention system of the EU (compare Chapter 2.2.2.1) (Figure 2.17). As in Canada, prices for all crops in Germany have strongly increased since harvest of 2006 due to tight supply situation on the world markets.

Prices for cereals in Germany range from around 70 EUR per tonne to around 150 EUR per tonne for the observed period until harvest of 2006. Since then, cereal prices increased to around 240 EUR per tonne. Prices for rapeseed range from around 150 EUR per tonne to 280 EUR per tonne for the period until the end of 2006 and have increased to more than 400 EUR per tonne since then.

Figure 2.17: Crop output prices (EUR/t) of major cash crops in Germany from 1998 to 2008



Crop	Sep. 2007	Ø 1998 - 2008	Max[1)]	Min[1)]	CV[2)]
Wheat	228.3	119.6	244.0	90.6	0.27
Rye	220.6	111.1	226.4	72.9	0.29
Feed Barley	207.4	111.4	224.0	82.8	0.26
Rapeseed	316.3	221.1	412.9	146.7	0.21

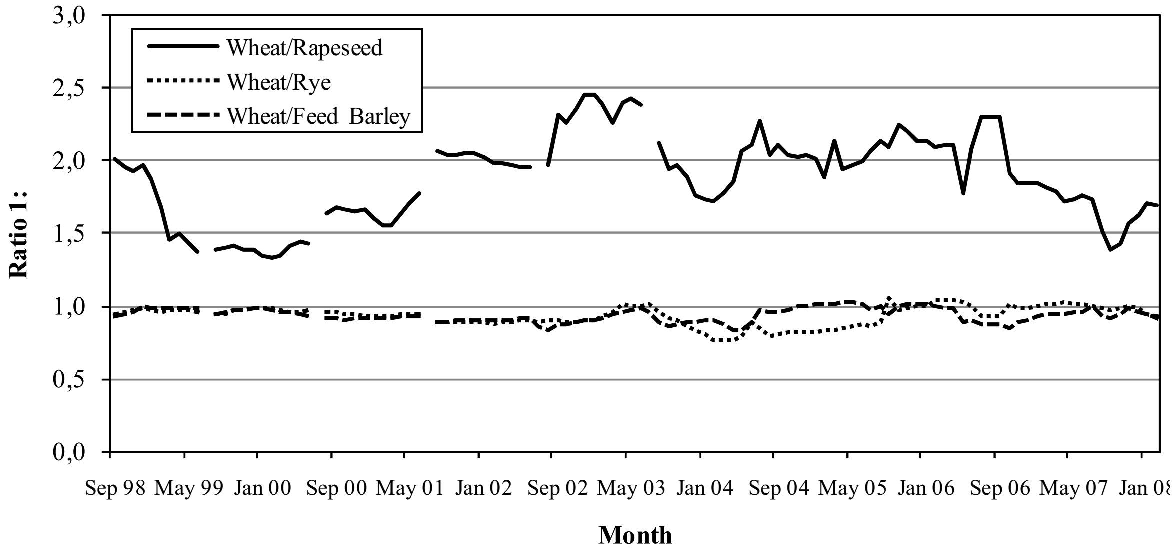
[1)] Maximum and minimum ratios in the observed period.

[2)] Coefficient of variation.

Source: Own illustration based on ZMP.

Price ratios between wheat and other cereals have been very stable for the 1998 to 2008 period, ranging from 0.8 to 1.0 with a coefficient of variation of 0.05 for the wheat-barley ratio and 0.07 for the wheat-rye-ratio (Figure 2.18). Price ratios for wheat and rapeseed are more volatile with a CV of 0.16 and ratios ranging from 1.3 to 2.4 in the observed period.

Figure 2.18: Crop output price ratios of wheat and major cash crops in Germany from 1998 to 2008



Price Ratio	Aug. 2007	Ø 1998 - 2008	Max[1)]	Min[1)]	CV[2)]
Wheat/Rapeseed	1.5	1.9	2.4	1.3	0.16
Wheat/Rye	1.0	0.9	1.0	0.8	0.07
Wheat/Feed Barley	0.9	0.9	1.0	0.8	0.05

[1)] Maximum and minimum ratios in the observed period.

[2)] Coefficient of variation.

Source: Own calculations based on ZMP.

Spatial distribution of cash crop production in Canada and Germany

Spatial distribution of cash crop production in Canada is shown by acreage of major cash crops by census agricultural regions in Table A19 in the Appendix. For Germany, the same is illustrated by rural districts in Figure A14 to Figure A19 in the Appendix.

2.5 Summary

Canada and Germany are important players in global markets for agricultural commodities. Though mostly the same crops are produced in Canada and Germany, production takes place under different framework conditions in each country. Agricultural policy in Canada supports producers of cash crops in managing their business risks, while agricultural policy in Germany is dominated by the Common Agricultural Policy (CAP) of the EU which provides direct payments and common market organizations. Further, both countries follow strategies for promoting production and consumption of bio-energies which will influence production of cash crops in both countries. Natural framework conditions in Canada are characterized by moisture deficits and short growing seasons resulting in low input production systems with comparably low yield levels in cash crop production. Temperate climate and soils in Germany favor high input production systems with comparably high yield levels. Further, spatial distribution of cash crop production within both countries reflects prevailing natural framework conditions.

3 Analysis of global cash crop production within the *agri benchmark* Cash Crop Network

The background of this thesis is provided by the context of research work done so far within the cash crop branch of the *agri benchmark* network. To understand the set up of this thesis it is thus necessary to lay out the context and framework of the *agri benchmark* network and the research work done so far. In Section 3.1, the basic ideas and the research concept are explained, followed by a description of research methods applied within *agri benchmark* in Section 3.2. This chapter then closes with the demonstration of selected results from *agri benchmark* research work and the historical development of the network in Chapter 3.3.

3.1 Research concept of *agri benchmark*

agri benchmark is a global network of farm economists providing a platform for research and exchange in the area of international agriculture. Research within the network is focused on farming and production systems and respectively their economics, perspectives and framework conditions at an international level. *agri benchmark* was founded to analyze driving forces of global agriculture change. The network is run on a partnership basis where research institutions share knowledge, workload and costs. Funding for the network activities is provided by the research institutions, governments, organizations and associations as well as agribusiness companies. *agri benchmark* is jointly managed by the German Agricultural Society (Deutsche Landwirtschaftsgesellschaft, DLG) and the Institute of Farm Economics of the Federal Research Institute for Rural Areas, Forestry and Fisheries (Johann Heinrich von Thünen-Institut, vTI)[1] of Germany.

3.1.1 Background

Global agriculture is changing and has changed to a very strong extent, especially in the past two decades. The two major drivers for this change are the liberalization of international trade (Globalization) and the increase in global demand for agricultural commodities and products which is outpacing supply, especially in recent years.

[1] *agri benchmark* was founded when the von Thünen-Institut still was organized as the Federal Agricultural Research Center (FAL). This denomination is found in most of the literature and publications related to *agri benchmark*.

3.1.1.1 Globalization of the world economy

The ongoing liberalization of world trade from the mid 1980s on in the context of the GATT and later the WTO had a major impact on local and international agricultural markets. In many countries, especially in the highly developed western countries such as in North America, Japan and the EU, agricultural sectors had been heavily protected and supported by policy means such as tariffs, export subsidies, price support and direct producer subsidies. The agreements of the GATT and WTO forced the participating countries to improve access to their markets and cut the level of market distorting support for domestic producers.[2] Since agricultural commodities and products are a major group of goods traded on world markets and due to partly high levels of support in many countries, regulations and agreements in the context of the GATT and WTO dramatically changed agricultural markets. This was particularly true for the direction of trade flows and the location of production of agricultural commodities. The extent of this change can be clearly seen in Table 3.1, which shows the development of production of major agricultural commodities and products for major world producing regions for the period from 1994 to 2006.

Table 3.1: Shift of agricultural production in different global regions (Average 1994-1996 to 2004-2006)

Commodity	EU-27	Rest of Europe[1)]	North America	South & Central America[2)]	Africa	Asia	Oceania
Wheat	16%	26%	-3%	18%	36%	12%	15%
Other cereals	11%	2%	17%	28%	24%	13%	14%
Oilseeds	38%	102%	30%	98%	30%	53%	27%
Sugar	3%	-9%	8%	59%	38%	21%	5%
Beef [3)]	-8%	-41%	4%	23%	29%	39%	16%
Pork	9%	-35%	23%	22%	28%	51%	15%
Poultry	18%	28%	37%	94%	48%	68%	59%
Sheep & Goat meat	-13%	-38%	-21%	-2%	24%	55%	-1%
Milk	2%	-19%	13%	30%	40%	50%	36%

1) Incl. Russia. 2) Incl. Caribbean. 3) Incl. buffalo meat.
Source: Own calculations based on FAOSTAT (2007).

The production of agricultural commodities/products, except for non-EU Europe and Russia and sheep and goat meat, shows mostly double-digit growth rates for the ten year period based on the average production volumes from 1994 to 1996 and 2004 to 2006. A

2 WTO (2004).

significant increase for all producing regions occurred in the production of oilseeds and poultry. Highest growth rates can be found in South and Central America as well as in Asia and Africa, though the latter shows a lower level of production than the other regions. The region of non-EU Europe and Russia clearly shows the situation of economies in transition after the breakdown of the Soviet Union. Production of most agricultural commodities and products has declined for the ten year period though production in the area of cash crops has rebounded again.

3.1.1.2 Increase in demand for agricultural commodities

The second major driver for the change of global agriculture is the growing global demand for agricultural commodities and products. This situation can be characterized by the three keywords: "Food, Feed and Fuel".[3]

The growth of the world population to more than 6.5 billion people in 2007 increased the demand for *food*. At the same time the growth in welfare and income in many developing and transition countries led to a change in the composition of the human diet. The consumption of "higher value" food such as meat and dairy products increased in these countries. Thus, the production of these "higher value" food products increased; raising the demand for *feed* needed to produce these goods (compare also Table 3.1).

Since the beginning of the 21st century the importance of agricultural commodities as a resource for producing *fuels* (bio-fuels) increased. Driven by the high price levels for crude oil, agricultural commodities are converted to bio-fuels and other bio-energy since the price of crude oil is higher than the energy value of the respective agricultural commodity. This is especially true for sugar and cereals like corn and wheat which are converted to bio-ethanol and vegetable oils derived from oilseeds to produce bio-diesel. In addition to the high price levels for crude oil, conversion of agricultural commodities to bio-fuels is driven by energy security and environmental policies. Many countries of the world are building up bio-energy industries to reduce their dependence on crude oil and to reduce carbon dioxide emissions in the context of climate change.

The conversion of agricultural commodities into bio-fuels created a new demand for agricultural commodities besides the traditional uses as a food and feed stock. As can be seen in Figure 3.1, the role of the different ways of using agricultural commodities has changed. Global food consumption increased for the first thirty years in the period from 1960 to 2006, peaking in the beginning of the 1990s. Since then the trend has been

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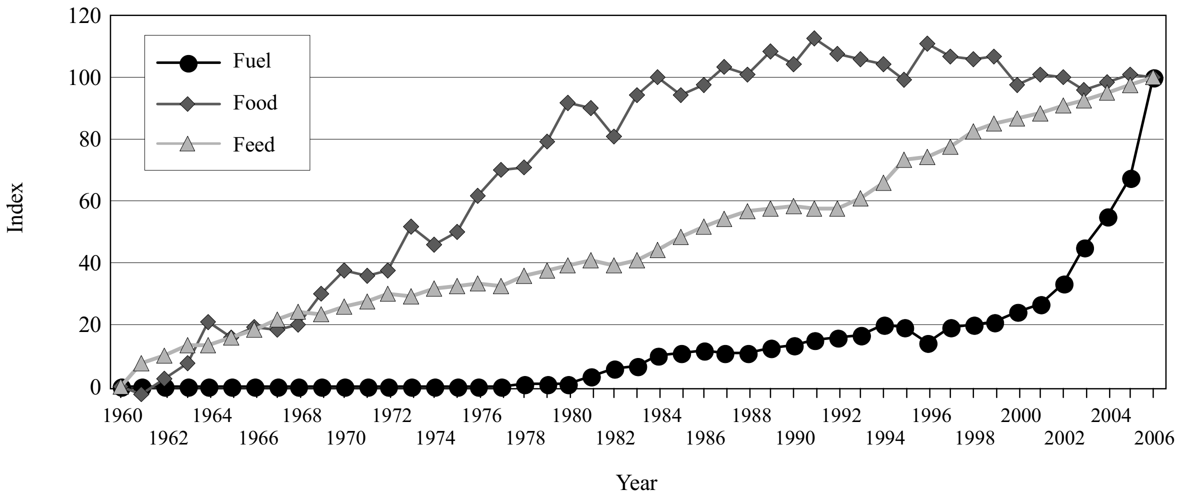
3 GOLDMAN SACHS (2007).

slightly declining or stagnant. This is different for global feed consumption which has steadily increased for the whole period. The global consumption of agricultural commodities as a resource for bio-fuels picked up in the early 1980s and has strongly increased since the end 1990s.

Figure 3.1: Global consumption of agricultural commodities by disposition, 2006 = 100



Source: Goldman Sachs (2007).

3.1.2 Motivation and goals

As was shown in the previous section, global agriculture has changed and still is changing. *agri benchmark* was founded to provide information about this change and its impacts, especially on the farming sector and the agribusiness. The new framework conditions, formed by policy reforms, technology and market developments, have an impact on allocation and quantities of agricultural production (see Table 3.1). *agri benchmark* therefore analyzes how the new overall framework conditions, with their driving factors, affect land use and agricultural production around the world. A major goal of *agri benchmark* is to provide answers about how farming will look in the future for the different agricultural products and producing regions in an international context.

Due to the changing framework conditions, the production of agricultural commodities and products will be more and more determined by the comparative advantages of the different producing regions in the future. The regional allocation of production will be less influenced by protection through agricultural policy and thus, competition on the agricultural markets will increase. This is especially true for agricultural sectors that have been highly protected so far as in the U.S. and EU,. Thus, the demand for information about the competitiveness and competitive position of the different agricultural sectors increases.[4]

agri benchmark follows the comparative concept of competitiveness and evaluates past, current and future competitiveness in an international context for different agricultural markets, regions, products and producers. This is of particular interest to policy makers, agribusiness and farmers around the world. Policy makers need a world-wide focused policy analysis in order to develop agricultural policy in a rational way considering the new framework conditions, especially the legal context of WTO agreements. This policy analysis needs to focus on the impact of different alternative policy measures on competitiveness and the competitive position of agricultural production for the different producing regions. Furthermore, reasons for insufficient competitiveness of certain regions in the production of certain agricultural products need to be identified and assessed in order to improve framework conditions and thus the competitiveness of agriculture in these regions.

Agribusiness companies need information regarding their competitive position and future developments in quantities and structures of agricultural production around the world. The reallocation of agricultural production may force the agribusiness as well to reallocate processing facilities and implement new technologies. Agricultural producers need world-wide benchmarking information as well as analyses of reasons for differences in cost structures of farming and production systems. This information will help them to identify their competitive position in an international context and support the development of useful strategies for future development of their farms.[5]

Competitiveness can be defined and measured in many different ways. MARTIN et al. define competitiveness as "the sustained ability to profitably gain and maintain market share" (1991, p. 1456). *agri benchmark* follows this definition and analyzes the development of market shares under the new framework conditions for the different agricultural sectors and their respective producers. Competitiveness can be analyzed for various levels of aggregation (entire economy, sector, enterprise) depending on the level of investigation. Another differentiation of competitiveness exists with regard to the spatial dimension of the analysis. Since it is a relative measure, the competitiveness of enterprises or regions within a country, or between countries, may be compared.[6]

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4 ISERMEYER (1988, Chapter 1) and HEMME et al. (1999, p. 157).

5 HEMME (2000, p. 1 et seq.).

6 FROHBERG and HARTMANN (1997, p. 5 et seq.).

agri benchmark directs its research activities at the farm level to analyze the competitive advantage of the different agricultural producing regions and the impact of the new framework conditions on their competitiveness. According to PORTER (1993, p. 59), two general competitive advantages exist on the enterprise (farm) level. These are “product differentiation and cost leadership”. Neither strategy excludes the other. Product differentiation enables a producer to demand a higher price for his product, which results in higher profitability under the condition of a comparable cost level as his competitors. Since agricultural products are mainly primary soft commodities, potential for product differentiation is limited. Therefore cost leadership is a strategy for producers of primary commodities to survive in increasingly liberalized and competitive world markets.

For that reason *agri benchmark* analyzes farming and production systems with the respective farming structures to get an insight in how farming and agricultural production is done around the world. *agri benchmark* calculates and compares cost of production for different agricultural commodities and products at the farm level as a way to assess competitiveness and identify competitive advantages. By doing so, benchmarking information is provided for policy makers, agribusiness and farmers.

In the context of the recent increase in world market prices for agricultural commodities fears that agricultural production in certain regions will decline due to lacking competitiveness seem to have become irrelevant. The perspective on competitiveness may thus change. In the future, competitiveness may be seen as the ability of the different agricultural commodities and products to compete for the limited resources needed for their production. This is especially true for land. A guideline for *agri benchmark* research for the future may thus be how production systems and farming structures as well as production quantities will change in this new context.

agri benchmark is organized as a network structure in order to produce reliable and profound results and information about international agriculture with limited financial resources. To improve the quality of research and provide better information and exchange, *agri benchmark* aims at establishing a sustainable co-operation between the network partners. This is achieved by the development of common tools and methods for analyzing farms and production systems with their respective costs and cost structures on a world-wide basis. At the same time the network is open to new partners to extend the geographical coverage and the numbers of commodities/products analyzed. Overall, *agri benchmark* wants to provide a better understanding of global agriculture.

3.1.3 Organization

The *agri benchmark* network was founded in 2006 as a co-operation between the German Agricultural Society (Deutsche Landwirtschaftsgesellschaft, DLG) and the Institute of Farm Economics of the – at that time – Federal Agricultural Research Center (FAL) of Germany.[7] *agri benchmark* is a non-political and non-profit activity. Rules and values of the network are developed by mutual agreement between the network partners. Rights and duties apply to all network partners do the rules and standards for research conducted within *agri benchmark*. All these are agreed upon by the network. To ensure high quality and relevance of results and information from the network, methods and main results are open for public discussion.

Three different branches exist within *agri benchmark* for the different major agricultural commodity groups/product groups to concentrate expert knowledge in the respective fields. These branches are the "*agri benchmark* Dairy Network", the "*agri benchmark* Beef Network" and the "*agri benchmark* Cash Crop Network". The dairy branch is covered through a co-operation with the European Dairy Farmers,[8] while the latter two networks are the successors of the respective networks of the International Farm Comparison Network (IFCN). *agri benchmark* is open to cover more agricultural branches, e. g., like pork or poultry as soon as demand for research exists and resources become available.

agri benchmark is run as a network with different groups of partners. *agri benchmark* is dependent on the support of various scientific and political institutions as well as private agribusiness companies. Network partners benefit from first-hand access to information and extra services. The three groups within *agri benchmark* are scientific partners, agribusiness partners and farmers around the world. The latter participate in the data collection process and are thus considered a part of the overall network.

The network itself is formed by scientific partners from different research institutions in participating countries. As a general rule there is only one scientific partner per branch and country. Large countries with diverse production systems may have more than one partner in the network. Scientific partners participate in financing overhead costs of the global network by paying an annual fee. At the same time they provide data and knowledge to the network. As a return they have access to primary data and results from the network of all countries and may participate in the annual conferences. Work and

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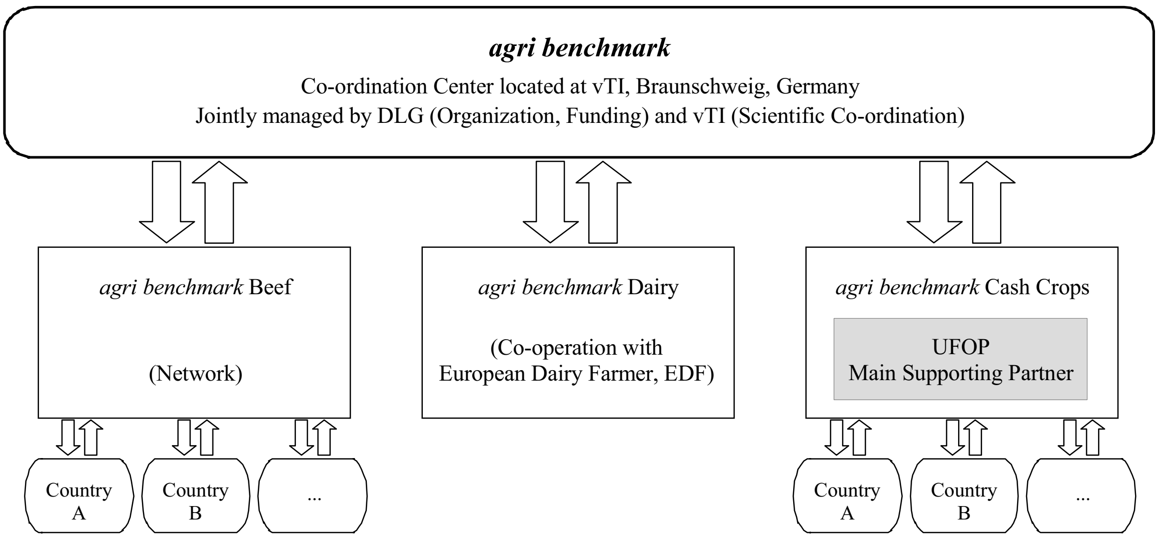
7 By 2008, the Federal Agricultural Research Center (FAL) was reorganized as Johann Heinrich von Thünen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries.

8 The "European Dairy Farmers" are a network of individual dairy farms from all over Europe, managed by DLG.

knowledge is shared among network partners according to the principle "put your country in and get the world back".

The agribusiness partners are non-scientific institutions (associations, companies, government institutions, international organizations) which want to support the development of the *agri benchmark* network. These partners provide funding in order to allow *agri benchmark* to expand to new countries, to open new branches and to analyze new aspects of international agriculture. Depending on the level of support, the agribusiness partners have access to different levels of information and involvement in *agri benchmark*. This applies to, for example, access to farm data, special studies regarding future developments of farming and production systems, participation in annual conferences and in-house workshops organized by *agri benchmark.*

Figure 3.2: General organizational structure of *agri benchmark*



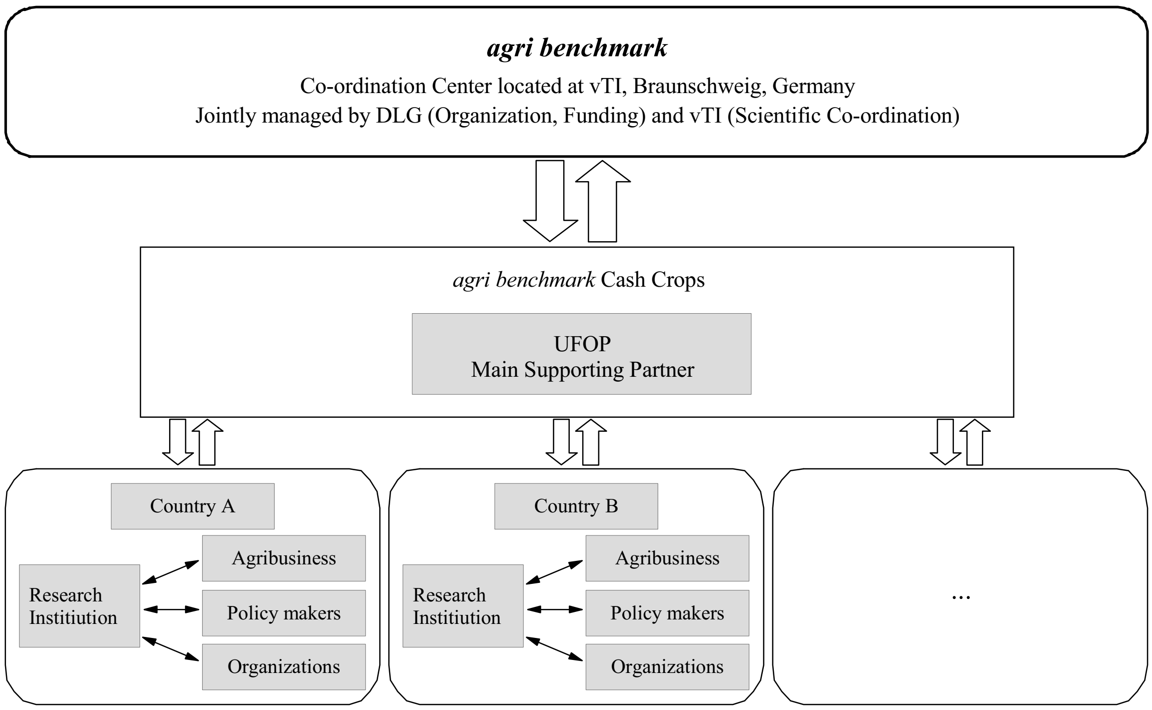
Source: Own illustration.

Figure 3.2 shows the general organizational structure of *agri benchmark* in 2008 and the three different branches form the overall *agri benchmark* network. The coordination center of *agri benchmark* is located at the Institute of Farm Economics of vTI in Braunschweig, Germany. *agri benchmark* is jointly managed by DLG and vTI. The German Agricultural Society (DLG), Frankfurt am Main, Germany, is responsible for overall organizational, technical and administrative issues as well as for coordinating financial issues. DLG also provides a major share of the funding of overhead costs. Besides that, DLG is activating funding and cooperation with agribusiness companies and organizations to support *agri benchmark* activities.

The scientific part of *agri benchmark* is organized and carried out by Institute of Farm Economics of vTI. *agri benchmark* staff at vTI is responsible for coordinating the scientific network partners and activities, developing methods and tools for research, generating results and providing information about results and activities. In terms of funding, vTI provides permanent staff for the network and research activities. The activities within the three branches are coordinated by the overall coordination center. The coordination center consists of the overall coordinator of *agri benchmark* and the branch coordinators of the respective networks, supported by representatives from DLG.

The *agri benchmark* Cash Crop Network covers the activities of *agri benchmark* in the field of cash crops and bio-energies. Figure 3.3 shows the organization of the Cash Crop Network (CCN). The organizational framework is more or less the same as in the *agri benchmark* Beef Network. The participating persons and member institutions from the different countries are coordinated by the branch coordinator and staff of the CCN, located at vTI in Braunschweig, Germany. The CCN is open to new members to extend regional coverage as well as product coverage. By the end of 2007 the *agri benchmark* Cash Crop Network consisted of 19 participating institutions from 17 countries world-wide. Within each country the partner institutions are connected with their local agribusiness sector. They may re-finance their network activities by contracting with companies and institutions and provide information and results from the network to them.

Figure 3.3: Detailed overview of the *agri benchmark* Cash Crop Network



Source: Own illustration.

The activities of the CCN are additionally supported by substantial funding from the Union for the Promotion of Oilseeds and Protein Plants (UFOP), Berlin, Germany. UFOP is an association of plant breeders, the German farmers' union and other agricultural associations which is promoting issues related to production and processing of oilseeds (mainly oilseed rape) and protein plants. UFOP supported the development of *agri benchmark* from the very beginning and thus shares a special interest in the work and results of the *agri benchmark* Cash Crop Network.

The network's activities mainly consist of an annual conference where the network partners as well as representatives from the funding institutions meet to discuss topics related to the network's activities in the context of international agriculture. During the conference, results from the farm comparison as well as from other studies are presented and discussed. Workshops are held on different topics, e. g., on improving the methodological approach and research questions of current or upcoming interest. All partners agree upon a time schedule for the activities and issues that have to be addressed in the upcoming year. The main results and activities of the *agri benchmark* Cash Crop Network are published in the annual *agri benchmark* Cash Crop Report.[9]

3.1.4 History

The *agri benchmark* network is the result of long time research work and experience in the field of international agriculture. This is especially true for the Institute of Farm Economics at FAL/vTI and its researchers, where analysis of international agriculture and its production systems have been a major field of work since the mid 1990s. Also numerous scientific network partners from many different participating countries show many years of experience in the field of production economics and international comparisons of agricultural production.

In the late 1980s and early 1990s, PhD studies by ISERMEYER (1988) and DEBLITZ (1993) formed the basis for the international comparisons of production systems and the economics of dairy and beef farming within *agri benchmark*. Both studies used existing data sets from different national and international research institutions. While most data sets were more or less representative, they also revealed several significant weaknesses for conducting cost comparisons. Most data sets were not comparable and often outdated and access to these datasets was often limited. A lack of data about input and output quantities made cost-per-unit calculations difficult and unreliable. Calculations for different figures, e. g., like depreciation, were often not transparent. Both authors thus

[9] Cash Crop Reports have been published in 2005 (PLESSMANN et al., 2005), 2006 (ZIMMER et al., 2006) and 2007 (ZIMMER et al., 2007).

concluded that the establishment of an own database was better than the use of existing data sets.

Based on these experiences, the network of the European Dairy Farmers (EDF)[10] was founded by ISERMEYER in 1990. EDF is a network of dairy farmers from Europe where regular meetings are held and comparative in-depth analysis of costs, returns and profitability are conducted. The network operates under the joint management of DLG (organizational part) and vTI (scientific part). With this approach a new database for cost comparisons in the area of dairy was established. Since the dataset is based on individual farm data, a generalization of results might be limited. However, the network is not limited to any farm type or size; it is though limited to dairy and covers only European countries.

As a next step the International Farm Comparison Network (IFCN) was founded jointly by Folkhard Isermeyer, Torsten Hemme and Claus Deblitz from Institute of Farm Economics, FAL, in 1997. The IFCN was based on a partnership approach and involved researchers, advisors and farmers. The organizational structure was set up to cover all important agricultural branches. IFCN started with a network for Dairy in 1997 and was then extended to Beef (2001) and Cash Crops (2003). The networks operated on a world-wide scale from the beginning. Instead of an individual farm approach, a "typical farm" approach was chosen. This way, less data was needed and was thus easier to handle on a world-wide basis. Additionally, research results could be generalized more easily. Data were collected on the whole farm level, and models and tools were developed which were suited to do both benchmark calculations and the simulation of farms over a period of ten years for policy and farm strategy analysis.

In 2006, a re-organization of the existing IFCN infrastructure was undertaken and the *agri benchmark* networks were founded by DLG and vTI/FAL. To facilitate further and unrestricted growth for all product branches, new organizational structures had to be implemented as described in Section 3.1.3. The *agri benchmark* networks for beef and cash crops are the successors of the respective networks from IFCN. In this respect *agri benchmark* can look back to more than ten years of network experience and research work in the area of international agriculture.

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[10] Http://www.dairyfarmer.net/.

3.2 Methods of *agri benchmark*

This section gives a brief overview of the methods and tools applied within *agri benchmark* which are relevant for this thesis. Further details can be found in the respective literature and sources noted within this section. A general description of *agri benchmark* (IFCN) methods and tools can be found in HEMME (2000), HEMME et al. (1997) and (1999), DEBLITZ et al. (1998) and the *agri benchmark* website.[11]

The major methodological and organizational achievement of *agri benchmark* is probably to set standards, make them transparent and apply them at an international level. This refers in particular to the collection and processing of data. *agri benchmark* follows the concept of "typical farms" in order to collect farm level data. The data is derived from a so called "panel" where farmers, advisors and scientists share their knowledge and data to "build" a typical farm. The data and information gained from the panel is then "processed" in the model "TIPI-CAL" to generate whole farm economic indicators as well as cost of production figures.

The approach of data collection and processing used in *agri benchmark* is based on a similar approach used at the Agricultural & Food Policy Center (AFPC) at Texas A&M University. Their network of "representative farms" with farms from all over the United States is used for policy analysis and policy consultancy within the US.[12] The approach from AFPC has thus been adapted to fit for application at an international level within the *agri benchmark* networks.

3.2.1 Concept of "typical farms"

A "typical" farm represents the prevailing type of farm in a certain region/country in regards to farm type, size, enterprise combination, resource endowment and production systems for the product/commodity considered. A typical farm can be based on a single real existing farm or on a group of real existing farms. In general, typical farms are not real existing farms and thus are "virtual model farms" though they are based on data and experience of real existing farms. Typical farms are derived from a so called "panel" which consists of farmers, advisors and scientists. The concept of "typical farms" is described in detail in HEMME (2000, pp. 19-24). For the purpose of defining typical farms within *agri benchmark*, a standard operating procedure (SOP) was developed to ensure

11 Http://www.agribenchmark.org.

12 A description of the network of representative farms, the model(s) used for analysis and a bibliography of publications with results can be found at the AFPC's website at http://www.afpc.tamu.edu/models (December 2007).

the same approach and working steps in all participating countries. The SOPs for the Beef and Cash Crop Networks are basically the same with slight modifications to best reflect the product related particularities.[13]

For analyses at the farm level there are mainly three approaches to derive data. These are individual farm data based on farm records and accounting data, average data from farm surveys and statistics (e. g., from the Farm Accountancy Data Network of the EU, statistics from the USDA) and panel farm data (network of representative farms of the AFPC, *agri benchmark*). All of them reveal particular strengths and weaknesses shown in Table 3.2.

The criteria and requirements for farm level data needed within *agri benchmark* have been derived from the experiences made in the past with research on international agriculture (compare Sections 2.1.2 and 2.1.4). *agri benchmark* needs detailed, up to date, internationally comparable and representative farm level data. In terms of representativeness of the data, survey and statistical data have an advantage, although for certain countries/regions and farm sizes (especially very large farms) approved data is often not available. The panel farm approach shows a weakness at the point that these farms are not representative in a statistical sense. For a better understanding of which part of the total farm population is represented by the typical farms, a classification of the typical farms within the total farm population of a country/region is carried out.

Table 3.2: Strengths and weaknesses of different types of farm level data

Characteristics	Individual farm data	Average farm data from surveys and statistics	Panel farm data
Representativeness	-	+/-	+/-
Consistency of data sets	+	-	+
Price & quantity structure	+	-	+
Data availability	+	+/-	+
Up-to-dateness	+/-	-	+
Feasibility of data collectior	+/-	-	+
Confidentiality of data	-	+	+
Cost of data collection	+/-	+/-	+/-

+ = strength of the sample method; - = weakness of the sample method
Source: Own illustration.

13 ZIMMER and DEBLITZ (2005).

The panel farm approach reveals advantages in that a harmonization of data in an international context is not needed as with statistical and survey data. The harmonization of data is implemented in the data collection procedure applied within the *agri benchmark* networks. Furthermore, the panel farm data is closer to reality and more up to date than the other type of data. Using the panel approach to collect typical farm data, more variables and other aspects not accounted for in statistical surveys can be considered (e. g,. tax burdens, off-farm income). Another advantage is that the functional context within a farm can be considered and explained (e. g., crop rotations, farm/labor organization). Furthermore, the particularities of an individual farm as well as the variations between different years (e. g., yields) are eliminated with the panel farm approach. Also privacy of data for the individual farms is ensured in this way. Thus, the panel farm approach is the most appropriate and suitable way of collecting data for international farm and cost of production comparisons in the context of *agri benchmark*.

agri benchmark has defined the following standard criteria for its typical farms. As a standard, *agri benchmark* defines a moderate size and a large size typical farm in each region analyzed. This way, a large number of farms and a major share of production are reflected. Size is defined as ‘total animals sold per year’ for beef farms and ‘land used for cash crop production’ measured in hectares for cash-crop farms. Regional statistics on farm size distribution or representative surveys are used to determine the position of the typical farms in the distribution of the farm population of a country/region. Further, the typical farms should have less than 50 % off-farm income or sustain at least the living of one person. The typical farms should represent an average level of management skills (average level of profits). In the future, it is planned to add a third farm with top management skills in order to reflect the potential in production of a country/region.

3.2.2 Producer panel-approach

The data sets for the typical farms are derived from a so called “panel” (producer panel). A panel consists of four to six farmers, one or two advisors and one or two *agri benchmark* scientists. Farmers and advisors within the panel share their knowledge and data about farming in the particular region analyzed. Each farm panel is interviewed using a consensus building process. Producers are asked to develop a typical farm drawing on their personal operations and experience. For each typical farm, the physical (resources), technical (yields, inputs ...) and monetary (prices, costs…) framework is delineated. In particular, this framework includes information about the size of the operation (hectares, head, etc.), tenure (owned vs. rented land) and asset values, enterprises (crops, livestock, etc.), variable cost for the different enterprises, fixed cost for the overall operation as well as machinery complement and its replacement strategy.

A producer panel is set up using the following process. The first step is the identification phase where the scientist and the advisor select regions within a country that are important for the production of the product/commodity analyzed. After regional farm structure is analyzed, both persons pre-define features of the typical farm(s). These features are crosschecked with statistical or survey data or both. The second step is the data collection phase where the panel itself is set up. The advisor contacts and selects farmers that operate farms similar to characteristics of the typical farms pre-defined in the first step. Then panel participants meet to delineate the full set of data needed (see above). The third step is the processing and crosschecking phase. Data from the panel meeting is processed in the model TIPI-CAL and whole farm economic statements like balance sheet, cash flows and profit and loss accounts are computed for the typical farm. These figures are then crosschecked with the producer panel again and adjustments are made to the typical farm data if necessary. An update of farm data, especially for prices and yields, is carried out after at least three years after the initial set up or last update.[14]

3.2.3 TIPI-CAL

The data collected in the panels are entered into the simulation model TIPI-CAL (**T**echnology **I**mpact and **P**olicy **I**mpact **Cal**culations). The model allows simulation of farms for up to ten years in the future as well as computation of a profit and loss account, a balance sheet and a cash-flow statement. The model is able to handle different regions and countries and different farm types, sizes and legal forms. Farms can also be simulated under different policy, market and technology scenarios as well as using different farm development and adjustment strategies.

Figure 3.4 shows the calculation scheme for whole farm costs, returns and profitability indicators of TIPI-CAL. Total expenses are deducted from total returns to calculate the Net Cash Farm Income. Farm Income is derived from Net Cash Farm Income and non-cash adjustments, which are mainly depreciation. Finally, a return to management is calculated by accounting for opportunity costs for owned resources.

[14] DEBLITZ and ZIMMER (2005).

Figure 3.4: Calculation scheme for whole farm cost, return and profitability indicators of TIPI-CAL

Total returns	**Total expenses**	
+ Cash crop enterprise	- Direct (variable) cost cash crop	
+ Market receipts		
+ Coupled direct payments		
+ Beef enterprise	- Direct (variable) cost beef	
+ Beef and live animal receipts		
+ Coupled direct payments		
+ Dairy enterprise	- Direct (variable) cost dairy	
+ Milk, beef and live animal receipts		
+ Coupled direct payments		
+ Other enterprises	- Direct (variable) cost other	
+ Market receipts	- Overall fixed expenses	
+ Coupled direct payments	- Paid wages	
+ Whole farm (decoupled) payments	- Paid rents (land & other)	
+ Financial returns	- Paid interest	
+ Total returns	**- Total expenses**	**= Net Cash Farm Income**
		- Non-cash adjustments
		- Depreciation
		+/- Change in inventory
		= Farm Income (Profit)
		- Opportunity costs
		- Calculated cost for owned land
		- Calculated cost for owned capital
		- Calculated cost for own labor
		= Return to management

Source: Own illustration.

TIPI-CAL is derived from the model "FLIPSIM" of the AFPC.[15] It was adjusted and extended to allow an application in an international context. TIPI-CAL is programmed in a MS Excel® environment and allows a dynamic-recursive calculation of cash-flows. It can be run in a deterministic or stochastic mode of operation. Further, it contains a detailed price and quantity structure for different enterprises (beef finishing, cow-calf, dairy, cash crop & forage production and other). It allows a ten year projection/simulation of the farm data for policy impact and farm strategy analysis. The main model output is a profit and loss account, a balance sheet and a cash-flow statement. In addition to TIPI-CAL, a whole set of analytical tools for benchmarking (cost and returns, profitability), further data analysis as well as data and scenario management for policy and farm strategy analysis are available within *agri benchmark*.

15 RICHARDSON and NIXON (1986) provide a detailed description of FLIPSIM.

3.2.4 Cost calculation

agri benchmark computes total cost of production (COP) figures at the farm level on a per unit basis for the commodities/products analyzed. These figures are derived from whole farm cost and return data. A major problem in estimating per-unit costs occurs with allocating overhead cost and whole farm returns to the different enterprises (units of output) of the farm. Many practical methods exist to allocate these costs, though there is no existing economic theory which gives a profound guideline for a solution of this problem.[16] Thus, within *agri benchmark* several different methods have been applied and much experience has been gained in this respect over time. The discussion about this issue is ongoing and advantages and disadvantages of the different methods for the accuracy and quality of results and thus the work of *agri benchmark* have been revealed. The methods applied are evaluated in terms of resources needed, their scientific appropriateness, their feasibility and their impact on the results itself. The following approach on allocating costs and returns is the outcome of this discussion within *agri benchmark* so far.

In order to reduce the bias in cost of production (COP) figures, as many cost positions as possible are treated as variable and output related. Furthermore, as many production factors as possible, like land use, labor and capital requirements are allocated to the different enterprises during data input instead of being allocated from whole farm level during computation. Thus, the remaining overhead and whole farm cost and returns are kept as low as possible. These can be allocated according to the following computed factors: a) share of the enterprise in farm land used, b) share of the enterprise in total farm labor/machinery hours, and c) share of the enterprise in total farm returns or gross margin. TIPI-CAL and its tools for cost analysis allow for various options on cost allocation from manual to semi-automatic. The semi-automatic cost allocation based on return shares is the most common method presently used within *agri benchmark*.

3.2.4.1 Cost equations

Costs and returns for the different crops are calculated within the *agri benchmark* Cash Crop Network according to the following procedure. Equations are laid out following the terminology and recommendations of the American Agricultural Economists Association (AAEA) Task Force identified in the Commodity Cost and Returns Estimation Handbook.[17] According to the AAEA Task Force recommendations, costs are divided into

[16] Compare, for example, EIDMAN (1992, p. 63 et seq.) and HARRINGTON (1992, p. 45 et seq.).

[17] AMERICAN AGRICULTURAL ECONOMISTS ASSOCIATION (2000).

two general categories: a) expendable and b) allocated overhead costs. Allocated overhead costs also include opportunity cost for own land, family labor and equity capital based on best exploitation of the respective factor at an alternative use. Then, average total costs at the farm gate are the following:

$$ATC_c^{Farmgate} = \sum_{c=1}^{n} \omega_c \left(\sum_{i=1}^{K} C_{ci} X_{ci} + \lambda_c OH \right) \quad (3.1)$$

where

$$OH = \sum (M, B, GB, L_{Hired}, R_{Cash}, I_{Debt}) + \sum (L_{Family}, R_{Own\ Land}, I_{Equity}) \quad (3.2)$$

and ATC = average total cost,

c = crop,

i = expendable input,

n = total number of crops,

k = total number of expendable inputs,

ω_c = weighted share of cropping system of each crop c,

C_i = price of direct cash input i,

X_i = quantity of direct cash input i,

λ_c = share of fixed and overhead charge for crop c,

OH = total allocable overheads,

M = machinery expenses including depreciation, lease and repairs,

B = building expenses including depreciation, lease and repairs,

GB = general business expenses,

L = labor expenses for hired labor, calculated cost for family labor,

R = land rent expenses for rented land, calculated cost for own land,

I = interest expenses for debt capital, calculated cost for equity capital.

Note that in many farms there can be many cropping systems for one crop, usually taking into account rotation or preceding crops. In this case, the equations are based on the weighted average of the systems, ω_c. Overhead costs are allocated to single crop based on its relative contribution to total farm returns, λ_c.

In some countries government program payments make up a substantial amount of total farm returns. This is especially true for decoupled direct payments in the EU and program payments in the US and Canada. These payments are allocated per crop since overall farm organization as well as costs for certain production factors, especially land, are still influenced by these payments. Thus, whole farm payments are allocated based on the following equations:

$$ATR_C^{Farmgate} = \sum_{c=1}^{n} \omega_c \left(P_c Q_c + \mu_c WFP\right) \quad (3.3)$$

where

$$WFP = \sum (Y_{DDP} + Y_{Other}) \quad (3.4)$$

and ATR = average total return,

c = crop,

n = total number of crops,

ω_c = weighted share of cropping system of each crop c,

P_c = market price for crop c,

Q_c = quantity of crop c,

μ_c = share of whole farm payments for crop c,

WFP = whole farm payments,

Y = amount of payments,

DDP = decoupled direct payments.

Allocation of whole farm returns is similar to the allocation of overhead costs. In case of more than one cropping system for one crop, the equations are based on the weighted average of the systems, ω_c. Whole farm payments are allocated to single crop based on its relative contribution to total farm returns, μ_c, since overhead costs are allocated in the same way.

3.2.4.2 Cost positions and cost groups

In terms of presentation of results, total costs and different cost positions are commonly grouped into different cost groups. The different cost groups are direct costs, operating costs, overhead costs, interest costs and land costs. The allocation of different cost positions to these cost groups is illustrated in Table 3.3.

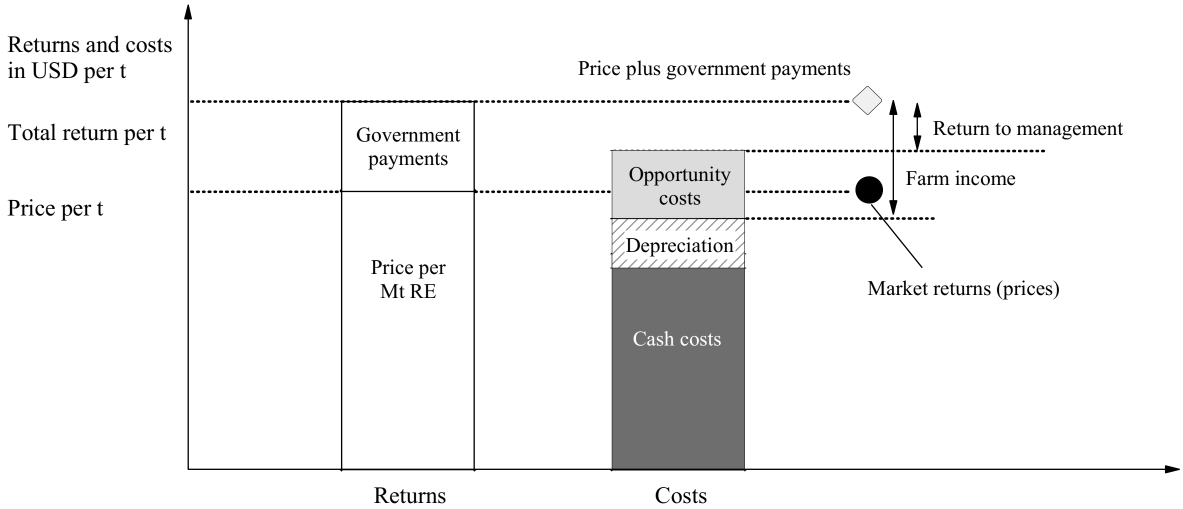
Table 3.3: Cost groups and cost positions for cost of production analysis within *agri benchmark*

	Cost Groups			
	Direct costs	**Operating costs**	**Overhead costs**	**Interest costs**
Cost positions	Seed	Drying costs	Building costs	Paid interest for debt
	Fertilizer	Fuel and lubricants	Maintenance buildings	
	Chemicals	Maintenance	Depreciation buildings	Unpaid interest for equity
	Herbicides	Depreciation	Taxes and duties	
	Fungicides	Machinery costs	Farm Taxes	
	Insecticides	Fuel and lubricants	Member fees	
	Growth regulators	Maintenance machinery	Insurances	**Land costs**
	Other	Depreciation machinery	Other	Paid rent for land
	Crop (Hail)	Contract work	Drainage maintenance	Unpaid rent for own land
	Insurance	Labor	Other energy	
	Marketing fees	Unpaid labor for family members	Water	
		Wages and social costs	Consulting and advisor costs	
			Office equipment and material	

Source: Own illustration based on Parkhomenko (2004, p. 15).

Figure 3.5 points out cost and return indicators used for international comparison in *agri benchmark*. Total costs are grouped by cash expenses, depreciation and opportunity costs according to the short-run need to cover these costs. In order to keep up the farm business, cash costs need to be covered in the short-run. Depreciation of machinery and buildings has to be recovered in the mid- to long-run in order to replace these production factors. Opportunity costs need to be covered by returns to sustain cash crop production in the long-run. Total returns are made up of market returns, which the farmer receives by selling his crops and by-products, and government payments, which the farmer receives as direct support from the government. On a per-tonne basis market returns thus equal market price. Total returns are then compared against total costs. The difference of total returns and the sum of cash costs and depreciation is denoted as farm income. If total returns are above total costs, the farmer achieves a return to management (entrepreneur's profit).

Figure 3.5: Cost and return indicators in *agri benchmark* Cash Crop



Source: IFCN Cash Crop Report 2005, Plessmann et al. (2005), own illustration.

3.2.4.3 Assumptions for cost calculations

Further, cost calculations within the *agri benchmark* Cash Crop Network are based on the following general assumptions:

- *Labor*: Costs for labor consist of expenses for hired labor and calculated costs for family members (operator; spouse etc.). Expenses for hired labor include the salary and according side costs. Calculated (opportunity) labor costs are based on a salary at the next best alternative use of working hours;
- *Land*: Costs for land comprise of cash rental rates for rented land and calculated rental rates for owned land. Cash rents as well as calculated (opportunity) rents are based on rental rates actually paid by the farmers in the respective region;
- *Capital*: Costs for capital consist of interest expenses for debt capital and calculated interest cost for equity capital. Equity capital is defined as assets without land plus circulating capital and is valued at real interest rates (adjusted for inflation) from the countries/regions compared;
- *Depreciation*: Machinery and buildings are depreciated by a straight line schedule on actual repurchase price minus salvage values provided by the participants of the panel;
- All costs and returns are calculated without value added tax (VAT).

A particularity arises when comparing costs and returns for different oilseeds (soybeans, rapeseed and sunflowers). Since oilseeds generally compete at North Sea ports, either at the markets for oil or meal, a common unit was defined in order to ensure comparability. The “Estimated Processed Value” (*EPV*) is based on the respective value of the oil and meal content of an oilseed.

$$EPV = \sum P_m W_m + P_o W_o$$

with EPV = estimated processed value,

P_m = price of meal,

W_m = meal content in oilseed,

P_o = price of oil,

W_o = oil content in oilseed.

The relation of *EPVs* for the different oilseeds and *EPV* for rapeseed is calculated to derive respective adjustment factors. This way, different oilseeds can be compared as a rapeseed equivalent (RE). In the past, RE adjustment factors for soybeans and sunflower ranged around factor one.[18]

3.3 Results and development of the *agri benchmark* Cash Crop Network

This section provides selected results of *agri benchmark* research work so far, focusing on cross country comparisons of cost and return (CAR) estimates for different crops derived from the *agri benchmark* Cash Crop Network from 2006.[19] Results presented in this chapter are thought to provide an example of cost comparisons only. A more comprehensive presentation of *agri benchmark* Cash Crop results are found in the respective *agri benchmark* Cash Crop Reports from 2005 to 2007.[20] Further, the development of the *agri benchmark* Cash Crop Network from 2005 to 2007 is presented in this chapter.

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18 PARKHOMENKO (2004, Chapter 3.2.2), ZIMMER (2006, p.45).

19 Results derived from *agri benchmark* methods before the network structure was established are found in ISERMEYER et al. (2000) and PARKHOMENKO (2004). The first study compares costs and returns for wheat and sugar production across countries, while the latter one compares the same for different oilseeds.

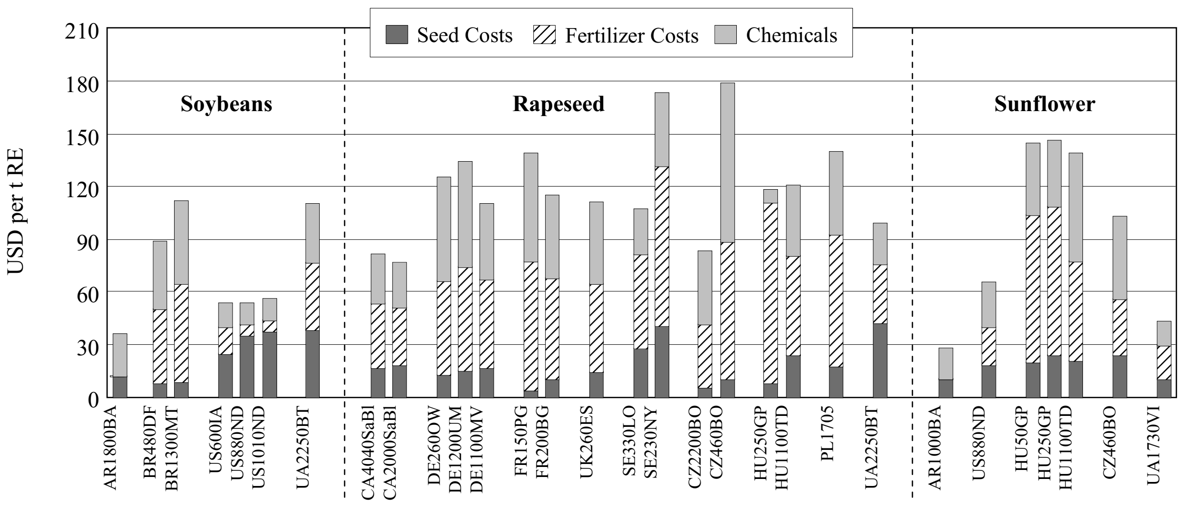
20 PLESSMANN et al. (2005), ZIMMER et al. (2006, 2007).

3.3.1 International comparison of cost of production for oilseeds in 2005

The major outputs of *agri benchmark* research work are international comparisons of cost of production for different commodities. These are calculated at the farm gate for various typical farms according to the definitions and methodology presented in Chapter 3.2. The labeling used to denote the different typical farms within *agri benchmark* is based on the following pattern. The names of the farms are an abbreviation consisting of country code (two letter international country code), farm size (in hectare) and location (two letter code). For example, US600IA is a 600 hectare farm located in Iowa, United States.

In the following charts, costs of production (CoP) figures are compared for different oilseeds in US-Dollar per metric tonne for the year 2005, calculated as Rapeseed Equivalent (RE) (see Section 3.2.4). Exchange rates used for the different national currencies are based on the annual average exchange rate to the US-Dollar. According to the various locations of the different farms, different oilseeds are produced. Farms in temperate climate like in Canada and Europe produce rapeseed. Soybeans are mainly grown in North- and South America whereas sunflowers are found in warm and dry regions with continental climate in Middle- and Eastern Europe and North- and South America.

Figure 3.6: Direct costs for oilseeds (USD/t RE) by typical farm in 2005

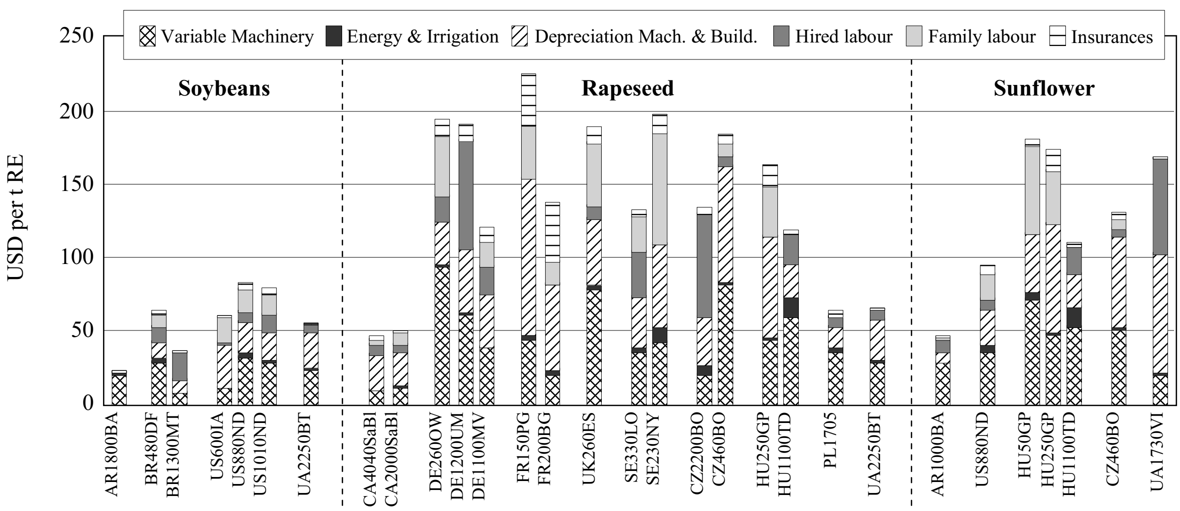


Source: *agri benchmark* Cash Crop Report 2006, Zimmer et al. (2006).

Costs for chemicals, fertilizer and seed (direct costs) range from around 30 USD per tonne to around 180 USD per tonne in this farm sample. Direct costs for soybeans are lower than for rapeseed and sunflowers. Typical farms in the Americas and Ukraine have lowest direct costs. The farms in Argentina do not apply any fertilizer and thus show lowest direct costs in the sample, though sustainability of this production system has to be questioned. Another particularity is the high fertilizer costs for the typical farms in Brazil. Fertilizer expenses are high compared to other soybean producers due to high amount of lime and gypsum applied to increase soil pH-level, which is decreased by high amounts of precipitation. Highest direct costs are found for the farms in Middle- and Eastern Europe though these data have to be handled with care since agriculture and especially production systems are still in a transition in these countries. Altogether, seed costs have lowest share in direct costs except for farms in the US.

Typical farms in the United States have highest seed costs, since soybean varieties used are genetically modified (GMO) and are herbicide resistant. Therefore, a so called "tech fee" is charged making GMO seed varieties more expensive. On the other hand, costs for chemicals are very low due to savings on specialized, expensive herbicides which more than offset the higher seed costs. Further, it has to be noted that typical farms in Argentina do not apply any fertilizer and thus have lowest direct cost in the sample. Typical farms in Eastern Europe show a mixed picture in direct costs, since farming sectors of these countries are still in a transition.

Figure 3.7: Operating costs for oilseeds (USD/t RE) by typical farm in 2005

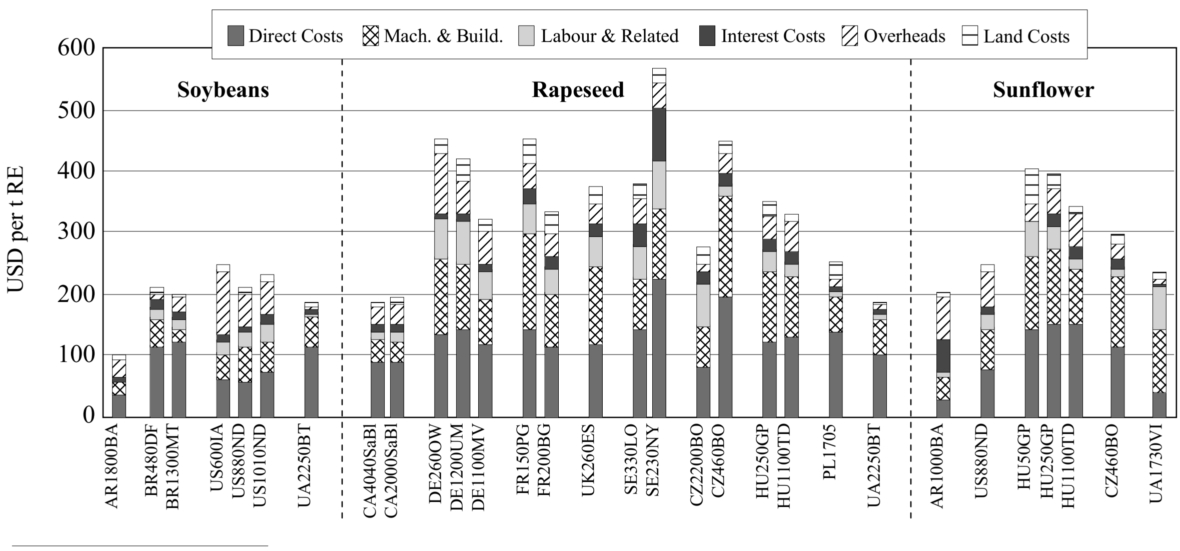


Source: *agri benchmark* Cash Crop Report 2006, Zimmer et al. (2006).

Figure 3.7 displays costs related to operating the farm (operating costs). These costs range from less than 25 USD per tonne to more than 220 USD per tonne. As was the case for direct costs, operating costs are highest for rapeseed production and thus European countries again. Lowest operating costs are found in South America. Soybean production shows lowest cost in general over this sample. A huge difference between operating costs can be seen in rapeseed production for two Canadian typical farms and farms in Western Europe. Canadian farms show operating costs around 50 USD per tonne whereas the level of these costs in one French farm is more than 200 USD per tonne. Thus, operating costs for the French farm are more than four times as high as those for the Canadian typical farms. The high performing farm in Eastern Germany has operating costs of around 120 USD per tonne, which is still more than double the level of Canadian typical farms. Costs for machinery and labor, both hired and family labor, are major cost drivers in operating costs in rapeseed production and thus for European farms.

Figure 3.8 shows the composition of total costs for oilseed production. Total costs range from around 100 USD per tonne to more than 550 USD per tonne. Lowest total cost are found in Argentina and highest in Sweden. Soybean production on a per-tonne basis shows lower costs than rapeseed and sunflower. Farms in the Americas and Ukraine show lowest costs whereas rapeseed production in Europe bears highest total costs. Major cost drivers for European typical farms are direct costs and machinery costs, labor and overhead costs play an important role as well. Overhead costs in Europe are high due to high costs related to administrative issues with keeping the farm business running and high building costs. Labor costs in Western Europe are high as well since wage levels are determined mainly by relatively high labor demand outside the agricultural sector. Furthermore, labor side costs like social security payments are high in Western Europe as well. In the US and the EU, land costs are very high and thus are a major cost driver as well. This is mainly due to government program payments which influence land prices and rental values. Especially in Western Europe, demand for land outside agriculture is high due to dense population in most regions of Europe. This drives land prices and opportunity costs to the highest level in the sample.

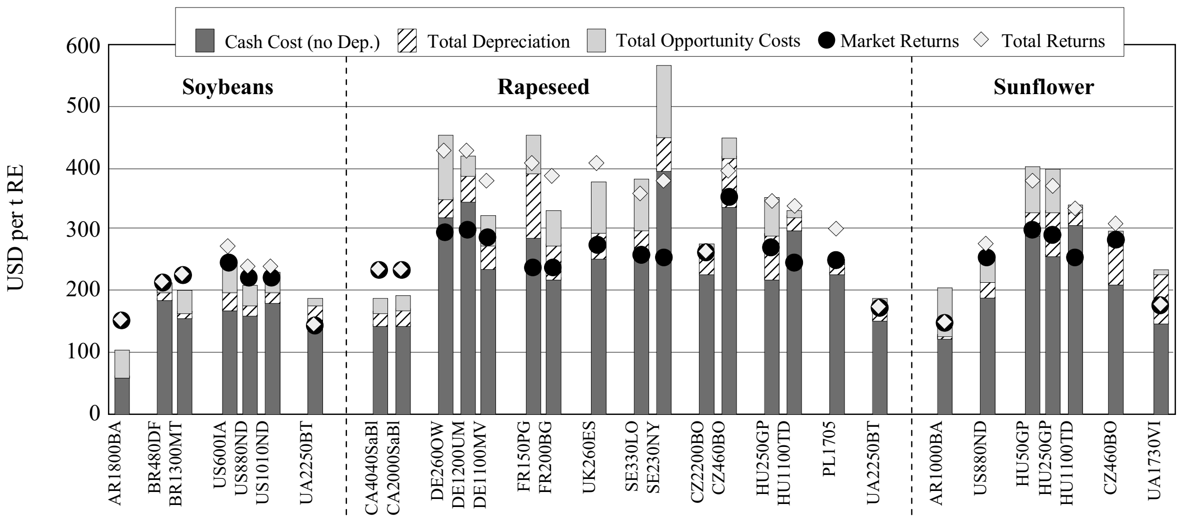
Figure 3.8: Total costs for oilseeds (USD/t RE) by typical farm in 2005



Source: *agri benchmark* Cash Crop Report 2006, Zimmer et al. (2006).

In Figure 3.9, total costs are compared against total returns of oilseed production in 2005, following the scheme displayed in Figure 3.5. Market returns vary from around 150 USD per tonne to around 350 USD per tonne for the typical farm sample in 2005. Market returns for soybeans are lower than for rapeseed and sunflowers and are found within a range of 150 USD per tonne to 250 USD per tonne. Rapeseed producers show market returns ranging from 180 USD per tonne to 350 USD per tonne. Market returns for sunflowers vary much more than for other oilseeds. Farms in the US and the EU benefit from government payments and thus show higher total returns than their competitors. Profitability of oilseed production in 2005 varies over countries and oilseeds. Soybean producers in the Americas and rapeseed growers in Canada are mostly able to cover total cost and achieve a return to management. Market returns for the European rapeseed producers mostly only cover cash costs and parts of depreciation. Most of them are only able to cover total costs due to government payments, though some of them also achieve a return to management. This situation is mostly the same for profitability of sunflower production in 2005.

Figure 3.9: Total costs and returns for oilseeds (USD/t RE) by typical farm in 2005



Source: *agri benchmark* Cash Crop Report 2006, Zimmer et al. (2006).

These results though have to be handled with care due to certain limitations in cost of production calculation methodology (compare Section 3.2.4). A major limitation for interpretation of results arises from the allocation of overhead costs, which is based on return shares for this comparison. Also, oilseeds (especially rapeseed and soybeans) provide benefits to other crops in the rotation. These benefits have not been accounted for in this comparison. Further, transportation costs to deliver crops to market have not been considered. Land-locked countries and those production regions with long distances to (international) markets (e. g., Canada) face higher transportation costs than those countries close to markets. Considering transportation costs in cross country comparisons might thus change the cost advantages of these countries at the farm gate. Results from this comparison might thus overall be misleading for assessing international competitiveness of oilseed production.

An approach to improve cost of production calculation and cross country comparisons can be found in MÖLLER and SCHONEY (2007). The approach presented accounts for benefits provided to crop rotations, different qualities and transportation costs in wheat production for selected IFCN/*agri benchmark* farms in Canada and Germany. The results show that when accounting for benefits, competitive advantage of wheat is based to a large extent on benefits provided by other crops in the rotation. Further, results show that when considering transportation and marketing costs to a common import destination for wheat (i. e. Northern Africa), the cost advantage in wheat production of Canadian against German farms is more than offset. The same is shown by EBMEYER and SCHONEY (2007) with a similar approach also accounting for transportation costs in wheat production, but furthermore, sensitivity of costs to changes in exchange rates and energy prices is illustrated as well.

3.3.2 Development of the *agri benchmark* Cash Crop Network

Since the foundation of the *agri benchmark* (IFCN) Cash Crop Network in 2003, the network showed continuous growth. A lot of experience has been gained oninternational cash crop farming, methodology to calculate costs of production and compare farms and their production systems, as well as managing an international network of researchers, advisors and farmers.

Table 3.4 shows the growth of the Cash Crop Network in terms of participating countries and number of typical farms compared as these are found in the first IFCN Cash Crop Report of 2005 to the *agri benchmark* Cash Crop Report of 2007. The number of participating countries has increased from 12 to 14 during that period and contacts to researchers in further countries promise further growth of the network in the future. The number of typical cash crop farms has increased from 25 in 2005 to 29 in 2007. This number is going to increase as well in the future as soon as further countries will join the network.

Table 3.4: Number of countries and farms of the *agri benchmark* Cash Crop Network from 2005 to 2007

Year	2005		2006		2007	
	Countries	**No. of farms**	**Countries**	**No. of farms**	**Countries**	**No. of farms**
	Argentina	2	Argentina	2	Argentina	2
	Brazil	1	Brazil	2	Brazil	3
	Canada	4	Canada	4	Canada	2
	Czech Republic	2	Czech Republic	2		
	Germany	3	Germany	3	Germany	2
	France	2	France	2	France	2
	Hungary	3	Hungary	3	Hungary	2
	India	1				
	Pakistan	1				
	Poland	1	Poland	1	Poland	3
	Ukraine	2	Ukraine	2	Ukraine	1
	USA	3	USA	3	USA	3
			Sweden	2	Sweden	2
			United Kingdom	1	United Kingdom	3
					Russia	2
					South Africa	1
					Italy	1
Total	**12**	**25**	**12**	**27**	**14**	**29**

Source: Own illustration based on Agri Benchmark Cash Crop Reports 2005 - 2007, Plessmann et al. (2005) and Zimmer et al. (2006) and (2007

The main results of the *agri benchmark* Cash Crop Network are presented at the annual *agri benchmark* Cash Crop Conference and are later published in the *agri benchmark* Cash Crop Reports. Coverage of the report has also increased over time as shown in Table 3.5. The IFCN Cash Crop Report focused on the analysis of oilseed production and included a presentation of the different participating countries (country page). In 2006, coverage of cost comparisons was extended from oilseeds to wheat as well. Analysis of oilseed production was extended by comparing different production systems for oilseeds around the world. For the *agri benchmark* Cash Crop Report of 2007, cost comparisons have been extended to coarse grains as well. Analysis of the economics of different tillage systems provides in-depth information about the different production system for cash crops around the world.

Table 3.5: Development of the *agri benchmark* Cash Crop Report from 2005 to 2007

Cash Crop Report	2005	2006	2007
Commodity Groups	Oilseeds	Oilseeds Wheat	Oilseeds Wheat Coarse grains
Special Issues	Country pages Special studies	Production systems for oilseeds Special studies	CC farming and energy Economics of tillage systems Global wheat market

Source: Own illustration based on Agri Benchmark Cash Crop Reports 2005 - 2007, Plessmann et al. (2005) and Zimmer et al. (2006) and (2007).

3.4 Summary

agri benchmark understands itself as a navigator in international agriculture which becomes increasingly complex. Further, *agri benchmark* wants to provide a better understanding of global agriculture. Therefore, production of agricultural commodities and products is analyzed by conducting international comparisons of cost of production and production systems. Farm level data for analysis is derived from the "panel-approach" for "typical farms" representing different regions of production. Overall analysis focuses on assessment of competitiveness of production under changing framework conditions. Research within *agri benchmark* has been driven by ongoing liberalization of international trade and expected increasing competition between producing countries and regions. In the context of the recent increase in world market prices for agricultural commodities perspective on competitiveness may thus change. In the future, competitiveness may be seen as the ability of the different agricultural commodities and products to compete for the limited resources needed for their production. A guideline for *agri benchmark* research for the future may thus be how production systems and farming structures as well as production quantities will change in this new context.

4 Advancement of *agri benchmark* methodology for analyzing crop output adjustments

As shown in Chapter 3, *agri benchmark* analyzes the competitiveness of cash crop production by comparing production systems and the related cost of production at the farm level. This is done for typical farms which are derived from the so called “panel-approach”. In this chapter, *agri benchmark* methodology is evaluated in terms of its ability to analyze adjustments in crop portfolio composition due to changing crop output price relations.

Cash crops are mainly produced in multi-product cash crop farms featuring joint production. The interrelated efficiency, profitability and competitiveness of crops in multi-product farms caused by jointness of production have to be considered in the analysis of crop portfolio composition. Therefore, the theoretical foundations of enterprise relationships and joint production are presented in Section 4.1. Following the theoretical outline, general factors which determine crop rotation choice and crop portfolio composition are presented in Section 4.2.

Based on the theoretical foundations laid out in the first two sections of this chapter, a different methodology for analyzing crop portfolio composition is discussed in Section 4.3. The focus is directed on *agri benchmark* Cash Crop Network cost of production methodology and Linear Programming. Both approaches bear limitations for analyzing crop portfolio composition in the context of this thesis. The panel-approach as a source for farm level data and information applied within *agri benchmark* so far provides a solution to overcome limitations identified with Linear Programming models in the context of this thesis. The panel-approach is extended to allow for analysis of crop portfolio composition and rotation choice. Therefore, the panel approach is evaluated and the extended panel procedure is described in Section 4.4.

4.1 Multi-product cash crop farms and joint production

Cash crop production around the world mostly takes place in farms producing several crops and these can thus be characterized as multi-product farms. This is especially true for farms growing broad-acre crops like cereals and oilseeds, which are major commodities, traded on world markets. A multi-product farm in general is thus a farm producing a minimum of two or more outputs (crops). The reasons for growing more than one crop using crop rotations can be grouped in four categories as found in MUNDLAK (2001, p. 41). The general reasons for farms to produce more than one output are:

(1) Interdependence in production where the marginal productivity of a factor of production in the production of one product depends on the level of production of another product.

(2) Better utilization of some fixed inputs, or alternatively due to production quotas on some outputs, which frees resources to produce other products.

(3) Savings due to vertical integration, where the farm produces intermediate inputs which are consumed on the farm, such as corn and hogs, or hay and livestock. Such integration saves marketing charges in the broad sense (transportation, trade margins, spoilage, etc.). This holds true mostly for mixed or livestock farms and is thus not further pursued here.

(4) Risk management.

Opposed to firms or farms with only one output, multi-product farms need to decide how to allocate their inputs among the production processes for several outputs. The different crops produced in multi-product farms as a whole represent a so-called crop portfolio. Composition of the crop portfolio is influenced by many factors and depends on the different characteristics of the different crops with regard to these four categories.

Production of cash crops in multi-product farms generally takes places under specific factor-factor, factor-product and product-product relationships. Since factor-factor and factor-product relationships for the multi-product firm do not differ in their general nature from those for single-output firms, they will not be further presented here. More information on these relationships is found in the general literature on production economics.[1]

The particularity of multi-product farms is the presence of product-product relationships, which will thus be further explained here. In multi-product cash crop farms certain product-product relationships exist, which cause interdependencies leading to an interrelated profitability, efficiency and competitiveness between enterprises (crops). Interdependencies or interrelations between enterprises are characterized as joint production in economic literature. The characteristics of joint production in cash crop farms are expressed by crop portfolio composition and growing crops in rotations.

The analysis of changes in crop portfolio composition in the context of shifting crop price relations thus has to consider crop rotations and interdependencies. An isolated analysis of only one enterprise (crop) is thus misleading when assessing competitiveness, efficiency and profitability of crops. Therefore characteristics and causes of different enterprise

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1 HEADY (1952), STEINHAUSER et al. (1992), PINDYCK and RUBINFELD (1992), BRANDES et al. (1997) and KAY et al. (2008).

relationships are explained in this section to provide a foundation for understanding the factors which determine crop portfolio composition and rotation choice.

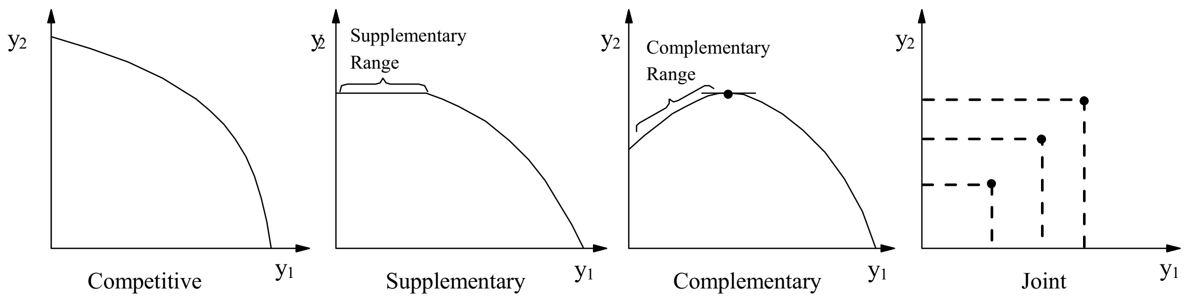
4.1.1 Enterprise relationships in multi-product farms

AS HEADY (1952, p.203) notes, the technical nature of product-product relationships in agriculture is complex. However, these must be understood if production opportunities are to be determined and the most efficient use of agricultural resources is to be specified.

This section outlines the different enterprise relationships in multi-product farms. Since many forms of enterprise relationships exist, the focus is directed on cash crop farms and relationships that exist among production systems for different crops. Relationships between crop and livestock enterprises or between on-farm and off-farm activities are excluded since they are beyond the focus of this thesis.

The enterprise relationships presented in this section are based on short-run production functions and production possibilities. This implies a farm with fixed resources (given land, labor and capital endowment) which can be transferred between competing products. It is further noted for reasons clarity, that this farm maximizes profits and is also a price taker for its products.

Figure 4.1: Enterprise relationships and corresponding transformation functions in agriculture



Source: Debertin (1986, p. 245).

The following product-product or enterprise relationships exist in agriculture (Figure 4.1). Enterprises may be:

(1) *competitive* independent products;

(2) *supplementary* products;

(3) *complementary* products;

(4) *joint* products.

In the general case with two outputs y_1, y_2 and fixed resources, the nature of enterprise relationships is described by the production possibility or transformation curve. A production possibility curve represents the possible alternative efficient sets of outputs from a given set of resources (input bundle). It is therefore sometimes also called "opportunity curve".[2]

The amount of sacrifice of one output for the other is expressed by the marginal rate of transformation (*MRT*). It refers to the absolute change in one product associated with a change of one unit in a competing product. *MRT* is thus measured as a ratio of the form

$$MRT_{Y_1} = \frac{dy_1}{dy_2} \text{ or } MRT_{Y_2} = \frac{dy_2}{dy_1}.$$

(1) Two enterprises are *competitive* in the use of given resources if output of one can be increased only through a sacrifice in production of the other. The transformation function can be derived from the production functions for the single outputs y_1 and y_2. In the general form, these are $y_1 = f(x_1, x_2 \ldots x_n)$ and $y_2 = f(x_1, x_2 \ldots x_n)$. Since the quantity or form of resources is constant while products are variable, the transformation function can be considered as $y_1 = f(x_1, x_2 \ldots x_n, y_2)$ or simply $y_1 = f(y_2)$ and $y_2 = f(x_1, x_2 \ldots x_n, y_1)$ or simply $y_2 = f(y_1)$. Thus, an output of y_2 sacrificed represents an input or cost in production of y_1 and, conversely, negative outputs of y_1 (product sacrificed) serve as inputs for y_2.[3] These relationships also point out that between competing enterprises, opportunity costs exist for the output sacrificed.

An example is the production of wheat and barley. They are competitive crops in most regions, since, with resource inputs constant, a greater acreage of one crop results in fewer acreage and a smaller output of the other. Thus, marginal rate of transformation MRT will be negative. Two outputs are said to be competitive when the product transformation function is downward sloping (see Figure 4.1).[4] Thus,

$$\frac{dy_1}{dy_2} \text{ or } \frac{dy_2}{dy_1} < 0 \qquad \text{implies competitive products.}$$

(2) Two enterprises bear a *supplementary* (independent) relationship when, with resources constant, output of one product can be increased with neither a gain nor a sacrifice in another product. Supplementary conditions arise mainly out of time and are to

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2 DEBERTIN (1986, p. 240) and Heady (1952, p. 207).

3 HEADY (1952, pp. 205-207).

4 DEBERTIN (1986, p. 244).

be found especially where (a) enterprises can be produced only during a distinct and limited period of the year and (b) resources employed give off a flow of services over all time periods. When resources employed for one product are in the form of fixed equipment which gives off services irrespective of use in production, these services may be captured in production through a second commodity forthcoming in the off-season of the first. The second product does not, therefore, require a reduction in output of the first product during its "active season", since flow factor services are generated irrespective of their use in production. In addition to this case of non-homogeneity of resource services in respect to time, supplementary enterprises may be produced simultaneously whenever the flow services of resources are concerned, and one product does not completely exhaust these.[5]

An example for supplementary conditions in cash crop farming is again production of wheat and barley. Especially in many regions of Europe, barley is the first grain crop to be harvested with a combine and wheat very often the last crop in a season. The harvest periods for barley and wheat thus do not overlap. Since use of combine (flow service of a resource) for production of barley can be extended without reducing use during wheat harvest, both products are supplementary in this regard. On the other hand, barley and wheat are competitive in the use of land. Thus, enterprises usually are supplementary only with respect to certain types of inputs contained in the input bundle (see Figure 4.1). In this example this is the combine. For the supplementary range of the transformation function the MRT is zero.[6] Thus,

$$\frac{dy_1}{dy_2} \text{ or } \frac{dy_2}{dy_1} = 0 \qquad \text{implies supplementary (independent) products.}$$

(3) Two enterprises are *complementary,* if increase in output of one product, with resources held constant, also causes output of the second product to increase. In other words, a shift of resources from a first product to a second product will increase rather than decrease output of the first product. This production situation prevails widely in agriculture. However, many of the so-called complementary enterprises in agriculture do not strictly belong to this category in the sense that resources are held constant in quantity. An example of a complementary enterprise is a legume crop in a rotation. The legume crop increases production of grain crops in alternate years due to nitrogen carry-over and other effects. As with supplementary enterprises, relationships usually are called complementary only with respect to certain inputs of the input bundle needed for

5 HEADY (1952, p. 231).

6 DEBERTIN (1986, p. 244).

production, for others they are competitive. For the complementary range of the transformation function the MRT will be positive.[7] Thus,

$\frac{dy_1}{dy_2}$ or $\frac{dy_2}{dy_1} > 0$ implies complementary products.

(4) One of the extreme product-product relationships in agriculture is that of *joint products*. Joint products are produced through a single production process; one of the commodities cannot be produced alone but must be accompanied by one or more others. All agricultural production includes joint products in some form. Wheat and straw, mutton and wool and hogs and manure are the most common examples. Joint products, narrowly defined, are those that must be produced in a fixed ratio to each other (see Figure 4.1). Over time, farmers may adjust the combination between the two products in a narrow range by changing to varieties or breeds with less straw or less wool output holding output of wheat or mutton constant. However, wheat cannot be produced without straw, nor can mutton be produced without wool. This is the major characteristic of joint products. Thus, MRT can either be stated as infinite or equal to one for joint products.[8]

The enterprise relationships presented above are the most common in agriculture. Further types, especially combinations of those presented, exist.[10] Agricultural production in general and cash crop production in particular is characterized by the coexistence of different enterprise relationships in many forms, combinations and proportions to each other.

4.1.2 Joint production

In production economic theory, interactions of coexistent enterprise relationships in multi-product farms (firms) are summarized under the concept of "*joint production*" or in short "*jointness*".[11] Enterprise relationships as described in Section 4.1.1 need to be differentiated when describing joint production. CARLSON (1956, p. 76) states that in pure theory of production, production of joint products with fixed proportions (1) becomes

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7 DEBERTIN (1986, p. 245).

8 HEADY (1952, p. 203 et seq.) and DEBERTIN (1986, p. 246).

10 HEADY (1952, Chapter 7).

11 Both expressions, joint production and jointness, will be used synonymously during this thesis.

merely a special case of single output production.[12] The cases of joint production with variable proportions (2-4) between products of a multi-product firm are thus designated by the term "*joint production*".

4.1.2.1 Characteristics of joint production

When proportions between different enterprises vary with different output levels, there is no longer a homogenous output unit to which productivities, costs and revenues of the different inputs can be related. Also it is not possible to relate these inputs separately to the different enterprises and to calculate their individual costs and revenues, since a change in one of the enterprises will generally influence technical, cost and demand relations of the others. This interrelationship between different products is the characteristic feature of joint production.[13] Similar to this characterization from Carlson, LYNNE (1988, p. 948) states that non-separability of costs is the feature of jointness and joint production.[14]

Joint production can be characterized via economies of scope, as done by LEATHERS (1991). Economies of scope exist when for all outputs y_1 and y_2 cost of joint production is less than cost of producing each product separately.[15] This is the case when, e. g., enterprises are complementary. Economies of scope can be formulated as done by TEECE (1980, p. 224) with two outputs y_1, y_2 and costs c:

$$c(y_1, y_2) < c(y_1, 0) + c(0, y_2)$$

Joint production occurs in the short-run, when production of different enterprises exhibits economies of scope, or stand-alone production of one of the outputs exhibits diseconomies of size. As CARLSON (1956, p. 81) states, there would be no inducement for joint production were this not true.

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12 HENDERSON and QUANDT (1971, p. 89).

13 CARLSON (1956, p. 76).

14 This point also shows that the production function for two products produced jointly cannot be stated separately and thus only one joint production function for these two products exists.

15 TEECE (1980, p. 224), following PANZAR and WILLIG (1975).

4.1.2.2 Sources of jointness

There are two general sources or causes of jointness between enterprises in a multi-product farm. These are (a) jointness in technology and (b) jointness in supply.[16]

The general understanding of joint production or jointness refers to technical interdependence between different enterprises as described in Section 4.1.1. Joint production in general is said to encompass all cases of production of two or more outputs that are technically interdependent.[17] This is type (a), called jointness in technology by LYNNE (1988). Technical interdependencies occur from many sources inherent to the technology applied in the production process. Technical interdependencies may arise for three different reasons: (1) One enterprise may contribute an element of production, a joint product of the first, required by a second enterprise. (2) One enterprise may divert surplus resources from a second product. (3) The products may interact with each other as proportions of non-usable joint products change with varying levels of output from a fixed technical unit. These technical interdependency reasons are directly linked to the problem of crop rotation economics or land use.[18]

The first reason, (1), is perhaps the most important in agriculture. For complementary enterprises, like cereals and legume crops, use of resources for the two enables a greater output of one or both than if each type were grown independently. Legume and other broadleaf crops may contribute elements required in production of grain, fiber or other crops by (a) increasing soil fertility through addition of nutrients, especially nitrogen, (b) improving soil structure through the addition of organic matter or aerating soil compactions, (c) preventing soil erosion, (d) (re)storing soil moisture and (d) controlling insects and diseases. Nutrients, soil structure, moisture and disease breaks serve as joint products from one enterprise which can increase output of a second enterprise.[19] An example are corn and soybeans in the corn belt of the US as well as wheat and rapeseed in Europe.

Complementarity based on a joint product furnished by one enterprise as an input for another is often expressed only over time. Increased grain output from a given land area comes about only as these crops follow legume/broad-leaf crops and benefit from nitrogen, organic matter or other production elements furnished by legume/broadleaf crops. Wheat and rapeseed are almost always competitive within the time span of a single

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16 LYNNE (1988, p. 948).

17 HENDERSON and QUANDT (1971, p. 89).

18 HEADY (1952, p. 222)

19 Compare HEADY (1952, p.222).

year; the more rapeseed produced on a given land area, the smaller the grain output must be within the same year. However, it is possible for two crops to bear a complementary relationship even within a single year. Break or intermediate crops like mustard or radish in sugar beet production in Europe fall partly in this category.

The second type of complementary relationships, (2), grows out of "surplus" factors or the fact that diminishing total returns may exist where too many resources are applied in producing either one of two products. This can be demonstrated with a limited amount of fertilizer applied to two different crops A and B. If input of fertilizer for crop A extends the production of crop A into the range of decreasing total returns (law of diminishing returns), then output of crop B can be increased by shifting fertilizer input from crop A to B and thus increasing total returns of both crops A and B. If the amount of fertilizer applied is reduced in a way that production of none of the two crops A and B is in the range of diminishing returns, then both crops compete for the input of fertilizer and are thus in a competitive relationship. HEADY (1952, p. 228) emphasizes, that under no conditions does this type of complementary relationship extend indefinitely, and it always merges into a competitive relationship.

The third type of complementary relationships, (3), may arise when an enterprise includes several joint products which change in proportions as output is increased or rearranged. Complementarity arising for this reason is mainly found in livestock production and is therefore not further explained here.[20]

The second general source of jointness, (b), is a bit more complex than the first. It is called jointness in supply by LYNNE (1988) and arises from the need to allocate fixed inputs between competing enterprises. The term "fixed inputs or factors" refers to factors of production that cannot be changed in total amounts in the short run. The importance of fixed factors in the theory of the multi-product firm arises in part from the possibility of transferring units of a fixed factor from use in producing one product to use in producing a different product (compare (2) in Section 4.1.1). This serves to link the production of different products together. Thus, within the firm, each enterprise is competing with all other enterprises of the firm for the use of available fixed factors. Furthermore, the available quantity of a fixed factor may not be entirely used during any operation period. Such a condition cannot exist with variable factors because the total quantity used by the firm can be adjusted in the short run. By definition this cannot be done for fixed factors. In the short run it may be economical for excess capacity to exist in some or all fixed factors.[21]

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[20] HEADY (1952, p. 228).

[21] PFOUTS (1961, p. 651).

As an example for fixed factors that are allocated within the production process among different enterprises is again the combine, which is used for harvesting wheat and barley (compare (3) in 4.1.1). In the short-run, and thus for the annual planting decision, maximum capacity in terms of harvest acreage of the combine cannot be extended and is thus fixed.[22] Thus, harvest capacity of such a combine is limited for a certain period. For two crops which have an overlapping harvest period the combine is thus a source of jointness since they compete for this fixed factor during the same period. Crop acreage and thus output of these two crops is determined by their ability to compete for use of the limited factor – in here the combine. Thus, their output is jointly determined by the ratio of output prices or gross margins, which are an indicator for on-farm competitiveness of crops in this sense.

The issue of allocable fixed factors as a source of jointness was widely discussed in a series of different articles by various authors in different scientific journals. An overview of this discussion can be found in ASUNKA and SHUMWAY (1996).

SHUMWAY, POPE and NASH (1984) demonstrated that fixed factors, which need to be allocated between enterprises (allocable fixed inputs), are a source of jointness, even for enterprises which are otherwise technically independent.[23] It was shown that an allocable input can cause short-run supplies of technically independent outputs to depend on alternative output prices. This type of jointness was later called jointness in supply by LYNNE (1988), since in the presence of allocable fixed inputs, output quantity of one enterprise is influenced by output prices of the different other products.[24] Later, SHUMWAY, POPE and NASH (1988) and CHAMBERS and JUST (1989) distinguished theoretically between "apparent" (short-run) jointness and "true" (long-run) jointness caused by technically interdependent enterprises. Furthermore, MOSCHINI (1989) showed that some short-run output supplies can decrease with an increase in alternative output price and can increase with a rise in input price.

The illustration of joint production, its characteristics and sources in this section reveals that jointness is a complex issue in economic theory. It was therefore only touched upon as briefly as possible and as far as necessary to understand the general driving forces behind the composition of crop portfolios and crop rotations.

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22 A second or more combines can be added by purchase, lease or contract labor of course. The maximum capacity in terms of harvest acreage of this one combine though cannot be extended and is thus fixed.

23 The proof of this statement is rather technical. It also was intensively discussed by LYNNE (1988) and SHUMWAY, POPE and NASH (1988). Thus, it is not displayed here in detail, since it would go beyond the scope of this thesis.

24 LYNNE (1988, p. 74 et seq.).

4.1.3 Production decisions in the short- and long-run

The different enterprise relationships and characteristics of joint production lead to the emergence of crop rotations in multi-product farms. Influence of these driving factors on crop choice though changes, when perspective of decision making is directed to the long-run. So far, enterprise relationships and sources of jointness were based on the assumption of short-run production possibilities that implied a farm with fixed factor endowment (see 4.1.1).

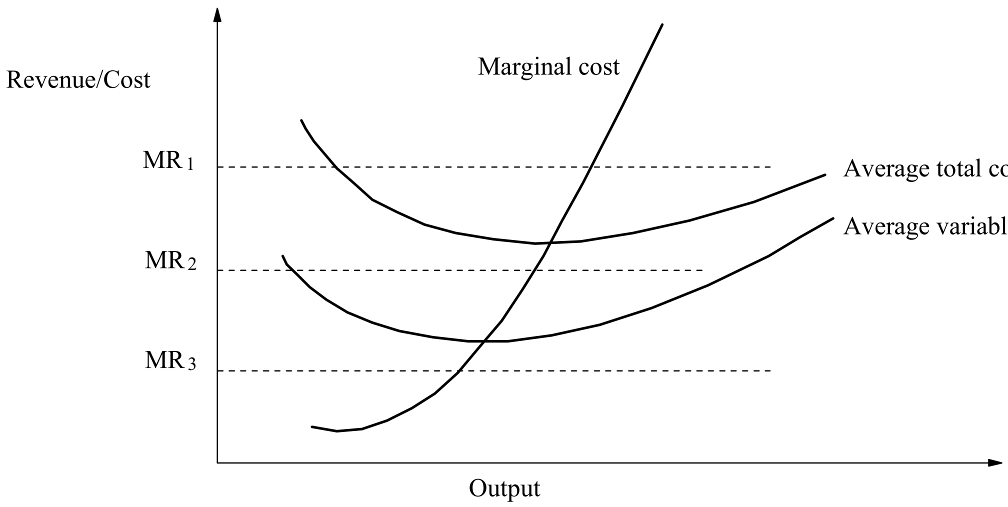
This situation usually holds for a farmer at times before planting season when decisions about crop output (in terms of planted acreage) are made. In such a situation the farmer needs to allocate a given acreage, a given set of machinery, buildings and equipment, a more or less fixed amount of labor (quasi-fixed) and other variable production factors to the different enterprises (crops).

Costs for fixed factors in this situation (fixed costs) do not influence the farmer's production decision, since their input cannot be adjusted and is thus fixed in the short-run. This, however, changes in the long-run, since fixed factors can be adjusted over time and become thus variable. Thus, in the long-run, total cost of production (fixed and variable) need to be covered by the farmer in order to continue production. A fixed factor becomes variable at the time when it is replaced, e. g. at the end of its lifetime or simply because it is newly added to the production process. This context of variable and fixed costs is illustrated in Figure 4.2.

If returns exceed minimum average total cost (*ATC*) (or total returns are greater than total cost), a profit can be achieved and is maximized by production where marginal revenue equals marginal cost (*MR* = *MC*). This is MR_1 and holds for short-run as well as long-run production decisions. If returns are less than minimum *ATC* but greater than minimum average variable cost (*AVC*) (or total returns are greater than total variable costs but less than total costs), a loss is made but will be minimized by producing where *MR* = *MC*. This is MR_2, where variable costs are compensated and only parts of fixed costs are covered. In MR_3, returns are less than minimum *AVC* (or total returns are less than total variable costs). A loss is made but is minimized by not producing. The loss will be equal to total fixed cost then. The difference in production decision for short- and long-run is located in MR_2. In the short-run, production will continue since parts of the fixed costs are covered. In the long-run, since all costs are variable and thus total costs need to be covered, the farm will cease cash crop production.[25]

[25] KAY et al. (2008, p.147 et seq.).

Figure 4.2: Illustration of short-run and long-run production decisions



Source: Kay et al. (2008, p. 148).

A cash crop farmer may thus be able to choose different crops in the short-run than in the long-run. Crop portfolio composition may change as soon as costs of an investment in a fixed factor need to be covered. Further conditions exist, which affect crop portfolio composition in the short-run and in the long-run in different ways. Jointness in supply (see 4.1.2) is caused by the presence of allocable fixed inputs. Since there are, by definition, no fixed inputs in the long-run, this source of jointness disappears. Thus, enterprises (crops) might be readjusted due to this condition in the long-run.

The effect of fixed costs in the long-run is similar to that of sunk costs. If an investment in a fixed factor is irreversible, i.e., its current value cannot be recaptured by its selling price, costs for this factor are sunk costs. This is often the case for buildings and fixed installed equipment. In presence of sunk costs, production decisions can be made without considering these costs. Thus, crop choice can be different in presence of sunk costs than without them. This is called temporary path dependency.[26] The general difference between long-run and short-run production decisions further results from different opportunity costs. A farmer producing with fixed factors and sunk cost (i. e., short-run) has lower or no opportunity costs than in the long-run where factors become variable. If production is to be maintained in the long-run, opportunity costs for resources employed need to be taken into account and might thus change crop choice as well as the overall farm business

[26] BRANDES et al. (1997, pp. 58-63).

organization.[27] A change in crop portfolio composition and overall farm organization is further also influenced by path dependency.[28]

Remarks made in this section indicate that in the long-run production decisions differ from the short-run. For further proceeding in this thesis, the analytical framework will be based on the short-run decision situation for a farm in the presence of allocable fixed inputs as described at the beginning of this section. Long-run crop choice and farming structures are influenced by many factors over time. Research interest of this thesis though is focused on the impact of short-run changes in crop output prices on crop portfolio composition and rotation choice.

4.2 Determinants of crop portfolio composition and rotation choice

Following the theoretical background presented in the previous Chapter 4.1, determinants of crop portfolio composition and rotation choice will be presented for short-run crop selection decisions for a price-taking farm with profit maximizing behavior. This will provide a theoretical foundation for analyzing price induced changes to crop portfolios and rotations.

A general assumption in neoclassic economic theory is profit (utility) maximizing behavior of an entrepreneur; i. e., activities are chosen which contribute to the highest possible profit (utility). A cash crop farmer will thus choose those crops to grow which provide highest overall profit. Due to jointness of cash crop production, activity decisions take place under input constraints for multiple outputs (crops) (compare previous section). Input constraints usually arise for available crop land, labor (hired and family) as well as capital for buying inputs.[29]

4.2.1 Profit maximizing under input constraints with multiple outputs

To generate maximum profit from a crop portfolio, the farmer will have to use inputs choosing the optimum crop (enterprise) combination under a minimum cost combination and optimum intensity levels. These conditions must hold simultaneously.

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[27] DEBERTIN (1986, p. 299) and PINDYCK and RUBINFELD (1992, pp. 197 – 200).

[28] BRANDES et al. (1997, Chapter 17.3) for an illustration of path dependency.

[29] DEBERTIN (1986, p. 289 et seq.).

The optimum, profit maximizing crop portfolio is chosen under the following conditions, based on the different production relationships (factor-factor, factor-product, and product-product):[30]

- Marginal revenue of a specific input must decrease for all enterprises. This must hold for all inputs used in production.
- Marginal rate of substitution for two inputs must decrease. This must hold for all inputs.
- Marginal rate of transformation for two outputs must increase. This must hold for all outputs.

If these conditions hold for all inputs and outputs, the optimum crop portfolio for two inputs $x_{1,2}$ with price $w_{1,2}$ and two outputs $y_{1,2}$ with price $p_{1,2}$ is selected under the following equilibrium conditions:[31]

$$\frac{\partial y_1}{\partial x_1}\frac{p_1}{w_1} = \frac{\partial y_1}{\partial x_2}\frac{p_1}{w_2} = \frac{\partial y_1}{\partial x_1}\frac{p_2}{w_1} = \frac{\partial y_1}{\partial x_1}\frac{p_2}{w_2} = \lambda \qquad (4.1)$$

The use of every input $x_{1,2}$ has to be increased until its marginal value product equals its price $w_{1,2}$. Further, for every output $y_{1,2}$ the marginal rate of substitution of the two inputs $x_{1,2}$ must equal their inverse price ratio. Also, for every input $x_{1,2}$ the marginal rate of transformation of the two outputs $y_{1,2}$ must equal their inverse price ratio.[32] The Lagrangian multiplier λ is the imputed value of an additional monetary unit (e. g., one dollar) available for the purchase of inputs, allocated according to these conditions.[33] A value for the Lagrangian multiplier λ of 1 would imply global profit maximization in this setting. For simplicity reasons only the two input-two output case is illustrated here. In case of n inputs and m outputs, there will be n times m expressions in the equality.[34]

The conditions for profit maximization in a multi-input, multi-output setting have further implications with regard to output (crop) choice. An isolated increase of p_1 results in a

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30 STEINHAUSER et al. (1992, p. 149).

31 HENDERSON and QUANDT (1971, pp. 95-98), STEINHAUSER et al. (1992, pp. 149-152) and BRANDES et al. (1997, pp. 63-67).

32 BRANDES et al. (1997, pp. 65 et seq.), based on HENDERSON and QUANDT (1971, pp. 95-98).

33 The Lagrangian multiplier λ is also called "shadow price" of the limited factor (input) x. If x could be increased by one unit, the shadow price λ represents the price a profit maximizing farmer would pay for it.

34 DEBERTIN (1986, pp. 290-292).

movement along the transformation curve in a sense that y_2 is substituted by y_1. The same holds for an isolated increase of $\frac{\partial y_1}{\partial x^2}$, which means a partial increase in productivity for y_1. Furthermore, assuming efficient production and a given amount of inputs, an increase in output for e. g., y_1 is only possible through a sacrifice in output of y_2. The costs associated with this increase depend on the marginal value product of input x used for the production of y_2 and thus on $\rho_2 \frac{\partial y^2}{\partial x}$. Therefore, under *ceteris paribus,* an increase in p_2 as well as an increase in productivity of y_2 leads to a cost increase for the production of y_1 as well as to an increment of the shadow price λ for input x. Another implication is the increase in opportunity cost for an expansion of one output for the normal case of concave transformation curves.[35]

Further implications with regard to price changes for inputs and outputs can be deducted from these conditions. Price elasticity of one output is greater the more easily this output can be substituted. It can be expected for an output which shares allocable fixed inputs (compare 4.1.2), that it shows a high elasticity in supply. In cash crop production, this typically holds for production of different cereals as well as for cereals and oilseeds. In case of limitations in supply for one competitive output y_2 (like a production quota, e. g., for sugar beets in EU), the output of y_1 is less elastic in terms of a change in its own price.[36]

Furthermore, when looking at the general case with n inputs and m outputs, definite statements can only be made in regard to the effects of an isolated change in own price. An increment (decrement) of output price p_m induces an expansion (reduction) of the production of y_m. An increment (decrement) of input price w_n induces a decrease (increase) in demand for input x_n. These are of course not the only effects of an isolated price change. In fact, a profit maximizing farmer will adjust his crop portfolio in a way that the conditions of the equality (4.1) still hold. For example, an increment in output price p_1 leads to an increase of the marginal value products of inputs x_1 and x_2. The adjustment in crop choice to the increase of *MVP* cannot be stated without exact knowledge of the different production functions. The induced increase of output y_1 by the change in p_1 can be achieved in different ways. The expansion of y_1 may take place at the sacrifice of y_2. Furthermore, input of x_1 or x_2 or of both can be increased and thus the ratio of the two inputs can be changed. Also, output of y_2 might be increased as a joint product of y_1.[37]

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35 Compare BRANDES et al. (1997, p. 64 et seq.).

36 BRANDES et al (1997, p. 65).

37 BRANDES et al. (1997, p. 66 et seq.), following HENDERSON and QUANDT (1971, p. 98).

4.2.2 Factors for crop selection and rotation choice

Crop portfolio composition and rotation choice is influenced by various factors in addition to profit maximization, though many of these factors influence profitability of the different crops as well. An overview of different reasons for growing crops in rotations is given in CAMPBELL et al. (1990), GEBREMEDHIM and SCHWAB (1998) and HENNESSY (2006).

As was demonstrated in Chapter 4.2 so far, profit maximization and thus level of gross margin is the key factor for determining which crops to grow. Farmers formulate expectations in terms of gross margins for the different crops prior to seeding. Relative price ratios, and thus gross margin ratios together with the technical rates at which products may be substituted for one another determine the most profitable combinations and levels of outputs.[38]

Besides all the advantages which come along with growing crops in a portfolio with more than one crop, some disadvantages exist as well. Diversified crop portfolios with different production systems may require more diverse equipment as well as diverse and greater management skills, capabilities and expertise.[39] For example, growing corn requires different seeding, harvesting and storage technology than other cereals. Complementarities in terms of using these fixed inputs with more than one crop are thus hard to achieve. Thus, benefits may exist from specialization, which generally arise from economies of scale and gains from experience.[40] In order to determine crop portfolio composition, farmers thus have to consider both benefits and costs from diversification.

Further, crop portfolio composition is influenced by existing organization of the farm operation, especially by existing machinery and equipment capacities. Once the investment in these production factors has been made, capacities are fixed and output is chosen that will use up these capacities. This leads to persistence in prevailing crop portfolio composition.[41] Persistence increases as machinery can only be used for a relatively small number of crops (e. g., corn head for a combine). This situation can also be compared with temporary path-dependency as mentioned in Chapter 4.1.3.

38 CAMPBELL et al. (1990, p. 19).

39 GEBREMEDHIM and SCHWAB (1998, p. 6).

40 CAMPBELL et al. (1990, p. 20), HENNESSY (2006, p. 900).

41 ODENING and BOKELMANN (2000, p.163).

4.2.2.1 Risk

Another important aspect in crop selection decisions is risk management. There are many risks faced by cash crop farmers. The most important risks are production risks which affect crop yields and thus outputs, and market risks which affect crop prices and thus returns. Production risks originate from variations in amounts and distribution of rainfall, temperature, insects, diseases, weeds and other uncontrollable factors of production. Market risks arise from unexpected changes in product prices, input costs and marketing opportunities. Farmers generally attach a positive value to cropping systems that exhibit low risk or low variability. The amount of risk that farmers are willing or able to accept depends on their personal preferences, past experiences, attitudes towards risk and their financial position (e. g., amount of equity or asset values). Farmers and farms differ in nature and quantity of physical (e. g., machinery, labor, and buildings), financial (e. g., operating and investment capital), and personnel (e. g., management skills) resources available to them. Risk attitude and impact of risks thus differs from farmer to farmer and thus has a different impact on crop portfolio composition.

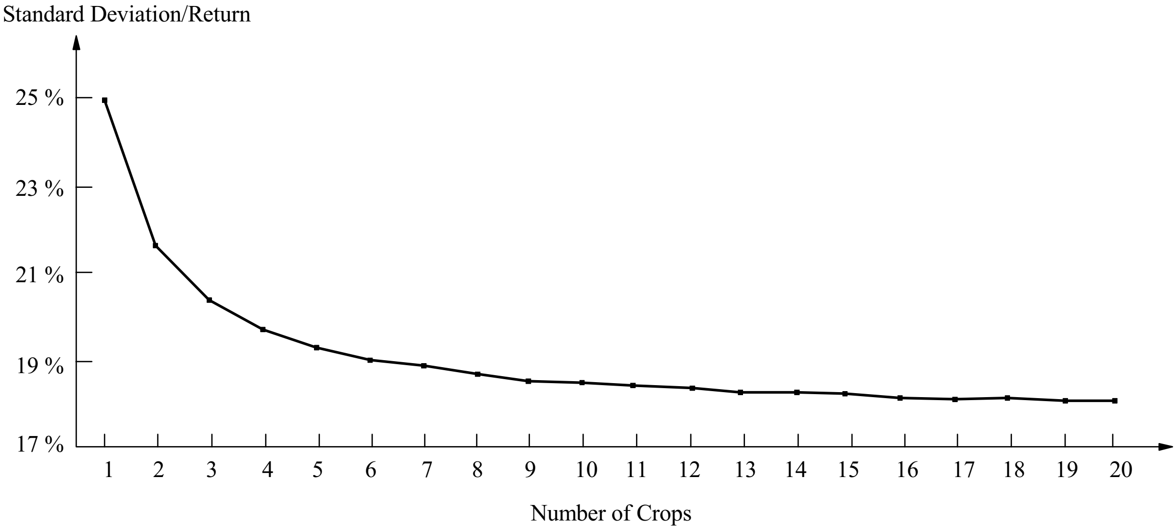
Crop diversification, and therefore the growing of more than one crop, is a means of reducing risk. Production risks can be diversified and thus reduced by growing crops with different (technical) characteristics in terms of susceptibility to yield-depressing factors. For example, broadleaf crops might be affected differently than cereals by the spread of a particular disease, and thus a potential yield loss or increase in input costs is limited. Market risk can be reduced by growing crops with only weak correlation of output prices. This reduces dependence (in terms of profit or income) on events in a single market, which might occur especially in the short-run. A weak correlation of output prices usually prevails for crops that are not close substitutes or those that are sold in different markets. For example, wheat and barley may serve as feedstock and are more or less substitutes and thus their prices are typically more correlated than cereals and for example oilseeds.[42]

The risk-reducing effect of crop diversification is illustrated, for example, in WEISENSEL and SCHONEY (1989). When covariances of net returns among crops are negative or low, additional crops will decrease risk. However, when correlations among cropping returns are highly positive, diversifying the crop portfolio by adding additional crops is ineffective in reducing portfolio risk. This is expressed by the following example. Assuming a crop portfolio where each crop is normally distributed with an expected rate of return above variable costs of 20 % and a standard deviation of 5 %. The correlation in net returns is .5. The relative riskiness of the portfolio is defined by the coefficient of variation or the standard deviation of the portfolio divided by mean return. The risk-

[42] CAMPBELL et al. (1990, p. 19 et seq.).

reducing effect of diversification by adding more crops to the crop portfolio is illustrated in Figure 4.3, assuming equal proportions of crops.

Figure 4.3: Risk implications of crop portfolio diversification



Source: Weisensel and Schoney (1989, p. 294).

As can be seen, the greatest risk reducing effect is derived from shifting from a one-crop to a two-crop and then to a three-crop portfolio. Thus, most of the benefits of diversification occur when the portfolio is small.[43] This is due to the diminishing benefits of adding more crops, because here, constant correlation is assumed and the number of covariances rises rapidly as more crops are added.

4.2.2.2 Agricultural policy

Another factor influencing crop portfolio composition is agricultural policy. Input and output prices are controlled and influenced by policy means to different extents in different countries which thus influence gross margins and profitability of crops. This is achieved by different government programs like production quotas (e. g., sugar beets in the EU), crop insurance (e. g., in the US and Canada), income stabilization schemes (e. g., in the US, Canada and EU), transportation and input subsidies (e. g., tax refund on farm diesel) or tax considerations.[44] Furthermore, environmental programs and legislation have

[43] In an empirical study, BLANK (1990) found a similar curvature for risk associated with crop portfolios in California.

[44] CAMPBELL et al. (1990, p. 19).

an impact on crop portfolio composition. Under this framework, restrictions are imposed on technology and inputs used in production aiming to reduce soil degradation, improve biodiversity by growing certain crops, following specific crop rotations and using less inputs.[45]

Crop portfolio composition in the presence of government programs and legislation is different than it would be without support. In the case of support programs, profitability of benefiting crops is likely to decrease in such a case, and thus lead to a reorganization of crop portfolios. For example, if price support for sugar beets in the EU were to be cut substantially, profitability of competing crops would increase and the share of sugar beets in the crop portfolio would decline.

4.2.2.3 Technical interdependence

As was already discussed in Chapter 4.1, technical interdependence is a major source of jointness which determines crop portfolio composition. Characteristics of technical interdependence between different crops are manifold, and do not only vary between locations, farms and crops but also between years. Thus, only the most common and general technical interrelations will be discussed here.

Crops grown in rotations provide certain intermediate (joint) products which affect production of the following crop (or all crops) in the sequence. This effect can either be positive, negative or both. Certain crops, especially legumes, increase soil fertility through the addition of nutrients, especially nitrogen. This usually improves the yield of the following crop and also saves on external inputs (i. e., fertilizer). Soil structure can be improved by root and tuber crops by loosening the soil or by crops increasing the organic matter content. Some crops might also show some disadvantages in this regard by destroying or depleting soil structure. These are crops that deplete organic matter or leave soil compaction after harvest, for example. Other crops prevent soil erosion because they cover the soil during critical periods of, e. g., high rainfall or strong winds. Good examples are cover or intermediate crops which are grown before a main crop.

In dry or semi-arid areas, management of water supply for crops is a critical issue, since this is usually a limiting factor in determining crop yields. Some crops use less water than others and thus leave more water for the following crop. In the semi-arid regions of the Great Plains in North America, summer fallow plays an important role for this reason. Though not providing any return in the period of fallow, soil moisture is restored and weeds are controlled providing more moisture and less weed pressure for the following

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45 HENNESSY (2006, p. 900 et seq.).

crop. This results in higher yields and less input costs and thus higher returns of the following crop. Another important agronomic aspect of crop rotations is to control for insects, plant diseases and weeds. High shares of specific crops, e. g., rapeseed, increase yield depression caused by increasing disease or insect pressure. Input costs may rise due to an increase in application of chemicals to control these factors, thus reducing profitability. Breaking disease, insect or weed development cycles by growing different crops not, or less, affected by these factors will improve yields, save input costs and thus increase overall profitability.[46]

Therefore, crops with low profitability (i.e., low gross margins) compared to other crops may be included in a crop rotation only due to their associated agronomic effects on the following crop(s). This means that the apparent profitability of such a crop might be lower, but profitability of following crop(s) is only higher because of positive agronomic benefits which come along with the preceding crop. In this regard, benefits need to be considered as a return for the providing crop and as an input cost for the following, consumptive crop.

Another aspect of technical interrelations between different crops refers to overall farm organization and seasonality of operations. Different crops have different resource requirements in different periods throughout the year. For example, winter crops and summer crops have different planting seasons and thus peak times in labor and equipment use may be prevented. Also, some crops may favor or enable less intense tillage systems, e. g. rapeseed and wheat can easily be grown in reduced tillage systems.

Agronomical effects and interdependencies between crops occur in different proportions and variations. Crops may provide some benefits and reduce others at the same time. Some crops may only provide benefits and others only consume them. Some crops also may leave disadvantages, for example soil compaction, which cause higher costs or lower yields or both in the following crop(s). Relationships between crops are not fixed and may change over time or by technical progress or both. Crop portfolio composition and rotation choice generally reflect these technical interrelationships where profitability of growing several crops is higher than growing a single crop.

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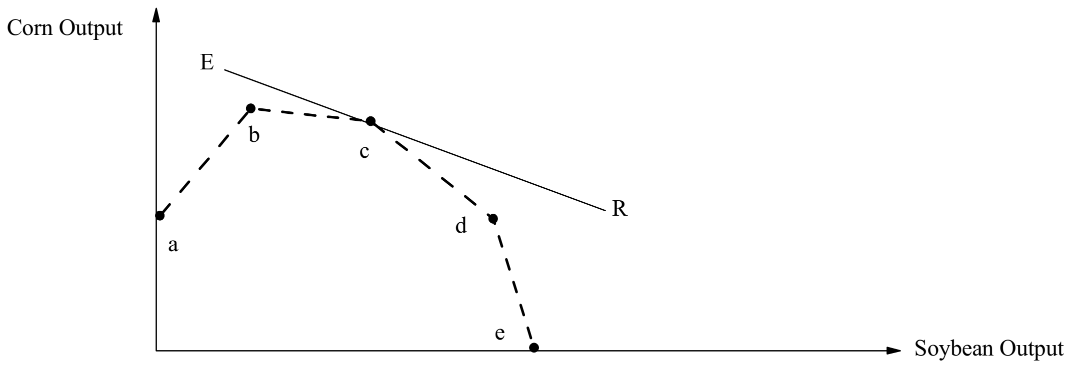
[46] HEADY (1952, p. 222), CAMPBELL et al. (1990) and HENNESSY (2006).

4.2.3 Stability in crop rotations and crop portfolios

The different factors which determine crop portfolio composition, especially technical interdependencies, lead to an interrelated profitability, efficiency and competitiveness of crops. Further, these factors cause stability in crop portfolio composition over certain ranges of input and output price ratios. In this regard, different crop combinations can be considered as discontinuous opportunities when choosing profit-maximizing crops. Choice of crop combinations involves no new rules and thus conditions outlined for profit maximizing choice of single outputs (crops) hold as well. Again for simplicity reasons, the two output (two crop) example for discontinuous choice opportunities will be illustrated. This case can be transferred of course to crop rotations (combinations) of multiple crops.

In Figure 4.4, the transformation (opportunity) curve *abcde* represents rotation possibilities when only crop combinations indicated as *a, b, c, d* and *e* can be attained. The in-between or dotted portions cannot be attained and the production possibility curve has corners indicating high stability in the crop combinations grown. When the soybean/corn ratio is of the magnitude represented by the slope of the iso-revenue curve *ER*, rotation or crop combination *c* results in maximum profits for the fixed quantity of resources employed. This rotation is most profitable over a wide range of price relationships. A shift to rotation *d* is not profitable unless the relative price of soybeans increases sufficiently to cause the slope of the revenue line to become greater than the *cd* portion of the transformation curve. Conversely, rotation *b* will not be profitable until corn prices increase sufficiently to cause the revenue line to have a slope of less than *bc*.

Figure 4.4: Crop rotations as discontinuous opportunities



Source: Base on Heady (1952, p. 256).

For all practical purposes, each of the discontinuous segments on the transformation (opportunity) curve in Figure 4.4 can be considered the same as a continuous, linear production possibility line. This situation can also be described by Leontief-Processes, which are based on Leontief production functions and are characterized by fixed proportions of input factors which cause stability in terms of input and output choice.[47]

The corn/soybean price ratio may vary from the slope of section *bc* to the slope of section *cd* before crop combination *c* becomes unprofitable. Thus, crop combination *c* is the most profitable for any prices of the two crops which show a price ratio in the range of *bc* and *cd*. Thus, crop combination *c* is stable over that range. Such stability situations are widely found in cash crop farms. They are the antithesis of constant and close rates of substitution between competitive crops, where profit maximization may require that use of resources "jumps" from specialization in one crop to specialization in another crop as prices change.[48] Stability in crop rotations results from jointness of cash crop production (compare 4.1.2). The main source is technical interdependence which results in complementary relationships between crops.

4.3 Methodology for analyzing crop portfolio composition

In preceding chapters, theoretical foundations of enterprise relationships and crop portfolio composition for multi-product farms have been laid out. This chapter will discuss a methodology which is suitable for modeling crop portfolios to analyze the effect of shifting crop price relations on crop portfolio composition.

Since this thesis is embedded in the research concept of *agri benchmark*, methodology applied within the network will be discussed in regard to its ability for analyzing crop portfolio composition (Section 4.3.1). Furthermore, farms can be described with linear models and thus Linear Programming might provide an option for modeling changes in crop portfolio composition (Section 4.3.2).

4.3.1 *agri benchmark* cost of production methodology

In this section, ability to calculate and compare costs of production in explaining crop portfolio composition will be discussed. This will be based on the procedure of cost calculation and farm level data collection used for multi-product cash crop farms within

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47 BRANDES et al. (1997, p. 37 and p. 67).

48 HEADY (1952, p.256).

the *agri benchmark* Cash Crop Network (CCN) so far. These methods have been presented in Chapter 3.2. Discussion of *agri benchmark* cost of production methodology needs to consider two major aspects. First, ability of cost of production to explain crop portfolio composition under current framework conditions (status quo) and second to explain and analyze adjustments in crop portfolio composition due to changes in output (crop) prices.

Costs of production (CoP) are compiled for various reasons in agriculture. Within *agri benchmark,* costs of production are calculated and compared to assess the international competitiveness of agricultural commodities at the farm level. The theoretical framework for using this approach is provided by MARTIN et al. (1991, p. 1456), who define competitiveness as "the sustained ability to profitably gain and maintain market share". Further, according to PORTER (1993, p. 59) firms (farms) can pursue two different general strategies to achieve a competitive advantage: product differentiation and cost leadership. The potential of product differentiation for cash crop farms is limited since these usually produce commodities. Cost leadership is thus a strategy for cash crop farmers to profitably gain and maintain market share, i.e. to generate profits in cash crop production (compare also Chapter 3.1.2).

In order to generate a profit, total costs need to be covered by total returns for the whole farm. This is true in the long-run. In the short-run only cash costs need to be covered to continue the farm operation (compare also Figure 3.5 in Section 3.2.4.2). Recovering depreciation is important in the medium-run when depreciable assets need to be replaced to continue the farm's operation. In the long-run opportunity costs also have to be covered, otherwise profit in the alternative use (usually outside agriculture) for resources employed is higher. Thus, the concept of total costs as used in *agri benchmark* CCN is a long-run concept. Crop portfolio composition which is relevant for the problem setting of this thesis, and as it thus was outlined in Section 4.2, is based on short-run decision making. Thus, the *agri benchmark* CCN cost concept appears in clear contrast to the short-run dimension of decision making and in this regard, the long-run based cost concept of the *agri benchmark* CCN is not suitable for analyzing crop portfolio composition.[49]

Furthermore, costs of production figures in *agri benchmark* CCN are based on ex-post farm level data. Decision making, though, involves forward-planning based on cost and price expectations reflected in gross margins as used for enterprise budgeting. Also, CoP figures are a point estimate (i. e., for one output or input price) and thus, as SHARPLES (1990, p. 1280) notes, an estimate of average unit costs tells little about the supply

[49] MILLER (1992, p. 352).

function. He further states that care must be taken in using cost data to evaluate how production or exports might respond to major changes in input or output price ratios. Producers facing a major change in price ratios likely would reorganize production, so a new cost structure would emerge.[50] Thus, cost of production figures may serve as a base for cost planning in enterprise budgets but cannot serve as an explanation for future crop portfolio composition.

Jointness of cash crop production in multi-product farms was pointed out in Chapter 4.1. Technical interdependence and the presence of allocable fixed inputs (e. g., land, tractors) are a major source of jointness which lead to the presence of joint costs for several (all) enterprises. Cost of production calculation thus has to consider joint costs and jointness in production in general, since cash crop farms are usually multi-product farms. In the presence of joint production, strong assumptions must be verified or departures assumed inconsequential in order to treat multi-product farms as single-output enterprises in economic analyses.[51] So far, the cost of production concept of *agri benchmark* CCN does not or only partly accounts for jointness and especially technical interdependence. Thus, costs of production relations between the different crops of a crop portfolio do not reflect real existing competitive positions of the different crops. This is another negative aspect of the *agri benchmark* CCN cost concept, not only in regard to analyzing crop portfolio composition, but also in comparing cost of production figures as done so far in the various *agri benchmark* Cash Crop Reports.

An approach to account for jointness in cash crop production and to adjust for on-farm benefits and costs generated by the different crops of a crop portfolio is presented by MÖLLER and SCHONEY (2006). A Linear Programming model is used, defining the different crops as an activity providing or consuming intermediate products or both (benefits/costs) based on restrictions imposed by these intermediate products. Cost of production results for different cash crop farms in Canada and Germany using the LP-approach are then compared against the traditional concept, as used, for example, within *agri benchmark* CCN. The comparison reveals that the competitive position of the different crops is much better reflected by the LP-approach accounting for jointness and intermediate products.

A general critique of cost of production calculation methods for multi-product farms is the arbitrariness of cost allocation between different enterprises (crops). This means no economic theory exists to justify any type of allocation of joint costs.[52] General farm

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[50] SHARPLES (1990, p. 1281).

[51] SHUMWAY et al. (1984, p 78).

[52] ISERMEYER (1988, p. 58), MOREHART et al. (1992, p. 106) and HARRINGTON (1992, p. 45).

overhead expenses as well as capital recovery charges (depreciation) for machinery and buildings (fixed assets) are such kind of joint costs. Since this is a general critique it also relates to cost of production procedure of *agri benchmark* CCN.

Within *agri benchmark* CCN, overhead costs, depreciation and whole farm expenses are allocated to the different enterprises (crops) using return shares (compare Section 3.2.4). Within the model TIPI-CAL, allocation factors for these costs are calculated based on the return share of the specific enterprise in total farm returns and overhead costs, etc., and are then allocated according to these factors. In the case of changing crop yields or crop prices or both, return shares also change and thus allocation factors, too. Comparing costs of production from year to year or over a longer period of time may then lead to a misinterpretation of results, since due to changing return shares one enterprise (crop) might carry more overhead costs, etc., in one year than in the other. A proper assessment of competitiveness is thus difficult. The bias caused by changing allocation factors is inherent to using return shares as these factors. Bias in this allocation procedure can be reduced by already allocating most of these costs to the different enterprises during data collection. In this way, the number of costs to be allocated is reduced, and thus bias in allocation is reduced.

Nevertheless, there is no logic that one crop should carry more overhead costs, etc., than another only because it has higher returns. High returns do not automatically mean high profitability, and thus a high share of allocated overhead costs, etc., could lead to a misinterpretation of the real competitive position of such a crop. A solution could be to use a share of single crop gross margins in whole farm gross margin as an allocation factor. This would reflect returns and costs as is also done in partial or enterprise budgeting.

Using cost of production data and figures of *agri benchmark* CCN, enterprise budgets (gross margins) can be calculated for whole farm planning and thus decision making for crop portfolio composition. Adjustments in crop portfolio composition due to changing output prices, and thus changing price ratios, can be analyzed using these enterprise budgets (gross margins). Changes in output price ratios of different crops will lead to a change in crop gross margin ratios. Though changes in gross margin ratios should lead to crop portfolio adjustments, jointness between crops may cause persistence in prevailing crop rotations and portfolios. Thus, changing crop gross margin ratios, based on *agri benchmark* CCN farm level data, can only be used as a starting point for analyzing adjustments in crop portfolio composition.

The following disadvantages come along with using enterprise budgets and gross margins to analyze crop portfolio composition. In order to achieve broad coverage in the analysis, as many potential crops as possible need to be included in the comparison. These are more crops than those currently grown at the farm analyzed, i. e., crops with low gross margins etc. In order to calculate gross margins for all these crops, data demand increases and usually would go beyond information provided by the *agri benchmark* producer panel. Another disadvantage is not considering jointness in production. Although gross margins can be adjusted by including a calculated value for benefits generated for or consumed from other crops, these values have to be determined exogenously and are thus biased. If these could be generated by a linear model (e. g., LP), these values were endogenous and would therefore consider all influencing factors in a consistent manner.[53]

Altogether, differences in cost of production as well as in crop gross margins do not represent an indicator suited to analyze crop portfolio composition and adjustments to it. Costs of production figures are not useful at all in this regard, though CoP and data behind these figures provide a basis for further calculations and explanations in regard to different aspects of cash crop farming. Differences in gross margins provide more insight in crop portfolio composition, but jointness in production of different crops usually is not considered. Modeling the farm, respectively the crop portfolio, by a linear model offers an opportunity to considerer the effects of joint production in an appropriate way. This will be discussed in the following section.

4.3.2 Linear programming models

The conditions outlined in Chapters 4.1 and 4.2 have implications for modeling choice of crops and crop rotations. Analyzing crop choice based on production functions implies knowledge of all production functions of the different crops to generate a whole farm production function. The production functions in multi-product farms are complex, as was shown in Chapter 4.1. The generation of a whole farm production function with sufficient accuracy is thus hard to achieve and would involve extended resources.[55]

As was shown in Section 4.2.3, selection of crops can be considered as the choice between discontinuous opportunities (crop combinations). Production possibilities with corner positions or discontinuous opportunities provide conditions which simplify modeling of crop choice in a way that the farm can be stated as a linear model. Linear Programming (LP) may thus serve as an option to model crop portfolio composition and rotation choice. The modeling of farms using Linear Programming is a common methodology, especially in

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[53] MÖLLER and SCHONEY (2006).

[55] STEINHAUSER et al. (1992, p. 153).

applied agricultural economics.[56] Examples for practical applications are widely found in literature.[57]

4.3.2.1 Cash crop farms described by linear models

A linear model implies that different opportunities of resource use for a farm operation (enterprises, etc.) are represented by a finite number of production processes (activities). Activities have certain requirements with regard to inputs and compete for the capacities of the overall fixed or limited farm resources. Then, a_{ij} represents the amount required of the fixed resource r_i ($i = 1,\ldots, m;\ j = 1,\ldots, n$) per-unit of activity (e. g., per hectare). Besides the demand in fixed resources, an activity uses variable inputs x_{jk} at prices w_{jk} ($k = 1,\ldots, r$) and delivers outputs y_{jl}, which can be sold at prices p_{jl} ($l = 1,\ldots,s$).[58]

An activity can be defined, for example, as growing one hectare of rapeseed. This activity then has requirements in terms of, for example, input of tractor and machinery hours, labor hours, etc., and faces constraints in the availability of these inputs. Besides fixed inputs, variable inputs are used in production. The production decision or crop choice process then becomes a matter of activity choice under constraints and can be modeled by Linear Programming (LP) techniques.[59]

Considering resource requirements of the different activities and respective on-farm interrelations, LP models can be used to identify the activity mix (crop portfolio) which represents the maximum profit.[60] LP models maximize profit based on contribution margins (gross margins) of the different activities, i. e. the whole farm gross margin is maximized. Contribution margin (gross margin) is defined as:[61]

$$c_j = \sum_{l=1}^{s} p_{jl} y_{jl} - \sum_{k=1}^{r} w_{jk} x_{jk} \qquad (j = 1, \ldots, n) \tag{4.2}$$

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56 CHIANG (1984), HAZELL and NORTON (1986), RAE (1994).

57 EL-NAZER and MCCARL (1986) and MUßHOFF and HIRSCHAUER (2004) provide practical applications of LP to crop rotations and farm planning.

58 BRANDES et al. (1997, p. 67).

59 BRANDES et al. (1997, p. 67 et seq.), ODENING and BOKELMANN (2000, p. 162).

60 Again assuming profit maximization behavior and fixed resources. Maximizing or minimizing and fixed resources are necessary conditions in Linear Programming.

61 BRANDES et al. (1997, p.68).

The maximization of profit π with *m* constraints (fixed resources) and *n* possible activities can then be stated as:[62]

Maximize

$$\pi = \sum_{j=1}^{n} c_j x_j \tag{4.3}$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_j \leq r_i \qquad (i = 1, \dots, m) \tag{4.4}$$

and

$$x_j \geq 0 \qquad (j = 1, \dots, n) \tag{4.5}$$

with

x_j = Level of the *j*th farm activity (here: acreage of a crop grown),

c_j = Gross margin of one unit of the *j*th activity (e. g. $ per ha),

a_{ij} = Quantity of the *i*th resource (e. g. acreage of land) required to produce one unit of the *j*th activity,

r_i = Amount of *i*th resource available (e. g. acreage of land).

Thus, the crop portfolio (with a respective set of activity levels (crop acreages) x_j) is identified that shows highest possible gross margin π (4.3) while at the same time not violating any of the fixed resource constraints (4.4) and not involving any negative activity levels (4.5).[63]

An expansion of one activity without sacrificing another activity is only possible as long as some of the resources needed for the expansion of the one activity are still available. If resources are fully used, expansion is only possible by reducing the level of the other activity. Cost of the expansion is the forgone gross margin of the reduced activity. These are opportunity costs. Expansion will only take place if the additional gross margin of the expanded activity is higher than the opportunity costs for the forgone activity. Activities (crops) are then chosen according to the highest gross margin and the requirements with regard to the limited fixed resource constraints. In Section 4.1.1 it was already mentioned that competitive enterprise relationships bear opportunity costs for the output sacrificed.

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62 CHIANG (1984, pp. 661 - 664) and HAZELL and NORTON (1986, pp. 10 - 13).

63 HAZELL and NORTON (1986), CHIANG (1984).

The same holds for the different activities that compete for the limited fixed resources in case of a linear model. Here, the existence of opportunity costs for the unit of activity sacrificed becomes obvious again.

Changes in output prices for the different crops result in changes of the respective gross margins of the activities. The profit maximizing solution of a Linear Programming model will then adjust activity levels (i. e., crop acreage) based on the modified gross margins and under consideration of constraints imposed by jointness of production. LP models will thus reflect the effects of output price changes on the allocation of farm resources (esp. land) to the different crops. Thus, Linear Programming methods may provide a suitable approach for modeling output price-induced changes in crop rotations and crop portfolio composition.

4.3.2.2 Advantages of Linear Programming

Resource endowment and production processes of cash crop farms can be stated in Linear Programming models by defining production processes as activities. These activities have certain requirements in regard to farm resources which are subject to restrictions in availability (limited capacity) (compare Section 4.3.2.1).

Each crop produced is usually defined as an activity, characterized by the respective crop gross margin based on crop price and yield as well as crop variable (expendable) costs. The farmer's risk attitude or risk associated with a crop can be considered by choosing a respective setting for crop price and yield. This can, for example, be based on price and yield distributions or risk-free (neutral) values.

In order to account for interrelations between different crops (joint production) multiple activities can be defined for the same crop. These activities will then differ in their gross margins due to different yield and input levels as well as in their requirements in regard to the different restrictions imposed by limiting factors. For example, wheat following rapeseed and wheat following wheat can be defined as two activities for the same crop (wheat). Wheat following rapeseed will have a higher gross margin than wheat following wheat due to higher yield level and lower input level. Thus, this activity will be preferred over the other in the LP solution, but only if the restriction imposed by the available rapeseed land is not binding. Instead of defining single crops as activities, whole crop rotations can be defined as activities as well, although rotation requirements for single crops can also be imposed by restrictions, e. g. for the land available for one crop.

Capacities of farm resources can be modeled by imposing restrictions, for example, by limiting the amount of land available for an activity or a group of activities. Restrictions arise for example from rotation requirements, which for example limit the total amount of land devoted to one specific crop. A typical example for this case is total rapeseed acreage in typical Western European rotations, which is limited to one third of total crop acreage. Further, restrictions may arise from risk management. In this regard a limit in total acreage of one crop might be imposed as well due to high risk exposure (e. g., increasing harvest or seeding risk with rising share in total farm acreage). Crops produced under a quota system (e. g. sugar beets in the EU) can also easily be modeled by imposing a restriction on this crop's acreage based on the quota allowance.

Further, LP models can be used to analyze the effect of changes in crop output prices on crop portfolio composition. Changes in output prices for the different crops will lead *ceteris paribus* to a change in crop (activity) gross margins. The profit maximizing solution of a linear programming model will then adjust activity levels (i.e. crop acreage) resulting in a new crop portfolio reflecting price changes. This can be repeated for different sets of output price combinations to study the effects of price changes on crop portfolio composition.[64]

Linear Programming methods are capable of extensive modeling of multi-product cash crop farms with joint production. The characteristics of different crops can be embedded in the design of the different activities. Restrictions can be imposed to model the different capacities of farm resources and further to enforce crop rotations. Further, the effect of changes in crop output prices on crop portfolio composition can be analyzed. Thus, Linear Programming provides a suitable approach for modeling output price induced changes in crop rotations and crop portfolio composition. However, Linear Programming shows certain characteristics which limit the use in the context of the *agri benchmark* Cash Crop Network and thus in the context of this thesis.

4.3.2.3 Limitations of LP-models in context of *agri benchmark* research

Due to the advantages of Linear Programming in modeling multi-product cash crop farms a LP model was developed for this thesis to provide a methodological approach to analyze adjustments in crop portfolio composition in the presence of changing output price ratios. However, development of the LP model was suspended at early stages since factors limiting use in the context of this thesis became apparent.

[64] Focus of this thesis is directed on output price changes. The impact of changes in input prices can of course be modeled with this approach as well.

A general requirement for methods used within *agri benchmark* is applicability to the whole network. In order to apply an approach for analyzing crop portfolios and crop rotations in the whole network, it must be easy for all network partners to handle and be applicable across countries. Experiences with applying different research tools and methods in different countries and across different cultural backgrounds have been gained within *agri benchmark* over time. These experiences show that keeping collection and processing of data and information as simple as possible is a requirement for successful co-operation within the networks and across countries. Examination of LP models in this context shows that these requirements would result in only a small and simple LP model which would bear limitations in accuracy and explanatory power.

Setting up Linear Programming models for analyzing crop portfolios and crop rotations across countries is very complex. Particularities of different countries have to be incorporated into the design of the model which results in extended number of constraints and activities which can no longer be handled easily. Also, modeling of cash crop farms and their respective crop portfolios is already very complex. Consideration of all suitable crops and crop rotations for a farm results in complex and extensive LP settings. The number of constraints increases rapidly when forcing different crops and crop rotations into the LP solution. Further, different activities have to be defined per crop to reflect different yield levels, preceding crops, tillage systems and other factors. Complexity increases though when different yield levels have to be assumed for crops at different shares in the crop portfolio (i. e., higher yield levels at low shares vs. lower yields at increasing shares due to yield depression). This increases numbers of constraints which have to be included in the LP matrix. Also, modeling of heterogeneous field types within a farm increases complexity of an LP model. This appears in cases where some crops cannot be grown on certain areas (fields) of the farm (e. g., sugar beets are usually grown only on fields/soils with highest yield potential and which can be operated by large and extensive sugar beet equipment). Further, growing crops on different soil types may lead to different yield and input levels which further increase numbers of activities and constraints.

Further, crops which are not included into the existing crop portfolio, but which can be potentially included, have to be considered in the analysis and thus in the LP model to provide a broad coverage of potential adjustments in crop portfolio composition. This increases input required for data collection and further increases complexity of the LP model. Overall, increasing numbers of activities and constraints are difficult to handle when explaining and interpreting results of such models. Difficulty in tracing back adjustments in crop portfolio composition to specific activities and constraints increases under rising numbers of constraints and activities.

Further limitations come along with methodological and theoretical assumptions in Linear Programming. The key assumption of profit (utility) maximization (or cost minimization) in LP models can hardly be maintained in general.[65] Besides profit maximization further goals are pursued by agricultural producers. Farmers thus do accept less than optimum or maximum (monetary) profit when other goals can be achieved. Such goals are for example risk reduction and diversification as well as reduction in work load and management requirements. Thus, crop portfolio composition may not reflect an optimum profit maximizing choice of crops.

Further, activities, and thus crops, can be combined freely under given restrictions in LP models. Exchange of crops can be carried out "free of charge" and does not involve any adjustment or switching costs. This is hardly the case in reality. Choice of crops is more or less predetermined by the specific prevailing organization of the farm operation, causing persistence in current crop rotations and portfolios. Thus, crops will much more likely be chosen which will use the existing equipment instead of crops that would involve investment in new technology, etc., and thus would cause switching costs.[66] In order to re-organize the prevailing production systems, and with it crop portfolio composition, such a change must be profitable. Thus, the magnitude of changes in price ratios must be high and last for a certain period of time in order to create an incentive for re-organization of production systems and crop portfolios.

Analysis of changes in crop output price ratios thus needs to differ between minor changes that only cause few adjustments in crop portfolios due to forces causing persistence in more or less the same crop portfolio, and major changes which lead to a re-organization of production. The first type of analysis can easily be performed by LP models although the increase in accuracy of results is marginal compared to simple partial budgeting calculations.[67] This changes when analyzing major price changes, which lead to a change in production systems (technology) and factor endowment of the farm. In this case, the holistic approach of Linear Programming is able to cover all factors, interrelationships and aspects of change in crop portfolios and crop rotations. However, this would result in dynamic, multi-period LP models which again result in complex LP settings which would involve extensive data input. Thus, the critique regarding complex LP models mentioned before holds for this case as well.

The critique regarding use of LP-models in this context is also shared by ODENING and BOKELMANN (2000, p. 164). They state that adjustments in crop portfolio composition are

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[65] BRANDES et al. (1997, p. 76).

[66] ODENING and BOKELMANN (2000, p. 162 et seq.).

[67] ODENING and BOKELMANN (2000, p. 162 et seq.).

rather small due to factors that cause persistence in prevailing crop portfolios and thus LP models are not necessary for analysis. In case of complex adjustments to crop portfolios involving changes in overall farm organization and production systems, evaluation of these complex alternative crop portfolio settings can be better handled by an analysis based on investment calculation procedures. Different sets of alternative types of farm organization or production systems under different framework conditions can be assessed by comparing cash-flows and profitability in this way. This will have to include a whole farm approach, in which interdependencies and interrelations between enterprises are accounted for as well.

Overall, the use of Linear Programming is limited in the context of this thesis and within the *agri benchmark* network though certain aspects (definition of activities and constraints) provide an option for modeling farms and crop portfolio composition. “Pure” and complex LP models cannot be handled across countries and further would involve too many resources. The methodological approach for analysis of crop portfolio composition in this thesis and within *agri benchmark,* will thus have to incorporate suitable aspects of Linear Programming while at the same time ensuring applicability to the *agri benchmark* network.

4.4 Extension of the *agri benchmark* panel-approach

Findings about the methodological framework for the analysis of crop portfolio composition in the context of this analysis revealed that *agri benchmark* Cash Crop cost of production calculation methodology is not suited to explain crop portfolio composition and adjustments to it. However, data collected for compiling CoP figures provide a starting point for further analysis (Chapter 4.3.1). Furthermore, Linear Programming provides a powerful method for modeling crop portfolio composition though limitations were shown for the use of “pure” LP models in the context of this thesis and the *agri benchmark* Cash Crop Network (Chapter 4.3.2).

A suitable methodology for analyzing crop portfolio composition in the context of this thesis will thus have to incorporate the advantages of Linear Programming while overcoming the negative aspects of limited applicability and feasibility at the same time. This will be achieved by combining Linear Programming techniques and the *agri benchmark* panel approach, which was described in Chapter 3.2.2. Application of the panel approach is not limited and should be feasible since it has already been implemented within *agri benchmark* and knowledge and experience about the approach have been gained by the partners within the network over time.

The *agri benchmark* "panel-approach" is the main source for farm level data and information within *agri benchmark*. Farm level data are collected from a panel of four to six farmers, one or two advisors and one or two *agri benchmark* researchers based on a consensus building process. The result is a data set including the physical (resources), technical (yields, inputs...) and monetary (prices, costs…) framework of a consensus farm, based on the farm operations and personal experience of the participating farmers.

In order to analyze crop rotation choice and crop portfolio composition the *agri benchmark* panel approach is extended by two stages. The starting and essential phase of farm level data collection as described in Chapter 3.2.2 and as already implemented within *agri benchmark* is followed by a stage to identify factors which determine crop rotation choice and crop portfolio composition. The influence of changing crop output price ratios on crop portfolio composition is analyzed in a third stage by incorporating and applying Linear Programming techniques with the panel approach.

Before describing the extension of the *agri benchmark* panel approach in the context of this thesis (Sections 4.4.2 to 4.4.4), the panel approach is evaluated to provide a critical reflection (Section 4.4.1).

4.4.1 Evaluation of the panel-approach

Advantages of generating farm level data using the panel approach have been presented in Chapters 3.2.1 and 3.2.2. An extensive description of the panel approach can be found in HEMME (2000, pp. 19-24) and ZIMMER and DEBLITZ (2005). In this section, further advantages and disadvantages of the panel approach will be discussed.

4.4.1.1 Disadvantages of the panel approach

A major critique regarding the panel approach refers to the data sets of the typical farms, especially that these are not representative in a statistical sense. This disadvantage is accounted for by classifying the typical farms into the whole farm population in terms of size and economic performance. Further, randomness of the data set and respective results is another aspect that comes along with the panel approach. Data sets and according calculations are dependant on panel participants, i.e., their personal data and experience. If two different panels were to be set up to generate one and the same panel farm (same region and size etc.), the outcome would be probably mostly the same regarding the general structure of the farm but data sets would differ in some points. A solution for this constriction is to split the panel into two groups during the workshops (data generation phase). The panel has to consist of a minimum of six farmers then and a minimum of two researchers are necessary as well to coordinate the process within each group. After data sets for the farm are collected, both groups are brought together again and the two different data sets are merged and discussed to achieve one consensus data set for the panel farm.

Another problem of the panel approach refers to confidentiality of data, especially data related directly to the personal situation of the participating farmer. Personal experience of the author gained through several panel workshops during the last five years shows that confidentiality of information in regard to financial statements of the farm or the farm owner are very critical. Information on financial debt levels, loan structure and overall financing structure are hard to acquire. This problem can be solved by using additional data from statistics in order to establish a proper debt level and interest payments level for the farm. It is though, most important to build up confidence with the panel participants in order to generate as much data as possible. This can be achieved by proper preparation of the whole panel process, professional management and coordination and extensive feedback on the data and results.

Furthermore, the group of participants of a panel may impose “social control” on the behavior and statements of a single participant. This may bias the data set and other information since participants may tend to conform to statements from other participants or the group as a whole, depending on the attitude and personality of the respective persons. Social control within a panel might thus interfere progressive thinking or problem solving, especially when discussing future developments of the farm. The problem of social control can be reduced by a careful and adapted selection of panel participants, but care must be taken not to create a too uniform thinking. Usually, critical thinking is brought into the discussion by single persons. Thus, the moderator (i. e., usually the researcher) has to pay attention and interact in a way that (new) ideas are revealed and discussed as well as critically assessed in the panel.

Although the panel approach provides a resource-saving research method compared to other sources of farm level data and information, limited time resources, especially of panel participants, are a critical issue. The researcher always has to balance the trade-off between extensive, far-reaching discussions about farm data and structure as well as other explanatory factors with the limited time of panel participants. If participation in a panel workshop meeting takes too much time, especially if several workshops (more than one meeting) are necessary, farmers and advisors are more likely to refuse to participate. This is especially true for top level farmers, who are managers of large and very large commercial size farms. This issue can again be addressed by careful preparation of the panel meetings and professional management and coordination by the executing researcher.

4.4.1.2 Advantages of the panel approach

The panel approach bears many advantages in generating and analyzing farm level data and information (compare Chapter 3.2.1). In comparison to other methods, the panel approach delivers reliable data and information, which are very close to reality of the type of farm analyzed. This is ensured by the direct interaction and discussion between the panel participants who bring in data and experience from their personal farm operation. Feedback and plausibility checks of the final data and results by the participants ensure high data quality and reliability. The panel approach is a unique data source and data can be directly compared across regions and countries. No harmonization of data is needed in the case of international comparisons and thus, this aspect is a major advantage of this approach especially compared to individual farm data or statistics.

Further, the panel approach provides access to data which otherwise is not available from statistics. This refers to certain aspects of farm level data and information (like off-farm income, tax considerations, etc.) but also to complete farm level data regarding certain farm types or sizes which do not show up in statistics. This is, for example, the case with large and very large farms. In many countries data for this group of farms is either classified in a combined group for farms larger than a certain size (e. g., larger than 100 ha), where the disparity between this “threshold” size and the actual farm size (e. g., 100 ha vs. 2000 ha) is misleading or misrepresenting. Furthermore, in case large and very large farms are considered in a separate size class, data are often missing due to privacy and confidentiality resulting from a very small sample in that size group.

Another disadvantage of data from statistics is the time lag. Usually most recent farm level data in statistics is more than one, often more than two years old. Getting up to date data is a further advantage of the panel approach. Besides data based on the current farm financial or harvest year, certain data like prices and yields can also be predicted – based on current developments and influencing factors – for the near future. These can be, for example, planning prices and costs for the upcoming planting season. Thus, the panel approach provides an option for analyzing and assessing recent and future developments for a particular farm.

Besides the “standard” farm level data about the monetary, physical and technical framework of the farm, additional information and factors can be acquired by the panel approach. This refers to functional contexts, factors that influence farmer’s behavior and decision making and future farm developments and strategies. This aspect is of particular importance in the context of this thesis, since the effect of changes in the overall framework conditions (e. g., price changes) for the farm can be analyzed and addressed as well. Using the panel approach, factors that determine choice of crop rotation and crop portfolio composition can be identified and discussed. In particular these are the different technical interdependencies between crops that shape crop rotations. Further, these are factors regarding crop choice and level of associated risk as well as utilization of machinery capacity etc. (fixed factors) by the different crops and the overall characteristics of the different production systems of the different crops. In terms of the effect of changes in crop output prices the panel approach is able to encompass all relevant factors which determine crop choice and crop portfolio composition in the analysis.

The panel approach is further able to monitor changes in the overall framework conditions and the corresponding impacts for a farm. Since framework conditions may change quickly, a continuous monitoring process is necessary to provide up-to-date information about the effect of these changes. By repeating the panel meetings after certain periods of time (e. g., three years) or after major changes in the overall framework (e. g., changes in technology, markets, policy, etc.), the panel approach provides instant hands-on information and experience for the analysis of these changes.

4.4.2 Stage I: Farm physical, monetary and technical framework

The first stage of the extended panel approach reflects the procedure already used to collect farm level data for typical farms within a*gri benchmark* as described in Chapter 3.2.2. At this stage the data set including the physical (resources), technical (yields, inputs...) and monetary (prices, costs…) framework of a consensus farm is delineated, based on the farm operations and personal experience of the farmers participating in the panel workshop. The procedure of collecting data and information about the physical, monetary and technical framework of the consensus farm is already implemented in *agri benchmark* Cash Crop research and thus applicability to the network is provided by this approach.

The first stage of the extended panel approach can further be divided into several steps. The first step of the building process is to pre-define general features of the consensus farm, like farm size, type of farm, labor organization etc. This step is undertaken by the researcher and the farm advisor/consultant. Pre-definition of the consensus farm is based on expert knowledge of the advisor and data from farm comparisons and other statistics.[68] Pre-defined data and information are entered in a questionnaire which serves as a guideline for the data collection and discussion process. The filled-in questionnaire with the pre-defined data set of the consensus farm is then sent to the different participants of the panel workshop itself. Together with further information which explains purpose and

[68] Compare HEMME (2000, p. 21).

procedure of the whole process, the filled-in questionnaire serves to make workshop participants familiar with the whole procedure and the consensus farm that will be developed and discussed. For the general procedure, pre-definition of the farm is not a prerequisite and data collection can be started directly with the whole group of producers. Though pre-definition is not a necessary step, experience from past workshops shows that a pre-definition of the consensus farms helps to improve data quality, save time and create a better feeling for the intention and direction of research for all participants.

The pre-defined data from the questionnaire represents the foundation for the workshop of the producer group itself. It serves as a starting point in the discussion and is used as a guideline to collect all necessary data to represent the defined farm type. The workshop meeting can be considered as the second step in the first stage of the panel approach. During the workshop, farm numbers and data are discussed, adjusted and further added to generate a complete data set for the consensus farm. In particular, data and numbers are collected about natural framework conditions of the farm, general and overhead figures, crop rotations and crop portfolio composition, labor organization, machinery, equipment and buildings, input and output prices and quantities and liabilities. These data and information are delineated and discussed based on personal data and experience from the participants and further data from available statistics, surveys or other studies. The final data set for the consensus farm is then developed from the consensus of the whole group during discussion.

This data set is then used to compute whole farm financial indicators like profit and loss account and balance sheet. Further, this data set can be used to calculate cost of production figures as done in *agri benchmark* so far.[69]

During the workshop the researcher has to take over the role of a moderator for the discussion and the whole procedure. Special attention needs to be directed to manage the limited time for the workshop.

4.4.3 Stage II: Determinants of crop portfolio composition

Following the first stage of the extended panel approach, the second stage consists of identification and discussion of factors which determine crop rotation choice and crop portfolio composition of the consensus farm. This stage is also based on data and experiences about the consensus farm from the first stage.

[69] See *agri benchmark* Cash Crop Reports: PLESSMANN et al. (2005), ZIMMER (2006, 2007).

As described in Chapter 4.1, cash crop production in multi-product farms is characterized by joint production where an interrelated efficiency, competitiveness and profitability among crops prevail. Interdependencies between crops do thus have a major influence on crop rotation choice and crop portfolio composition. Thus, discussion in the second stage of the extended panel approach focuses on identification and influence of different interdependencies between crops and overall factors that further determine crop rotation choice and crop portfolio composition.

Determination of crop rotations and crop portfolio composition for the consensus farm is closely related to the respective machinery and equipment complement. Thus, discussion and data collection for these issues go together since choice of crops is dependent on the different machinery and equipment capacities. Vice versa, the necessary machinery complement can be derived from the crops grown. The definition of the crop portfolio for the consensus farm begins with determination of the corresponding crop rotations. A general framework for the rotations is delineated based on the interdependencies and other influencing factors between the different crops. Further, in cases where crop rotations are very specific and cannot be stated in a general way, a detailed setting of the crop sequence can already be determined. A general framework for a crop rotation may look like "cereals – pulses – cereals – oilseeds".

Following the determination of (possible) crop rotations, the exact crop sequence and thus composition of the crop portfolio is "assembled". This step usually starts with determining acreage or share of these crops, which is limited by one or only few factors which are easy to identify. An example is acreage of sugar beets for farms in the EU, which is limited by a production quota. Since sugar beets show a competitive gross margin against other crops, its acreage is usually extended to the maximum quota allowance which thus serves as a single limiting factor. Further, oilseed production is very often limited due to increasing disease pressure when extending its share in crop portfolios above a certain threshold. Once acreage of these crops has been determined, the remaining acreage is allocated to crops which in this sense can be characterized as "fill up" crops. These are typically cereals, which benefit from joint products delivered in a complementary sense from the other crops in the rotation/portfolio. Share of the different cereals in the portfolio usually depends on respective gross margin, where wheat commonly shows the highest gross margins and thus holds high shares in crop portfolios.

By assembling the crop portfolio, different factors that limit or benefit the share of the different crops in a portfolio are indentified and discussed by the producer group. Further, potential developments and reactions by the farmers that would bypass the limiting or enhance the benefiting factors are discussed. This helps to assess to what extent the limiting factors are binding in determining crop portfolio composition. It has to be noted that some factors can be limiting for one crop but beneficial for another. Furthermore, limiting and beneficial characteristics of factors for one and the same crop may differ in different situations depending on the share of this crop in the portfolio. In a portfolio showing a high share of cereals for example, adding more cereal acreage would face more limitations (e. g. in combine capacity) than in a situation with low share of cereals.

Limiting and benefiting factors as a whole are determinants with major influence on crop rotation choice and crop portfolio composition. Knowledge of these factors is a necessary condition to assess and analyze as well current crop portfolio composition as potential adjustments to it in the presence of changes in crop output prices. Discussion and identification of factors determining crop rotation choice and crop portfolio composition is thus accompanied by a discussion about the influence of changing output price ratios on crop rotation choice and crop portfolio composition. This discussion especially aims to reveal stability of the prevailing production systems and crop portfolios under changing framework conditions.

4.4.4 Stage III: Influence of output prices on crop portfolio composition

Detailed adjustments in crop rotation choice and crop portfolio composition under changing output price ratios are calculated by combining Linear Programming techniques and the panel approach in the third stage of the extended panel approach.

The third stage of the extended panel approach consists of multiple steps which are partly performed by the researcher and partly performed together with the participants of the producer panel. The objective of the third stage of the extended panel approach is to identify changes in crop portfolio composition under different scenarios of changing output prices. The following steps are conducted under the third stage of the extended panel approach:

1) Definition of cropping activities and crop rotations

In the first step, different cropping activities are defined by the producer panel and the researcher based on production systems and characteristics of the different crops grown by the consensus farm. The different cropping activities are defined by different crop characteristics such as preceding crop, yield level, tillage system and gross margin. An example for one of the cropping activities for wheat is wheat following rapeseed, with a yield level of 8.8 tonnes per hectare under minimum tillage and a gross margin of e. g., 420 EUR per hectare. Values for yield levels and prices as well as variable costs to calculate gross margins are taken from the data set derived from the first stage of the extended panel approach. Definition of cropping activities is the same as would be needed for a Linear Programming model (compare Chapter 4.3.2.1).

After generating all necessary cropping activities, different feasible crop rotations for the consensus farm are defined based on the different cropping activities already defined. Crop rotations are defined by the sequence of the respective cropping activities, for example rapeseed, wheat following rapeseed, wheat following wheat.

2) Calculation of output price ratios based on available time series data

Data for crop output prices are necessary in order to analyze the impact of different crop output prices on crop portfolio composition. Current and average output prices for the different crops grown by the consensus farm are derived from the producer panel. Historical data to analyze price development over time is taken from available statistics. Development of price ratios between prices for different crops and correlation of prices are of particular interest to determine price development scenarios for analysis.

3) Definition of price development scenarios

Based on steps one and two of the third stage of the extended panel approach, different scenarios of crop output price developments are defined by the researcher. These scenarios are based on the existing price ratios between crops under the current setting of the consensus farm as defined in the first stage of the panel farm approach. Price development scenarios may consist of price steps with different increments, decrements and constant prices for the different crops analyzed.

4) Calculation of gross margins for cropping activities and crop rotations for different crop output prices

After defining cropping activities, crop rotations and respective scenarios of output price development, gross margins for the different cropping activities and crop rotations are calculated for the different scenarios. Calculations result in changing or constant gross margins based on prices of the five price steps of the different scenarios. Gross margins will then serve as an indicator which cropping activities and crop rotations will be chosen for the consensus farm to form the crop portfolio under the different scenarios of output price changes.

5) Choice of cropping activities and crop rotations under total gross margin maximization and imposed constraints by the producer panel

The final step of the third stage of the extended panel approach is to compile crop portfolios for the different scenarios of crop output price development. This step is performed by the producer panel and the researcher. Crop portfolios are constructed by choosing from crop rotations and their respective gross margins as defined in steps one and four of the third stage of the extended panel approach. Crop rotations are chosen based on maximization of total portfolio gross margin while at the same time considering imposed constraints for the respective crops or crop rotations. Constraints which limit acreage of a specific crop have been identified in the second stage of the extended panel approach.

Construction of crop portfolios starts with choosing the crop rotation with highest gross margin. Acreage of this rotation is extended until constraints limit expansion and thus crop rotation with second highest gross margin is chosen until constraints limit expansion. This step is repeated until the portfolio is completed and total portfolio gross margin is maximized. Composition of the crop portfolio is characterized by the share of the different crops, which is derived by the share of respective crops in the chosen crop rotations. In technical terms, this step of the third stage of the extended panel approach replaces the Simplex-algorithm of a Linear Programming model to find a solution with maximum gross margin by not violating any of the imposed constraints.

Using the producer panel to identify the appropriate, gross margin maximizing crop portfolio which does not violate any of the imposed constraints bears advantages and disadvantages. A major disadvantage is the fact that the solution (crop portfolio composition) derived from the producer panel is not generated and thus proven by a mathematical model. In the context of difficulties that arise with the set up of such a model (see Section 4.3.2.3) the explanatory power of such a model has to be questioned. In fact, using the producer panel to generate a solution overcomes the problems of setting up Linear Programming models in this context and ensures to reflect constraints and other factors influencing crop portfolio composition in reality. This relates in particular to the extended numbers of constraints that exist in reality and influence choice of crops, crop rotations, input intensity and tillage systems at a very detailed level. Thus, by using the producer panel to determine crop portfolios under changing crop output prices, the process of practical decision making of producers is considered and reflected as close as in reality of the farm operation.

After deriving composition of crop portfolios for the different scenarios from the producer panel, crop portfolio composition and changes in total portfolio gross margin can be compared against the initial situation as set up in the first stage of the extended panel approach. Changes in portfolio composition and total gross margin can then be used as an indicator to assess the influence of changing crop output prices on crop portfolio composition.

4.4.5 Further adaptations to the panel-approach

In addition to the extension of the panel approach, advancements referring to type of farm analyzed, data source for the producer panel and organization of the whole panel process are made.

4.4.5.1 Typical vs. leading edge farms

Within the *agri benchmark* Cash Crop Network typical farms are compared which represent cash crop production in a certain region. Typical farms are defined based on the most prevailing farm type in a region with regard to farm size and production systems. As a standard, one moderate and one large size farm are defined in order to reflect a large number of farms and a major share in production. Both farms represent an average level of management competence, which is defined by an average performance in terms of profit level. It is further intended to define a third farm with top management competence level in order to reflect future potential of the region analyzed.[70]

The analysis in this thesis is not based on typical farms and aims in the direction of farms with top management competence level. Therefore, the concept of leading edge farms is introduced and used for the analysis within this thesis. No exact definition for leading edge farms exists in an economic sense. The concept used here is more descriptive and refers to top management competence level, cutting edge technology and a very large farm size for the region analyzed. Leading edge or cutting edge farms (farmers) set the tone in terms of farm size, management competence, production systems and technology within a region or even across regions. They can be characterized as early adapters and pioneers and they have a very high level of management competence which they acquired by high level education and quite often do have experience from outside the agricultural sector. They take an active part in regional and national associations and lobby groups and are often involved in value-adding agribusiness or business outside agriculture. The characteristics of these farms are not reflected in statistics. Either because they are too big and the sample size becomes too small (data confidentiality) or they consist of a structure of different companies with no general single company reflecting the whole operation.

Leading edge farms are further assumed to be efficient farms in the sense that no other farm can economically produce more output given their resources. Though efficiency is not measured and proven in the context of the panel approach in a scientific sense due to lack of resources and data. The efficiency criterion is considered during data collection in a way that the panel participants discuss and adjust input and output levels to be efficient based on their personal recordings and regional farm comparisons. Further, leading edge farms do form a very small group and thus represent only a small part in total production of the overall farming community of a region or a country. Altogether, leading edge farms can not exactly be defined and their efficiency not be proven and further they only represent a very special type and small number of farms. However, these farms are of

[70] See ZIMMER and DEBLITZ (2005, p. 2).

particular interest for analyzing crop portfolio composition and effects of crop output price changes.

This refers particularly to the early adapting/pioneer behavior of these farms. If framework conditions do change for these farms, leading edge farmers will be among the first to adapt their farm operation to the new framework conditions. This step is undertaken very often before the actual change in framework conditions takes place. In this sense, leading edge farmers can be seen as an indicator and pathfinder for adjustment strategies in the context of changing framework conditions. Besides the pioneer behavior, the financial situation of leading edge farms very often forces them to adjust quickly in order not to lose any overall potential profit. Leading edge farms are often characterized by comparably high debt levels since these farms very often performed large steps in farm growth or investments in new, state of the art and capital intense technology.

Leading edge farmers do thus represent the potential of a production location or region in terms of production output, type, size and organization of the farm operation as well as production systems and technology. Further, leading edge farms embody the underlying forces of structural change. Therefore, leading edge farms are a good indicator for future developments in farming and are further very suitable for analyzing determinants of crop portfolio composition and the effect of changes on it. This is the value and advantage of the leading edge farm concept which is therefore followed for analysis within this thesis. A general remark has further to be made on the results and conclusions derived from the leading edge farm concept used in this thesis. Since leading edge farms represent a very special and small group of farms, care has to be taken when drawing conclusion for the overall group of farms.

Along with the concept of leading edge farms, some aspects of terminology used within this thesis as well as in the *agri benchmark* Cash Crop Network have to be clarified. Since leading edge farms can not be characterized as "typical", they cannot be named "typical" farms. Therefore, the leading edge farms that are analyzed in this thesis are called "representative" farms, following the representative farm concept of AFPC (compare Chapter 3.2.1). This denomination requires further definition of what these farms do represent; in this case these are leading edge farms. Furthermore, these farms are consensus farms since they are delineated by the consensus of the participants of the panel.

4.4.5.2 Farm consulting groups

Applying the panel approach in the last years, experience has been gained in working with farm consulting groups (Arbeitskreise, Beratungsringe or Marketing Clubs) as a source for setting up producer groups and generating representative farm data. The cooperation with these kinds of groups bears many advantages and simplifies the whole process of collecting farm level data and information. Usually, these groups are coordinated and consulted by one or two advisors or consultants, who serve as the respective contact persons for the researcher. The advisor/consultant is further able to choose those farmers among the group or club members, which are suitable for joining the producer group meetings for setting up the consensus farm(s).

A big advantage of working with consulting groups is the existence of extensive, detailed and proven farm comparison data of the respective group members. This serves as an excellent foundation for setting up consensus farms, since usually all necessary data and information are already available from the comparison data. This ensures a high quality of data for the consensus farm. Further, since detailed data and information about farm inputs and outputs are available for the whole group, the efficiency criterion for leading edge farm can be considered and assessed when discussing these data for the consensus farm.

More advantages arise for this kind of data source due to the fact that farmers and advisors already know each other and usually confidence exists among the whole group. This is a good starting position for sharing confidential and personal data, information and experience during the producer panel workshops. Since farmers already know each other, there is much better interaction when discussing farm numbers and new ideas. Further, these farmers show high motivation and interest in participating and discussing in a producer panel workshop. Also, there is less "social control" as mentioned in Section 4.4.1 due to the fact that farmers usually have known each other for quite a long time.

4.4.5.3 Organization and feedback

The procedure of the panel approach is concluded by extensive feedback being exchanged between all participants including advisor(s) and researcher(s). After the workshop meeting, the researcher provides feedback by sending the dataset for the delineated consensus farm to all participants. Furthermore, major facts and findings in terms of the different discussions are summarized and first calculation results are presented as well. These follow-up activities are necessary to generate confidence and access for further co-operation/workshop meetings with producers and advisors in the future. This is of particular importance if it is intended to monitor changes in framework conditions for the respective representative farms using the panel approach over time.

4.5 Summary

The theoretical outline presented in this chapter shows that crop portfolio composition and crop rotation choice is a complex issue influenced by many different factors in different ways. Different enterprise relationships exist in multi-product farms leading to an interrelated efficiency, profitability and competitiveness of enterprises (crops) which is referred to as joint production or jointness. Jointness in production is mainly caused by technical interdependence between crops, but also by allocable fixed inputs which are used in the different enterprises. Interdependencies are expressed by benefits and costs provided and consumed by different crops in crop rotations and portfolios. Further, interdependencies have a major influence on crop rotation sequence and crop portfolio composition and thus have to be considered in further analysis. Crop portfolio composition in general is characterized by profit (utility) maximization under input constraints with multiple inputs. Further factors influencing crop portfolio composition are risk diversification and agricultural policy. Overall, these factors lead to stability of crop rotations and thus crop portfolio composition over certain ranges of price ratios.

Methodology applied for analyzing crop portfolio composition and rotation choice in this thesis is based on the panel-approach applied within *agri benchmark* so far. Cost of production as analyzed within *agri benchmark* Cash Crop are not suited as an indicator since this is an ex-post concept and joint production is not accounted for in a sufficient way. Linear Programming bears limitations in the context of *agri benchmark* research and thus for this thesis since applicability to the network is limited. This is due to high complexity of LP matrices in modeling potential cropping activities and crop rotations and due to limited capability of modeling decision making and crop rotation choice close to reality.

Therefore, the panel-approach as already implemented within *agri benchmark* is developed and extended to analyze crop portfolio composition and rotation choice. At Stage one of the extended panel approach the farm physical, technical and monetary framework is delineated from the consensus of the producer group. Determinants of crop rotation choice and crop portfolio composition are identified and discussed in Stage two. Finally, the influence of changes in crop output prices on crop rotation choice and crop portfolio composition is analyzed in Stage three of the extended panel-approach. Different price development scenarios are defined and gross margins for cropping activities and crop rotations are calculated for different price development steps. The producer panel is then used to choose crop rotations and compile crop portfolios at the different price steps. Differences in shares of crops in crop portfolios at different price steps reflect the influence of changing output prices on crop portfolio composition. Finally, farms analyzed in this thesis will be based on the leading edge farm concept opposed to typical farms analyzed within *agri benchmark* so far.

5 Crop portfolio composition on selected locations in Canada and Germany

In this chapter representative cash crop farms in Canada and Germany derived from the extended panel approach are presented and respective crop portfolios and crop rotations are described and discussed. Results presented in this chapter are based on stage one and two of the extended panel approach as described in Chapter 4.4.

Within each Canada and Germany, two regions are selected. For each region, one leading edge farm is set up based on the extended panel approach to analyze crop rotation choice and crop portfolio composition. Based on the general framework conditions for cash crop production in both countries described in Chapter 2, leading edge cash crop farms are selected for analysis and described by their location and resource endowment in Chapter 5.1.

Although mostly the same crops are produced, production systems differ markedly between and also partly within both countries. The same holds for crop rotations and composition of crop portfolios since both production systems and crop rotations are interdependent. Production systems prevailing in Western Canada and Germany as well as for the selected representative farms are therefore described in Chapter 5.2.

In Chapter 5.3, the different crop rotations and crop portfolios for the selected representative farms are described and discussed providing insight into factors that determine crop portfolio composition and rotation choice for the different locations. Further, influence of changing output prices on crop portfolio composition and rotation choice is discussed. Composition of crop portfolios and determinants of crop rotation choice are derived from Stage two of the extended panel approach conducted for each representative farm and location.

5.1 Description of representative farms

This analysis is based on different representative farms which have been set up for this thesis. Each farm represents a particular region in Canada and Germany. For Canada, regions selected are Alberta and Saskatchewan. North Rhine-Westphalia and Saxony-Anhalt are the respective regions for Germany. Since each region is represented by one leading edge cash crop farm, the analysis and comparison of determinants of crop rotation choice and crop portfolio composition is based on a total of four consensus farms. Regions are selected in terms of relevance in cash crop production, not focusing on a particular crop but cash crop production in general. Leading edge farms are selected according to the prevailing structure and size of farms within respective regions.

When selected representative farms are compared in monetary units, the US-Dollar is chosen as a common currency unit. Unless otherwise noted, the exchange rates used in the calculation are based on the average exchange rates of 2006 for CAD/USD and EUR/USD respectively. These rates are 1.135 for the Canadian Dollar to US-Dollar and 0.797 for the Euro to US-Dollar. Further, farm level data for representative farms analyzed has been collected in 2007 and is thus based on 2006 values for inputs, outputs and prices.

5.1.1 Classification of representative farms

The four representative cash crop farms selected for analysis of determinants of crop rotations and crop portfolio composition are CA1800AB, CA4000SK, DE300EW and DE1300SA (Table 5.1).[1] All farms are highly specialized cash crop farms with no other enterprises contributing to total farm income.

Table 5.1: Size and location of selected representative farms in Canada and Germany

Farm	CA1800AB	CA4000SK	DE300EW	DE1300SA
Country	Canada	Canada	Germany	Germany
Province/Bundesland	Alberta	Saskatchewan	North Rhine-Westphalia	Saxony-Anhalt
Farm size in ha	1,800	4,000	300	1,300
Gross revenue in local currency (CAD, EUR)	$1,005,000	$1,975,000	€ 441,000	€ 1,809,000
Gross revenue in USD	$886,000	$1,741,000	$554,000	$2,270,000

Exchange rates: 1 USD = 1.135 CAD and 0.797 EUR.
Source: Own illustration based on panel-approach.

CA1800AB is a cash crop farm with 1800 hectares of farmland used for crop production in the Canadian province of Alberta. CA4000SK is the other Canadian farm with 4000 hectares of crop land located in the province of Saskatchewan. DE300EW is the smallest farm in this comparison with 300 hectares of crop land and is located in the *Bundesland* of North Rhine-Westphalia in Western Germany. DE1300SA is the second German cash crop farm with 1300 hectares of crop land and is located in the *Bundesland* of Saxony-Anhalt in Eastern Germany.

[1] For explanation of farm denomination see chapter 3.1.1.

The two Canadian farms are larger than the German farms in terms of area farmed. This changes though when measuring farm size by gross revenue of the farms. DE300EW is still the smallest farm then with 554,000 USD gross revenues, followed by CA1800AB with 886,000 USD, CA4000SK with 1,741,000 USD and DE1300SA with 2,270,000 USD as the largest farm. The difference in ranking between farmed area and gross revenues is due to the difference in production systems, especially yield levels between the two countries (compare Chapter 2.4) and the amount of government payments, which make up a substantial amount of gross revenue for the two German farms.

All four representative farms are leading edge farms with regard to farm size compared to other farms in their region. The two Canadian farms belong to the biggest farm size class with more than 1,420 hectares (Table 5.2). This size class is made up of 3,592 farms (8.1 %) of a total of 44,329 farms in Saskatchewan and of 2,673 farms (5.4 %) of a total of 49,431 farms in Alberta. In terms of gross revenues, these two farms belong to the second highest farm size class with gross revenues between one and two million $CAN. CA1800AB is located at the lower end of this size class while CA4000SK is found at the upper end.

It has to be noted that figures in Table 5.2 include not only cash crop farms but all farm types. Thus classification of the two Canadian representative farms by gross revenues has to consider livestock and horticulture farms. These farm types are likely to generate high gross revenues from a lower farmed acreage and are thus found in the size classes of more than one million $CAN in gross revenue.

Table 5.2: Distribution of farms by farm size class (in ha) and gross farm receipts (in CAD) for Canada, Saskatchewan and Alberta in 2006

Region	2006								
	Total number of farms	Farm size class by farmed acreage in ha							
		0 - 100	100 - 300	300 - 450	450 - 650	650 - 900	900 - 1,160	1,160- 1,420	1,420 and over
Canada	229,373	112,117	60,338	16,128	13,177	10,611	5,820	3,534	7,648
Saskatchewan	44,329	7,948	11,908	5,448	5,589	5,103	2,946	1,795	3,592
Alberta	49,431	17,696	14,574	4,807	3,924	3,012	1,681	1,064	2,673
		Farm size class by gross farm receipts in $CAN							
		$0 - $24,999	$25,000 - $50,000	$50,000 - $100,000	$100,000 - $250,000	$250,000 - $500,000	$500,000 - $1,000,000	$1,000,000 - $2,000,000	$2,000,000 and over
Canada	229,373	88,392	30,608	31,422	39,971	22,837	10,241	3,691	2,211
Saskatchewan	44,329	12,194	6,737	8,376	10,674	4,466	1,406	328	148
Alberta	49,431	18,511	7,170	7,448	8,805	4,333	1,871	688	605

Source: Statistics Canada, Census of Agriculture 2006.

The two representative farms from Germany can be classified by farmed acreage only (Table 5.3). DE300EW belongs to the size class of 200 to 500 hectares of farmed area which is made up of 226 farms (4.4 %) of a total of 51,161 farms in North Rhine-Westphalia. This size class does not contain the largest farms in this region, though the larger size classes only consist of 19 farms. DE1300SA is found in the largest size class of more than 1,000 hectares in farm area, which is made up of 279 farms (5.7 %) of a total of 4,887 farms in Saxony-Anhalt. Farms in size class 200 to 500 hectares farm a total of 61,695 hectares in North Rhine-Westphalia, which is 4.1 % of 1,511,861 hectares of agricultural area in this region. In Saxony-Anhalt, farms with more than 1,000 hectare in farm size farm a total of 498,794 hectares, which is 42.5 % of 1,174,257 hectares of agricultural area in this region.

Table 5.3 also reveals the structural differences between farms in Eastern and Western Germany. North Rhine-Westphalia has more but smaller farms than Saxony-Anhalt while the majority of total agricultural area (87 %) in Saxony-Anhalt is farmed by farms larger than 200 hectares opposed to only 5.1 % in North Rhine-Westphalia.

Table 5.3: Distribution of farms and agricultural area by farm size class (in ha) in Germany, North Rhine-Westphalia and Saxony-Anhalt in 2005

Region	Item	2005						
		Total	Farm size class in ha					
			0-50	50 - 100	100 - 200	200 - 500	500 - 1,000	1,000 and over
Germany	Number of farms	396,581	311,878	54,406	20,708	6,224	1,816	1,549
North Rhine-Westphalia		51,161	40,870	8,098	1,948	226	14	5
Saxony-Anhalt		4,887	2,343	465	604	826	370	279
Germany	Agricultural area in ha	17,023,959	4,658,354	3,803,403	2,766,765	1,830,383	1,282,774	2,682,281
North Rhine-Westphalia		1,511,861	627,138	557,498	249,819	61,695	8,551	7,161
Saxony-Anhalt		1,174,257	29,409	33,702	89,345	263,756	259,250	498,794

Source: Statistisches Bundesamt, Fachserie 3, Reihe 2, various years.

Classification by economic performance of the four representative farms is difficult since regionally differentiated statistical data are hardly available for very large and specialized cash crop farms to allow accurate classification. Available statistical data are highly aggregated and mostly provide only average values for smaller farms not separated by farm type. Operating profit margins[2] for the two Canadian representative farms are above the 50 % level for all grain and oilseed farms in Canada as well as for farms in Canada

[2] Operating profit margin is defined by operating income divided by farm returns. Operating income is calculated as total farm returns less operating expenses and depreciation.

with more than $500,000 gross farm receipts.[3] Classification by economic performance of the Canadian representative farms can only proof that these farms are above average, though precise classification is not possible due to lack of data differentiated by location, farm type and farm size. Classification results have thus to be interpreted carefully. Classification of the two German farms reveals similar problems though it can be stated that both farms are found in the upper third of operating profit margins for large but comparably small cash crop farms of the Farm Accountancy Data Network (FADN) in Germany.[4]

Classification of the four representative farms reveals that all farms can be considered as leading edge farms in terms of their farm size in comparison to other farms in their respective regions. Classification by economic performance is difficult and has to be interpreted carefully; operating profit margin of the Canadian representative farms is above average and for the German representative farms it is in the upper third. It has to be further noted that with regard to representativeness, all four farms only do represent a minority (less than 9 %) of farms of the respective farming community in their region and province or *Bundesland*.

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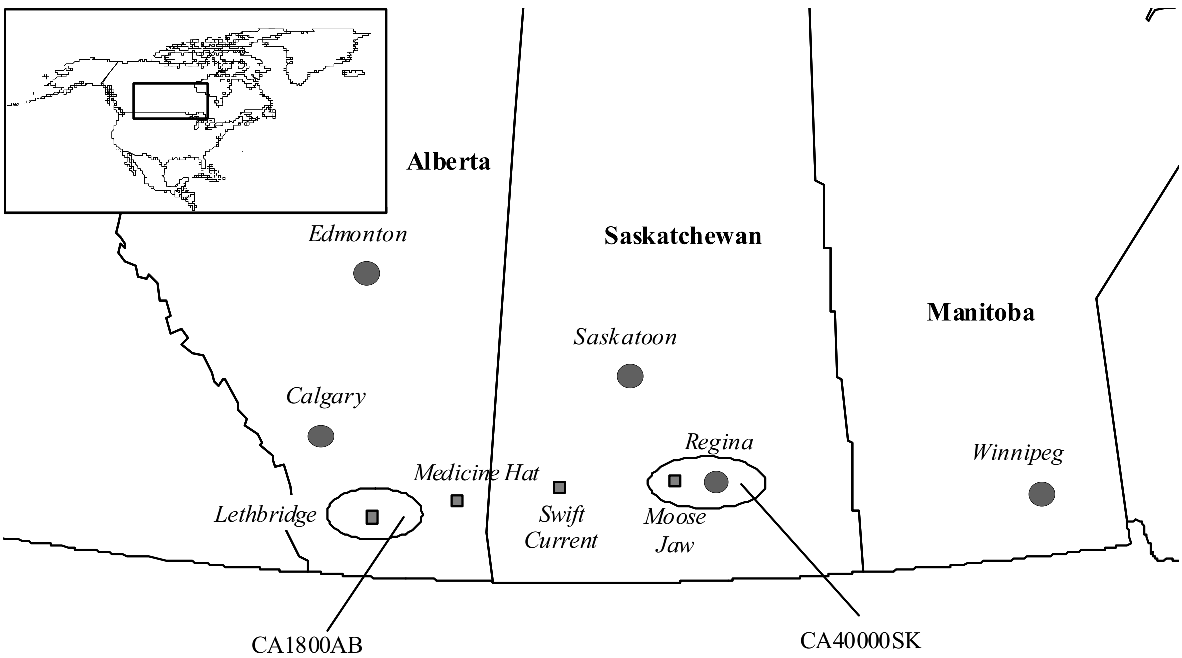
3 CANSIM, farm financial ratios.

4 BMELV (2007b).

5.1.2 Location and natural location factors of representative farms

Figure 5.1 shows the location of the representative farms CA1800AB and CA4000SK in Alberta and Saskatchewan respectively. Detailed maps for both locations can be found in Figure A20 and Figure A21 in the Appendix.

Figure 5.1: Location of representative farms in Alberta and Saskatchewan



Source: Map compiled by FAL-Farm Economics.

CA1800AB is located in Southern Alberta (AB) and represents the region around the city of Lethbridge. This region is further defined as census division "2" and is part of the Dark Brown Soil Zone in Alberta. The other Canadian representative farm, CA4000SK, is located in Central Saskatchewan (SK) and represents the region around the cities of Moose Jaw and Regina. This region is further defined as Census Agricultural Region "2B" and is part of the Dark Brown Soil Zone of Saskatchewan.

Location of the representative farms in Germany is illustrated in Figure 5.2. DE300EW is located in the region of East Westphalia-Lippe (EW) which forms the eastern part of North Rhine-Westphalia in Western Germany. DE1300SA is located in Central Saxony-Anhalt (SA) in Eastern Germany. This farm represents the region around the city of Bernburg.

Figure 5.2: Location of representative farms in Germany

Source: Map compiled by FAL-Farm Economics.

An overview of natural location factors of the four different representative farms is given in Table 5.4. The different climates between locations in Canada and Germany can easily be identified. Climate at Canadian locations with 5.5° C for CA1800AB and 4.0° C for CA4000SK is colder than for German locations with 8.5° C for DE300EW and 9.2° C for DE1300SA. A similar situation holds for length of growing season which is much shorter for Canadian locations than for German locations. Precipitation levels range from 360 mm per year at the location of CA4000SK to 850 mm per year for the DE300EW farm. Due to continental climate in Saxony-Anhalt, annual rainfall for DE1300SA is lower than for the West German location and closer to the amount of Canadian locations. Relative soil quality is better for the locations in Saskatchewan and Saxony-Anhalt resulting in higher yield potential, though soil quality is not a limiting factor for yield levels at all locations. A major difference between all four farms can be observed for average field size. Field structure is largest for the farm in Saskatchewan where multiple quarters (64 ha each) are combined to form larger blocks to operate very large equipment. The smallest structure is found in Eastern Westphalia since this region is densely populated and operation of larger machinery and equipment is limited.

Table 5.4: Location and natural location factors of representative farms

Farm	CA1800AB	CA4000SK	DE300EW	DE1300SA
Location	Southern Alberta, Lethbridge region, CD 2	Central Saskatchewan, Moose Jaw region, CAR 2B	Eastern Westphalia-Lippe	Central Saxony-Anhalt, Bernburg region
Average annual temperature	5.5 °C	4.0 °C	8.5 °C	9.2 °C
Average annual precipitation	410 mm	360 mm	850 mm	470 mm
Growing period	April - October	April - October	March - November	March - November
Elevation above sea level	950 m	580 m	120 m	90 m
Prevailing soil type	Sandy loam, Dark Brown Soil Zone	Regina heavy clay, Dark Brown Soil Zone	Sandy loam	Chernozem
Relative soil quality	Good	Very good	Good	Very good
Average field size	64 ha	240 - 480 ha	8 ha	30 ha

Source: Own illustration based on panel-approach.

5.1.3 Farm resources

The four different representative farms have different resources that they use in their farm operation. Table 5.5 shows owned and rented land of the representative farms in Canada and Germany. All four farms have a substantial share of rented land with CA1800AB having the lowest share (33 %) and DE300EW having the highest share (73 %).

Table 5.5: Land resources of representative farms

Farm		CA1800AB	CA4000SK	DE300EW	DE1300SA
Farm land					
Owned	ha	1,200	2,000	80	520
Rented	ha	600	2,000	220	780
Total arable land	ha	1,800	4,000	300	1,300

Source: Own illustration based on panel-approach.

Table 5.6 shows the different labor input with total labor input ranging from 2,500 hours per year for DE300EW to 10,000 hours per year for DE1300SA. It can be observed that total labor input is not related to farm size in hectares, but to the different production systems prevailing on the four different farms. Labor input in hours per hectare ranges from 1.88 for CA4000SK to 8.30 for DE300EW since low input production systems are prevailing for Canadian farms compared to high input systems for German representative farms.

Table 5.6: Labor resources of representative farms

Farm	CA1800AB		CA4000SK		DE300EW		DE1300SA	
	Number	Hours per year	Number	Hours per year	Number	Hours per year	Number	Hours per year
Hired labor								
Full-time	1	2,250	2	3,200			3	6,300
Seasonal	1	500	2	600	1	500	2	1,600
Family labor								
Farm operator	1	2,500	1	2,600	1	2,000	1	2,100
Other family	1	500	2	1,200				
Total full time	2	4,750	3	5,800	1	2,000	4	8,400
Total part-time	2	1,000	4	1,800	1	500	2	1,600
Total labor input		5,750		7,600		2,500		10,000
Total labor input per ha	3.17		1.88		8.3		7.69	

Source: Own illustration based on panel-approach.

Capital endowment of the four farms is illustrated in Table 5.7. Land values for the German farms are generally higher than for the Canadian farms, though land values differ within both countries as well. It has to be noted that land values are not only influenced by the agricultural sector but also from sectors outside agriculture. This is especially the case for DE300EW and CA1800AB, since locations are either dominated by urban residence and industry or the booming oil sector in Alberta causes high demand for land. Building assets are low for both Canadian farms and very high (1,757 USD/ha in 2006) for DE300EW, which is due to the fact that this farm owns and maintains very old historic buildings with some being built more than 200 years ago. Operating assets, which mainly consist of machinery assets, are lower for CA4000SK since a substantial share of farm machinery and equipment is leased.

Liability structure is different between all four representative farms. CA1800AB (656 USD/ha) and DE1300SA (697 USD/ha) have highest liabilities per hectare in 2006 since farm growth in the past was accompanied by buying farm land. This also true for CA4000SK but financing of equipment is managed by lease arrangements which reduce short and medium term liabilities. Lowest liabilities per hectare are found in DE300EW (134 USD/ha in 2006) since farm growth in the past was achieved by renting farm land (compare Table 5.5).

Table 5.7: Capital resources of representative farms

Farm	CA1800AB		CA4000SK		DE300EW		DE1300SA	
	USD	USD/ha	USD	USD/ha	USD	USD/ha	USD	USD/ha
Farm assets								
Owned land	5,288,207	2,906	3,745,814	927	3,011,179	10,037	12,593	3,864
Buildings	91,662	50	283,800	70	526,956	1,757	2,204	436
Operating assets	752,688	414	482,108	119	292,335	974	1,223	663
Total farm assets	6,132,558	3,370	4,511,722	1,117	3,830,471	12,768	16,020	4,964
Farm liabilities								
Long term	753,570	414	903,402	224	0	0	0	217
Medium term	440,684	242	229,156	57	40,149	134	168	480
Total farm liabilities	1,194,253	656	1,132,558	280	40,149	134	168	697
Farm equity	4,938,304	2,713	3,379,164	836	3,790,322	12,634	15,852	4,267
Total farm assets excluding land	844,350	464	765,909	190	819,292	2,731	3,426	1,099

Exchange rates: 1 USD = 1.135 CAD and 0.797 EUR (Average of 2006).
Source: Own illustration based on panel-approach.

The different sets of machinery and equipment of the four representative farms are listed in Table A20 to Table A23 in the Appendix.

5.2 Production systems

Production systems for cash crop production in Canada and Germany differ markedly since they are a result of the respective framework conditions. Production systems are mainly influenced by natural location conditions, agricultural policy, situation on commodity markets and available technology.

5.2.1 Zero tillage systems in Canada

Production systems in the Canadian Prairies reflect the prevailing natural location conditions which are characterized by low levels of precipitation and high water deficits (compare Chapter 2.3.1). This places crop production at high risk and water management and moisture conservation is thus a major component of crop production systems. Further, most crops are grown as spring varieties and are thus summer crops.

These circumstances were reflected by the traditional production systems which prevailed for many decades and consisted of cereal monoculture and summer fallow. In the Brown and Dark Brown soil zones mainly spring wheat was grown in rotation with summer fallow while in the Black soil zone spring wheat was complemented by barley and oats. Share of summer fallow in the rotation depended on precipitation and water deficit levels and reached 50 % in the very dry regions of the Brown soil zone and declined to less than 10 % in regions of the Black soil zone.[5]

Summer fallow is used to restore soil moisture by leaving land idle and control weeds, either by tillage operations or herbicide applications or both. Disease and insect development cycles are also managed this way and succeeding crop benefits from summer fallow by higher and more stable yields and lower input costs. Summer fallow is still used today though importance of the traditional production systems is declining. The downward trend of acreage under summer fallow and wheat can be observed from Figure 2.5 in Chapter 2.4.1.

Today, three different general types of tillage systems can be differentiated in the Canadian Prairies which are conventional tillage (CT), minimum tillage (MT) and no-till or zero tillage (ZT). The latter two systems are also referred to as conservation tillage systems. CT systems are characterized by multiple tillage operations with cultivators and discs after harvest and before seeding for weed control and seedbed preparation. Some operations may include applications of fertilizer. MT systems consist of fewer tillage operations compared to CT systems and crop residue is not fully worked into the ground and remains mostly on the surface to protect against erosion. Weeds are mostly controlled by herbicides and the seedbed is prepared by one tillage operation which includes application of nitrogen fertilizers. ZT systems do not include any tillage operation and soil is only disturbed by seeding operation. In direct seeding, soil is only opened at a narrow band to place seed and also fertilizer into the existing stubble of the preceding crop. Weed control is generally done by application of herbicides before seeding.

Zero tillage systems have gained in importance in the Canadian Prairies in the past. Table 5.8 shows the different shares of the three general tillage systems in Canada, Alberta and Saskatchewan. 39 % of the farms reporting to Census 2006 and 60 % of the corresponding acreage are farmed by zero tillage systems in Saskatchewan which is the highest share among all provinces in Canada. In Alberta, 48 % of the acreage is no-till

[5] ZENTNER et al. (2002, p. 218).

farmed. Conservation tillage systems dominate in both provinces with 76 % share in acreage in Alberta and 82 % in Saskatchewan.

Table 5.8: Tillage systems in Canada, Alberta and Saskatchewan

Region	Total number of farms reportet	Total acreage reported ('000) ha	Conventional Tillage (CT) - incorporating most crop residue into soil				Minimum Tillage (MT) - retaining most crop residue on the surface				Zero Tillage (ZT) - No-till seeding or zero-till seeding			
			Farms	Share (%)	('000) ha	Share (%)	Farms	Share (%)	('000) ha	Share (%)	Farms	Share (%)	('000) ha	Share (%)
Canada	174,414	29,049	87,204	50	8,140	28	43,495	25	7,428	26	43,715	25	13,481	46
Alberta	34,007	7,578	15,930	47	1,857	25	8,956	26	2,099	28	9,121	27	3,622	48
Saskatchewan	39,925	13,348	14,210	36	2,443	18	10,267	26	2,876	22	15,448	39	8,029	60

Source: Statistics Canada, Census 2006.

Reduction in summer fallow and wheat acreage and diversification of production systems and crop rotations has been caused by several factors in the past. A decline in cereal prices lead to a reduction in profitability of the traditional cereal-summer fallow production system.

In the Brown soil zone long-term disadvantages of summer fallow like increased risk of wind erosion and salinization as well as reduction in soil organic matter, which is important for water holding capacity additionally lead to changes in perception of this system. At the same time improved drought, disease and frost resistance of canola and legume crops (especially peas and lentils) as well as herbicide tolerance of genetically modified (GMO) canola enabled inclusion of these crops into diversified production systems and crop rotations. Specialty crops such as chickpeas, mustard, canary seed and other crops have gained in importance in addition to major crops in crop rotations as well.

The change in crop rotations was accompanied by increased moisture conserving tillage systems, especially zero tillage (ZT) systems. Both diversified crop rotations including cereals, oilseeds, pulses as well as fewer or no summer fallow and use of conservation tillage systems can be seen as complementary. Moisture saving zero tillage systems allows reduction in summer fallow towards continuous cropping without fallow at all. Weed control, which is more critical and difficult without fallow, has become easier with introduction of herbicide tolerant canola varieties (e.g. Roundup Ready) and by alternating broadleaf crops with cereals in the crop sequence.

In the Black soil zone, spring wheat, barley and canola are major crops being produced. These crops are complemented by peas, oats, winter wheat and flax. Conservation tillage systems have a longer tradition than in the Brown soil zone and are broadly implemented by the farms since reasons for adoption of these systems are different. Higher levels of soil moisture and soil compaction by multiple tillage operations impede early soil trafficability for seeding in the spring. Time available for timely operations can become very narrow due to early frosts in the fall and late frosts in the spring which results in use of larger equipment which increases machinery investments and labor costs. In addition, more tillage operations are needed to control weeds in conventional tillage systems which also increase costs. The advantage of conservation tillage systems thus results from savings from lower machinery and labor costs, which are higher than the increase in fixed machinery and chemical costs.[6]

Since in zero tillage systems no other machines and equipment than a seed drill is used to work the soil, technology and equipment of this machine has increased in importance. Air seeders with separate cart for seed and fertilizer storage are very common on farms with zero tillage systems. Seed and fertilizer are transported and distributed by air to be placed in different rows and depths in the soil. In recent years air seeders increased in size and newest models are available with working widths up to 24 m (80’) requiring tractors for pulling with up to 500 hp in engine power. Increase in working width has helped to increase productivity of labor which has gained in relevance at rising labor costs and unstable labor supply. Zero tillage systems are further a prerequisite for extended farm growth and managing large and very large cash crop farms since fewer field operations have to be carried out and managed. The two Canadian representative farms CA1800AB and CA4000SK both use zero tillage systems and crop rotations on both farms do not include summer fallow.

5.2.2 Intensive and conservation tillage systems in Germany

Production and tillage systems in Germany differ from those prevailing in the Canadian prairies and are generally characterized by intense tillage input. Conventional tillage systems in Germany involve plowing which is accompanied by several tillage operations of stubble cultivation by disk harrows and cultivators. Seedbed preparation either takes place with harrows or is integrated in the seeding operation when using integrated seed drills.

Weed control is easier in conventional tillage systems than in conservation tillage systems. Also soil aeration can be a critical issue on certain locations with high rainfall or particular soil types which gives an advantage to complete and deep soil disturbing systems like conventional tillage systems. The same holds for managing high amounts of crop residue which comes along with high yield levels prevailing in Germany (compare Chapter 2.4.2).

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[6] ZENTNER et al. (2002, p. 219).

In the past conservation tillage systems emerged where plowing is reduced depending on climate, soil conditions and crop requirements. Conservation tillage systems in Germany range from non-plowing systems to plow-dominated systems where only particular crops are not seeded on plowed land. Variations between these two systems are possible and common, varying in number of tillage operations, depth of working the soil and type of tillage equipment used.

Driving factors for conservation tillage systems are lower fuel consumption and increased labor efficiency with regard to acreage per hour, which is an advantage in times of peak workload. A major factor for locations with low precipitation levels and water deficits is moisture conservation when applying conservation tillage systems, resulting in increased yield levels compared to conventional (plow) tillage systems. Weeds have to be controlled by intense use of herbicides and this has become a critical issue over time due to increased resistances of particular weeds. Further, control for snails and mice which can damage emerging new crop after seeding has become a critical issue as well. Thus, conservation tillage systems require higher input of management and chemicals for weed and pest control which may offset the advantages from conservation tillage systems in comparison to conventional tillage systems.

Conservation tillage is very common after broadleaf crops like rapeseed, peas and sugar beets which leave good soil structure and few or easy to handle crop residue after harvest.

The majority of broad acre crops (mainly cereals and rapeseed) in Germany are grown as winter crops and seeding takes places in late summer and fall resulting in peak periods of workload together with harvest of preceding crops.

Less productive soils are either set aside in the context of the mandatory set-aside regulation of the CAP or are farmed with crop rotations dominated by rye which is a water efficient crop (compare Figure A15 in the Appendix).

High yield levels per hectare in Germany (compare Chapter 2.4.2) are the result of favorable natural conditions and comparably high fertilizer and chemical input per hectare. Both representative farms DE300EW and DE1300SA apply up to 240 kg per hectare of nitrogen. Application of lime fertilizer is necessary to control soil pH-level for nutrient mobility, especially in DE300EW. Number of chemical applications is higher for DE300EW with up to 3 applications of fungicides due to climatic conditions.

Production systems of DE300EW are characterized by conventional tillage systems and about 75 % of total farm acreage is cultivated by plow. Rapeseed is a typical crop providing conditions for conservation tillage at this location. Though rapeseed itself is seeded on plowed land, winter wheat succeeding rapeseed is seeded on land prepared by field cultivator operations without plowing. Sugar beets are planted using both conventional and conservation tillage systems depending on prevailing soil moisture and weather conditions at time of planting. The same holds for winter wheat which is the succeeding crop of sugar beets at this location. Use of conservation tillage is possible on half of sugar beet and wheat following sugar beet acreage on average and share of conservation tillage varies from year to year depending on precipitation and soil drainage. Conservation tillage is applied for wheat following rapeseed every year.

Wet soil conditions and limited soil trafficability restrict the use of conservation tillage systems on farm DE300EW. Conservation tillage is applied when soil conditions allow for it but is still limited to winter wheat following rapeseed and sugar beets and planting of sugar beets. Advantages of conservation tillage are limited compared to the other representative farms since moisture conservation is not an issue on this location though dealing with wet soil conditions. Aeration of soils, high pressure of weeds and better management of crop residue are further aspects which give conventional tillage an advantage over conservation tillage systems on this location. Savings on fuel consumption and labor are comparably low for conservation tillage systems on DE300EW. Savings range about 10-20 EUR per hectare which are mostly consumed by increased herbicide costs and thus reducing the economic advantage of conservation tillage systems to a minimum. Overall, machinery endowment of DE300EW is set up to provide flexibility in choosing between conventional and conservation tillage systems. This way, conservation tillage can be applied when conditions (soil moisture and trafficability) allow for it.

Opposed to prevailing conventional tillage systems on farm DE300EW, conservation tillage systems prevail on farm DE1300SA. Water management and moisture conservation is most critical on this location due to low rainfall (see Table 5.4) and water deficits during the seeding period. For this reason only 10 % of total farm acreage on average is cultivated by plow depending on crop, weather and soil moisture conditions. This system is used in a cereal sequence of a rotation where one cereal crop succeeds another cereal (typically wheat following wheat) to collect the benefits of lower weed pressure and cleaner fields. Further, rapeseed is partly seeded on plowed land for better crop emergence and establishment.

5.3 Crop portfolios and crop rotations

Crop portfolios and crop rotations for the selected representative farms in Canada and Germany reflect the prevailing natural location conditions, technology and organizational structure as well as legal and economic framework conditions. Though crop portfolios and crop rotation differ between farms and countries, certain overall factors can be observed that influence crop portfolio composition and rotation choice in a similar way.

5.3.1 Overall framework of crop portfolios and rotations

Wheat is the dominating crop in all crop portfolios of selected representative farms in Canada and Germany with a share ranging from 30% for CA4000SK to 51 % for DE1300SA (Table 5.9). Barley as a second cereal crop shows lower shares, ranging from 13 % for DE300EW to 20 % for CA4000SK while no barley is grown on farm DE1300SA. Rye is a third cereal crop of minor relevance and is only grown on the German representative farms. Overall, cereals are the dominating type of crops grown with a share in crop portfolios ranging from 50 % for the Canadian farms to 65 % for DE300EW.

Table 5.9: Composition of crop portfolios of selected representative farms in Canada and Germany

Farm	CA1800AB	CA4000SK	DE300EW	DE1300SA
Prevailing tillage system	Zero tillage (100 %)	Zero tillage (100 %)	Conventional tillage (60 %)	Conservation tillage (90 %)
Crop		%		
Wheat	35	30	44	51
Barley	15	20	13	
Rye	-	-	8	6
Canola/Rapeseed	25	20	17	28
Peas	25	15	-	7
Lentils	-	15	-	-
Sugar Beets	-	-	12	7
Set-Aside	-	-	6	1
Cereals	50	50	65	57
Oilseeds	25	20	17	28
Pulses	25	30	-	7
Tubers	-	-	12	7
Set-Aside	-	-	6	1

Source: Own illustration based on panel-approach.

The second most important crop is rapeseed or canola. Share of this crop in crop portfolios range from 17 % for DE300EW to 28 % for DE1300SA. Pulse crops like field peas and lentils play an important role in Canadian cash crop farming with share in crop portfolios ranging from 25 to 30 %. In Germany pulse crops only play a very minor role though share of field peas reaches 7 % for DE1300SA. Another major difference between farms in both countries is production of sugar beets. Both Canadian farms do not grow sugar beets while sugar beets are of major importance despite small shares in crop portfolios (12 and 7 %) for both German farms. Another particularity for the German farms is inclusion of set-aside which is mandatory due to regulations of the EU Common Agricultural Policy (see Chapter 2.2.2).

Crop rotations and cropping systems differ between the selected representative farms (Table 5.10). Canadian farms follow an oilseed – cereal – pulse – cereal cropping system. The oilseed element of the cropping sequence is dominated by canola which can be replaced by flaxseed as an alternative oilseed crop. The pulse crop element is dominated by field peas and chick peas or lentils are added to fill up the share of pulse crops in the rotation/portfolio. Cereals (barley and different types of wheat[7]) are grown following oilseed or pulse crops to benefit from nutrient carryover, soil moisture and structure and disease breaks of the oilseed and pulse crops.

Table 5.10: Crops rotations and cropping systems of selected representative farms in Canada and Germany

Farm	CA1800AB	CA4000SK	DE300EW	DE1300SA
Crop Sequence[1)]				
1st Element	Canola	Canola/Lentils	Sugar Beets/Winter Rapeseed	Sugar Beets/Field Peas
2nd Element	Spring Barley/Winter Wheat (CWRW)	Durum Wheat (CWAD)	Winter Wheat	Winter Wheat
3rd Element	Field Peas/Chick Peas	Field Peas/Lentils	Winter Wheat/Winter Rye	Winter Rapeseed
4th Element	Spring Wheat (CWRS)/Winter Wheat (CWRW)	Spring Barley/Spring Wheat (SWSW)	Winter Barley	Winter Wheat
5th Element				Winter Wheat/Winter Rye
6th Element				Winter Rapeseed
7th Element				Winter Wheat
Cropping System				
1st Element	Oilseed	Oilseed/Pulse	Broadleaf	Broadleaf
2nd Element	Cereal	Cereal	Cereal	Cereal
3rd Element	Pulse	Pulse	Cereal	Oilseed
4th Element	Cereal	Cereal	(Cereal)	Cereal
5th Element				Cereal
6th Element				Oilseed
7th Element				Cereal

1) Wheat in Canada is characterized by different types: CWRS = Canadian Western Red Spring wheat, CWAD = Canadian Western Amber Durum wheat, CWRW = Canadian Western Red Winter wheat, SWSW = Soft White Spring Wheat.

Source: Own illustration based on panel-approach.

7 Canadian wheat is characterized by different types and classes depending on their milling, baking and general characteristics and quality. For more information see CANADIAN GRAIN COMMISSION (2008).

Unlike Canadian representative farms, crop rotations and cropping systems for the German representative farms differ in rotation length and cropping system sequence. For DE300EW, cropping system sequence consists of broadleaf crops (sugar beets and rapeseed) followed by cereals. The sequence is a four year rotation but can be reduced to a three year rotation if necessary. Compared to DE1300SA cereals also perform well following cereals on this location and thus alternation with broadleaf crops is not a requirement. The most extended and differentiated crop rotation is found on farm DE1300SA. Crop sequence consists of an alternation of broadleaf or oilseed crops with cereals in a seven year rotation. Compared to the Canadian representative farms, crops grown on the German farms are mostly winter varieties except for sugar beets and field peas, while Canadian farms mostly grow spring seeded varieties except for winter wheat.

5.3.2 Crop rotations and crop portfolios of selected farms in Canada

5.3.2.1 Crop portfolio composition

Gross margins, yield levels and share in the crop portfolio of crops grown at the selected Canadian representative farms are shown in Table 5.11. Gross margin is defined as market returns over variable costs (seed, chemicals, fertilizer, fuel, custom work, hail insurance, other variable cost and calculated interest).

Table 5.11: Crops, yield levels and gross margins of selected representative farms in Canada in 2006

Farm	**CA1800AB**	**CA4000SK**	**CA1800AB**	**CA4000SK**	**CA1800AB**	**CA4000SK**
Prevailing tillage system	Zero tillage (100 %)		Zero tillage (100 %)		Zero tillage (100 %)	
Crop[1)]	**Share in crop portfolio in %**		**Yield in t/ha**		**Gross margins in USD/ha[2)]**	
Spring Wheat (CWRS)	20	-	2.9	-	194	-
Durum Wheat (CWAD)	-	25	-	2.8	-	244
Winter Wheat (CWRW)	15	-	4	-	288	-
Spring Wheat (SWSW)	-	5	-	3		235
Spring Barley	15	20	3.8	3.5	246	277
Canola	25	20	1.7	1.4	205	162
Field Peas	18	15	2.7	2.5	248	214
Lentils	-	15	-	1.7	-	287
Chick Peas	7	-	1.5	-	281	-

1) Wheat is characterized by different types: CWRS = Canadian Western Red Spring wheat, CWAD = Canadian Western Amber Durum wheat, CWRW = Canadian Western Red Winter wheat, SWSW = Soft White Spring Wheat.
2) Exchange rates: 1 USD = 1.13 CAD and 0.79 EUR (Average of 2006).
Source: Own illustration based on panel-approach.

Both farms use zero tillage systems for soil cultivation and seeding of crops. Wheat types grown on both farms reflect the prevailing natural location conditions, especially climatic conditions. Spring wheat (CWRS) grown on CA1800AB is the most common wheat type in the Canadian Prairies. Further, winter wheat (CWRW) is grown on this farm since risk of frost damage is lower at this location compared to the location in Saskatchewan. Compared to spring wheat, winter wheat achieves a higher yield level (4.0 vs. 2.9 t/ha) thus resulting in a higher gross margin (288 vs. 194 USD/ha).

CA4000SK produces durum wheat (CWAD) which is a high quality wheat used for pasta production. Thus, a price premium can be achieved over other wheat types resulting in high gross margins (244 USD/ha). Durum wheat is suited for being grown on locations with high temperatures and high water deficits resulting in high and stable yields (2.8 t/ha) under these conditions. Production of durum takes place under higher risk than production of other wheat types since quality requirements have to be met to achieve a price premium. Spring wheat grown on this farm (SWSW) is a low quality, higher yielding (3.0 t/ha) wheat type used for production of bio-ethanol. A gross margin of 235 USD per hectare is mainly achieved by lower input levels compared to durum wheat.

Barley produced on both farms differs in quality as well. CA1800AB produces feed barley used in livestock production due to proximity of beef cattle production in Southern Alberta. Though malting barley can be grown on this location as well, growing feed barley reduces risk of meeting quality requirements for malting barley. CA4000SK produces malting barley due to prevailing climatic conditions which reduce risk of producing minor qualities at this location. Thus, despite a small yield disadvantage (3.8 vs. 3.5 t/ha), malting barley produced at CA4000SK achieves a higher gross margin (277 vs. 246 USD/ha) due to a quality price premium.

Yield levels of canola (1.7 and 1.4 t/ha) are lower on both farms compared to other crops grown. The same holds for gross margin levels, which are lowest among all crops. Genetically modified canola varieties which are herbicide resistant are grown on both farms. There exists no difference in gross margins between GMO and conventional varieties since savings on herbicide input with GMO varieties are consumed by the technology fee that comes along with GMO varieties. Advantage of GMO canola varieties over conventional varieties comes from easier weed control. Furthermore, GMO varieties allow seeding of canola before other crops since pre-seeding application of glyphosate, which is a requirement in zero tillage systems, can be carried out in the established canola crop. Seeding of other crops can be carried out only after pre-seeding weed control. Also, so called “dormant seeding” of canola is possible this way. Canola can be seeded in the fall or spring in frozen soil which results in earlier maturing and harvest period as well as higher yield levels.

Pulse crops grown also differ between both farms, again reflecting different climatic conditions. Field peas are grown on both farms while lentils are a crop well suited to the hot and dry conditions in the Brown and Dark Brown soil zone in Saskatchewan. Chick peas are considered a special crop since it requires high management and means of production input which limit acreage under this crop.

5.3.2.2 Determinants of crop rotations

As shown in Table 5.10, the general crop rotation sequence on both farms consists of oilseed – cereal – pulse – cereal cropping systems. This general frame of crop rotation is relatively fixed since it is interdependent with zero tillage seeding systems. Zero tillage systems require an alternation of broadleaf crops with cereals in order to allow for appropriate weed control. Alternation of crops is also necessary to reduce disease pressure which comes along with high shares of cereals in a rotation and zero tillage seeding systems. Furthermore, soil damage from wind erosion is likely to increase under less diversified rotations. Risk associated with diversified crop rotations is also lower than with narrow crop rotations.

Zero tillage systems and diversified crop rotations are also necessary to manage very large farm operations like CA4000SK. Diversification of crop portfolios helps to distribute work load and management capacities as well as to increase use of equipment and machinery which results in reduced fixed costs. On the other hand, farms with more than 5,000 acres are limiting the number of crops in their portfolios in order to achieve economies of scale. A reduction in the number of crops further helps to better manage hired labor which becomes more relevant as farms become larger. Overall, these factors lead to an increase in stability and persistence of existing crop rotations. Farms with less than 5,000 acres tend to grow more specialty crops with higher gross margins which require higher management input.

For both farms in general, cereals are grown following oilseed or pulse crops to benefit from nutrient carryover, higher soil moisture levels (especially after pulse crops) and disease breaks. Within the general frame of the oilseed – cereal – pulse – cereal rotation, crops belonging to the same cropping system can be substituted for each other. This is usually determined by the prevailing or expected market conditions for the respective crops.

Crop rotations followed on farm CA1800AB are canola – barley/winter wheat – field peas/chick peas – wheat/winter wheat (Table 5.10). Possible alternative crops are durum wheat for the cereal cropping system, flaxseed and mustard for the oilseed cropping system and lentils for the pulse cropping system.

Canola has a share of 25 % in the overall rotation/portfolio (Table 5.11) which can be increased to 33 % in single years depending on market situation. The 33 % limit on canola is imposed by an increase in disease pressure with long-term disadvantages for crop health and resulting yield depression. Even the 33 % limit is critical for disease build-up and thus expansion of canola up to this level is limited to single years only. On average a share of 25 % of canola in a rotation is considered as sustainable and thus followed on this location. The canola crop in the rotation provides benefits to the following crops by increasing yield levels. Further, including canola in the rotation allows for easy and appropriate weed control due to GMO varieties.

A similar situation prevails for pulse crops on farm CA1800AB. Field peas have a share of 18 % and chick peas a share of 7 % in the crop rotation, totaling in a share of 25 % for pulse crops (Table 5.11). Share of chick peas is limited due to limited management capacity and chick peas are thus considered a "niche" crop. Share of pulse crops can be increased to 33 % as well though this is more critical than with canola. Yield depression due to increasing disease pressure can be observed when growing more than 25 % of pulse crops in a rotation. Thus, as with canola, expansion of pulse crop acreage is limited to single years depending on market situation. Increasing disease pressure in pulse crops can be relaxed by growing different types of pulse crops (e. g. peas, lentils, chick peas) within the pulse cropping systems sequence of a rotation since different pulse crops are affected differently by the same type of diseases. Pulse crops provide benefits to following crops in the rotation by increasing yield levels due to higher soil moisture levels and nutrient carryover and by increasing protein levels which increases quality levels.

Cereals grown on farm CA1800AB include winter wheat, spring wheat and barley and can be considered as "fill up" crops in the rotation. In general, all cereal crops can be substituted for each other within the cereal cropping system sequence of the rotation. Cereal crops consume benefits provided by oilseed and pulse crops in the rotation resulting in increased yield levels. Share of winter wheat, spring wheat and barley is 15 %, 20 % and 15 % respectively (Table 5.11) and depends on price expectation and diversification of associated risk. The latter is especially relevant for winter wheat, which has an increased risk of frost damage since it is fall seeded.

Determinants of crop rotation for farm CA4000SK are mostly the same as for CA1800AB. Crop rotations followed on farm CA4000SK are canola/lentils – durum wheat – field peas/lentils – barley/wheat (Table 5.10). Possible alternative crops are spring wheat (CWRS) for the cereal cropping system, flaxseed and mustard for the oilseed cropping system and chick peas for the pulse cropping system. Further, canary seed which is used as bird feed can be included in the oilseed/pulse cropping system sequence.

Share of canola in the crop portfolio is 20 % and field peas and lentils have a share of 15 % each. Determinants of oilseed and pulse crop share for this farm are the same as for CA1800AB. A difference occurs with lentils which are better adapted to the hot and dry conditions of the Dark Brown soil zone in Saskatchewan and are thus preferred over chick peas.

Another difference exists with type of wheat produced on farm CA4000SK. Cereals grown on this farm are durum wheat, spring wheat (SWSW) and barley. Though all cereals are substitutes for each other within the cereal cropping system sequence of the rotation, durum wheat is the dominating cereal crop. As with lentils, durum wheat is well suited to the hot and dry conditions of the Brown and Dark Brown soil zones and is thus preferred over other types of wheat. Durum wheat can be expanded to 50% of total farm acreage by replacing barley and other spring wheat. Durum acreage is usually lower than 50% to reduce marketing and production risk. Production of durum wheat is time critical since it must be seeded early to reach sufficient maturity at harvest time. Further, quality is a critical issue in order to achieve a price premium. Both factors result in a narrow seeding-harvesting window which imposes a maximum acreage restriction. Soft white spring wheat is part of the crop rotation since disposition of the crop is ensured by a local bio-ethanol plant. Further, this is an option to sell wheat besides the Canadian Wheat Board (compare Chapter 2.2.1.2).

5.3.3 Crop rotations and crop portfolios of selected farms in Germany

5.3.3.1 Crop portfolio composition

Gross margins, yield levels and share in the respective crop portfolio of crops grown at the selected German representative farms are shown in Table 5.12. As described in Chapter 5.2.2, different tillage systems are applied at the selected German representative farms. Tillage systems on farm DE300EW are characterized as conventional tillage while conservation tillage prevails on farm DE1300SA. Both farms mostly grow the same crops except for winter barley which is not grown on DE1300SA and field peas which are not grown on DE300EW. Crops of the German farms are characterized either by their preceding crop or according tillage system or both since these factors affect yield and input levels. Further differentiation is made by disposition of crops (industrial consumption vs. food or feed use) which reflect different price levels for the output.

Yield levels for wheat are dependant on preceding crops and differ between both farms. Wheat yields at DE300EW range from 8.0 to 8.5 tonnes per hectare compared to 6.5 to 9.0 tonnes per hectare at DE1300SA. Further, input levels vary with different preceding crops for wheat leading to different gross margin levels ranging from 460 to 592 USD per hectare for DE300EW and from 643 to 982 USD per hectare for DE1300SA. Note that gross margins cannot be compared directly between both farms since variable costs for custom harvest operations, which are about 150 USD per hectare, are included for cereals and rapeseed at DE300EW and not with DE1300SA. The difference occurs since harvest operations for cereals and rapeseed are done by custom operations in DE300EW and by owned machinery and equipment in DE1300SA.

Rapeseed and field peas are favorable preceding crops for wheat leading to highest yield levels of 8.5 (rapeseed) tonnes per hectare at DE300EW and 8.8 (rapeseed) and 9.0 (peas) tonnes per hectare at DE1300SA. The same holds for gross margin levels which are highest among all crops except sugar beets. Wheat following rapeseed and peas reaches gross margins of 942 and 982 USD per hectare at DE1300SA respectively and 592 USD per hectare following rapeseed at DE300EW. Yield advantage of wheat grown on rapeseed or pea stubble results from nutrient carryover and improved soil structure. Further, reduced crop residue and improved soil structure enables application of minimum tillage systems which reduce tillage costs and thus improve gross margins.

Table 5.12: Crops, yield levels and gross margins of selected representative farms in Germany in 2006

Farm	**DE300EW**	**DE1300SA**	**DE300EW**	**DE1300SA**	**DE300EW**	**DE1300SA**
Prevailing tillage system	Conventional tillage (75 %)	Conservation tillage (90 %)	Conventional tillage (75 %)	Conservation tillage (90 %)	Conventional tillage (75 %)	Conservation tillage (90 %)
Crop[1)]	**Share in crop portfolio in %**		**Yield in t/ha**		**Gross margins in USD/ha[2)]**	
Wheat on Rapeseed	17	28	8.5	8.8	592	942
Wheat on Sugar Beets	12	7	8.2	6.5	546	572
Wheat on Peas	-	7	-	9	-	982
Wheat on Wheat, Plow	15	4	8	7.1	460	687
Wheat on Wheat, Min-Till	-	5	-	7.1	-	643
Winter Barley	13	-	7.8	-	427	-
Winter Rye	8	6	8.5	8.5	524	690
Winter Rapeseed, Plow	15	6	3.9	4	455	673
Winter Rapeseed Min-Till	-	14	-	3.9	-	638
Winter Rapeseed, Industrial	2	8	3.7	3.9	323	575
Sugar Beets, Quota	11	6	60	52.8	1,838	1,709
Sugar Beets, Industrial	1	1	60	52.8	671	619
Peas	-	7	-	4.5	-	478

1) Min-Till = Minimum Tillage,
2) Exchange rates: 1 USD = 1.13 CAD and 0.79 EUR (Average of 2006).

Source: Own illustration based on panel-approach.

For wheat grown on sugar beets and wheat grown on wheat, yield and gross margin levels differ between both German farms. Sugar beets are a favorable preceding crop for wheat at DE300EW with a yield level of 8.2 tonnes per hectare and a gross margin of 546 USD per hectare. Further, yield of wheat grown on wheat is lower than of wheat following rapeseed or sugar beets (8.0 t/ha) at DE300EW though yield depression is lower than for wheat grown on wheat at DE1300SA. Wheat on sugar beets (6.5 t/ha and 572 USD/ha) and wheat on wheat (7.1 t/ha and 643 USD/ha) at DE1300SA show lowest yield and thus gross margin levels for all wheat production systems. Differences in yield levels between wheat grown on the two farms occur from different natural location conditions, especially from different precipitation levels and length of growing period. Sugar beets are harvested in the fall from late September to December often resulting in late clearing of fields for succeeding wheat. This is a problem for wheat grown on sugar beets at DE1300SA since wheat has to be seeded by end of September for optimum crop establishment. Further, sugar beets consume high amounts of soil moisture leaving a moisture deficit for succeeding wheat on DE1300SA. Wheat on sugar beets can be established up to mid December on DE300EW due to a longer growing season. Further, precipitation levels are higher leaving no moisture deficit for succeeding wheat (compare Chapter 2.3.2).

Wheat seeded on rapeseed and sugar beets is suited for minimum tillage systems at DE300EW. Minimum tillage is applied to wheat on rapeseed every year as a standard operation. Application of minimum tillage with wheat on sugar beets depends on weather and soil conditions which vary from year to year at time of seeding. On average 50 % of wheat on sugar beet is seeded using minimum tillage. The remaining 50% is seeded on plowed land when wet soil conditions require plowing to establish a proper seedbed. Both tillage systems are thus reflected by their respective share in gross margin calculation for wheat on sugar beets at DE300EW.

Barley is grown at DE300EW only and is used for livestock feed in the local livestock industry. Barley is not included in the crop portfolio at DE1300SA since growing barley on wheat stubble can be critical in minimum tillage systems due to old crop wheat contamination in new crop barley. Rye is a “niche” crop on both farms despite comparably high yield and gross margin levels (8.5 t/ha and 524 USD/ha at DE300EW and 8.5 t/ha and 690 USD/ha at DE1300SA). Rye is well suited to dry climates and poor soils though production of rye on both farms faces quality and marketing risks which may reduce gross margins by more than 100 USD/ha. Thus, these risks limit share of rye in the crop portfolio despite favorable gross margins.

Rapeseed production systems differ between both farms. While DE300EW uses conventional tillage systems for rapeseed production, both conventional and conservation tillage systems are applied for rapeseed on DE1300SA. Yield of rapeseed seeded on plowed land is slightly higher than for minimum tillage seeded rapeseed (4.0 t/ha vs. 3.9 t/ha) on farm DE1300SA. Use of conventional tillage for rapeseed production is dependant on amount of crop residue of preceding crop, soil moisture levels and date of seeding. High amounts of crop residue can be better handled with plowing. Higher costs of conventional tillage are offset by higher stability of yield levels compared to minimum tillage. Further, rapeseed production systems are differentiated by disposition of the output. Rapeseed is either used for food consumption (edible oil) or used as renewable resources mainly for production of bio-diesel. Rapeseed as renewable resources for biodiesel production is traded at price discounts of 10 to 15 EUR per tonne resulting in lower gross margins than regular traded rapeseed (455 vs. 323 USD/ha at DE300EW and 638 vs. 575 USD/ha at DE1300SA). Further, rapeseed for bio-diesel production can be grown to fulfill the mandatory set-aside requirement imposed by the EU Common Agricultural Policy (compare Chapter 2.2.2 and Table 5.9).

Sugar beets are grown on both farms under the production quota regime of the EU common market organization for sugar (compare Chapter 2.2.2). Further, sugar beets are grown for industrial purposes which differ between both farms. Industrial sugar beets produced at DE300EW are used for industrial production of yeast which is a niche market and thus production of industrial sugar beets at this farm is considered as a niche crop as well. Industrial sugar beets at DE1300SA are used for production of bio-ethanol and are at this point a niche crop as well. Prices for sugar beets produced under the production quota regime reflect the first price cut under the reform of the sugar market organization and are set at 41 EUR per tonne (51 USD/t). This price level results in highest gross margins for sugar beets among all crops grown on both farms (1,838 USD/ha at DE300EW and 1,709 USD/ha at DE1300SA).[8] Industrial sugar beets achieve lower price levels of 25 EUR per tonne (31 USD/t) resulting in gross margins of 671 and 609 USD per hectare respectively.

Field peas are only grown at farm DE1300SA and are considered a niche crop as well. Field peas show lowest gross margin (478 USD/ha) among all crops at DE1300SA though they provide highest yield advantage to following wheat.

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[8] Further price reductions will take place under the reform of the sugar market organization. Final prices for sugar beets on both farms will range about 33 EUR/t (41 USD/t) from marketing year 2009 onwards (compare chapter 2.2.2).

5.3.3.2 Determinants of crop rotations

Crop rotations differ in rotation length and cropping system sequence between DE300EW and DE1300SA. For both farms in general, cereals are grown following broadleaf crops to benefit from nutrient carryover, improved soil structure, reduced tillage opportunities, higher soil moisture levels (especially at DE1300SA) and disease breaks.

The general frame of the broadleaf – cereal – cereal – cereal cropping system sequence determines crop rotations on farm DE300EW (Table 5.10). The general frame for DE1300SA is more extended as well as diversified and consists of a broadleaf – cereal – oilseed – cereal – cereal – oilseed – cereal cropping system sequence. Within the general frame of cropping systems, crops belonging to the same cropping system can be substituted for each other. This is usually determined by the prevailing or expected market conditions for the respective crops.

The general rotation frame on farm DE300EW is the most flexible among all representative farms compared. Conventional tillage systems as applied on this farm enable narrow crop rotations since seedbed preparation by plow allows for optimum weed control and enhances crop emergence and establishment. In general though, advantages of conventional tillage systems come along with increased machinery and operating costs compared to conservation tillage systems. Disease pressure is managed by growing different types of cereals (wheat, rye, barley) and application of fungicides. Though cereals (especially wheat) benefit from alternation with broadleaf crops (sugar beets, rapeseed) by achieving higher yields and lower costs, cereals can be grown continuously with only minor yield depression and gross margin reduction on this location. Thus, alternation of broadleaf crops and cereals is not a strong requirement as in zero tillage or minimum tillage systems as prevailing on the Canadian or East German farms.

Crop rotations followed on farm DE300EW are sugar beets/winter rapeseed – winter wheat – winter wheat/winter rye – winter barley. In some cases, rotations are shortened to sugar beets/winter rapeseed – winter wheat – winter wheat/winter barley (Table 5.10). Possible alternative crops are winter triticale, oats, spring wheat and spring barley for the cereal cropping system and faba beans or field peas for the broadleaf cropping system. Corn for silage or corn for grain can be placed instead of broadleaf cropping system in the rotation.

Growth of spring seeded varieties for cereals is limited since a yield depression of more than 2.0 tonnes per hectare compared to fall seeded varieties can be observed on this location.

Sugar beets are the most profitable crop on farm DE300EW with a total share of 12 % in the crop portfolio (Table 5.12). Sugar beets produced on DE300EW comprise of 11 % sugar beets produced under quota and 1 % sugar beets produced for industrial purposes. Share of sugar beets under quota is determined by the amount of production quota owned or devoted to the farm (compare Chapter 2.2.2). This amount can only be increased by either buying or renting additional quota if available which increases cost of production of sugar beets. Share of industrial sugar beets is limited and determined by annual delivery agreements with the processing plant. Since sugar beets marketed for this purpose are a niche crop share in acreage cannot be extended arbitrarily.

Rapeseed is the second broadleaf crop grown on DE300EW with a total share of 17 % in the crop portfolio. Rapeseed produced comprises of rapeseed used as renewable resources (for production of bio-diesel) with a share of 2 % and “regular” rapeseed with a share of 15 % in the crop portfolio. Share of industrial rapeseed (renewable resource) is mainly determined by the mandatory set-aside rate of the EU Common Agricultural Policy regulations. For North Rhine-Westphalia this rate is set at 8.5 % of crop land for 2006. The remaining 6.5 % acreage requirement for set-aside are not cropped (see Table 5.9) since land devoted to permanent set-aside is difficult to farm due to poor or difficult soil conditions and small field structure. Share of rapeseed in crop rotations and in the crop portfolio can be extended to 33 % and is limited at this point due to an increase in disease pressure which causes yield depression and long-term disadvantages to the whole crop rotation including rapeseed. In the long-run a share of 25 % of rapeseed is considered sustainable by the panel participants. Share of rapeseed in the current crop portfolio does not reach these levels since competing sugar beets are more competitive than rapeseed (1,838 and 671 vs. 455 USD/ha). This circumstance and a comparably short history of rapeseed production at this location provide potential for expansion of rapeseed production if competitiveness of rapeseed improves. Though potential for expansion of rapeseed acreage exists at DE300EW, expansion can become critical due to peak workload at the time of rapeseed seeding which overlaps with harvest of winter wheat at mid to end of August. This constraint can be relaxed by buying in additional custom work which is available at this location but which increases overall costs.

Cereal crops grown at DE300EW include winter wheat, winter rye and winter barley with winter wheat being the dominant crop with highest share in the crop portfolio (44 %) and highest gross margins among all crops except sugar beet (460 to 592 USD/ha). In general, all cereal crops can be substituted for each other within the cereal cropping system sequence of the rotation. Cereal crops consume benefits provided by broadleaf crops in the rotation resulting in increased yield levels and lower costs. Share of wheat on rapeseed and wheat on sugar beets is determined by share of the respective preceding crop. Wheat on wheat, rye and barley are used as “fill up” crops which further are used to diversify production and marketing risk and workload.

Share of winter rye is limited at two harvest days which is 50 ha or 8 % for DE300EW. This constraint is imposed by increased risk caused by an extended harvest period which increases risk of rainfalls to reduce grain quality. Reduced grain quality causes price discounts and increases overall marketing risk. Price discounts may lead to a reduction in gross margin of more than 100 USD/ha. Thus, share of rye in the crop portfolio is limited despite a favorable gross margin (524 USD/ha) compared to wheat on wheat (460 USD/ha) and barley (427 USD/ha).

Winter barley has minimum requirements with regard to preceding crops and is thus grown as the last element within a crop rotation. Though wheat on wheat has a higher gross margin than barley, barley has a share of 13 % in the crop portfolio since it helps to relax and distribute work load. Winter barley is seeded and harvested at first of all cereal crops which relaxes work load on other cereals. Furthermore, barley provides a benefit to succeeding rapeseed which can be well established due to lower crop residue and early clearing of fields with improved rotting of crop residue. This is an advantage for rapeseed which is difficult to establish on fields with difficult soil conditions and if late harvest of preceding wheat delays seeding of rapeseed on wheat.

The overall crop rotation frame of broadleaf – cereal – oilseed – cereal – cereal – oilseed – cereal on farm DE1300SA is determined by the chosen tillage system (conservation tillage). Conservation tillage systems prevail on DE1300SA since conservation of soil moisture is a key target of cropping practices at this location (compare Chapter 5.2.2). Further, conservation tillage systems require a consistent alternation of broadleaf and cereal crops for easier crop establishment and weed control. These aspects are comparable to requirements of zero tillage systems in Canada (compare Chapter 5.3.2.2).

Crop rotations on farm DE1300SA are rather fixed and consist of sugar beets/field peas – winter wheat – rapeseed – winter wheat – winter wheat/winter rye – winter rapeseed – winter wheat (Table 5.10). Possible alternative crops are winter barley, spring barley, spring wheat and durum wheat for the cereal cropping system. Corn production, either for silage or grain, is limited at this location due to high water deficits during the corn growing period which limit corn yields.

As for DE300EW growth of spring seeded cereal varieties is limited at DE1300SA by yield depression compared to winter seeded varieties.

Sugar beets are the most profitable crop in the crop portfolio of DE1300SA as they were at DE300EW. Total share of sugar beets in the crop portfolio is 7 % (Table 5.12) which comprises of sugar beets under quota (6 %) and industrial sugar beets (1 %). Determinants of sugar beet acreage at DE1300SA are the same as for DE300EW.

Share of rapeseed totals 28 % in the crop portfolio and comprises of rapeseed as renewable resources (8 %) and “regular” rapeseed (20 %). Share of industrial rapeseed (renewable resources) is determined by the same factors as for DE300EW. Overall share of rapeseed can be expanded to 33 % on this farm though rapeseed acreage below this level (28 %) is considered more sustainable and is thus performed on DE1300SA. Expansion of rapeseed acreage beyond the 28 % level is seen very critical by the panel participants since an increase in disease pressure will cause yield depression and long-term damage to the whole crop rotation and soil health by accumulating soil-borne diseases.

Field peas are a third broadleaf crop grown at DE1300SA with a share of 7 % in the crop portfolio. Though field peas have the lowest gross margin (478 USD/ha) of all crops on farm DE1300SA they are included in the crop portfolio since they provide benefits to succeeding wheat crop by increasing wheat yields and reducing costs. This is provided by nitrogen carryover, improved soil structure and higher soil moisture levels. Share of field peas is determined by share of sugar beets since they are used to fill up the broadleaf cropping system sequence of the overall rotation frame. The overall share of field peas is limited at 14 % due to increasing disease pressure causing long-term yield depressions.

Cereal crops grown at DE1300SA include winter wheat and winter rye with a share of 51 % and 6 % respectively. In general, all cereal crops can be substituted for each other within the cereal cropping system sequence of the rotation. Cereal crops consume benefits provided by broadleaf crops in the rotation resulting in increased yield levels and lower costs. Share of wheat on rapeseed, wheat on peas and wheat on sugar beets is determined by the share of the respective preceding crop. Wheat on wheat and rye are used as “fill up” crops. Share of winter rye is limited due to increased price and marketing risk caused by the abolishment of the intervention system (see Chapter 2.2.2). The limit is set at three harvest days which is 10 % or 130 ha for this farm though quality risk is not as critical as for rye produced on DE300EW. If winter barley were included in the crop rotation, it would either replace wheat on wheat or rye.

5.3.4 Changes in output prices and stability of crop portfolios

5.3.4.1 Overall factors causing stability in crop rotations and portfolios

Identification and assessment of factors which determine crop rotation choice and crop portfolio composition revealed a general interdependency of crop rotations and tillage systems for all representative farms analyzed.

Tillage systems prevailing at the four representative farms are zero tillage (direct seeding) for CA1800AB and CA4000SK, conventional tillage (plow) for DE300EW and conservation tillage (minimum tillage) for DE1300SA (compare Chapter 5.2). Choice of tillage systems for all farms is influenced by two major factors: prevailing natural location conditions (climate and soils) and farm size.

Water management and soil moisture conservation are the key strategy on locations with water deficits appearing during the growing season thus resulting in application of tillage systems which conserve soil moisture. This is the case for both Canadian representative farms and DE1300SA which show water deficits and low levels of precipitation (see Table 5.4) leading to zero tillage and minimum tillage systems. In contrast to managing water deficits on these farms handling of high moisture levels is an issue for DE300EW. This results in the need for intensive soil aeration and thus high soil disturbance either by plowing or deep cultivating. Further, prevailing soil types influence choice of tillage systems. Heavy soils with high clay content, shallow soils or elevated and sloping soils may require use of conservation tillage systems for better crop establishment or reduction of soil erosion. This does not apply to soils on any of the representative farms compared. In fact, high precipitation levels with prevailing soil types on DE300EW (sandy loams) lead to soil compactions requiring intensive tillage systems for soil aeration.

The second major factor influencing choice of tillage systems is farm size. Zero tillage and conservation tillage systems enable management of large and very large farm operations since fewer field operations are necessary or equipment used enables cultivation of more acreage per machine or equipment compared to conventional tillage systems. Furthermore, due to larger equipment and machinery as well as higher working speeds productivity in terms of acreage operated per hour is higher than in intensive tillage systems. This is an important factor if labor efficiency has to be increased when seeding windows are narrow like in the Canadian representative farms and DE1300SA. This is not the case for DE300EW since seeding windows for cereals are longer compared to the other representative farms and thus do not require use of conservation tillage systems.

Tillage systems chosen under the prevailing natural framework conditions and farm sizes determine the general frame for crop rotations depending on type of tillage system. Tillage systems have different requirements with regard to cropping system sequence (e. g. alternation of broadleaf and cereal crops) which are inherent to the system. Cropping system sequence (e. g. oilseed – cereal – pulse – cereal) is mainly determined by the ability of the different tillage systems to achieve stable and highest possible yields by establishing healthy crops, managing soil moisture and soil structure, controlling for weeds and breaking disease cycles.

Crops allocated to the same cropping system (oilseed, pulse, cereal, broadleaf) have the same or similar agronomical characteristics. These crops can thus be substituted within a cropping system since they provide the same or similar characteristics (benefits or disadvantages or both) to the crop rotation (e. g. field peas and lentils provide both nutrient carryovers to succeeding crop). Choice of crops within a cropping system is determined by their economic profitability (gross margin), associated risks (production risks, quality risks, price risks etc.) and labor and management requirements. Crops are further chosen by their ability to diversify associated risks depending on the producer's risk attitude and by the need to distribute work load, machinery utilization and management requirements over the season. Further, a certain threshold for a minimum acreage of each crop exists on all farms compared. A minimum acreage is needed to pay-off input for organization of field operations and general management and know-how related to a crop. The threshold depends on size of the farm operation and management input required per hectare for each crop.

The overall determinants of crop rotation choice can be observed across regions and countries for all farms analyzed despite different natural framework conditions, production systems, legal framework conditions and farm sizes.

Further, overall determinants of crop rotations (natural location conditions, farm size, tillage system and agronomical characteristics) have to be considered as relatively fixed, especially in the short-run. Thus, crop rotations for the analyzed farms are relatively stable and are characterized only by minor changes which mostly appear within the same cropping system (e. g. barley is substituted for wheat) (compare Chapter 4.2.3). Natural location conditions have to be considered fixed in the short-run and might change in the long-run due to global climate change. Farm size has to be considered fixed in the short-run as well. Farm growth which will affect choice of tillage systems might be observed for DE300EW in case farm size is extended to a size where use of more labor efficient conservation tillage systems becomes necessary. Remaining farms analyzed already apply tillage systems which are needed for efficient large and very large farm operations. Tillage systems have to be considered fixed in the short-run as well since once investment in respective equipment is made capital costs have to be recovered.

A change in the overall determinants of crop rotation choice which will lead to a major change in crop rotations is most likely to occur by technical progress. Development of new crop varieties with different or new agronomical characteristics (e.g. disease resistant rapeseed varieties which allow for an increase in share of rapeseed) or new technology for tillage and seeding equipment (e. g. disc openers for direct seeding) might lead to new production systems with a reorganization of crop rotations.

Altogether, tillage systems prevailing at the different representative farms in Canada and Germany and the respective resulting cropping system sequences will not change in the short-run and which thus leads to an overall stability in crop rotations and thus crop portfolios. For farms compared, crop rotations for zero tillage systems on the Canadian farms are most inflexible, followed by crop rotations for conservation tillage systems in DE1300SA. Most flexible rotations are found in conventional tillage systems at DE300EW.

5.3.4.2 Influence of changing output price relations

Given the overall stability of crop rotations and crop portfolios determined by prevailing natural location conditions, farm sizes and tillage systems, influence of changes in crop output prices on crop rotation choice and crop portfolio composition is limited.

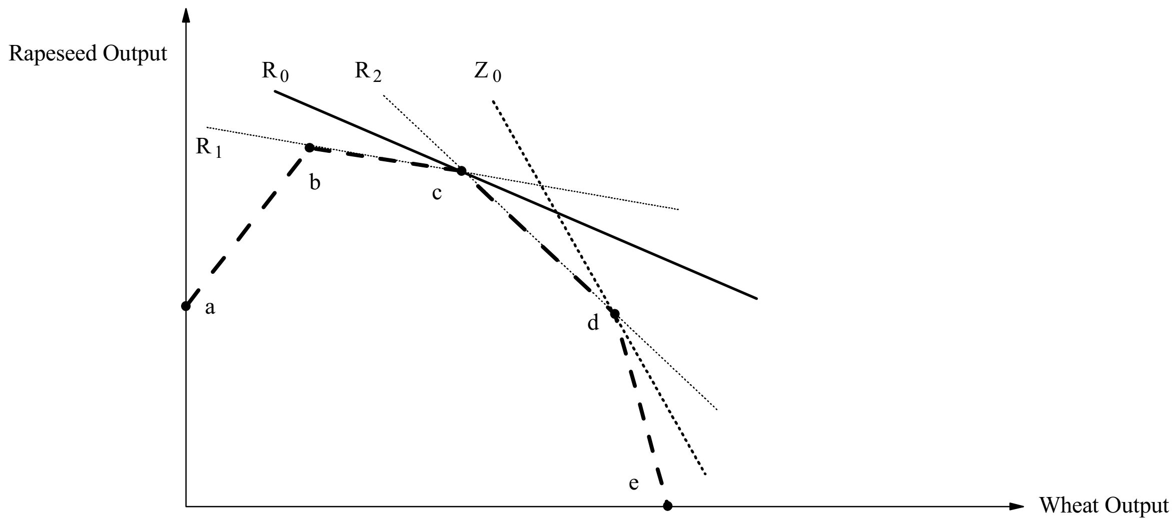
Minor changes are possible for the representative farms in Canada. The general crop rotation of oilseed – cereal – pulse – cereal can be altered to a (1) pulse – cereal – cereal rotation or (2) oilseed – cereal – cereal rotation in case of declining oilseed prices (1) or declining pulse prices (2) (c. p.). Both rotations are also possible under rising cereal prices though it has to be kept in mind that these rotations are not sustainable and will only appear in either single years or only for a few years in a row. According to the producer panel, negative aspects of narrow crop rotations and risks increase with an alternation of the general crop rotation. Factors limiting expansion of single crops (e.g. disease build-up and long-term yield depression) are too strong to change the overall crop rotation for a longer period of time in the context of changing output price relations. Further, prevailing tillage systems (here: zero tillage) predetermine an overall frame of crop rotations which cannot be changed without adjusting tillage systems. Thus, for farms CA1800AB and CA4000SK the overall rotation of oilseed – cereal – pulse – cereal is considered as relatively stable over time and crops are only changed within their respective cropping system sequence under changing output price relations.

Discussions within the producer panels for representative farms in Germany revealed that prevailing crop rotations for both farms are relatively stable in the context of changing crop output prices. For DE300EW, rapeseed expansion is limited at 33 % of total acreage and by sugar beets which are more competitive. Rapeseed will replace sugar beets in the rotation in case of declining competitiveness of sugar beets. Sugar beets will though remain competitive at this location even after final price reductions of the reform of the EU sugar market organization. Expansion of sugar beets is limited by the quota regime and sugar beets grown for industrial purposes remain as a niche crop. In case of increasing cereal prices rotations can easily be extended to increase the share of cereals. Further, sustainable continuous cropping of cereals is also possible at this location. Among all farms rotations are most flexible at DE300EW. This is due to favorable natural location conditions and prevailing conventional tillage systems which have no certain requirements with regard to cropping system sequences.

For DE1300SA, crop rotations are even more fixed due to prevailing tillage systems. Conservation tillage systems applied at DE1300SA require consistent alternation of broadleaf and cereal crops in the rotation. Share of rapeseed in the crop portfolio is limited at 33% resulting in low potential for expansion from the current share of 28%. Sugar beets are likely to drop out of the rotation if prices decline further (reform of sugar market organization) since following wheat shows too much yield depression consuming the gross margin advantage of sugar beets. Sugar beet acreage in the rotation/portfolio will be either replaced by rapeseed up to the 33% limit and by field peas up to the 14% limit. Rapeseed will remain in the crop rotation in case of low prices since broadleaf crops are required for alternation with cereals. Field peas are likely to drop out of the rotation if prices will further decline and will be either replaced by rapeseed or cereals. Cereals in general will be grown even at low prices.

Discussions within producer panels of all representative farms revealed the importance of crop rotations respectively cropping systems over importance of single crops with regard to crop portfolio composition under changing output price ratios. Cropping system sequence is stable over wide ranges of price ratios between crops within a rotation or portfolio due to prevailing interdependencies. This aspect was laid out theoretically in Chapter 4.2.3. Further, extents of changes in price ratios between crops have to be substantial to cause changes in crop rotation choice and thus crop portfolio composition.

Figure 5.3: Stability in crop portfolios under changing price ratios



Source: Own illustration base on Heady (1952, p. 256).

This is demonstrated by the example illustrated in Figure 5.3. The given price ratio of rapeseed and wheat represented by iso-revenue curve R_0 results in choice of crop rotation (portfolio) *c* as the profit maximizing solution. This crop rotation remains as the profit maximizing solution over a wide range of price ratios represented by iso-revenue curves R_1 to R_2. Price ratios of rapeseed and wheat have to change substantially, resulting in a change of the slope of the iso-revenue curve (Z_0), to cause a shift from rotation *c* to rotation *d*.

Also it can be revealed that stability in choice of crop rotations is dependant on location of corner points (i.e. crop rotations). Price ratios have to change to a lower extent to move from rotation *c* to *b* compared to price ratios required to move from rotation *c* to *d*. Location of the different profit maximizing corner points and thus crop rotations is determined by the different (technical) interdependencies that shape crop rotations.

Results from the different producer panels as well as the theoretical background reveal that substantial changes in price ratios are required to change overall crop rotation choice and crop portfolio composition. Further, discussions have revealed that persistence in price ratio changes is very important for portfolio re-organization. Producers participating in the different panels expect most changes in crop output price ratios to appear as a short-term issue. Farmers will adjust portfolios in the short-run based on respective cropping system sequences prevailing for their farms, thus resulting only in minor adjustments in share of crops in portfolios. Major adjustments in crop portfolios, crop rotations and an overall re-organization of the farm operation will only take place under major price shifts which will persist over the mid- to long-run. However, producers from all panel groups do not expect such substantial shifts to appear. In case price shifts will stimulate production of a particular crop, acreage and thus production of this crop is expanded on a large scale (across many farms and regions). This will result in higher supply and thus declining prices for this crop and declining supply and thus increasing prices for competing crops at the same time. If long-term substantial changes of price ratios are anticipated for the future, producers expect prices of competing crops to increase since existing demand for these crops will have to be met. Thus, price ratios of crops are expected to range around their long-term average while price levels as a whole may rise in the future.

In order to analyze and assess short-term adjustments in crop portfolios and crop rotations a detailed view on price ratios and determinants of crop portfolio composition is necessary. This will be provided as an example for one farm in Chapter 6.

5.4 Summary

Four representative farms are analyzed and compared based on the extended panel-approach. CA1800AB is located in Southern Alberta, Canada and farms 1800 hectares of crop land; CA4000SK is located in Central Saskatchewan, Canada, with 4000 hectares. DE300EW is located in Eastern Westphalia-Lippe and consists of 300 hectares of crop land. DE1300SA farms 1300 hectares and is located in Central Saxony-Anhalt. All farms are leading edge farms in terms of farm size in their respective regions.

Production systems differ between farms analyzed, mostly reflecting prevailing natural framework conditions at the different locations. Both Canadian farms apply zero tillage systems since conservation of soil moisture and high labor efficiency in narrow seeding windows are two major goals in cash crop production in semi-arid climates of Western Canada. Conservation tillage systems prevail on DE1300SA since conservation of soil moisture and high productivity in seeding operations apply to this location as well. For DE300EW, conventional tillage systems prevail since prevailing climate and soil types require aeration of soils.

Tillage systems have a major influence on choice of crops and crop rotations. Zero tillage and conservation tillage systems require consistent alternation of broadleaf and cereal crops in prevailing rotations to conserve soil moisture, control for weeds and break disease cycles. Crops grown at the different farms analyzed can be substituted within each cropping system (e. g. oilseeds, cereals, pulses) to maintain a rotation. Overall, cropping system sequence causes inflexibility and stability in crop rotations and crop portfolios. Conventional tillage prevailing at DE300EW provides most flexible rotations since no consistent alternation of broadleaf and cereal crops is required. Further, continuous cropping of cereals is competitive as well. Overall stability in crop rotations and crop portfolios is also observed under changing output price ratios which is mostly determined by prevailing tillage systems and different agronomical characteristics of crops.

6 Impact of commodity price changes on crop portfolio composition for DE300EW

This chapter provides a detailed analysis and assessment of crop portfolio composition and rotation choice under changing output price relationships for DE300EW. Results presented in this chapter are based on Stage three of the extended panel-approach after results of Stage one and two have been presented in Chapter 5.

Technically, stage three of the extended panel-approach can be applied to any farm derived from a panel-approach. For further analysis within this thesis however, Stage three is only applied with DE300EW since prospects for adjustments in crop portfolios and crop rotations under changing output prices are limited for the other representative farms. Crop rotations and crop portfolio composition is mostly predetermined by zero and conservation tillage systems prevailing on CA1800AB, CA4000SK and DE1300SA which limit potential for adjustments (compare Chapter 5.3.4). Conventional tillage systems prevailing on DE300EW provide the the highest potential for adjustments since requirements for alternation of crops (cereal and broadleaf crops) are lowest among all representative farms. Thus, crop rotations and crop portfolio composition are most flexible for DE300EW. Further, prevailing conventional tillage systems can be changed to conservation tillage systems which may result in different crop rotations and crop portfolios as well.

According to the procedure of Stage three of the extended panel-approach as described in Chapter 4.4.4, analysis of adjustments in crop portfolio composition follows five steps. Cropping activities and potential crop rotations for DE300EW are defined in Chapter 6.1, followed by calculation of output price ratios and definition of price development scenarios in Chapter 6.2. Finally, gross margins for cropping activities and crop rotations for the different price development scenarios and resulting crop portfolio composition are presented in Chapter 6.3.

6.1 Cropping activities and feasible crop rotations

Prevailing and potential cropping activities which are feasible for DE300EW under prevailing framework conditions are described in Section 6.1.1 and 6.1.2. Values are based on input and output prices and quantities for 2006 unless otherwise noticed and are derived based on data of stage one of the extended panel-approach for this representative farm.

6.1.1 Prevailing cropping activities

Cropping activities are defined based on yield level, output price level, direct input and input related to field operations (machinery, labor, custom work and fuel). Gross margins for each activity are calculated as net returns over direct and operating costs, which is the sum of market and other returns less sum of direct costs and operating costs. Costs and input values are based on 2006 and 2007 input data taken from the producer panel. Direct costs include costs for seed, chemicals, fertilizer, hail insurance and calculated interest (5 % on direct costs). Operating costs include costs for machinery (depreciation, repairs and calculated interest), custom work, fuel and labor (hired and family). Operating costs are included in the calculation to allow for economic evaluation of different tillage systems which will differ in both direct and operating cost levels.

Prevailing set up of the farm operation for DE300EW includes eleven cropping activities for five different crops (Table 6.1). Rapeseed production is represented by two cropping activities which mainly differ in their yield level (3.9 t/ha and 4.5 t/ha). Both activities feature conventional tillage (plow). Net returns over direct and operating costs are higher for the higher yielding rapeseed activity (269 EUR/ha vs. 145 EUR/ha), which is mainly due to higher market returns. While the lower yielding rapeseed activity reflects the common activity for rapeseed cropping at this farm, the higher yielding rapeseed activity reflects yield levels which can only be achieved on soils with higher productivity. These soil types are usually devoted to sugar beet cultivation on this farm. Thus, this activity is only available when competitiveness of sugar beets is lower than for this rapeseed activity.

Sugar beet production is represented by two activities as well which only differ in output price levels. Sugar beets produced under quota (compare Chapter 2.2.2) achieve output prices of 33 EUR per tonne compared to 25 EUR per tonne for sugar beets produced for industrial purposes. The chosen price level for sugar beets under quota reflects the final stage of price cuts under the reform of the EU sugar market organization (see Chapter 2.2.2) to provide a more appropriate picture about future competitiveness of sugar beet production. Sugar beets for industrial use (compare Chapter 5.3.3.1) are produced independently from the quota regime based on individual delivery contracts. As with rapeseed, both activities feature conventional tillage systems. Since input levels for both activities are the same, sugar beets produced under quota have a higher gross margin compared to industrial sugar beets (907 vs. 427 EUR/ha) which is due to higher output price level for quota sugar beets.

Wheat production is differentiated by five different cropping activities which differ in terms of preceding crop, tillage system and yield level. Wheat following rapeseed achieves highest yield level (8.5 t/ha) and also highest gross margin level (382 EUR/ha) of all wheat cropping activities. This is due to a yield advantage and low operating costs since wheat on rapeseed is seeded using minimum tillage.

Table 6.1: Cropping activities of the prevailing crop portfolio for DE300EW

Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Sugar Beets (Plow, 8.2 t/ha)	Wheat on Sugar Beets (Min-Till, 8.2 t/ha)
Yield (t/ha)	3.9	4.5	60	60	8.5	8.2	8	7.8	8.3	8.2	8.2
Price (EUR/t)	225	225	33	25	125	125	125	115	115	125	125
	EUR/ha	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**
Market Returns	917	1,058	1,980	1,500	1,063	1,025	1,000	897	955	1,025	1,025
Other Returns											
Total Returns	**917**	**1,058**	**1,980**	**1,500**	**1,063**	**1,025**	**1,000**	**897**	**955**	**1,025**	**1,025**
Direct Costs											
Seed	55	55	230	230	46	48	50	40	55	48	48
Chemicals											
Herbicides	83	83	195	195	46	46	50	55	36	46	46
Fungicides	60	60	10	10	80	80	85	60	55	80	80
Insecticides	21	21			10	10	10	2	10	10	10
Growth Regulators	5	5			10	10	11	20	18	10	10
Other	12	12	10	10	5	5	5	5	5	5	5
Fertilizer											
Nitrogen (N)	90	105	55	55	90	90	95	85	70	90	90
Phosphorus (P)	27	27	20	20	25	25	25	23	21	25	25
Potash (K)	17	17	20	20	20	20	20	18	18	20	20
Lime (CaO)	12	12	10	10	15	15	15	15	15	15	15
Other	8	8			5	5	5			5	5
Hail Insurance	12	12	10	10	11	11	11	11	11	11	11
Calculated Interest (5%)	9	10	7	7	8	8	8	7	7	8	8
Total Direct Costs	**411**	**427**	**567**	**567**	**371**	**373**	**390**	**341**	**321**	**373**	**373**
Net Returns over Direct Costs	**506**	**631**	**1,413**	**933**	**692**	**652**	**610**	**556**	**634**	**652**	**652**
Operating Costs											
Machinery Costs	128	128	99	99	106	100	132	132	133	109	90
Custom Work	120	120	313	313	115	115	120	120	120	115	115
Fuel Costs	55	55	47	47	41	38	56	56	56	43	34
Labor Costs	59	59	46	46	48	44	59	59	59	48	41
Total Operating Costs	**360**	**361**	**506**	**506**	**309**	**297**	**367**	**367**	**368**	**315**	**280**
Net Returns over Direct and Operating Costs	**145**	**269**	**907**	**427**	**382**	**355**	**243**	**189**	**266**	**337**	**372**

Source: Own calculations based on panel-approach.

Wheat following sugar beets has a yield level of 8.2 tonnes per hectare and a gross margin of 355 EUR/ha. Difference in gross margin compared to wheat on rapeseed is caused by lower market returns. Operating costs for this activity are low though tillage operations are split between conventional (plow) and minimum tillage. On average, half of wheat following sugar beet acreage is seeded on plowed land. This is mostly the case for wheat seeded in late fall due to late harvest of sugar beets when wet soil conditions require plowing for establishing a proper seedbed. Remaining acreage of wheat on sugar beets is seeded applying minimum tillage under comparably dry soil conditions. Detailed figures for wheat on sugar beets at different tillage operations are thus presented in Table 6.1 for illustrating differences in operating costs only.

Wheat following wheat is the wheat cropping activity with lowest yield level (8.0 t/ha) and lowest gross margin (243 EUR/ha). Lowest gross margin among all wheat cropping activities is caused by lower market returns and higher direct costs as well as higher operating costs. Direct input in wheat following wheat is higher due to increased weed and disease pressure. Higher operating costs are due to conventional tillage compared to minimum tillage and minimum/conventional tillage for the other wheat cropping activities.

Winter barley and winter rye are represented each by one cropping activity featuring conventional tillage only. Both crops are seeded following cereals, usually following wheat. Winter barley achieves a lower gross margin than winter rye (189 vs. 266 EUR/ha).

Among all crops, sugar beets achieve highest gross margins (907 EUR/ha for quota sugar beets and 427 EUR/ha for industrial sugar beets). Wheat on rapeseed and wheat on sugar beets follow with gross margins of 382 EUR/ha and 355 EUR/ha respectively. Wheat on wheat, winter rye and high yielding rapeseed show gross margins ranging around 250 EUR/ha. Winter barley and low yielding rapeseed show lowest gross margins among all cropping activities (189 EUR/ha and 145 EUR/ha respectively). Compared to the initial crop portfolio for DE300EW described in Chapter 5.3.1 and 5.3.3, industrial rapeseed and set-aside are not included in this analysis. Industrial rapeseed is left out for reasons of simplicity and set-aside is not included since mandatory set-aside has been suspended by the European Commission from crop year 2007/2008 onwards.

6.1.2 Assessment and comparison of conservation tillage systems

Cropping activities based on minimum tillage operations include nine different activities for seven different crops (Table 6.2). Conservation tillage cropping activities have the same general characteristics as those for the prevailing crop portfolio (yield and output price levels) however tillage system applied is different (conservation vs. conventional tillage). Also, two potential cropping activities (faba beans and spring wheat) are included.

Table 6.2: Potential cropping activities and minimum tillage cropping activities for DE300EW

Cropping Activity	Rapeseed (Min-Till, 3.9 t/ha)	Rapeseed (Min-Till, 4.5 t/ha)	Sugar Beets Quota (Min-Till, 60 t/ha)	Sugar Beets Industrial (Min-Till, 60 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Winter Barley (Min-Till, 7.8 t/ha)	Winter Rye (Min-Till, 8.3 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)	Spring Wheat (Min-Till, 5.0 t/ha)
Yield (t/ha)	3.9	4.5	60	60	8	7.8	8.3	4.3	5
Price (EUR/t)	235	235	33	25	125	115	115	125	125
	EUR/ha	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**	**EUR/ha**
Market Returns	917	1,058	1,980	1,500	1,000	897	955	538	625
Other Returns									
Total Returns	**917**	**1,058**	**1,980**	**1,500**	**1,000**	**897**	**955**	**538**	**625**
Direct Costs									
Seed	55	55	260	260	50	40	55	35	50
Chemicals									
Herbicides	101	101	195	195	75	75	62	55	40
Fungicides	60	60	10	10	90	60	60	20	55
Insecticides	21	21			10	2	10	12	5
Growth Regulators	5	5			11	20	18		
Other	12	12	10	10	5	5	5	5	5
Fertilizer									
Nitrogen (N)	90	105	55	55	95	85	70	10	40
Phosphorus (P)	27	27	20	20	25	23	21	15	12
Potash (K)	17	17	20	20	20	18	18	10	10
Lime (CaO)	12	12	10	10	15	15	15	10	10
Other	8	8			5				
Hail Insurance	12	12	10	10	11	11	11	8	8
Calculated Interest (5%)	10	10	7	7	9	7	7	4	5
Total Direct Costs	**430**	**445**	**597**	**597**	**421**	**361**	**352**	**184**	**240**
Net Returns over Direct Costs	**487**	**613**	**1,383**	**903**	**579**	**536**	**603**	**354**	**385**
Operating Costs									
Machinery Costs	107	107	92	92	108	108	102	58	85
Custom Work	120	120	313	313	120	120	120	178	120
Fuel Costs	44	44	39	39	45	45	43	26	39
Labor Costs	51	51	54	54	50	49	47	27	40
Total Operating Costs	321	322	498	498	322	321	312	289	283
Net Returns over Direct and Operating Costs	**165**	**291**	**885**	**405**	**257**	**215**	**291**	**64**	**102**

Source: Own calculations based on panel-approach.

Wheat on rapeseed and wheat on sugar beets are not included in Table 6.2 since these activities are already part of the prevailing crop portfolio. Furthermore, wheat on rapeseed is always seeded using minimum tillage. The particular situation for wheat on sugar beets is described in Section 6.1.1.

Spring wheat and faba beans are included as two activities which have a potential – though very limited – to replace other broadleaf crops (faba beans) and cereals (spring wheat). Both crops show lowest gross margins for all activities (64 and 102 EUR/ha respectively). Since both crops are spring seeded, the general disadvantage of spring seeded crops (except sugar beets) in terms of yield and gross margin level on this location can be observed. Thus, faba beans are usually not included in the crop portfolio. Spring wheat is only included if weather and soil conditions do not allow for appropriate establishment of cereals (mainly winter wheat) in the fall. Spring wheat is thus not considered a “first choice” cropping activity.

Compared to cropping activities based on conventional tillage (plow), conservation tillage activities differ in direct input levels and operating input levels (Table 6.1). Generally, direct costs are higher and operating costs are lower (Table 6.3). Higher direct costs result from higher input of herbicides (rapeseed and cereals) and fungicides (wheat and rye). Direct input for minimum tillage sugar beets is higher due to increased seed expenses for mustard grown as an intermediate crop. Cost disadvantage for direct costs of conservation tillage activities ranges from 18 EUR per hectare to 31 EUR per hectare.

Table 6.3: Cost and return advantage of conservation tillage activities over conventional tillage activities for DE300EW

Cropping Activity	Rapeseed (3.9 t/ha)	Rapeseed (4.5 t/ha)	Sugar Beets Quota (60 t/ha)	Sugar Beets Industrial (60 t/ha)	Wheat on Wheat (8.0 t/ha)	Winter Barley (7.8 t/ha)	Winter Rye (8.3 t/ha)
Difference in Cost and Returns				**EUR/ha**			
Direct Costs	18	18	30	30	31	20	31
Operating Costs	-39	-39	-8	-8	-46	-46	-56
Net Returns over Direct and Operating Costs	-21	-21	22	22	-15	-26	-25

Source: Own calculations based on panel-approach.

Operating costs for conservation tillage systems are lower ranging from 8 EUR per hectare to 56 EUR per hectare. Fewer field operations and higher labor productivity result in lower machinery, fuel and labor costs compared to conventional tillage activities. For sugar beets, seeding of mustard as an intermediate crop reduces advantages in operating costs compared to other minimum tillage activities. Compared to conservation tillage systems on other locations in Germany (e. g., DE1300SA), cost advantages in operating costs are lower due to required deep tillage operations for soil aeration.

Cost advantages in operating costs are reduced by cost disadvantages in direct costs. Overall, conservation tillage activities achieve a cost advantage ranging from 15 to 26 EUR per hectare compared to conventional tillage activities. Seeding of intermediate crops results in an overall cost disadvantage of minimum tillage activities for sugar beets of 22 EUR per hectare.

When comparing conservation tillage activities and conventional tillage activities for DE300EW, cost advantages of conservation tillage shown in Table 6.3 have to be further reduced for an appropriate assessment. Experiences of farmers participating in the producer panel meetings show higher direct input levels ranging from 20 to 50 EUR per hectare for rapeseed and cereal activities based on conservation tillage. Cost figures presented in Table 6.3 include higher direct costs at the lower end of this range to reflect the optimum case. Thus, for an overall assessment of conservation tillage activities, direct input levels can easily increase by 20 to 30 EUR per hectare for rapeseed and cereals. This leads to a further reduction of apparent cost advantages resulting in only minor overall differences in net returns over direct and operating costs.

Further, experiences of farmers participating in the producer panel show increased yield variability for crops produced based on minimum tillage systems. Also, management input for conservation tillage systems is higher. Given these factors and only minor overall cost advantages, a general application of conservation tillage systems for all cropping activities does not lead to a significant increase in whole farm gross margin for DE300EW. Discussions with the producer panel revealed two major factors which would lead to a general shift to conservation tillage systems. Locations within Eastern Westphalia-Lippe characterized by heavy soils, shallow soils or sloping soils show yield and cost advantages under conservation tillage systems due to better crop establishment. Further, cash crop farms over 600 hectares in farm size show advantages in operating costs, better organization of the whole farm operation and lower management input in this region. Both factors do not apply to DE300EW since prevailing soil types are sandy loams and existing farm size and labor organization (mainly family labor) can be handled by conventional tillage systems (compare Chapter 5.1.2).

Analysis of factors determining crop portfolio composition and rotation choice revealed requirements in terms of alternation of broadleaf and cereal crops in zero and conservation tillage systems for CA1800AB, CA4000SK and DE1300SA (see Chapter 5.3). A change to conservation tillage systems for DE300EW might thus impose requirements in this regard as well and provide further options for analysis. Again, this factor does not apply to DE300EW. Statements and experiences of panel participants pointed out that crop rotations do not have to be changed under conservation tillage systems on this location.

Thus, the general cropping system sequence of broadleaf – cereal – cereal – (cereal) (see Chapter 5.3) is maintained under conservation tillage systems as well.

As a conclusion, cropping activities with conservation tillage, as long as not already included in the prevailing crop portfolio (wheat on rapeseed and sugar beets), are not included in further analysis of adjustments in crop portfolios under changing output price relations.

6.1.3 Crop rotations

Based on the different cropping activities described in Section 6.1.1, different feasible crop rotations are defined for further analysis. Table 6.4 shows 18 different crop rotations based on the general cropping system sequence of broadleaf – cereal – cereal (– cereal – cereal) and prevailing interdependencies between crops.

Rotations 1 to 4 include rapeseed (3.9 t/ha) and up to four cereal crops following. Wheat is following rapeseed due to highest yield and gross margin. If barley is included in the rotation, it is placed as the last element since barley has lowest requirements with regard to preceding crop among all crops. Different rotation lengths are defined to vary share of rapeseed in the rotation (20 % in rotation 1 to 33 % in rotation 3 and 4).

Rotations 5 to 8 show the same setting as rotations 1 to 4. The low yielding rapeseed activity is replaced by the higher yielding rapeseed activity (4.5 t/ha). Rotations including this type of rapeseed activity can only be selected on land which is usually devoted to sugar beets (see Chapter 6.1.1) and thus when competitiveness of sugar beets is lower than for this activity.

Rotations 9 to 13 include sugar beets under quota and up to four cereal crops following. Thus, setup of these rotations is similar to rotations 1 to 4. Rotation 14 is different from the other rotations since two broadleaf crops (sugar beets and rapeseed) are included. Each broadleaf crop is followed by wheat due to favorable yield and gross margin levels. This rotation is designed to increase share of rapeseed in the overall crop portfolio. Including sugar beets and rapeseed in the same rotation has some agronomical disadvantages and can thus be critical. Old crop rapeseed plants may be found in new sugar beet crop and have to be controlled by herbicides which can be critical and increases costs.

Rotations 15 and 16 have the same setup as rotations 11 and 12. Sugar beets under quota are replaced by industrial sugar beets. Rotation 17 has the same setting as rotation 1 while rapeseed is replaced by faba beans. This rotation is designed to include an alternative broadleaf crop to rapeseed and sugar beets in the crop portfolio when needed. Rotation 18 includes only cereals reflecting the potential of this location for continuous cropping of cereals. Different cereals are included to lower share of wheat and relax work load at seeding and harvesting periods.

Table 6.4: Feasible crop rotations for DE300EW

Rotation Index	Rotation Element 1st	 2nd	 3rd	 4th	 5th
1	1 Rapeseed (Plow, 3.9 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)
2	1 Rapeseed (Plow, 3.9 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)	
3	1 Rapeseed (Plow, 3.9 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)		
4	1 Rapeseed (Plow, 3.9 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)		
5	2 Rapeseed (Plow, 4.5 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)
6	2 Rapeseed (Plow, 4.5 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)	
7	2 Rapeseed (Plow, 4.5 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)		
8	2 Rapeseed (Plow, 4.5 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)		
9	3 Sugar Beets Quota (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)
10	3 Sugar Beets Quota (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)	
11	3 Sugar Beets Quota (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	
12	3 Sugar Beets Quota (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)		
13	3 Sugar Beets Quota (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)		
14	3 Sugar Beets Quota (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	2 Rapeseed (Plow, 4.5 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	
15	4 Sugar Beets Industrial (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	
16	4 Sugar Beets Industrial (Plow, 60 t/ha)	6 Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)		
17	19 Faba Beans (Min-Till, 4.3 t/ha)	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)
18	5 Wheat on Rapeseed (Min-Till, 8.5 t/ha)	14 Wheat on Wheat (Min-Till, 8.0 t/ha)	8 Winter Barley (Plow, 7.8 t/ha)	9 Winter Rye (Plow, 8.3 t/ha)	7 Wheat on Wheat (Plow, 8.0 t/ha)

Figures associated to rotation elements refer to index of cropping activities used for calculation.

Source: Own illustration based on panel-approach.

It has to be noticed that gross margins for activities and crop rotations are biased to some extent. Biases result from definition of activity costs and returns as well as activity choice for crop rotation design. This is accepted to reduce and ease modeling input and since biases are negligible with regard to overall rotation choice. In particular, direct input is assumed to be constant for each activity over all crop rotations defined. For example, direct input for sugar beets will be higher in rotation 14 to control for rapeseed in sugar beet crop. A bias in rotation design is accepted for rotation 18 where wheat on rapeseed and wheat on wheat (min-till) activities are included in the rotation to represent wheat on wheat (plow). Bias in average rotation gross margin though is less than 20 EUR per hectare and can thus be neglected. A general bias exists in defining cropping activities since direct input and field operations differ from farm to farm which provided the background data for modeling of activities.

6.2 Commodity price relationships and price development scenarios

For analysis of crop portfolio adjustments under changing output price relations, 18 different scenarios of crop output price development are defined (Table 6.5). Crops grown in DE300EW include rapeseed, sugar beets, wheat, rye and barley. Price developments are calculated for rapeseed, sugar beets and wheat. Prices for wheat, rye and barley are highly correlated with a coefficient of 0.970 for wheat and rye and 0.984 for wheat and barley (compare Chapter 2.4.2. and Figure 2.18).[1] Thus, price developments for rye and barley are linked to wheat price development based on respective correlation coefficients. Further, prices of industrial sugar beets are linked to price development of quota sugar beets with a coefficient of 0.75. This assumption further reduces number of scenarios.

Table 6.5: Scenarios of crop output price development

Scenario		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Price	Rapeseed	=	▼	▼	=	=	=	▼	▲	▲	=	=	=	▲	▲	▼	▲	▼	=	=
Development	Sugar Beets	=	▼	=	▼	=	▼	=	▲	=	▲	=	▲	=	▼	▲	=	=	▲	▼
	Wheat	=	=	▼	▼	▼	=	=	=	▲	▲	▲	=	=	=	=	▼	▲	▼	▲

"▲" = price increment, "▼" = price decrement, "=" = unchanged price.

Source: Own illustration.

The baseline scenario (scenario 0) reflects output prices and crop portfolio composition under status quo, based on crop portfolio and prices defined under Stage one of the extended panel-approach for DE300EW (compare Chapter 5.3.3). Scenarios 1 to 6 include

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[1] Based on ZMP (various years).

a price decrement for one or two of three crops holding prices for remaining crop(s) constant (c. p.). Scenarios 7 to 12 have the same setup as scenarios 1 to 6 while declining price developments are replaced by increasing price developments. Scenarios 13 to 18 include a price increment for one crop and a price decrement for another. Price development for the remaining crop is unchanged.

Table 6.6: Development of crop output prices and price relationships

Wheat vs. Rapeseed				**Wheat vs. Sugar Beet**			
Price (EUR/t) Wheat	Rapeseed	**Price Ratio**	**Change in Price Ratio**	**Price (EUR/t)** Wheat	Sugar Beet	**Price Ratio**	**Change in Price Ratio**
125	118	0.94	-50%	125	16	0.13	-50%
125	141	1.13	-40%	125	20	0.16	-40%
125	165	1.32	-30%	125	23	0.18	-30%
125	188	1.5	-20%	125	26	0.21	-20%
125	212	1.69	-10%	125	29	0.23	-10%
125	235	1.88	Initial Setup	125	33	0.26	Initial Setup
125	259	2.07	10%	125	36	0.29	10%
125	282	2.26	20%	125	39	0.31	20%
125	306	2.44	30%	125	42	0.34	30%
125	329	2.63	40%	125	46	0.36	40%
125	353	2.82	50%	125	49	0.39	50%

Rapeseed vs. Wheat				**Rapeseed vs. Sugar Beet**			
Price (EUR/t) Rapeseed	Wheat	**Price Ratio**	**Change in Price Ratio**	**Price (EUR/t)** Rapeseed	Sugar Beet	**Price Ratio**	**Change in Price Ratio**
235	66	0.28	-50%	235	18	0.08	-50%
235	79	0.34	-40%	235	21	0.09	-40%
235	92	0.39	-30%	235	25	0.11	-30%
235	105	0.45	-20%	235	28	0.12	-20%
235	118	0.5	-10%	235	32	0.14	-10%
235	132	0.56	Initial Setup	235	35	0.15	Initial Setup
235	145	0.62	10%	235	39	0.17	10%
235	158	0.67	20%	235	42	0.18	20%
235	171	0.73	30%	235	46	0.2	30%
235	184	0.78	40%	235	49	0.21	40%
235	197	0.84	50%	235	53	0.23	50%

Sugar Beet vs. Wheat				**Sugar Beet vs. Rapeseed**			
Price (EUR/t) Sugar Beet	Wheat	**Price Ratio**	**Change in Price Ratio**	**Price (EUR/t)** Sugar Beet	Rapeseed	**Price Ratio**	**Change in Price Ratio**
33	63	1.9	-50%	33	113	3.41	-50%
33	75	2.27	-40%	33	135	4.09	-40%
33	88	2.65	-30%	33	158	4.77	-30%
33	100	3.03	-20%	33	180	5.46	-20%
33	113	3.41	-10%	33	203	6.14	-10%
33	125	3.79	Initial Setup	33	225	6.82	Initial Setup
33	138	4.17	10%	33	248	7.5	10%
33	150	4.55	20%	33	270	8.18	20%
33	163	4.93	30%	33	293	8.87	30%
33	175	5.31	40%	33	315	9.55	40%
33	188	5.69	50%	33	338	10.23	50%

Source: Own calculations.

Calculated developments of crop output prices and price relationships are shown in Table 6.6. Based on initial prices and price relationships derived from data from Stage one of the extended panel-approach, output prices for the different crops are calculated by changing price relationships by 10 % at each step. Price ratios are changed over a -50 % to +50 % range. Thus, each scenario is based on five price steps either including a -50 % to -10 % price decrement or a +10 % to +50 % price increment.

6.3 Crop portfolio composition under changing output price relations

Constraints for the different cropping activities which influence crop portfolio composition are described in Chapter 6.3.1. Detailed and extended results for crop portfolio composition under the different scenarios are included in the Appendix. Thus, calculations and presentations of results are explained in Chapter 6.3.2 to provide an understanding of detailed results included in the Appendix. Changes in crop portfolio composition for the different scenarios are then described in Chapter 6.3.3, followed by an overall assessment of crop portfolio composition under changing crop output price relationships in Chapter 6.3.4.

6.3.1 Activity constraints for crop portfolio composition

For composition of crop portfolios, different constraints which limit acreage of certain crops have been identified by the producer panel (Table 6.7). Constraints imposed reflect determinants of crop portfolio composition as described in Chapter 5.3.3.

Table 6.7: Constraints imposed for crops and cropping activities

Cropping Activity	**Acreage in ha**[1)]	**Share in portfolio in %**[1)]	**Constraint type**[1)]
Sugar Beets Quota	Max. 33	Max. 11%	Max. quota allowance: 1980 t @ 60 t/ha
Sugar Beets Industrial	Max. 7.5	Max. 2.5%	Max. annual delivery contract: 450 t @ 60 t/ha
Rapeseed	Max. 100	Max. 33%	Critical disease level: Long-term disease build-up
Rye	Max. 50	Max. 17%	Harvest & quality risk: 2 harvest days @ 25 ha/d
Barley	Min.	Min.	Establishment of rapeseed: Min. 33% of rapeseed acreage
Wheat	Max. 180	Max. 60%	Machinery & Labor capacity: Limit peak work load

1) Max = Maximum, Min = Minimum.

Source: Own illustration based on panel-approach.

Acreage of sugar beets is limited by maximum quota allowance devoted to the farm (compare Chapter 2.2.2.1). Also acreage is limited at 7.5 hectares for industrial sugar beets reflecting maximum delivery amount of 450 tonnes. This restriction is imposed since industrial disposition of sugar beets is a niche market. Acreage of rapeseed is limited under all circumstances at 33 % of a rotation and thus of the overall portfolio due to long-term disease build up and yield depressing agronomical effects.

Acreage of rye is limited by a constraint in harvest capacity. In order to limit risk of low grain quality an effective harvest for total rye acreage is necessary. Thus, total rye acreage is limited at 50 hectares resulting from two harvest days with a capacity of 25 hectare a day. A minimum acreage is required for barley which depends on total rapeseed acreage in the portfolio. 33 % of all rapeseed has to be grown on barley since establishment of rapeseed is less risky on barley and emergence of rapeseed on difficult soils is much better following barley. Total wheat acreage is limited at 60 % of the overall portfolio to limit peak work load at seeding and harvesting periods. Though custom work is available at this location to relax peak periods, wheat acreage is limited and barley and rye are included in the overall portfolio to diversify production and marketing risks in cereal production.

6.3.2 Presentation of results

Results for the different scenarios are illustrated in different figures and tables in the Appendix. Illustration of results for each scenario includes output prices and price ratios used for calculation of gross margins (Table 6.8), calculated gross margins for the different activities based on development of output prices (Table 6.9) and changes in total gross margin and crop portfolio composition (Table 6.10).

Table 6.8: Output prices and price ratios for scenario 1

Scenario		**1**	**Price Steps / Price (EUR/t)**					**Initial Price (EUR/t)**	**Price Steps / Price (EUR/t)**				
Price Index	**Crop**	**Price Development**	1 -50%	2 -40%	3 -30%	4 -20%	5 -10%		1 +10%	2 +20%	3 +30%	4 +40%	5 +50%
1	Rapeseed	▼	118	141	165	188	212	235					
2	Sugar Beet	▼	16	20	23	26	29	33					
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet	12	15	17	20	22	25					
Price Ratio	Wheat	Rapeseed	0.94	1.13	1.32	1.5	1.69	1.88					
	Wheat	Sugar Beet	0.13	0.16	0.18	0.21	0.23	0.26					
	Rapeseed	Sugar Beet						0.14					

Source: Own calculations based on panel-approach.

Table 6.8 includes development of crop output prices for each price step based on prices shown in Table 6.6. Prices are calculated depending on direction of development trends: "▼" indicates declining output prices, "▲" indicates increasing output prices and "=" indicates constant output prices for respective crops. As mentioned in Chapter 6.2, price development for rye and barley is linked to wheat price and prices for industrial sugar beets are linked to prices for quota sugar beets. According to development of output prices, development of output price ratios is illustrated as well.

Table 6.9: Gross margins and share of crops in crop portfolio under status quo

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
0	-	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = =	**Cropping Activity[1)]**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow 60 t/ha)	Sugar Beets Industrial (Plow 60 t/ha)	Wheat on Rapeseed (MT, 8.5 t/ha)	Wheat on Sugar Beets (Plow/MT 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (MT, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	382	355	243	189	266	257
Crop Acreage (ha)		300	55	0	33	3	55	36	55	39	24	0
Share in crop portfolio		100%	18%	0%	11%	1%	18%	12%	18%	13%	8%	0%
Total GrossMargin (EUR)		100,124	7,986	0	29,946	1,282	21,014	12,786	13,427	7,304	6,379	0
Rotation Index			3	4	10	11	13	15				
Rotation Acreage (ha)			85	80	12	84	27	12				
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	55	36	146	24	39	0				
Share in crop portfolio		100%	18%	12%	49%	8%	13%	0%				

1) MT = Minimum Tillage.

Source: Own calculations based on panel-approach.

Based on development of crop output prices, cropping activity gross margins are calculated for each price step in each scenario. This is demonstrated in Table 6.9 for scenario 0, which reflects status quo of crop portfolio composition for DE300EW. In addition to cropping activity gross margins, share of each activity in the portfolio and contribution of each activity to total farm gross margin are illustrated. Share of each activity in the crop portfolio is derived from acreage allocated to selected crop rotations. Crop rotations chosen for each price step are illustrated using index numbers. Different crop rotations and related index numbers are shown in Table 6.4 in Chapter 6.1.3.

Crop portfolio composition for DE300EW under status quo comprises of rapeseed with a share of 18 % and sugar beets with a total share of 12 %. Wheat is dominating among cereal crops with a total share of 49 %, with barley (13 %) and rye (8 %) following.

Changes in whole farm gross margin and changes in acreage of each crop for each price step are illustrated to demonstrate the influence of changing output prices on crop portfolio composition (Table 6.10).

Table 6.10: Change in gross margins and share of crops in crop portfolio for scenario 1

Scenario	Change in Price Ratios			Change in Total Gross Margin			Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%						
1	-50%	-50%	=	76,342	-24%	-	-100%	-100%	9%	150%	55%
	-40%	-40%	=	76,354	-24%	12	-100%	-9%	20%	88%	19%
	-30%	-30%	=	82,724	-17%	6,370	-100%	-9%	20%	88%	19%
	-20%	-20%	=	89,094	-11%	6,370	-100%	-9%	20%	88%	19%
	-10%	-10%	=	88,006	-12%	-1,088	-28%	0%	3%	38%	3%

Source: Own calculations based on panel-approach.

Crop portfolio composition under the different scenarios of price development defined in Chapter 6.2 is described based on figures and tables included in the Appendix (Figure A22 to Figure A39 and Table A24 to Table A41 in the Appendix).

Scenario 1 (Figure A22 and Table A24)

In Scenario 1, prices for rapeseed and sugar beets decline while holding prices for wheat constant. Resulting gross margins for rapeseed and sugar beets at step one (lowest prices) are negative and thus both crops are not included in the portfolio. Faba beans are selected at a share of 7 % to include some broadleaf crop. Share of barley and rye increase compared to status quo – even above limits set by constraints – to reduce share of wheat for diversification of risks and work load. Price increase for sugar beets at step two is sufficient for including quota sugar beets in the portfolio, thus replacing faba beans as a broadleaf crop. Portfolio composition is the same for price steps two to four, since expansion of quota sugar beets is limited by the quota restriction and rapeseed is not competitive compared to cereals. At step five, portfolio composition is approaching the situation under status quo. Rapeseed is included at 13 % replacing rye, wheat and barley. Further, industrial sugar beets are included at 1 %.

Whole farm gross margin has declined by 24 % at step one compared to the initial situation. Increase in sugar beet and rapeseed prices from step one to two results in a nearly unchanged gross margin, since sugar beets are substituted for faba beans and rapeseed is not included in the portfolio. Total gross margin increases by 6,370 EUR from step two to three and from three to four which is only due to price increase for sugar beets. From step four to five, change in gross margin is slightly negative (-1,088 EUR) since crop portfolio is reorganized again. Decrease in gross margin is accepted by producers due to increased diversification of risks and work load.

Scenario 2 (Figure A23 and Table A25)

In Scenario 2, prices for rapeseed and cereals decline while holding prices for sugar beets constant. Decline in prices for rapeseed and all cereals results in maximum expansion of sugar beets, both quota sugar beets (11.5 %) and industrial sugar beets (2.5 %) at all price steps. Gross margins of cereals and rapeseed are low or negative at price steps one to four leading to an inclusion of faba beans in the portfolio. At step five, increase in rapeseed price is sufficient to replace faba beans.

Whole farm gross margin is negative at price step one (-12,397 EUR) and increases by 22,113 EUR at each step until step four. This increase is only caused by increase in cereal prices since rapeseed is not included and prices for sugar beets remain constant. Increase in gross margin from step four to five is lower than for the other price steps (20,440 EUR) which is caused by portfolio reorganization. Again, lower increase in gross margin is accepted due to increased portfolio diversification.

It has to be noted that if expected prices reach levels as calculated for step one and whole farm gross margin is negative or around zero, production of crops will cease for DE300EW. In such a situation, reorganization of the farm operation is likely to happen.

Scenario 3 (Figure A24 and Table A26)

In Scenario 3, prices for sugar beets and cereals decline while holding prices for rapeseed constant. At price steps one and two, gross margins for sugar beets are low or negative resulting in substitution of sugar beets by rapeseed. Rapeseed is expanded to the maximum, limited by the imposed constraint at a share of 33 % in the portfolio. Rye is replaced by barley to comply with the minimum acreage constraint imposed for barley (33 % of rapeseed must be grown following barley). At price steps three and four, gross margins for quota sugar beets are highest among all crops leading to expansion of quota sugar beets to maximum quota allowance (11 %). Since gross margins for cereals are either negative or lower than for rapeseed at both price steps, expansion of sugar beets replaces cereals instead of rapeseed. At price step five, gross margin advantage of industrial sugar beets has increased compared to rapeseed resulting in inclusion of industrial sugar beets in the portfolio at 1 %.

Whole farm gross margin is negative at price step one and reaches 5,205 EUR at step two. From step two to three, increase in gross margin is highest (35,133 EUR) due to inclusion of quota sugar beets. Further increases in prices for sugar beets and cereals result in total gross margin increase at around 26,000 EUR per price step.

Scenario 4 (Figure A25 and Table A27):

In Scenario 4, prices for cereals decline while holding prices for rapeseed and sugar beets constant. Since gross margins for cereals are negative (price steps one and two) or low (steps three and four), share of rapeseed and sugar beets has to be maximized. Share of these crops is limited at 33 % in a rotation (rapeseed) and by quota and delivery allowance (sugar beets). This results in a share of 41 % of both crops in the portfolio at price steps one to four. This can only be achieved by incorporating rapeseed into the sugar beet rotation (see rotation 14 in Table 6.4). Share of cereals is determined by gross margin advantage for wheat and minimum acreage requirement for barley. Thus, rye is not included. At price step five, rapeseed is substituted by rye at 5 % due to gross margin advantage for rye.

Whole farm gross margin increases by 19,021 EUR for each price step except for step four to five where increase is reduced to 16,077 EUR. This difference is again accepted for increased diversification of the portfolio. Since only cereal prices are increasing in this scenario, change in total gross margin is only caused by these crops.

Scenario 5 (Figure A26 and Table A28)

In Scenario 5, prices for sugar beets are declining while holding prices for rapeseed and cereals constant. Since gross margins for sugar beets are negative or low at price steps one and two, these activities are not included in the portfolio. Thus, high yielding rapeseed activity (4.5 t/ha) can be selected to replace sugar beets. Overall, share of rapeseed is not extended to the 33 % limit since gross margins of cereals show a slight advantage against rapeseed. At price steps three and four, quota sugar beets are included in the portfolio since gross margin for sugar beets (quota) is higher than for rapeseed. Sugar beets replace barley and rye at 5 % each. Further, since rapeseed is not substituted by sugar beets, rapeseed and sugar beets are incorporated in the same rotation (rotation 14 in Table 6.4). Thus, rapeseed and sugar beets are grown in separate rotations again at step five to reduce risk and higher input associated with combined rapeseed-sugar beet-rotations.

Changes in total gross margin are comparably low for all price steps ranging from 0 to 6,435 EUR. Since only prices for sugar beets are increasing, total gross margin only increases from step three onwards when sugar beets are included in the portfolio.

Scenario 6 (Figure A27 and Table A29)

In Scenario 6, prices for rapeseed are declining while holding prices for sugar beets and cereals constant. At price steps one to four, gross margins for rapeseed are negative. Thus, rapeseed is not included in the portfolio at these price steps resulting in maximum sugar beet acreage of 14 % (both quota and industrial sugar beets). Further, 4 % of total acreage is allocated to faba beans to include some broadleaf crop on land with no sugar beet rotation. At price step five, faba beans are replaced by rapeseed since gross margins of both crops are nearly equal.

Whole farm gross margin is nearly unchanged for all price steps since rapeseed is not included in the portfolio. At step five, when rapeseed is included, gross margin change is marginally negative due to a small gross margin disadvantage of rapeseed against substituted faba beans.

Scenario 7 (Figure A28 and Table A30)

In Scenario 7, prices for rapeseed and sugar beets are increasing while holding prices for cereals constant. Price increase for rapeseed and sugar beets favors both crops over cereals and are thus maximized in acreage (40 % of the portfolio). Sugar beets are limited by quota and delivery allowance and rapeseed by the 33 % maximum acreage constraint imposed. Barley is included in the portfolio due to minimum acreage constraint imposed. Price increase and thus increase in gross margins for rapeseed and sugar beets results in unchanged portfolio composition over all price steps due to binding constraints for rapeseed and sugar beets. A 10 % price increase for rapeseed and sugar beets is sufficient to shift to a new crop portfolio composition maximizing rapeseed and sugar beet acreage.

Thus, changes in whole farm gross margins are highest (21,517 EUR) for price step one when portfolio composition is changed. Increase in total gross margin is constant at 15,603 EUR for all remaining price steps since portfolio composition remains constant.

Scenario 8 (Figure A29 and Table A31)

In Scenario 8, prices for rapeseed and cereals are increasing while holding prices for sugar beets constant. At price step one portfolio composition is similar to status quo since price increase for rapeseed is not sufficient to compete against sugar beets and cereals. At price step two, gross margins for rapeseed are competitive compared to industrial sugar beets and also competitive compared to cereals when incorporated into sugar beet rotation. This leads to an increase in share of rapeseed in the portfolio of 24 % at price step two replacing industrial sugar beets, rye and wheat. Share of barley is slightly increasing due to minimum acreage requirement. For price steps three to four further price increases lead to a further expansion of rapeseed acreage replacing rye in the portfolio. Expansion is limited by sugar beets and the 33 % rotation maximum acreage constraint thus leading to unchanged portfolio composition for price steps three to four. Quota sugar beets are included at all price steps in the portfolio despite prices are held constant. Price increases for rapeseed and cereals result in gross margins lower than those for quota sugar beets.

Shifts in crop portfolio composition at price steps one to three lead to rising increment steps in whole farm gross margin (24,459 EUR to 28,520 EUR). For price steps four and five, increase in total gross margin is constant but lower compared to step two and three (26,447 EUR).

Scenario 9 (Figure A30 and Table A32)

In Scenario 9, prices for sugar beets and cereals are increasing while holding prices for rapeseed constant. Increase in prices for sugar beets and cereals results in exclusion of rapeseed from the portfolio except for price step one and thus maximization of sugar beet and cereal acreage. Sugar beets are limited by quota and delivery allowance while rye and barley are included in the portfolio at 16 % each to limit share of wheat due to distribution of work load and risk diversification.

Increase in whole farm gross margin is highest at price step one (52,886 EUR) since unfavorable rapeseed is reduced and sugar beets and cereals (barley and rye) are expanded. Increase per price step is then declining to 35,031 EUR and remains constant for steps three to five.

Scenario 10 (Figure A31 and Table A33)

In Scenario 10, prices for cereals are increasing while holding prices for rapeseed and sugar beets constant. Increase in cereal prices and the ability for continuous cereal cropping result in exclusion of rapeseed from the portfolio at all price steps. Sugar beets are included as the only broadleaf crop at a total share of 12 % in the portfolio. Share of barley and rye is expanded compared to status quo to distribute work load and diversify risk.

Increase in whole farm gross margin is highest at price step one (43,768 EUR) due to shifts in portfolio composition. For all other price steps, increase in total gross margin is constant at 27,310 EUR resulting only from price increases for cereals.

Scenario 11 (Figure A32 and Table A34)

In Scenario 11, prices for sugar beets are increasing while holding prices for rapeseed and cereals constant. Expansion of sugar beets is limited by maximum quota allowance (11 %) and maximum delivery allowance for industrial sugar beets (2.5 %) despite further increases in gross margins. Overall, acreage of sugar beets is maximized for all price steps at 14 %. Marginal increase in acreage of industrial sugar beets replaces rapeseed while shifts in share of other crops are marginal compared to status quo.

Increase in whole farm gross margin is lower per price step (7,532 EUR) compared to other scenarios since acreage of sugar beets cannot be expanded due to constraints imposed. Since portfolio composition is constant over all price steps, increase in total gross margin is constant as well, only resulting from price increase in sugar beets.

Scenario 12 (Figure A33 and Table A35)

In Scenario 12, prices for rapeseed are increasing while holding prices for sugar beets and cereals constant. Since gross margins for rapeseed are higher than those of cereals but stay behind gross margins for quota sugar beets, acreage of rapeseed and sugar beets is maximized resulting in a share of 40 % for both crops. Expansion of both crops replaces rye and some barley. Shift in portfolio composition already takes place at price step one and portfolio composition remains constant for all other price steps.

Increase in whole farm gross margin is highest at price step one (13,467 EUR) due to shifts in portfolio composition. For all other price steps, increase in total gross margin is constant at 8,573 EUR resulting only from price increases for rapeseed. Compared to other scenarios increase in total gross margin is lower since share of rapeseed is lower compared to cereal crops.

Scenario 13 (Figure A34 and Table A36)

In Scenario 13, prices for rapeseed are increasing and prices for sugar beets are decreasing while holding prices for cereals constant. At prices steps one and two, which represent highest prices for rapeseed and lowest prices for sugar beets (+50 % /+40 % and -50 %/-40 % steps respectively), rapeseed acreage is maximized and sugar beets are excluded since gross margins for rapeseed are highest and lowest for sugar beets among all crops. Share of rapeseed is limited by the 33 % maximum acreage constraint. Expansion of rapeseed replaces acreage of rye since rye is not included in rapeseed rotations selected. At price steps three to five, increase in gross margins for sugar beets results in inclusion of quota sugar beets in the portfolio replacing part of rapeseed but mainly wheat acreage. Barley is not replaced due to minimum acreage constraint.

Change in whole farm gross margin is higher (9,785 EUR) at price steps one and two when sugar beets are not included in the portfolio. At steps three to four when sugar beets are included total gross margin changes at a lower rate at 2,187 EUR per step.

Scenario 14 (Figure A35 and Table A37)

In Scenario 14, prices for sugar beets are increasing and prices for rapeseed are decreasing while holding prices for cereals constant. At price steps one to four gross margins for rapeseed are negative or very low resulting in exclusion of rapeseed from the portfolio. Sugar beets are maximized at a share of 14 % due to favorable gross margins for both quota and industrial sugar beets. Remaining acreage is allocated to cereals with each barley and rye reaching a share of 16 % to distribute work load and diversify risks. At price step five, rapeseed is included in the portfolio with a share of 10 % replacing both parts of barley and rye acreage. Rapeseed is included despite lower gross margins compared to cereals since effects of crop diversification (work load and risks) pay-off for lower gross margin of rapeseed at this price step.

Change in whole farm gross margin is highest at the +10 %/-10 % price step (11,247 EUR) resulting from shift on portfolio composition. Changes in total gross margin are lower at the other steps (7,532 EUR) since portfolio composition is constant. Changes result only from sugar beets since rapeseed is not included in the portfolio at these price steps.

Scenario 15 (Figure A36 and Table A38)

In Scenario 15, prices for rapeseed are increasing and prices for cereals are decreasing while holding prices for sugar beets constant. Since prices for cereals are declining acreage of broadleaf crops has to be maximized. For all price steps, sugar beets and rapeseed reach a maximum share of 41 % in the portfolio. This is achieved again by incorporating rapeseed into sugar beet rotation. Further, even at highest prices gross margins for rapeseed are lower than those for quota sugar beets. Thus, quota sugar beets are included in the portfolio. At price steps four and five, gross margins for industrial sugar beets are higher than those for rapeseed and thus, industrial sugar beets are included at a share of 2.5 % replacing rapeseed.

Whole farm gross margin changes per price step range from 9,632 EUR to 10,527 EUR and are thus relatively constant. Overall, price reduction for cereals consumes most of the gains resulting from price increases for rapeseed.

Scenario 16 (Figure A37 and Table A39)

In Scenario 16, prices for cereals are increasing and prices for rapeseed are decreasing while holding prices for sugar beets constant. Decline in prices for rapeseed leads to negative or very low gross margins and thus result in exclusion of rapeseed from the portfolio. Gross margins for sugar beets are higher than for cereals and thus quota sugar beets are included to a maximum of 11 % due to quota allowance. Industrial sugar beets are included at their maximum share of 2.5 % since higher gross margin of following wheat pays-off for lower gross margin of industrial sugar beets. Disadvantages in gross margins of rapeseed exist for all price steps resulting in unchanged portfolio composition for all price steps.

Due to constant portfolio composition, changes in whole farm gross margin per price step remain constant at 25,529 EUR. Increases in total gross margin solely result from price increases for cereals since rapeseed is not included in the portfolio.

Scenario 17 (Figure A38 and Table A40)

In Scenario 17, prices for sugar beets are increasing and prices for cereals are decreasing while holding prices for rapeseed constant. Decline in cereal prices results in selection of rotations with highest shares of broadleaf crops. These are three year rotations like broadleaf – cereals – cereals. Then, share of sugar beet is maximized up to quota and delivery allowance (total share of 14 %). Remaining acreage is allocated to rapeseed – cereal – cereal rotation. Overall, share of broadleaf crops reaches 34 % in the portfolio. Rye is not included since rye is only found in extended rotations with a sequence of more than three cropping systems. Barley is included in the portfolio due to minimum acreage requirement and distribution of work load. Further, portfolio composition remains constant over all price steps.

Due to constant portfolio composition, changes in whole farm gross margin per price step remain constant at 12,744 EUR. Contribution of sugar beets to the increase is lower compared to cereals since acreage of sugar beets is not expanded.

Scenario 18 (Figure A39 and Table A41)

In Scenario 18, prices for cereals are increasing and prices for sugar beets are decreasing while holding prices for rapeseed constant. At price steps one and two when prices for sugar beets are lowest (-50 %/-40 % steps), gross margins for sugar beets are negative or low resulting in exclusion of sugar beets from the portfolio. Though gross margins for cereals are higher than those for rapeseed, some rapeseed (10 %) is included in the portfolio to include some broadleaf crop for distribution of work load and risk diversification. A change in crop portfolio composition takes places from step two to three when rapeseed is replaced by quota sugar beets. For steps three to five, portfolio composition remains unchanged.

Change in whole farm gross margin is highest from step one to two (27,882 EUR), solely caused by increase in cereal prices since sugar beets are not included in the portfolio. From step two to three, total gross margin changes by 23,685 EUR resulting from shift in portfolio composition. Changes in total gross margin remain constant for price steps three to five at 20,656 EUR since portfolio composition remains constant as well.

6.3.3 Assessment of crop portfolio composition under changing output price relations

Crop portfolio composition varies for the different scenarios of output price development. Crop portfolios are reorganized compared to portfolio composition at status quo as soon as prices for one crop change. Thus, portfolio composition is different for each of the eighteen scenarios compared to status quo. Further, crop portfolio composition differs between scenarios though some similarities can be observed.

Among all scenarios, six scenarios show changes in crop portfolio composition compared to status quo and remain unchanged for all price steps following (scenarios 7, 10, 11, 12, 16, 17). The remaining twelve scenarios show changes in crop portfolio composition compared to status quo and also changes between different price steps. For these scenarios, five scenarios show crop portfolios with only one change in portfolio composition between price steps and constant portfolio composition for remaining price steps (Scenarios 2, 4, 6, 9, 14). In these scenarios, crop portfolios are reorganized between status quo and the +10 %/-10 % step in price ratio changes and between the +10 %/-10 % step and +20 %/-20% step in price ratio changes. The remaining seven scenarios show crop portfolios with either one or two changes in portfolio composition between price steps (Scenarios 1, 3, 5, 8, 13, 15, 18). In these scenarios, portfolio composition differs at two price steps from portfolio composition at remaining price steps.

Comparison of crop portfolio composition among all price steps and scenarios reveals high degrees of stability in portfolio composition. For all scenarios, crop portfolio composition already changes when output price relations shift by 10 % not depending on direction of price shift. This indicates high sensitivity in crop portfolio composition for comparably minor price changes. Once portfolios are reorganized at the 10 % step, composition of most portfolios remains unchanged. If not, portfolio composition for most scenarios is reorganized between the 10 % step and the 20 % step and remains unchanged for remaining price steps, again not depending on direction of output price change. Only two out of eighteen scenarios (Scenarios 1 and 8) show a “developing trend” in portfolio composition, where one or more crops are expanded and others are replaced from one price step to another.

The extent of portfolio reorganization is strongly dependent on extent of price change and on type of crop for which prices are changing. Competitiveness of sugar beets (quota) is very high even for the reduced initial price level assumed. Sugar beets (quota) are included in crop portfolios in all scenarios. Sugar beets (quota) are not included in portfolios when prices reach both -50 % and -40 % price levels but at all other price levels. Under increasing prices, expansion of sugar beets is limited by quota and delivery allowances. Share of quota sugar beets are thus very insensitive to price changes. Industrial sugar beets are limited at a total share of 2.5 % thus playing only a minor role in portfolio composition. Further, the quota regime of the EU sugar market organization (see Chapter 2.2.2) and insensitivity to price changes leads to inflexible shares of sugar beets in portfolios. Quota sugar beets are either included in portfolios if gross margins are favorable or not included at all when gross margins are uncompetitive. Continuously increasing or decreasing shares of sugar beets are not observed from any of the scenarios.

Rapeseed is very sensitive to price changes. Share of rapeseed in portfolios is strongly decreasing when output prices decline. After the first and mostly after the second step in price reductions, rapeseed is excluded from portfolios in all scenarios independently from price development of other crops. Further, when prices for rapeseed are held constant and prices for cereals are increasing, rapeseed is excluded from portfolios at early price steps as well (e. g., scenarios 9 and 10). This is due to the fact that rapeseed is competing against sugar beets which are usually more competitive. Further, rapeseed is competing against cereals since continuous cereal cropping is a suitable option at this location when competitiveness (prices) of cereals is higher compared to rapeseed. Expansion of rapeseed in portfolios is limited by the 33 % maximum acreage constraint (see Table 6.7) in case of increasing output prices. Share of rapeseed in portfolios is expanding when prices for cereals and sugar beets are decreasing or remain unchanged and prices for rapeseed are increasing. Further, when prices for rapeseed and sugar beets are increasing, expansion of sugar beets is limited by quota and delivery allowances thus favoring rapeseed for expansion (Scenario 7). In case prices for rapeseed and cereals are increasing share of rapeseed in portfolios is also expanding since cereals with lower gross margins (barley and rye) are replaced.

Faba beans are only included in three scenarios since competitiveness is low compared to other broadleaf crops. Faba beans only play a minor role when included in portfolios and are considered an exception in portfolio composition.

Compared to broadleaf crops grown on DE300EW which are produced under most binding constraints (quota for sugar beets, 33 % acreage maximum for rapeseed), cereals are most flexible crops. Further, cereals can easily be substituted among each other due to similar agronomical characteristics. Lowest shares of cereals in portfolios (60 %) can be found in scenarios where prices for cereals are declining or remain unchanged and prices for rapeseed increase (scenarios 3, 4, 7, 12, 13, 15). In general, cereals remain even competitive under decreasing prices. Further, share of cereals is only slightly reduced (scenario 17) or even expanded (scenario 2) under decreasing prices when prices for rapeseed are either decreasing or remain unchanged. Overall, cereals are thus considered as “fill up” crops. Share of cereals is generally increased when competitiveness of rapeseed is lower (either due to price increases in wheat or decreases in rapeseed). Among cereal crops, wheat and barley are included in all portfolios of all scenarios. Rye has most binding constraints among cereal crops which result in exclusion of rye in some scenarios. Barley is always included since it is best suited for distribution of work load for the whole farm operation (early harvest and early seeding periods compared to other cereals). This is also reflected in the minimum acreage constraint which requires 33 % of rapeseed being grown on barley.

Price changes for the different crops have a different influence on whole farm gross margin. Adjustments in acreage allocated to sugar beets are limited the most due to quota and delivery constraints. Expansion of acreage beyond the quota limit in case of rising sugar beet prices is thus not possible. Contribution to increases in total gross margin results only from increase in sugar beet gross margins for limited acreage of sugar beets in portfolios and not from further expansion of sugar beet acreage. Compared to other crops included in portfolios, quota sugar beets show highest gross margins in the initial setup (see Table 6.1) and are thus most competitive. Competitiveness is also very high under the different scenarios since sugar beets are included in portfolios even under declining prices. Thus, sugar beets provide a comparably stable contribution to total gross margin which is though limited in case of increasing prices due to low shares in portfolios.

For rapeseed, the situation is similar to sugar beets. The maximum acreage constraint limits contribution of rapeseed to whole farm gross margin though share of rapeseed in portfolios can be extended to 33 % compared to only 14 % for sugar beets. Contribution of rapeseed to whole farm gross margin is though small since initial gross margins are lowest among all crops. Further, rapeseed is most sensitive to price changes and excluded from portfolios as soon as prices decrease. Thus, rapeseed provides no contribution to total gross margin in these cases. In scenarios with increasing prices, contribution of rapeseed to total gross margin is limited by the maximum acreage constraint. Compared to sugar beets, acreage of rapeseed can be extended to higher shares in portfolios which thus result in higher contribution to total gross margin under increasing prices compared to sugar beets.

Cereals have the highest shares in portfolios among all scenarios and thus price changes for cereals result in highest changes in whole farm gross margin. Leverage effect of minor price changes is highest for cereals due to larger shares in crop portfolios among all scenarios. In case of declining cereal prices, cereals remain included in portfolios since they are “fill up” crops for rotations. In these cases total gross margins are lowest for all scenarios. Increasing cereal prices and resulting higher gross margins contribute directly to total gross margins since acreage of cereals faces no general constraint which could limit increased contribution to total gross margin.

7 Conclusions

Conclusions from the analysis of crop portfolio composition and rotation choice under shifting output price relations can be drawn regarding factors which determine crop portfolio composition (Chapter 7.1) and the application of the extended panel-approach (Chapter 7.2).

7.1 Crop portfolio composition

The influence of changing crop output prices on crop portfolio composition and rotation choice in multi-product cash crop farms is limited. Analysis of factors determining crop portfolio composition revealed that interdependencies (jointness) between different crops included in crop portfolios lead to stability in crop rotation choice and crop portfolio composition. Altogether, crop portfolio composition and rotation choice is not only determined by economic factors (gross margin levels or profitability of crops) but also by technical factors (technical interdependencies and agronomical characteristics of crops). Depending on the degree and extent of technical factors, economic factors are outweighed in some situations. For example, rapeseed or canola cannot be extended beyond the 33% maximum acreage limit under increasing profitability since agronomical factors (disease build-up and yield depression) are stronger in limiting acreage than higher profitability would lead to expansion of acreage.

Altogether, crop portfolio composition and rotation choice is mostly predetermined by tillage systems. Zero tillage systems have the strongest requirements with regard to degree of diversification of portfolios and rotations. In particular, a consequent alternation of cereal and broadleaf crops is a requirement in zero tillage systems as applied in CA1800AB and CA4000SK. Conservation tillage (minimum tillage) systems as applied on DE1300SA also show requirements with regard to cropping system sequence and thus alternation of broadleaf and cereal crops. Lowest requirements with regard to alternation of crops are observed for conventional tillage (plow) systems applied in DE300EW resulting in most flexible crop rotations and crop portfolios among all farms analyzed.

Tillage systems prevailing at the analyzed farms are thus a major factor determining crop portfolio composition and rotation choice. Further, requirements of the different tillage systems (zero tillage, minimum tillage and conventional tillage) with regard to alternation of crops in crop rotations lead to stability and inflexibility in crop portfolio composition and rotation choice. Crops which are needed to “maintain” rotations due to their specific agronomical characteristics are included in rotations even if prices for these crops decline and thus show lower profitability. Share of such crops in portfolios under decreasing prices is strongly related to extent of benefits provided to the whole rotation and portfolio in terms of yield advantage and lower input levels for following crops. Further factors are diversification of work load and risks. On the other hand, expansion of crops is often limited to particular overall shares in rotations and portfolios due to their respective agronomical characteristics. Very often increasing disease pressure, causing long-term disease problems in rotations and portfolios, limits expansion of such crops in the case of rising prices or declining prices of competing crops.

Thus, tillage systems applied are a key factor in determining crop portfolio composition and rotation choice. The choice of tillage systems is influenced by two factors: prevailing natural location conditions and farm size. Conservation of soil moisture to increase yield levels is a major goal on locations with low precipitation and high water deficit levels. This can be observed for CA1800AB, CA4000SK and DE1300SA resulting in application of zero tillage systems (Canadian farms) and minimum tillage systems (DE1300SA). Management of high soil moisture levels is an issue for DE300EW resulting in application of deep tillage as found in conventional tillage systems.

The second factor which influences choice of tillage systems is farm size. Zero tillage systems facilitate large and very large farm operations as represented by both Canadian farms, since zero tillage systems allow the most efficient use of machinery and labor input. A change in tillage systems for both CA1800AB and CA4000SK, which might lead to different crop portfolio composition, is thus not an option; otherwise total farm reorganization and probably a smaller size of the farm operation would be the outcome. A similar situation prevails for DE1300SA. Besides conservation of soil moisture, efficient use of labor and machinery input at limited seeding windows in the fall require minimum tillage systems at existing farm size. For DE300EW, smaller farm size compared to the other farms analyzed does not require minimum tillage operations. This will change as soon as this farm will grow in size beyond a certain threshold in size, identified by the producer panel as 600 ha total farm size.

Overall stability in crop rotations and crop portfolio composition under changing crop output prices result in limited adjustments in crop acreage and thus output for all representative farms analyzed. Detailed analysis of crop portfolio composition for DE300EW revealed that portfolio reorganization already takes place under comparably minor price changes which on the other hand result in only minor adjustments in crop acreages. When price relations further shift to higher spreads, expansion of crops is soon limited by existing constraints. Exchange of crops in crop portfolios does not take place arbitrarily since alternative crops are usually limited. Altogether, producers tend to persist in prevailing rotations and crop portfolios under changing output price relations. This is due to long-term experiences and existing farm organization (machinery endowment) which is fixed in the short-run.

Analysis of crop portfolio composition and rotation choice under changing crop output price relations should therefore focus on prevailing restrictions and constraints for the different crops already or potentially included in portfolios and rotations. Assessment of overall potential for adjustments in crop portfolios under changing output prices can be carried out in a sufficient way by identification of restrictions and constraints and by assessment of their influence on (limiting) acreage of respective crops.

In addition to crop output prices, farm input prices and available technology influence crop portfolio composition and rotation choice as well. As with output prices, farm input prices have a direct influence on crop gross margins and thus do directly affect profitability. For example, prices for fuel and fertilizer have risen in the past in Canada and Germany. Crops with lower fertilizer and fuel input than other crops in the respective portfolios thus do gain in competitiveness which therefore should lead to an expansion of such crops under rising input prices. Future research should thus include farm input prices as a factor for determining crop portfolio composition and rotation choice.

Furthermore, available technology is a key factor in determining crop portfolio composition and rotation choice. New technologies as a result of technical progress influence production systems and thus choice of crop rotations and crop portfolio composition. For example, development of direct seeding technology in Canada over the last 25 years enabled expansion of zero tillage systems which led to diversified crop rotations. Breeding of new seed varieties may improve performance of particular crops compared to others and thus resulting in higher gross margins or improved agronomical characteristics. For example, GMO varieties for rapeseed have improved the agronomical characteristics of rapeseed in terms of weed control in Canada. Also, development of 00-rapeseed varieties has helped expansion of rapeseed in Germany. On the other hand, available technology might be restricted by policy means. For example, maximum fertilizer levels or limitations in use of certain chemicals will favor crops with less fertilizer and chemical input requirements. Overall, technical progress may provide new technologies and characteristics which could change determining factors of rotation choice and crop portfolio composition. Technical progress is a major factor which could lead to a change in tillage and thus production systems. Technical progress in whatever direction is thus an important factor to overcome limitations and requirements for crop portfolio composition and rotation choice imposed by tillage systems.

Finally, it has to be noted that results derived from this analysis are based on a total of four representative farms and representativeness of results is thus somewhat limited. Limitations arise from the small number of farms analyzed and their specific characteristics in terms of farm size, management performance level and natural location conditions. Each farm has to be considered a leading edge farm in terms of farm size and management performance. Determinants of crop portfolio composition and rotation choice might differ for smaller farms and lower management performance levels. Future research will thus have to analyze differences in determinants of crop portfolio composition for different farm sizes and management levels. Further, natural location conditions are a major factor in determining crop portfolio composition and rotation choice. Since these conditions differ between locations even already on a small scale within regions, a generalization of results for all locations within a country is limited and has to be handled carefully. However, determinants of crop portfolio composition and rotation choice identified for the different farms in this analysis can be assigned to other locations which show similar framework conditions and similar natural location conditions in particular. Future research will have to extent the number of representative farms on locations and regions with different natural location conditions to analyze if determinants of crop portfolio composition are similar and can thus be further generalized.

7.2 Application of the extended panel-approach

The extended panel-approach as developed in this thesis proved to be useful for analysis of crop portfolio composition and rotation choice under shifting output price relations. Application of the panel-approach enables identification of functional relationships for cash crop farms and thus within crop portfolios and crop rotations. The extended panel-approach therefore provides access to farm level information which is otherwise not available.

A major advantage of the extended panel-approach is that decision making processes on the different farms can be captured and represented by the members of the panel. Thus, analysis of decision making for crop portfolio composition is as close to reality as possible. Application of the extended panel-approach is thus also able to overcome limitations and difficulties associated with Linear Programming techniques. An appropriate modeling of decision making for crop portfolio composition using LP models is not possible in the context of *agri benchmark* research. Further, LP models assume overall maximization of target functions (i. e., gross margins). Farmers tend to have additional goals besides maximizing profit from their farm operation. Reducing risks, work load and management requirements are two major factors which may result in lower overall profits (gross margins) which are accepted by producers. Thus, by representing the decision making process of producers using the producer panel, all constraints and “soft” factors influencing overall goals and decision making are considered.

The overall requirement of applicability to the whole *agri benchmark* Cash Crop Network is fulfilled by the extended panel-approach. The first stage is already implemented and well-known to the network partners in the different countries. Resource requirements for applying the extended stages are kept at a minimum since the existing set up of the producer panel is used for further stages of analysis.

Future application of the extended panel-approach should focus on stage two since identification of factors determining crop portfolio composition and rotation choice is a necessary step for further analysis of adjustments in crop portfolios of the different farms included in the network. Identification of tillage systems as well as different restrictions and constraints prevailing at the different farms already provides sufficient data and information for assessing potential adjustments in crop portfolios under changing framework conditions.

Furthermore, leading edge farms should be further implemented in *agri benchmark* research. Leading edge farms and respective leading edge producers are the most valuable source of farm level information available. Leading edge farmers are able to provide an overview and information for different types and sizes of farm operations within respective regions. Leading edge farms are of particular interest for *agri benchmark* research since they set the tone in terms of production systems and technology as well as farm size and thus do reflect structural change and potential future shapes of cash crop farming at the different locations. Since farms analyzed in this thesis have to be considered as leading edge farms further research is necessary to analyze influence of farm size and economic performance on crop portfolio composition and rotation choice.

Analysis of adjustments in crop portfolios and thus production of agricultural commodities under changing framework conditions within the *agri benchmark* Cash Crop Network will be an ongoing task. Joint production expressed by technical interdependence of crops and further prevailing tillage systems causes stability and inflexibility in crop rotations and crop portfolios in the short-run. These influencing factors are most likely to change by technical progress in the long-run. Thus, a continuous monitoring of technical progress and developments influencing crop rotation choice and crop portfolio composition is necessary for assessment of future adjustments in production output for the different cash crop farms included in the network. In particular, changes in agricultural policy, input and output prices and technical progress have to be monitored.

The panel-approach of *agri benchmark* is suited for monitoring these kinds of changes, especially by providing a holistic approach to assess influence of such factors at the farm level from the farmer’s point of view. The overall influence of these factors on crop portfolio composition and on the farm operation in general can be monitored by consulting the producer panel on a continuous basis. Producer panel meetings should be repeated at least every three years to achieve an update about status quo situation and future developments. Periods between meetings can be shortened or extended as necessary. The panel approach is thus able to provide answers on all issues related to farm operations on short notice.

In order to enable a continuous co-operation with the different producer panels from around the world, benefits have to be provided to the different participating farmers. This is especially the case for leading edge farmers since their time resources for participation are usually very limited. Access to exclusive information as generated by *agri benchmark* and provided to panel participants is a key factor for maintaining a continuous and fruitful relationship between farmers and *agri benchmark.*

Finally, randomness and limited representativeness of results derived from the (extended) *agri benchmark* panel-approach has to be addressed in future research work of *agri benchmark*. Results from the panel-approach are strongly dependent on participants in the panel meetings. Influence of different panel composition on outcome of results should be analyzed within *agri benchmark* in the future. Further, number of representative farms (typical and leading edge) should be extended not only across countries but also within countries to provide better coverage and representativeness. As was also shown in this thesis, natural location conditions have a major influence in determining crop rotation choice and crop portfolio composition. Since natural framework conditions differ within countries and even within regions on a small scale already affecting crop choice, generalization of results on crop portfolio composition and rotation choice is limited when being based only on a small number of representative farms.

8 Summary

This thesis analyzes the influence of shifting commodity price relationships on crop rotation choice and crop portfolio composition for selected representative cash crop farms in Canada and Germany. As a necessary precondition for this analysis, factors which determine crop portfolio composition and rotation choice are identified, assessed and compared between farms and countries. Further, since this thesis is embedded in the research concept of *agri benchmark*, a methodology set for analyzing crop portfolio composition and rotation choice is developed which is feasible for analysis and application to cash crop farms within the world-wide *agri benchmark* Cash Crop Network.

Global markets for agricultural commodities are changing in consequence of increasing demand and varying supply. Population growth results in rising demand for food and growing welfare in developing and transition countries leads to increasing consumption of high-value food like meat and dairy products which increases demand for feed. Further, agricultural commodities are increasingly consumed as a feedstock in the growing bio-fuel industry. Supply of agricultural commodities is staying behind growing demand and shows increased variability from year to year. This situation is reflected in the development of prices for agricultural commodities. Prices have risen due to increasing demand and have become more volatile due to variations in supply. As a result, price relationships between different agricultural commodities are changing and might further shift in the future. Changes in price relations affect production decisions of producers since they lead to shifting profitability in the production of agricultural commodities. Changes in production decisions and thus production patterns and land use are important for farmers, policy makers, input suppliers and output processors since they affect whole supply chains and agricultural sectors world-wide.

Global cash crop production is analyzed within the *agri benchmark* Cash Crop Network which comprises of farmers, advisors and researchers from different countries around the world. *agri benchmark* Cash Crop aims to provide information and research for stakeholders in agricultural supply chains about current and future developments of global production of cash crops. Research of *agri benchmark* has been driven by ongoing trade liberalization in the past. In the future, *agri benchmark* Cash Crop will direct its research at analysis of opportunities for expansion of production and the influence of changing price relationships on production of agricultural commodities due to changing perspectives on global markets.

In developed agricultural sectors like in Canada and Germany, potential for expansion of production of agricultural commodities is limited since almost all farmland is used in production already. Furthermore, production of cash crops in these countries mostly takes place in multi-product farms under joint production systems and crop rotations resulting in the fact that acreage expansion of one crop will reduce acreage allocated to other crops. In crop portfolios of multi-product farms, technical interdependencies exist between crops leading to an interrelated efficiency, profitability and competitiveness of crops. Production decisions in multi-product farms are thus not only affected by single crop profitability but on profitability and characteristics of whole crop rotations and portfolios. Shifts in price relations in favor to one crop thus do affect composition of whole rotations and crop portfolios.

An overview of cash crop production in Canada and Germany provides background information about framework conditions for cash crop production in both countries. Both Canada and Germany are major producers and exporters of major agricultural commodities and produce mostly the same crops. The agricultural policy framework in Canada is shaped by federal and provincial programs which aim to support producers in managing their business risks. Agricultural policy in Germany is based on implementation of the Common Agricultural Policy (CAP) of the EU. Common market organizations and the Single Payment Scheme are of major relevance to producers in Germany. Further, both countries follow strategies for promoting bio-energies which have an influence on demand for agricultural commodities and farmland use. Natural framework conditions differ between as well as within both countries. Locations in Canada are characterized by short growing seasons, semi-arid climates with hot summers and low levels of precipitation resulting in high water deficits for cash crop production. Climate in Germany is more diverse. Overall, natural location conditions favor cash crop production by generating higher yield levels compared to Canadian locations. Developments of acreage, yield levels and output prices demonstrate recent and historic trends in cash crop production in both countries.

The research concept of *agri benchmark* provides the background and motivation of this thesis. *agri benchmark* is organized as a network of researchers, farmers and advisors from different countries around the world which aim to analyze global production of different agricultural commodities and products. The concept of typical farms and the producer panel-approach represent the methodological foundation for analysis of farm level competitiveness and characteristics of production of agricultural commodities and products. Cost of production comparisons are conducted to assess and compare competitiveness of different locations around the world in producing agricultural commodities and products. As an example for *agri benchmark* research, an international comparison of cost of production for major oilseeds is presented.

Analysis of crop portfolio composition and rotation choice under shifting output price relationships has to consider particularities of crop production in multi-product farms. Different enterprise relationships exist in multi-product cash crop farms that are referred to as joint production or jointness. Joint production arises from technology, which is technical interdependence between crops, or from supply, which is allocable fixed inputs (e. g., machinery) being used for the production of several crops or from both. Further, the effects of jointness are expressed by growing crops in crop portfolios and specific rotations. Joint production leads to an interrelated efficiency, profitability and competitiveness of crops which thus has to be considered in the analysis of crop portfolio composition.

Crop portfolio composition is dependent on many factors. Profit maximization is the overall goal assumed in neoclassical economics which determines choice of crops. Farmers have to choose how to allocate their limited resources and inputs among several crops, resulting in a general competitive relationship between enterprises. Further factors influence crop selection. The most important are risk management, agricultural policy and technical interdependencies. Diversification of the crop portfolio by growing various crops usually reduces risk. Agricultural policy measures may support input or output prices which affect profitability of crops in a different way. Technical interdependence between crops is manifold and is characterized as benefits and costs provided and consumed as joint products between the different crops of a portfolio. Furthermore, factors that influence crop portfolio composition, especially technical interdependencies, lead to stability in crop portfolio composition for certain ranges of both different output and input price relations.

The methodological approach for this analysis has to consider the particularities of multi-product cash crop farms (i. e. joint production) which determine crop portfolio composition and rotation choice. Since this analysis takes place in the context of the *agri benchmark* Cash Crop Network, methodology applied within the network so far is evaluated in terms of its ability to analyze the determinants of crop portfolio composition. It is revealed that costs of production are not an appropriate indicator in this context, especially since this is an ex-post, long-run concept and jointness in production is not considered. Further, gross margins might be more capable of explaining crop portfolio composition though accounting for jointness in production is difficult to achieve in an appropriate way.

Linear Programming (LP) is evaluated as another option to analyze crop portfolio composition. LP models are capable of analyzing crop portfolio composition by defining crop production processes as activities, which are described by their gross margins and requirements in regard to (limited) farm resources and other restrictions. Defining multiple activities for one crop (e. g., by differentiating in regard to preceding crops, wheat following rapeseed etc.) and imposing restrictions for these is a way of accounting for joint production in LP models. Although LP models seem to be an appropriate method for analyzing crop portfolio composition, certain disadvantages in the context of this thesis come along with this approach. A dynamic LP model with an extended matrix of activities and restrictions would be necessary to cover many crops and to consider adjustments in the production systems in the analysis. Furthermore, results (output) of the LP model would become more and more difficult to handle and interpretable. A further major limitation comes from applicability for the different research partners of the *agri benchmark* Cash Crop Network.

The methodological approach followed in this thesis is thus based on the *agri benchmark* panel-approach. Using and adapting the panel-approach for this analysis ensures applicability to the whole *agri benchmark* Cash Crop Network since the approach is well implemented and experiences with its application have been gained in the past for the different member countries. The panel-approach delivers reliable farm level data which are close to reality. Further, it is a unique data source and data and information can be compared directly across countries. Also, functional contexts within a farm operation and information not available in statistics or literature can be obtained. A major advantage of the panel-approach is timeliness of data and information. Further, potential future developments can be identified and discussed. Disadvantages associated with the panel-approach are limited representativeness of results, randomness of data sets and “social control” among panel participants. Classification of the representative farms derived from the panel-approach into whole farm population of the different regions analyzed helps to point out which type and size of farm are represented. Reliability of data sets and social control can be managed by the moderator of the panel workshop meetings by various means. Overall, managing the limited time resources of all participants is a very critical issue for successful accomplishment of the panel-approach.

For analysis of crop portfolio composition and rotation choice under shifting crop output prices, the panel-approach is extended and finally comprises of three stages. The first stage represents data collection about the physical (resources), technical (yields, inputs etc.) and monetary (prices, costs etc.) framework of the representative farms delineated from a consensus building process. This stage is already implemented within the *agri benchmark* Cash Crop Network. The second stage of the extended panel-approach identifies determinants of crop portfolio composition and rotation choice. Crop portfolio composition is closely related to machinery and equipment endowment and resulting tillage systems of farms. During this stage crop rotations are defined for the respective farm based on the different characteristics of crops. Usually, a general framework for crop rotation sequences is delineated which may look like cereals – oilseeds – cereals – pulses. Based on the general framework of crop rotations, the exact composition of the crop portfolio is formed by determining shares of each crop in the portfolio. At this step, factors which limit or enhance share of crops in portfolios are revealed and discussed. Following the definition of crop portfolio composition, adjustments to the portfolio under changing output price relations are discussed. This discussion further reveals factors which limit or enhance share of crops in portfolios. Also, stability of existing crop rotations and crop portfolios under changing price ratios is analyzed.

Knowledge of factors which determine crop portfolio composition provides the foundation for detailed analysis of adjustments in crop portfolios under changing output price relations. This step is performed under stage three of the extended panel-approach which incorporates Linear Programming techniques into the panel-approach. Different steps are followed under stage three of the extended panel-approach. Under the first step, cropping activities and crop rotations are defined which are feasible under the given framework conditions for the representative farm. The different cropping activities are defined by different crop characteristics such as preceding crop, yield level, tillage system and gross margin. Data and information for this step are based on those determined under stage one of the extended panel-approach. Steps two and three consist of definition and calculation of price development scenarios for further analysis. Under step four, gross margins for the different cropping activities and crop rotations defined at step one and based on price development scenarios at step two and three are calculated for each scenario. The final step consists of choice of cropping activities and crop rotations under total gross margin maximization and imposed constraints for the different scenarios. At this step, the producer panel is used to "replace" the Linear Programming model. Though crop portfolio composition derived from the producer panel is not proven by such a model, the process of practical decision making of producers is considered and reflected as close as in reality of the farm operation.

Analysis of crop portfolio composition under shifting crop output price relations is carried out for four different representative farms based on the extended panel-approach. Farms selected are leading edge farms in terms of farm size and thus not typical. For Canada, one cash crop farm with 1,800 hectares represents the region of Lethbridge, Southern Alberta (CA1800AB). The second Canadian cash crop farm is CA4000SK with 4,000 hectares in farm size and represents the region of Moose Jaw, Central Saskatchewan. In Germany, DE300EW with 300 hectares represents the region of East Westphalia-Lippe. The second farm is DE1300SA with 1,300 hectares located in the region of Bernburg, Central Saxony-Anhalt. At both Canadian farms, zero tillage systems are applied for seeding of crops since conservation of soil moisture is an overall goal of cash crop farming in the Canadian Prairies. In Germany, tillage systems prevailing at the two representative farms differ. At DE300EW, conventional tillage systems (plowing) are applied since higher precipitation levels and prevailing soil types require aeration of soils. At DE1300SA, conservation tillage systems (minimum tillage) prevail since as for the Canadian farms conservation of soil moisture is necessary for achieving high yield levels.

Crop portfolios and crop rotations at the selected representative farms differ due to different natural framework conditions and resulting different tillage systems. For the

Canadian representative farms, a cereal – oilseed – cereal – pulse crop rotation framework prevails. A consequent alternation of broadleaf and cereal crops is a requirement of zero tillage systems, e. g., for improved weed control. A similar framework is observed for DE1300SA since application of minimum tillage systems also requires alternation of broadleaf and cereal crops though to a lesser extent than for the Canadian farms. The overall framework for DE1300SA consists of broadleaf – cereal – oilseed – cereal – cereal – oilseed – cereal. Requirements with regard to cropping system sequence are lowest at DE300EW since application of conventional tillage systems provides highest flexibility. The shortest cropping system sequence for all farms compared is thus found in DE300EW which consists of broadleaf – cereal – cereal – (cereal).

Altogether, prevailing tillage systems and choice of crop rotations are interdependent for all farms analyzed. Tillage systems are chosen depending on prevailing natural framework conditions and farm size. Cropping system sequence (e. g, oilseed – cereal – pulse – cereal) is then mainly determined by the ability of the different tillage systems to establish healthy crops, manage soil moisture, control for weeds and break disease cycles. The overall determinants of crop rotation choice can be observed across regions and countries for all farms analyzed despite different natural framework conditions, production systems, legal framework conditions and farm sizes.

Under changing output price relations prevailing tillage systems cause stability and inflexibility in crop rotations and crop portfolios. Only limited potential for adjustments in crop portfolio composition can be observed for representative farms from Canada. The same holds for DE1300SA since requirements of alternation of crops outweigh higher or lower profitability of crops under shifting output prices.

Detailed analysis of crop portfolio composition and rotation choice under shifting output price relations as part of stage three of the extended panel-approach is conducted for DE300EW only. Prospects of adjustments in portfolios for the other representative farms are limited since requirements with regard to crop rotation sequence of prevailing tillage systems lead to stability and inflexibility of rotations. A total of 20 cropping activities are defined which are included in a total of 18 different crop rotations. Further, in addition to status quo, 18 scenarios of output price developments are defined with each being based on five price steps of different crop output prices. Prices for different crops do either increase, decrease or remain constant. Price levels at the different price steps are calculated by shifting price relations between crops over a +50 % to a -50 % range. Crop rotations and respective cropping activities are then chosen based on respective changing gross margins for the different scenarios and price steps. Selection of crops and crop rotations has to consider a total of six constraint imposed by the producer panel.

Comparison of crop portfolio composition among all price steps and scenarios reveals high degrees of stability in portfolio composition. For all scenarios, crop portfolio composition already changes when output price relations shift by 10 % not depending on direction of price shift. This indicates high sensitivity in crop portfolio composition for comparably minor price changes. Once portfolios are reorganized at the 10 % step, composition of most portfolios remains unchanged. Further, influence of output price changes on share of crops in portfolios differs between crops. Competitiveness and stability of sugar beets in all scenarios is caused by the quota regime. On the other hand, rapeseed is very sensitive to price changes resulting in exclusion from portfolios as soon as prices decline. Cereals are always included in portfolios since they have to be considered as “fill up” crops.

Conclusions are drawn about the influence of changes in crop output prices on crop portfolio composition and rotation choice as well as about the application of the extended panel-approach. Analysis of factors determining crop portfolio composition revealed that interdependencies (jointness) between different crops included in crop portfolios lead to stability in crop rotation choice and crop portfolio composition. Altogether, crop portfolio composition and rotation choice is not only determined by economic factors (gross margin levels or profitability of crops) but also by technical factors (technical interdependencies and agronomical characteristics of crops). Depending on the degree and extent of technical factors, economic factors are outweighed in some situations. Prevailing tillage systems are a major factor which causes stability and inflexibility in crop rotations. Zero tillage systems in Canada and minimum tillage systems applied in DE1300SA have high requirements with regard to alternation of crops in the crop rotation sequence. Highest flexibility is observed for conventional tillage systems (plowing) in DE300EW. Choice of tillage systems depends on prevailing natural location conditions and farm size.

Overall stability in crop rotations and crop portfolio composition under changing crop output prices result in limited adjustments in crop acreage and thus output for all representative farms analyzed. Altogether, producers tend to persist in prevailing rotations and crop portfolios under changing output price relations. This is due to long-term experiences and existing farm organization (machinery endowment) which is fixed in the short-run. In addition to crop output prices, technical progress and farm input prices are two other important factors which determine crop portfolio composition and rotation choice. These factors have to be included in future research.

Application of the extended panel-approach proved to be useful for analysis of crop portfolio composition and rotation choice under shifting output price relations. Future analysis of crop portfolios and crop rotations within the *agri benchmark* Cash Crop network should focus on identification of prevailing tillage systems and associated constraints for crop portfolio composition of the different farms included in the network.

Further, a continuous monitoring of technical progress, farm input and output prices as well as agricultural policy is necessary across the whole network to provide results about future adjustments in crop portfolios and crop rotations and thus production of agricultural commodities.

9 References

AGRICULTURE AND AGRI-FOOD CANADA (2005) Agricultural Policy Framework, Federal – Provincial – Territorial Programs, by Program Planning, Integration and Management Directorate, Spring 2005

AGRICULTURE AND AGRI-FOOD CANADA (2007) Farm Income, Financial Conditions and Government Assistance – Data Book 2007, Research and Analysis Directorate, Strategic Policy Branch

AGRICULTURE AND AGRI-FOOD CANADA (2008) Agricultural Policy Framework, http://www.agr.gc.ca, retrieved March 3rd, 2008

AGRICULTURE AND AGRI-FOOD CANADA (2008a) Canadian Agricultural Income Stabilization (CAIS) program handbook, CAIS – PCSRA

AGRICULTURE FINANCIAL SERVICES CORPORATION (2006) Annual Report 2006, Alberta, http://www.afsc.ca

AGRICULTURE FINANCIAL SERVICES CORPORATION (2007) Annual Report 2007, Alberta, http://www.afsc.ca

AGRICULTURAL SERVICE LABORATORIES (1996) Soil climatic zones of the Canadian Prairies, Saskatoon

ALBERTA AGRICULTURE AND FOOD AND RURAL DEVELOPMENT (2007) Conservation and Development Branch
http://www.agric.gov.ab.ca

ALBERTA AGRICULTURE AND FOOD (2008) Alberta Farm Fuel Benefit (AFFB), http://www1.agric.gov.ab.ca/general/progserv.nsf/all/pgmsrv9. retrieved March 7th, 2008

AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION (2000) Commodity costs and returns estimation handbook, a report of the AAEA Task Force on Commodity Costs and Returns. Ames, Iowa

ASUNKA S, SHUMWAY CR (1996) Allocatable Fixed Inputs and Jointness in Agricultural Production: More Implications, in: Agricultural and Resource Economics Review, pp. 143-148

BLANK SC (1990) Returns to limited crop diversification, in: Western Journal of Agricultural Economics, 15, pp. 204-212

BRANDES W, RECKE G, BERGER T (1997) Produktions- und Umweltökonomik, Band 1, UTB Ulmer

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV) (2005) Agrarpolitischer Bericht 2005, Berlin

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV) (2006) Agrarpolitischer Bericht 2006, Berlin

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV) (2006a) Die Umsetzung der EU-Agrarreform in Deutschland, Berlin

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV) (2007) Agrarpolitischer Bericht 2007, Berlin

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV) (2007a) Aktualisierte Schätzwerte für die regional einheitlichen Zahlungsansprüche im Rahmen der Betriebsprämienregelung http://www.bmelv.de, retrieved March 9th, 2008

BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (BMELV) (2007b) Die wirtschaftliche Lage der landwirtschaftlichen Betriebe, Buchführungsergebnisse der Testbetriebe, Wirtschaftsjahr 2006/2007, Referat 426

BUNDESMINISTERIUM DER FINANZEN (BMF) (2008) Informationen zur Steuerentlastung für Betriebe der Land- und Forstwirtschaft http://www.zoll.de, retrieved March 9th, 2008

CAMPBELL CA, ZENTNER RP, JANZEN HH, BROWN KE (1990) Crop rotation studies on the Canadian Prairies, Agriculture Canada Research Branch, Publication 1841/E

CANADIAN GRAIN COMMISSION (2008) Western Canadian Wheat Classes http://www.grainscanada.gc.ca/Quality/Wheat/classes-e.htm, retrieved April 10th, 2008

CANADIAN WHEAT BOARD (2007) Annual Report 2006 – 2007, Winnipeg http://www.cwb.ca

CANSIM – Canadian Socio-economic Information Management System, Statistics Canada http://www.statcan.ca.

CARLSON S (1956) A study on the pure theory of production, Kelley & Millman, New York

CHAMBERS RG, JUST RE (1989) Estimating Multioutput Technologies, in: American Journal of Agricultural Economics, 71, pp. 980-995

CHAPMAN L, BROWN D (1978) The Canada Land Inventory: The Climates of Canada for Agriculture, Report No. 3, Environment Canada and Lands Directorate

CHIANG A (1984) Fundamental Methods of Mathematical Economics, Third Edition, McGraw-Hill

DEBERTIN DL (1986) Agricultural Production Economics, Macmillan Publishing

DEBLITZ C (1993) Internationaler Vergleich von Systemen extensiver tiergebundener Grünlandnutzung – produktionstechnische und ökonomische Analyse, Wettbewerbsfähigkeit, internationale Übertragbarkeit, Mellen University Press

DEBLITZ C, HEMME T, ISERMEYER F, KNUTSON R, ANDERSON D, GOERTZ D, MOELLERC, RIEDEL J (1998) A framework for developing international representative farms: The case of dairy, AFPC working paper 98-8, Texas A&M University

DEPAUW R, THOMAS J, TOWNLEY-SMITH T (1986) Spring Wheat Production in the Brown and Dark Brown Soil Zones of Western Canada, in: SLINKARD A, FOWLER D (eds.): Wheat Production in Canada – A Review, Proceedings of the Canadian Wheat Production Symposium, University of Saskatchewan, Saskatoon

DOWNEY RK (1988) Canola: A Quality Brassica Oilseed, in: JANICK J, SIMON JE (eds.): Advances in New Crops: Proceedings of the 1st National Symposium on New Crops, Portland, Timber Press

EBMEYER C, SCHONEY RA (2007) A comparison of cost and returns for wheat production on selected locations in Canada and Germany, paper presented at the International Conference on Agricultural Policy Changes: Canada, EU and the WTO, Victoria, B.C., Canada, Sep. 13-15th, 2007

EIDMAN V (1992) Theoretical and practical considerations in measuring cost and returns, in: AHEARN MC, VASAVADA U (eds.): Cost and returns for agricultural commodities – Advances in concepts and measurement, Westview Press

EL-NAZER T, MCCARL BA (1986) The choice of crop rotation: A modeling approach and case study, in: American Journal of Agricultural Economics, 68, pp. 128-136

ENCYCLOPEDIA BRITANNICA (2008) Germany
http://www.britannica.com, retrieved March 1st, 2008

EUROPEAN COMMISSION (2006) An EU strategy for biofuels, COM(2006) 34, Bruxelles
http://ec.europa.eu/agriculture/biomass/biofuel, retrieved March 10th, 2008

EUROPEAN COMMISSION (2006a) Biofuels in the European Union: an agricultural perspective – fact sheet
http://ec.europa.eu/agriculture/biomass/biofuel, retrieved March 10th, 2008

EUROPEAN COMMISSION (2007) 36th Financial Report from the Commission on the European Agricultural Guidance and Guarantee Fund, Guarantee section, 2006 financial year, COM(2007) 562, Bruxelles
http://ec.europa.eu/agriculture/fin

EUROPEAN COMMISSION (2007a) The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets, DG Agri, AGRI G-2/WM D(2007), Bruxelles
http://ec.europa.eu/agriculture/analysis/markets/, retrieved March 11th, 2008

EUROPEAN COMMISSION (2008) Single Payment Scheme – Info sheets on the different aspects of the CAP reform
http://ec.europa.eu/agriculture/markets/sfp, retrieved March 8th, 2008

EUROPEAN COMMISSION (2008a) The arable and rice sectors – Info sheets on the different aspects of the CAP reform
http://ec.europa.eu/agriculture/markets/sfp, retrieved March 8th, 2008

EUROPEAN UNION (2008) Markets for Agricultural Products, Common organization of the sugar market
http://europa.eu/scadplus/leg/en/lvb/l60041.htm, retrieved March 9th, 2008

EVANS L (1986) Spring Wheat Production in the Black and Grey Soil Zones of Western Canada, in: Wheat Production in Canada – A Review, Proceedings of the Canadian Wheat Production Symposium, University of Saskatchewan, Saskatoon

FACHAGENTUR FÜR NACHWACHSENDE ROHSTOFFE (FNR) (2008) Cultivation of renewable raw materials in Germany
http://www.fnr.de, retrieved March 11th, 2008

FAOSTAT (2007, 2008) Statistical databases of the Food and Agriculture Organization (FAO) of the United Nations, accessed December 2007 and February 2008

FREEBAIRN JW (1987) Implications of Wages and Industrial Policies on the Competitiveness of Agricultural Export Industries, in: Review of Marketing and Agricultural Economics, Vol. 55, No. 1, April 1987

FROHBERG K, HARTMANN M (1997) Comparing measures of competitiveness, Discussion paper No. 2, 1997, Institute of Agricultural Development in Central and Eastern Europe (IAMO), Halle

GAY SH, OSTERBURG B, BALDOCK D, ZDANOWICZ A (2005) Recent evolution of the EU Common Agricultural Policy (CAP): state of play and environmental potential, MEACAP WP6 D4b, FAL Braunschweig

GEBREMEDHIM B, SCHWAB G (1998) The economic importance of crop rotation systems: Evidence from the literature, Staff paper no. 98-13, Department of Agricultural Economics, Michigan State University

GOLDMAN SACHS (2007) Food, Feed and Fuel - An agriculture, livestock and biofuel primer, Goldman Sachs Commodities Research

GOVERNMENT OF SASKATCHEWAN, MINISTRY OF FINANCE (2008) Farm Fuel Program, http://www.finance.gov.sk.ca/programs-services/farmfuel, retrieved March 7th, 2008

HARRINGTON DH (1992) Measurement issues relating to policy analysis, in: AHEARN MC, VASAVADA U (eds.): Cost and returns for agricultural commodities – Advances in concepts and measurement, Westview Press

HAZELL P, NORTON R (1986) Mathematical Programming for Economic Analysis in Agriculture, New York, Macmillan

HEADY EO (1952) Economics of Agricultural Production and Resource Use, Prentice Hall, New York

HEMME T, ISERMEYER F, DEBLITZ C (1997) TIPI-CAL Version 1.0, Ein Modell zur Politik- und Technikfolgenabschätzung für typische Betriebe im internationalen Vergleich, Arbeitsbericht 2/1997, Institut für Betriebswirtschaft, FAL Braunschweig

HEMME T, DEBLITZ C, GOERTZ D, ISERMEYER F, KNUTSON R, ANDERSON D (1999) Politik- und Technikfolgenanalysen für typische Betriebe im Rahmen des „International Farm Comparison Network" (IFCN), in: Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus e.V., Vol. 35, 1999, pp. 157-164

HEMME T (2000) Ein Konzept zur international vergleichenden Analyse von Politik- und Technikfolgen in der Landwirtschaft, Landbauforsch SH 215

HENDERSON JM, QUANDT RE (1971) Microeconomic Theory – A mathematical approach (Sec. ed.), McGraw-Hill, New York

HENNESSY DA (2006) On monoculture and the structure of crop rotations, in: American Journal of Agricultural Economics, 88, pp. 900-914

HUBER U (2000) Agriculture in Germany – Production and Structure, in: TANGERMANN S (ed.), Agriculture in Germany, DLG-Verlag, Frankfurt am Main

ISERMEYER F (1988) Produktionsstrukturen, Produktionskosten und Wettbewerbsstellung der Milcherzeugung in Nordamerika, Neuseeland und der EG, Wissenschaftsverlag Vauk, Kiel

ISERMEYER F, RIEDEL J, MÖLLER C (2000) Analyse der internationalen Wettbewerbsfähigkeit mit Hilfe des IFCN, dargestellt am Beispiel der Weizen- und Zuckerproduktion, in: Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V., Vol. 36, 2000, pp. 101-108

KAY RD, EDWARDS WM, DUFFY PA (2008) Farm Management, Sixth Ed., McGraw-Hill

KLOHN W, WINDHORST H-W (1998): Die Landwirtschaft in Deutschland, 2nd Ed., Vechta

KRUGMAN P (1994) Competitiveness: A dangerous obsession, in: Foreign Affairs, 73/2, pp. 28-44

LEATHERS HD (1991) Allocable Fixed Inputs as a Cause of Joint Production: A Cost Function Approach, in: American Journal of Agricultural Economics, 73, pp. 1083-1090

LIBRARY OF CONGRESS (2005) A country study: Germany, Country profile, Federal Research Division
http://lcweb2.loc.gov/frd/cs/detoc.html, retrieved Feb. 29th, 2008

LYNNE GD (1988) Allocatable Fixed Inputs and Jointness in Agricultural Production: Implications for Economic Modeling: Comment, in: American Journal of Agricultural Economics, 70, pp. 947-949

MARTIN L, WESTGREN R, VAN DUREN E (1991) Agribusiness Competitiveness Across National Boundaries, in: American Journal of Agricultural Economics, December 1991, pp. 1456-1464

MILLER TA (1992) How Economic Theory Should Guide What We Measure, in: AHEARN MC, VASAVADA U (eds.): Cost and Returns for Agricultural Commodities - Advances in Concepts and Measurement, Westview Press

MÖLLER C, SCHONEY RA (2006) Accounting for joint production and quality aspects in international cost comparisons: A case study of Saskatchewan and German wheat production, internal discussion paper, agri benchmark, Braunschweig

MOREHART M, JOHNSON JD, SHAPOURI H (1992) The National Commodity Cost and Return Estimates, in: AHEARN MC, VASAVADA U (eds.): Cost and Returns for Agricultural Commodities - Advances in Concepts and Measurement, Westview Press

MOSCHINI G (1989) Normal Inputs and Joint Production with Allocatable Fixed Inputs, in: American Journal of Agricultural Economics, 71, pp. 1021-1024

MUNDLAK Y (2001) Production and Supply, in: GARDNER BL, RAUSSER GC: Handbook of Agricultural Economics, Vol. 1A, Agricultural Production, Elsevier

MUßHOFF O, HIRSCHAUER N (2004) Optimierung unter Unsicherheit mit Hilfe stochastischer Simulation und Genetischer Algorithmen – dargestellt anhand der Optimierung des Produktionsprogramms eines Brandenburger Marktfrucht-betriebes, in: Agrarwirtschaft, 53, Issue 7

NATURAL RESOURCES CANADA (2008) ecoENERGY for Biofuels, Office of Energy Efficiency
http://oee.nrcan.gc.ca, retrieved March 7th, 2008

ODENING M, BOKELMANN W (2000) Agrarmanagement, Ulmer

ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD) (2007) Agricultural Policies in OECD Countries: Monitoring and Evaluation 2007, OECD, Paris

PANZAR J, WILLIG R (1975: Economies of Scale and Economies of Scope in Multi-Output production, Economic Discussion Paper No. 33, Bell Laboratories 1975

PARKHOMENKO S (2004) International competitiveness of soybean, rapeseed and palm oil production in major producing regions, Dissertation, Landbauforsch SH 267, Braunschweig

PFOUTS RW (1961) The theory of cost and production in the multi-product firm, Econometrica, 29, pp. 650-658

PINDYCK R-S, RUBINFELD DL (1992): Microeconomics, Second Ed., MacMillan

PLESSMANN F, EBMEYER C, GOERG K (eds.) (2005) IFCN Cash Crop Report 2005 – Oilseeds, IFCN, FAL Braunschweig

PORTER ME (1993) Nationale Wettbewerbsvorteile. Erfolgreich konkurrieren auf dem Weltmarkt (The competitive advantage of nations), Droemer/Knaur

PULSE CANADA (2008): http://www.pulsecanada.com, retrieved March 20th, 2008

PUTNAM D, PUTNAM R (1970) Canada: A regional analysis. J. M. Dent and Sons (Canada) Ltd

RAE AN (1994) Agricultural Management Economics, Activity Analysis and Decision Making, Centre for Agriculture and Biosciences International

RICHARDSON JW, NIXON CJ (1986) Description of FLIPSIM V: A general firm level policy simulation model, Agricultural and Food Policy Center, Department of Agricultural Economics, Texas A&M

SASKATCHEWAN AGRICULTURE AND FOOD (2005) Geomatics Unit http://www.agriculture.gov.sk.ca

SASKATCHEWAN CROP INSURANCE CORPORATION (2007) 2006 – 2007 Annual Report, Government of Saskatchewan http://www.saskcropinsurance.com

SHARPLES JA (1990) Cost of Production and Productivity in Analyzing Trade and Competitiveness, in: American Journal of Agricultural Economics, 72, pp. 1278-1282

SHUMWAY CS, POPE RD, NASH EK (1984) Allocatable Fixed Inputs and Jointness in Agricultural Production: Implications for Economic Modeling, in: American Journal of Agricultural Economics, 66, pp. 72-78

SHUMWAY CS, POPE RD, NASH EK (1988) Allocatable Fixed Inputs and Jointness in Agricultural Production: Implications for Economic Modeling: Reply, in: American Journal of Agricultural Economics, 70, pp. 948-952

STATISTICS CANADA (2007) Census of Agriculture 2006, http://www.statcan.ca

STATISTISCHES BUNDESAMT: LAND- UND FORSTWIRTSCHAFT, FISCHEREI (various years) Fachserie 3, Reihe 2 and 3. Bodennutzung und pflanzliche Erzeugung, Struktur der land- und forstwirtschaftlichen Betriebe

STEINHAUSER H, LANGBEHN C, PETERS U (1992) Einführung in die landwirtschaftliche Betriebslehre, Allgemeiner Teil, 5th ed., UTB Ulmer

TEECE DJ (1980) Economies of scope and the scope of the enterprise, in: Journal of Economic Behavior and Organisation, 1, pp. 223-247

USDA – Foreign Agricultural Service (FAS) (2006) EU-25 Bio Fuels Annual 2006, USDA-FAS GAIN report No. E36102

USDA – Foreign Agricultural Service (FAS) (2007) Bio Fuels Canada 2007, USDA-FAS GAIN report No. CA7041.

USDA – Foreign Agricultural Service (FAS) (2007a) EU-27 Bio Fuels Annual 2007, USDA-FAS GAIN report No. E47051.

WEISENSEL WP, SCHONEY RA (1989) An analysis of the yield-price risk associated with specialty crops, in: Western Journal of Agricultural Economics, 14, pp. 293-299

WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK BEIM BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND VERBRAUCHERSCHUTZ (2007) Nutzung von Biomasse zur Energiegewinnung – Empfehlungen an die Politik, BMELV, Berlin

WTO (2004) WTO agriculture negotiations – The issues, and where we are now. http://www.wto.org/english/tratop_e/agric_e/negs_bkgrnd00_contents_e.htm, retrieved December 5th, 2007

ZENTNER RP, WALL DD, NAGY CN, SMITH EGH, YOUNG DL, MILLER PR, CAMPBELL CA, MCCONKEY BG, BRANDT SA, LAFOND GP, JOHNSTON AM, DERKSEN DA (2002) Economics of Crop Diversification and Soil Tillage Opportunities in the Canadian Prairies, in: Agronomy Journal, Vol. 94, pp.216-330

ZENTRALE MARKT- UND PREISBERICHTSTELLE (ZMP) (various years) ZMP Marktbilanz, Getreide, Ölsaaten, Futtermittel, various years, ZMP GmbH Bonn

ZIMMER Y (ed.) (2006) agri benchmark Cash Crop Report 2006, agri benchmark, FAL Braunschweig

ZIMMER Y (ed.) (2007) agri benchmark Cash Crop Report 2007, agri benchmark, FAL Braunschweig

ZIMMER Y, DEBLITZ C (2005) agri benchmark cash crop – A standard operating procedure to define typical farms, FAL/agri benchmark

Appendix

Figure A1: Map of the Canadian territory

Source: Map compiled by FAL-Farm Economics.

Table A1: Barley production and export ('000 t) of major global producing and exporting countries from 2003 to 2005

Production ('000 tonnes)					Exports ('000 tonnes)				
Country	Rank (2005)	Year 2003	2004	2005	Country	Rank (2005)	Year 2003	2004	2005
Russian Federation	1	18,003	17,180	15,791	France	1	5,470	4,893	5,394
Germany	2	10,596	12,993	11,614	Australia	2	2,205	6,710	3,928
Ukraine	3	6,833	11,084	8,975	Ukraine	3	1,895	3,710	3,502
France	4	9,844	11,032	10,313	Germany	4	3,179	911	2,929
Canada	5	12,328	13,186	12,481	Canada	5	777	1,655	2,021
Turkey	6	8,100	9,000	9,500	Russian Federation	6	3,099	955	1,768
Spain	7	8,698	10,640	4,626	United Kingdom	7	1,121	675	831
United Kingdom	8	6,370	5,816	5,495	USA	8	667	269	744
USA	9	6,059	6,091	6,091	Netherlands	9	166	190	473
Australia	10	10,382	7,740	9,869	Czech Republic	10	159	109	441
China	11	2,721	3,225	3,447	Belgium	11	201	100	403
Denmark	12	3,776	3,589	3,797	Denmark	12	872	590	358
Poland	13	2,831	3,571	3,581	Argentina	13	66	197	325
Iran, Islamic Rep	14	2,908	2,940	2,857	Romania	14	16	63	317
Morocco	15	2,620	2,760	1,102	Sweden	15	349	167	316
EU (27)	(1)	55,691	64,289	54,818	EU (27)	(1)	12,054	8,630	12,949

Source: FAOSTAT (2008), own illustration.

Table A2: Corn production and export ('000 t) of major global producing and exporting countries from 2003 to 2005

Production ('000 tonnes)					Exports ('000 tonnes)				
Country	Rank (2005)	Year 2003	2004	2005	Country	Rank (2005)	Year 2003	2004	2005
USA	1	256,278	299,914	282,311	USA	1	43,811	49,029	45,601
China	2	116,001	130,438	139,502	Argentina	2	11,913	10,692	14,602
Brazil	3	48,327	41,788	35,113	China	3	16,421	2,318	8,611
Mexico	4	20,701	21,670	18,012	France	4	7,081	6,156	7,379
India	5	11,152	14,984	14,172	Ukraine	5	943	1,234	2,796
Argentina	6	15,045	14,951	20,483	South Africa	6	799	480	2,176
France	7	11,991	16,372	13,688	Hungary	7	1,311	1,237	1,813
Indonesia	8	10,886	11,225	12,524	Brazil	8	3,566	5,031	1,070
Italy	9	8,702	11,368	10,428	Germany	9	859	952	882
Canada	10	9,587	8,836	9,461	Serbia & Mont.	10	186	210	687
Romania	11	9,577	14,542	10,388	Bulgaria	11	216	252	519
Hungary	12	4,532	8,332	9,050	Paraguay	12	805	370	477
South Africa	13	9,705	9,710	11,716	Romania	13	101	311	430
Egypt	14	6,530	6,236	7,085	Greece	14	36	52	426
Nigeria	15	5,203	5,567	5,957	India	15	543	1,069	421
EU (27)	(3)	52,506	71,689	63,086	EU (27)	(3)	10,690	10,142	12,719

Source: FAOSTAT (2008), own illustration.

Table A3: Soybean production and export ('000 t) of major global producing and exporting countries from 2003 to 2005

Production ('000 tonnes)					Exports ('000 tonnes)				
Country	**Rank (2005)**	**Year 2003**	**2004**	**2005**	**Country**	**Rank (2005)**	**Year 2003**	**2004**	**2005**
USA	1	66,778	85,013	85,035	USA	1	31,111	25,618	25,682
Brazil	2	51,919	49,550	51,182	Brazil	2	19,890	19,248	22,435
Argentina	3	34,800	31,500	38,300	Argentina	3	8,710	6,520	9,915
China	4	15,396	17,407	16,803	Paraguay	4	1,727	2,575	2,215
India	5	4,655	7,819	6,876	Netherlands	5	1,557	1,566	1,493
Paraguay	6	4,205	3,584	3,988	Canada	6	874	984	1,181
Canada	7	2,268	3,048	3,161	Uruguay	7	179	342	428
Bolivia	8	1,718	1,612	1,690	China	8	282	348	409
Ukraine	9	232	363	613	Ukraine	9	42	38	175
Russian Federation	10	393	555	689	Bolivia	10	115	90	128
Indonesia	11	672	723	808	Belgium	11	64	60	127
Uruguay	12	183	377	478	Romania	12	25	13	50
Nigeria	13	494	528	565	Panama	13	9	0	36
Italy	14	397	518	553	France	14	28	18	32
South Africa	15	137	220	273	Germany	15	26	26	29
EU (27)	(9)	891	1,107	1,194	EU (27)	(9)	1,766	1,751	1,804

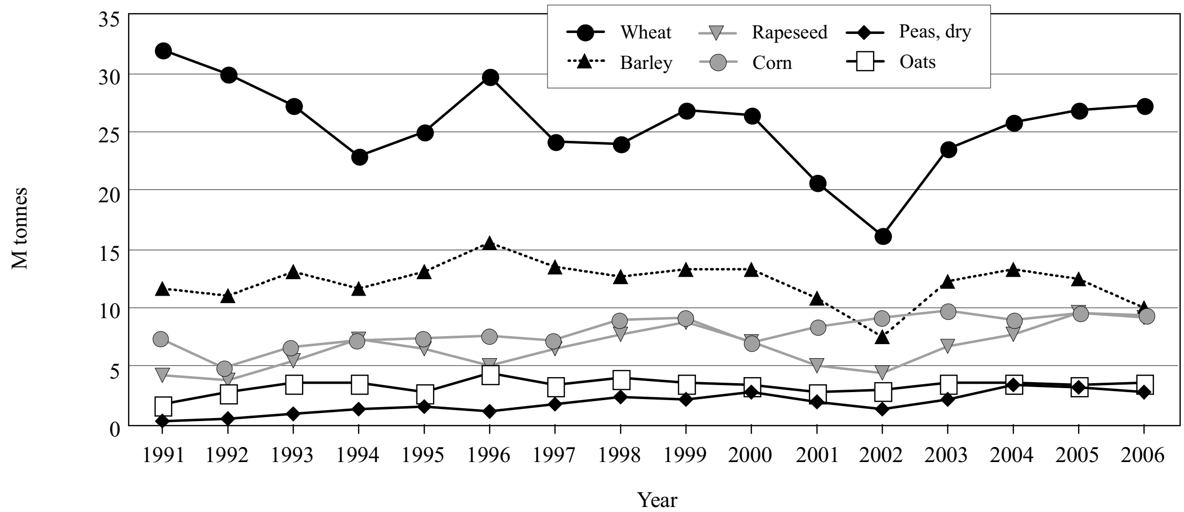
Source: FAOSTAT (2008), own illustration.

Table A4: Sugar production and export ('000 t) of major global producing and exporting countries from 2003 to 2005

Production ('000 tonnes)					Exports ('000 tonnes)				
Country	**Rank (2005)**	**Year 2003**	**2004**	**2005**	**Country**	**Rank (2005)**	**Year 2003**	**2004**	**2005**
Brazil	1	26,400	28,150	29,500	Brazil	1	4,561	6,198	6,568
India	2	22,144	15,153	14,173	France	2	2,518	2,117	2,321
China	3	10,505	10,012	9,700	Belgium	3	1,168	1,074	1,896
USA	4	7,856	7,146	6,741	Germany	4	1,122	1,054	1,702
Russian Federation	5	5,841	4,828	5,600	Thailand	5	2,575	2,365	1,458
Thailand	6	7,680	7,298	5,443	United Kingdom	6	672	774	769
Mexico	7	4,928	5,024	5,796	Colombia	7	624	648	731
Australia	8	5,461	4,994	5,196	Poland	8	414	409	654
France	9	4,275	4,442	4,419	Malaysia	9	384	526	545
Colombia	10	4,326	4,460	4,405	United Arab Emirates	10	485	430	487
Germany	11	4,120	4,729	4,032	Belarus	11	329	433	482
Ukraine	12	1,604	1,956	2,064	Netherlands	12	223	268	407
Pakistan	13	4,000	4,373	3,191	China	13	126	118	392
South Africa	14	2,565	2,305	2,313	Korea, Republic	14	299	304	309
Indonesia	15	2,179	1,955	2,255	Czech Republic	15	31	168	278
EU (27)	(2)	19,488	21,302	21,335	EU (27)	(2)	7,347	6,823	9,635

Source: FAOSTAT (2008), own illustration.

Figure A2: Canada – Production (M tonnes) of major agricultural commodities from 1991 to 2006



Source: FAOSTAT (2008), own illustration.

Table A5: Canada – Production (‘000 t) of major agricultural commodities and commodity groups from 1991 to 2006

Commodity/ Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Wheat	31.946	29.877	27.256	22.92	24.989	29.801	24.28	24.082	26.941	26.536	20.63	16.198	23.552	25.86	26.775	27.277
Barley	11.617	11.032	12.972	11.692	13.033	15.562	13.527	12.709	13.196	13.229	10.846	7.489	12.328	13.186	12.481	10.005
Corn	7.413	4.883	6.501	7.043	7.271	7.536	7.18	8.952	9.161	6.954	8.389	8.999	9.587	8.836	9.461	9.268
Rapeseed	4.224	3.872	5.48	7.233	6.436	5.062	6.393	7.643	8.798	7.205	5.017	4.407	6.771	7.728	9.66	9.105
Oats	1.794	2.829	3.557	3.64	2.873	4.361	3.485	3.958	3.641	3.403	2.691	2.911	3.691	3.683	3.432	3.602
Soybeans	1.46	1.455	1.851	2.251	2.293	2.17	2.738	2.737	2.781	2.703	1.635	2.336	2.268	3.048	3.161	3.533
Peas, dry	410	505	970	1.441	1.455	1.173	1.762	2.337	2.252	2.864	2.045	1.366	2.124	3.338	3.1	2.806
Linseed	635	337	627	960	1.105	851	895	1.081	935	693	715	679	754	517	1.082	1.041
Lentils	343	349	349	450	432	403	379	480	724	914	566	354	520	962	1.278	693
Beans, dry	125	123	131	171	203	133	161	185	285	261	289	407	344	214	319	373
Rye	339	281	319	400	310	309	320	408	387	260	228	134	327	418	359	302
Chick peas	1	3	1	1	1	4	15	51	187	388	455	157	68	51	104	182
Sunflower seed	135	65	79	117	66	55	65	112	122	119	104	157	150	54	89	153
Beet sugar, raw	160	118	113	182	164	157	105	93	122	121	86	55	96	118	103	130
Canary seed	100	124	128	240	155	285	115	235	166	171	114	176	226	301	227	117
Mustard seed	121	133	216	319	244	231	243	239	306	202	105	154	226	306	201	116
Cereals Total	53.857	49.648	51.483	46.617	49.344	58.494	49.557	50.993	54.078	51.038	43.391	36.303	50.174	52.684	53.086	50.895
Oil crops Total	6.575	5.863	8.253	10.881	10.147	8.369	10.336	11.813	12.946	10.93	7.579	7.736	10.173	11.656	14.197	13.951
Pulses Total	897	991	1.456	2.07	2.097	1.718	2.32	3.066	3.454	4.443	3.366	2.292	3.065	4.58	4.81	4.072
Sugars Total	160	118	113	182	164	157	105	93	122	121	86	55	96	118	103	130

Source: FAOSTAT (2008), own illustration.

Table A6: Canada – Exports ('000 t) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	23,459	23,757	18,446	21,572	17,031	16,691	18,962	17,807	16,226	18,898	17,688	12,257	11,704	15,134	13,978
Rapeseed	1,778	1,790	2,364	3,670	3,416	2,416	2,837	4,115	3,786	3,873	3,963	2,420	3,244	3,588	4,001
Peas, dry	206	309	507	693	1,055	854	871	1,137	1,434	1,817	1,999	694	1,056	1,599	2,367
Barley	3,970	2,507	2,949	3,534	2,317	3,347	2,536	1,473	1,355	1,843	1,771	839	777	1,655	2,021
Oats	344	520	1,042	1,130	1,464	1,331	1,586	1,139	1,175	1,510	1,425	829	1,109	1,147	1,354
Soybeans	233	247	415	464	654	476	500	908	876	771	593	549	874	984	1,181
Lentils	152	235	260	262	294	288	305	379	421	525	496	355	375	375	580
Linseed	422	421	496	681	892	767	893	826	578	608	674	648	690	547	563
Beans, dry	89	119	78	130	146	135	138	181	238	252	264	275	317	318	274
Corn	744	404	359	391	444	515	263	262	889	274	160	256	273	350	269
Canary seed	70	85	122	117	159	105	134	127	145	151	166	142	170	154	175
Mustard seed	125	118	177	192	168	173	160	164	135	159	152	138	122	114	123
Rye	314	187	211	150	214	174	137	85	83	83	85	58	50	213	108
Chick peas	0	5	0	0	1	1	1	12	21	133	149	112	89	68	59
Sunflower seed	46	81	59	33	75	28	33	46	42	62	88	94	102	71	34
Sugar, refined	35	39	37	60	26	29	15	15	11	13	14	17	17	14	31

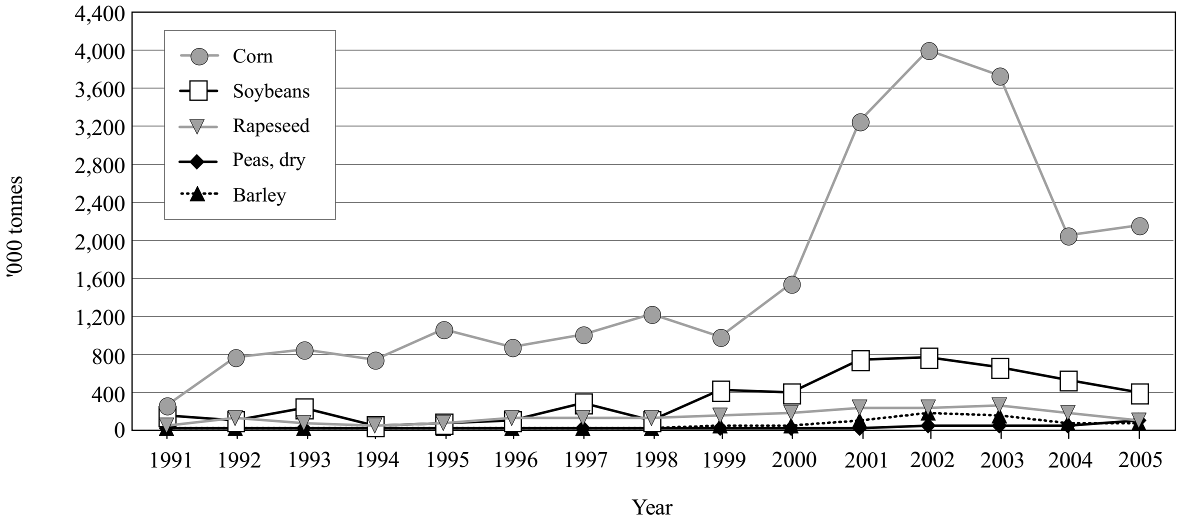
Source: FAOSTAT (2008), own illustration.

Table A7: Canada – Export value (M US$) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	3,315	3,871	2,242	2,582	2,952	3,401	3,157	2,796	2,286	2,488	2,548	1,964	2,023	2,689	2,232
Rapeseed	443	417	553	1,023	1,038	759	892	1,157	898	774	825	620	930	1,096	1,074
Peas, dry	48	67	90	126	201	199	191	195	229	271	319	147	205	293	405
Soybeans	62	62	112	114	167	147	151	231	184	179	137	139	237	295	342
Barley	393	269	298	356	308	567	370	200	173	244	254	124	125	255	290
Lentils	70	90	82	84	113	127	114	137	162	186	148	114	152	159	227
Linseed	86	75	102	148	216	213	244	219	128	113	138	166	205	183	213
Oats	34	57	103	102	160	198	217	126	115	144	156	127	154	148	185
Beans, dry	38	46	36	63	82	75	71	90	114	103	115	142	145	165	161
Mustard seed	39	32	47	50	49	59	64	60	47	46	46	50	52	50	52
Canary seed	18	22	30	38	53	49	43	40	37	40	51	73	75	54	51
Corn	93	52	49	62	65	102	49	43	96	38	25	41	44	61	49
Chick peas	0	1	0	0	0	0	0	5	9	55	54	39	29	32	31
Rye	28	19	23	17	25	27	23	11	9	9	10	9	8	31	18
Sugar, refined	18	20	19	31	13	14	7	9	6	7	6	7	8	6	18
Sunflower seed	12	19	18	12	25	14	13	20	17	20	26	31	37	29	17

Source: FAOSTAT (2008), own illustration.

Figure A3: Canada – Imports ('000 t) of major agricultural commodities from 1991 to 2005



Source: FAOSTAT (2008), own illustration.

Table A8: Canada – Imports ('000 t) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Corn	243	777	836	737	1,052	869	1,000	1,216	990	1,530	3,247	4,017	3,740	2,055	2,154
Soybeans	147	81	236	27	79	94	273	104	421	392	738	766	654	512	390
Rapeseed	47	111	60	37	56	115	128	134	153	167	237	227	251	175	102
Peas, dry	8	10	7	8	8	9	10	11	11	11	18	36	34	28	84
Barley	1	2	3	8	14	10	22	13	42	36	84	170	159	55	67
Sugar, refined	123	120	151	141	93	29	14	29	29	55	37	40	30	34	59
Linseed	0	0	0	0	1	1	1	4	2	7	25	22	20	38	41
Sunflower seed	14	12	24	17	12	14	10	13	21	16	22	28	20	20	35
Beans, dry	10	11	14	14	15	17	19	23	49	34	28	35	35	19	31
Oats	2	3	3	2	4	9	5	4	4	4	35	34	22	22	19
Wheat	19	21	23	10	19	79	75	105	18	25	101	33	50	14	18
Lentils	3	3	2	3	2	4	3	5	11	7	5	8	7	9	9
Chick peas	2	2	2	2	3	4	4	3	3	5	9	10	5	3	5
Mustard seed	0	0	0	0	1	1	1	1	2	1	2	9	3	2	1
Rye	0	0	0	0	0	0	0	0	2	5	3	4	1	0	0
Canary seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

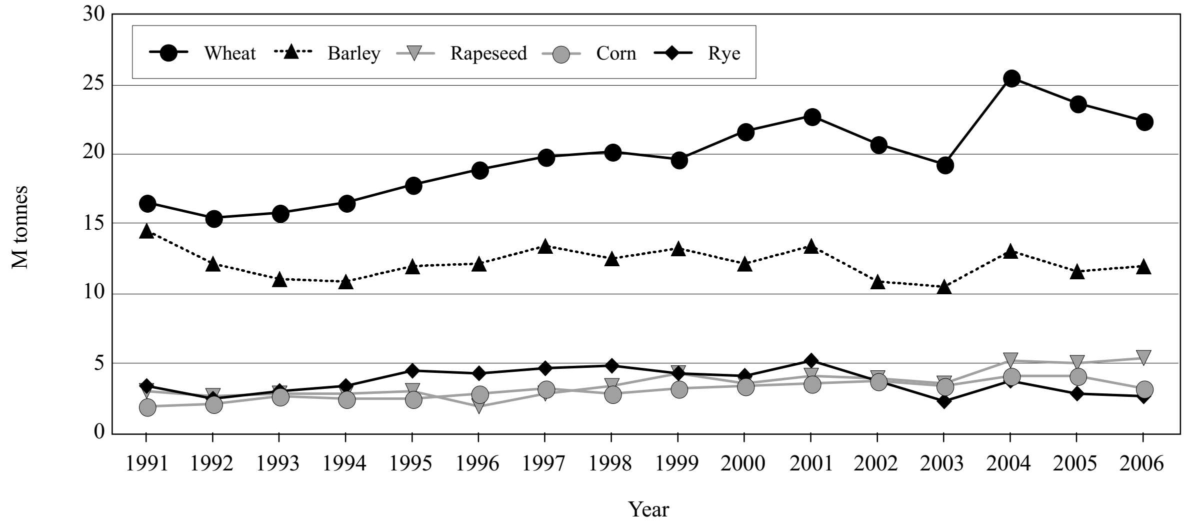
Source: FAOSTAT (2008), own illustration.

Table A9: Canada – Import value (M US$) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Corn	39	93	93	90	130	153	148	158	118	170	319	428	386	253	240
Soybeans	34	18	57	7	18	25	76	25	76	74	131	138	154	151	90
Rapeseed	11	28	14	9	15	35	35	37	36	41	54	55	69	51	30
Beans, dry	8	8	9	10	11	12	14	15	30	22	18	25	20	17	26
Sugar, refined	46	41	51	52	36	10	5	11	10	19	13	12	11	12	25
Sunflower seed	9	8	11	10	8	8	7	8	11	9	10	14	12	14	24
Peas, dry	6	6	4	5	5	5	5	6	6	6	7	11	11	9	14
Linseed	0	0	0	0	0	0	0	1	0	2	6	5	7	11	12
Barley	0	0	1	2	2	1	3	5	4	4	9	20	26	7	9
Lentils	2	2	1	2	2	2	2	2	5	3	3	4	4	4	4
Wheat	3	3	4	3	4	16	13	11	3	4	13	4	6	3	3
Chick peas	2	1	1	2	2	3	2	2	2	3	3	3	2	2	3
Oats	0	0	0	0	0	1	0	0	0	0	3	4	3	3	2
Mustard seed	0	0	0	0	0	1	1	0	0	0	1	3	1	1	0
Rye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canary seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: FAOSTAT (2008), own illustration.

Figure A4: Germany – Production (M tonnes) of major agricultural commodities from 1991 to 2006



Source: FAOSTAT (2008), own illustration.

Table A10: Germany – Production ('000 t) of major agricultural commodities and commodity groups from 1991 to 2006

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wheat	16,612	15,542	15,767	16,539	17,763	18,922	19,827	20,187	19,615	21,622	22,838	20,818	19,260	25,427	23,693	22,428
Barley	14,494	12,196	11,006	10,903	11,891	12,074	13,399	12,512	13,301	12,106	13,495	10,928	10,596	12,993	11,614	11,967
Rapeseed	2,972	2,617	2,848	2,896	3,103	1,970	2,867	3,388	4,285	3,586	4,160	3,849	3,634	5,277	5,052	5,337
Beet sugar, raw	4,251	4,401	4,359	3,992	4,159	4,569	4,397	4,388	4,784	4,765	4,066	4,395	4,120	4,729	4,032	3,254
Corn	1,937	2,139	2,656	2,446	2,395	2,913	3,188	2,781	3,257	3,324	3,505	3,738	3,422	4,200	4,083	3,220
Rye	3,323	2,422	2,984	3,451	4,521	4,214	4,580	4,775	4,329	4,154	5,133	3,666	2,277	3,830	2,794	2,644
Triticale	717	890	1,147	1,125	1,643	2,128	2,621	2,814	2,374	2,800	3,395	3,068	2,480	3,290	2,676	2,237
Oats	1,867	1,314	1,724	1,663	1,420	1,606	1,599	1,279	1,339	1,087	1,151	1,016	1,202	1,186	964	830
Peas, dry	75	74	134	151	216	301	400	589	610	409	560	413	392	464	346	288
Sunflower seed	126	161	214	311	111	103	85	85	84	64	54	52	73	70	67	62
Cereals Total	39,268	34,758	35,549	36,336	39,863	42,136	45,486	44,575	44,461	45,271	49,686	43,391	39,426	51,097	45,980	43,475
Oil crops Total	3,124	2,862	3,104	3,245	3,271	2,158	3,079	3,676	4,536	3,746	4,254	3,918	3,729	5,377	5,154	5,423
Sugars Total	4,251	4,401	4,359	3,992	4,159	4,569	4,397	4,388	4,784	4,765	4,066	4,395	4,120	4,729	4,032	3,254
Pulses Total	242	152	225	246	304	380	492	683	706	471	641	478	453	528	406	337

Source: FAOSTAT (2008), own illustration.

Table A11: Germany – Exports ('000 t) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	2,568	4,846	3,839	5,543	3,685	4,205	3,863	4,936	4,668	4,575	5,712	5,900	4,481	3,927	4,628
Barley	2,436	3,067	1,810	2,580	2,713	3,241	1,516	1,132	2,751	6,146	2,891	2,252	3,179	911	2,929
Sugar, refined	1,454	1,349	1,609	1,441	1,375	1,201	1,343	1,419	1,380	1,399	1,581	1,059	1,122	1,054	1,702
Rye	286	981	1,073	575	2,228	1,574	580	586	1,126	1,993	1,001	1,003	954	1,344	1,196
Corn	272	270	250	320	248	283	356	359	396	554	605	671	859	952	882
Triticale	0	0	0	1	11	18	118	192	108	69	164	220	170	148	269
Rapeseed	445	771	755	570	430	399	251	367	891	622	683	775	389	538	255
Oats	48	24	9	13	14	25	25	39	24	26	28	38	30	36	82
Peas, dry	11	9	8	10	33	38	39	33	53	21	42	86	50	39	77
Sunflower seed	32	23	32	36	62	5	21	12	24	45	100	18	18	45	33

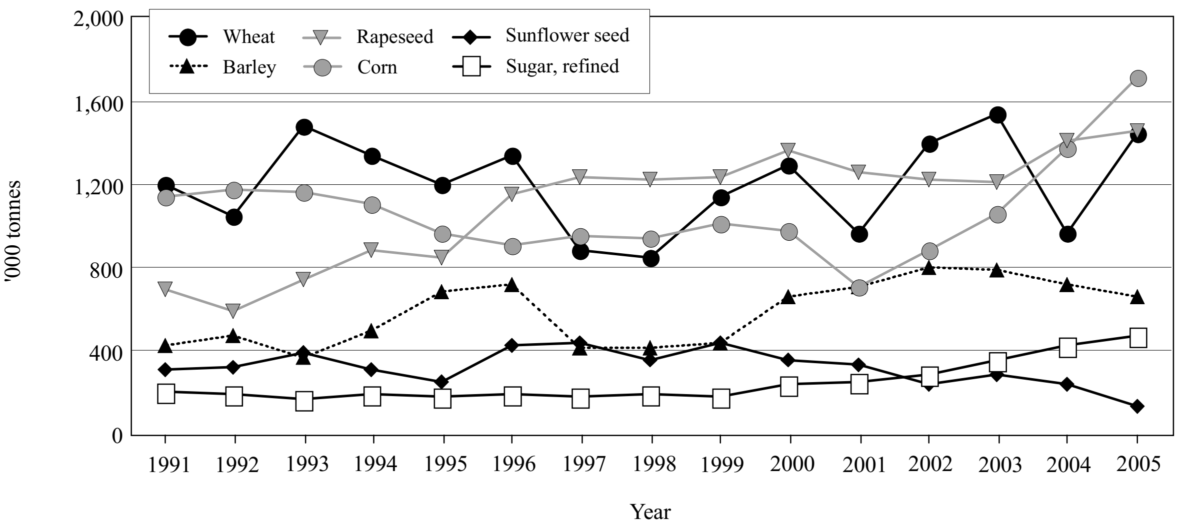
Source: FAOSTAT (2008), own illustration.

Table A12: Germany – Export value (M US$) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	463	883	620	831	684	859	662	810	656	618	755	772	677	709	715
Sugar, refined	543	572	539	594	635	586	590	581	505	439	507	410	465	505	700
Barley	323	437	221	263	379	563	228	118	276	699	330	252	416	145	403
Corn	88	79	67	80	75	83	77	75	80	87	94	110	167	224	168
Rye	23	112	136	62	243	244	78	56	109	140	95	84	93	181	128
Rapeseed	166	252	181	162	130	122	72	109	190	115	148	185	131	176	85
Triticale	0	0	0	0	2	4	18	27	14	8	18	23	22	21	36
Sunflower seed	17	9	11	15	21	4	9	8	8	18	29	8	10	20	19
Peas, dry	9	7	7	7	12	14	11	10	10	5	10	17	12	12	16
Oats	11	7	2	3	3	5	5	6	4	4	4	6	5	6	13

Source: FAOSTAT (2008), own illustration.

Figure A5: Germany – Imports ('000 t) of major agricultural commodities from 1991 to 2005



Source: FAOSTAT (2008), own illustration.

Table A13: Germany – Imports (‘000 t) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Corn	1,139	1,174	1,167	1,111	960	911	950	946	1,016	976	706	888	1,060	1,380	1,718
Rapeseed	696	590	740	878	847	1,149	1,236	1,218	1,229	1,363	1,258	1,221	1,211	1,410	1,461
Wheat	1,201	1,051	1,477	1,341	1,197	1,335	878	848	1,140	1,291	968	1,393	1,541	966	1,441
Barley	425	469	372	501	685	723	416	421	434	655	705	799	784	717	656
Sugar, refined	204	189	173	193	184	198	178	198	186	241	252	282	361	423	473
Rye	13	13	77	69	82	24	10	21	17	17	14	17	79	20	145
Sunflower seed	306	322	390	315	256	423	439	359	438	354	331	240	284	239	139
Oats	35	103	87	34	74	167	86	43	59	111	87	97	101	81	98
Peas, dry	606	556	506	467	425	223	141	131	164	79	57	38	37	91	26
Triticale	1	0	5	3	1	2	1	6	7	2	2	2	1	2	25

Source: FAOSTAT (2008), own illustration.

Table A14: Germany – Import value (M US$) of major agricultural commodities from 1991 to 2005

Commodity/ Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Sugar, refined	170	171	149	167	176	185	146	163	144	162	169	190	287	355	404
Rapeseed	297	234	179	240	246	326	336	346	261	242	254	285	361	461	394
Corn	392	402	340	306	301	311	249	233	234	181	144	185	255	371	375
Wheat	296	271	319	255	256	276	157	154	169	167	129	186	245	190	222
Sunflower seed	187	153	132	146	112	160	156	145	146	107	106	98	119	113	105
Barley	115	129	86	102	159	174	85	69	73	93	101	114	133	130	103
Rye	5	5	15	17	22	13	5	5	5	4	4	5	10	5	20
Oats	7	24	18	6	15	34	14	7	8	16	12	13	15	13	15
Peas, dry	176	154	117	88	82	51	31	29	27	16	14	12	13	25	11
Triticale	0	0	2	1	0	1	0	1	1	0	0	0	0	0	3

Source: FAOSTAT (2008), own illustration.

Table A15: Canada – Government expenditures in support of the Agri-food sector, by category, Canada and Provinces, 2004-05 to 2007-08

Expenditures		Provincial				Federal			
		2004-05	2005-06	2006-07 Forecast	2007-08 Estimates	2004-05	2005-06	2006-07 Forecast	2007-08 Estimates
		($000)				($000)			
A.	**Operating Expenditures**	661,447	654,126	667,227	756,583	1,286,740	1,391,620	1,563,383	1,385,757
B.	**Capital Expenditures**	63,576	90,877	96,861	78,042	54,703	48,620	63,033	48,976
C.	**Program Expenditures**	2,077,902	2,170,803	2,188,385	1,842,433	3,161,754	3,591,151	3,248,007	3,088,052
c.1	Income Support & Stabilization	1,050,307	1,193,488	1,282,964	963,166	945,168	1,158,715	1,948,050	1,381,300
c.2	Ad hoc and Cost Reduction	210,560	142,458	38,911	34,519	1,036,421	874,798	107,831	422,121
c.3	Production Insurance	225,972	301,492	317,455	305,228	342,546	289,453	285,301	344,770
c.4	Financing Assistance	49,936	58,901	74,862	58,758	31,998	23,922	38,026	168,832
c.5	Storage and Freight	8,466	4,915	6,372	9,816	12,309	12,007	1,967	-
c.6	Social and Labor	15,543	16,558	20,172	16,265	545	829	864	864
c.7	Research	74,595	105,663	86,190	88,988	13,004	29,842	69,190	60,594
c.8	Food Inspection	47,533	48,959	44,139	57,665	82,757	27,478	19,876	73,319
c.9	Food Aid	-	-	-	-	420,332	434,825	472,431	394,788
c.10	Marketing and Trade	103,953	30,940	29,455	33,313	106,729	557,322	106,891	74,075
c.11	Rural and Regional Devt.	120,700	67,170	91,923	73,611	108,890	88,365	61,383	53,912
c.12	Environment	41,400	53,568	57,875	60,192	54,977	71,554	99,219	111,210
c.13	Education	104,774	126,929	115,028	117,644	25	91	86	8
c.14	Extension	24,162	19,761	23,039	23,266	6,054	21,951	36,892	2,259
D.	**Tax Expenditures**	410,360	475,143	507,679	501,390	-	-	-	-
Sub-Total Gross Expenditures		3,213,285	3,390,949	3,460,153	3,178,449	4,503,197	5,031,392	4,874,423	4,522,785
Recoveries		-178,857	-174,388	-165,085	-144,592	-164,422	-175,223	-88,030	-23,700
Total Net Expenditures		3,034,428	3,216,560	3,295,067	3,033,857	4,338,774	4,856,169	4,786,393	4,499,085

Source: Agriculture and Agri-food Canada (2007).

Table A16: Expenditures of the EAGGF-Guarantee section (M EUR) from 2002 to 2006

Budget Year	Agriculture (1a)	Rural Development[1)] (1b)	Storage	Export Refunds	Direct Aids	Other Measures	Rural Developme nt
	(M EUR)		(M EUR)				
2002	38,864.8	4,349.4	1,163.1	3,432.3	28,800.8	5,468.7	4,349.4
2003	39,781.6	4,679.6	928.1	3,729.6	29,692.4	5,431.5	4,679.6
2004	38,298.5	6,462.0	322.4	3,384.2	29,824.6	4,767.4	6,462.0
2005	42,100.8	6,827.4	851.5	3,051.9	33,700.8	4,496.6	6,827.4
2006	42,175.3	7,689.9	756.9	2,493.6	34,051.3	4,873.4	7,689.9

1) EAGGF - Guarantee section only.
Source: European Commission (2007), own illustration.

Table A17: Expenditures of the German federal agricultural budget (M EUR) from 2004 to 2007

Expenditures (M EUR)	2004	2005	2006	2007
Agricultural social policy	3,778.3	3,677.0	3,779.7	3,712.0
Consumer protection (incl. BfR, BVL, vzbv)	103.7	109.5	79.3	84.1
Research (without research institutes)	33.0	34.1	36.4	56.4
Fishery	24.1	23.8	36.4	49.3
Grants	15.9	15.8	15.4	15.0
Renewable resources	30.5	53.3	52.2	50.0
Demonstration projects	17.5	18.5	9.8	8.0
Innovation initiative	-	5.0	-	-
Federal program for organic farming	20.0	20.0	20.0	16.0
International organizations	28.3	32.1	30.8	29.5
Bilateral cooperation with the FAO	10.0	14.0	10.0	10.0
General budget reduction	-30.0	-15.0	-100.0	0.0
Other measures	23.7	25.1	26.8	21.6
Total general measures	**4,029.9**	**3,981.3**	**3,996.8**	**4,051.9**
Joint Issue "Improvement of agricultural structure and coastal protection"	764.0	720.0	650.0	630.0
General budget reduction	-35.0	-35.0	-35.0	-35.0
Market regulation	124.9	122.6	104.1	105.0
Administration, federal agencies and federal research institutes	305.0	289.5	347.4	399.7
Total budget	**5,211.6**	**5,106.9**	**5,090.2**	**5,171.5**

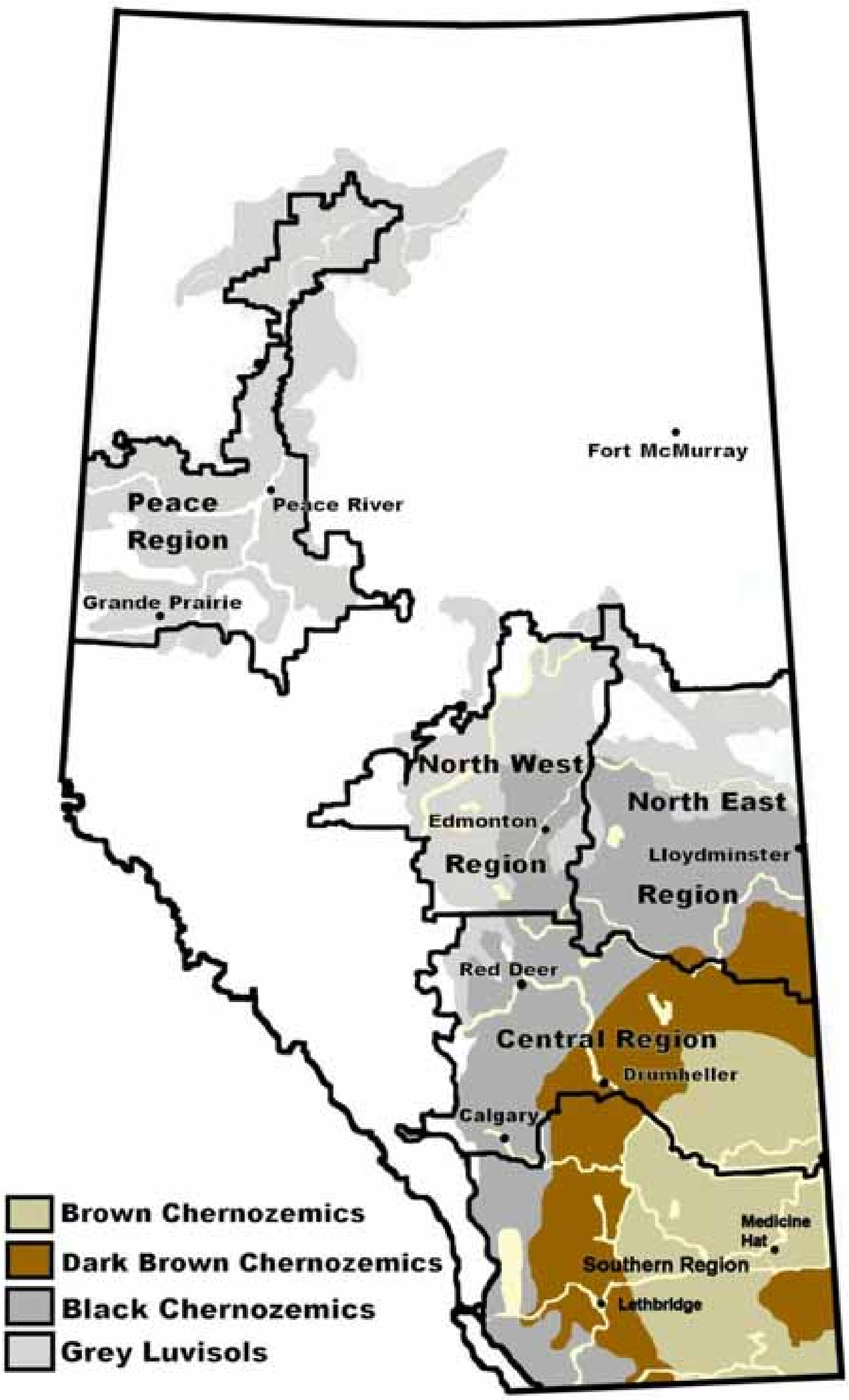
Source: BMELV, Agrarpolitischer Bericht, 2005 - 2007, own illustration.

Table A18: Expenditures of the EU agricultural budget and expenditures related to Germany (M EUR) from 2004 to 2007

Expenditures (M EUR)	EU			EU expenditures to Germany		
	2004	2005	2006	2004	2005	2006
Decoupled direct aids	**-**	**1,449.2**	**15,947.5**	**-**	**-**	**4,952.7**
Market-related measures and coupled direct aids						
Cereals	17,245.4	17,811.4	8,602.2	3,674.5	3,859.7	152.0
Rice	180.2	436.2	258.9	0.0	0.0	0.0
Sugar	1,278.9	1,792.9	1,520.7	205.3	268.9	107.5
Olive Oil	2,372.5	2,311.5	2,341.5	0.0	0.0	0.0
Textile plants	853.5	972.5	935.6	0.1	0.2	0.2
Fruits and vegetables	1,583.0	1,748.4	1,656.4	22.9	25.7	27.7
Wine	1,100.5	1,267.2	1,487.2	20.6	27.2	24.4
Tobacco	923.9	922.7	811.0	35.9	32.3	-
Other plant products/measures	732.0	600.9	589.7	36.0	35.5	8.1
Refund of non-program products	380.3	.	274.1			27.4
Milk and dairy products	2,070.1	2,755.2	2,463.4	230.2	391.0	141.3
Beef and veal	7,789.2	8,176.1	3,497.5	963.1	1,030.1	33.2
Sheep meat and goat meat	1,197.9	1,837.3	942.1	40.0	44.8	0.0
Pig meat, eggs & poultry, bee-keeping	174.7	140.9	101.1	10.6	6.4	4.0
Fish	23.9	28.5	25.2	0.5	0.3	0.3
Food programs	209.8	222.1	228.8	0.3	0.0	0.0
Monitoring, fraud-prevention, accounts	-486.6	-582.9	-275.2	-7.8	-18.7	-0.9
Advertising, promotion of sales, planning	56.6	35.7	44.3	1.6	2.7	4.8
Veterinary and phytosanitary measures	360.3	227.5	256.0	0.0	0.0	0.0
Recoveries	-70.3	-90.2	-93.1	-	-7.0	-13.8
Other direct aids	1.8	4.4	514.5	0.0	0.0	96.9
Total market regulation expenditures and direct aids	**37,977.6**	**42,067.3**	**42,129.4**	**5,233.8**	**5,699.1**	**5,603.3**
Agrarian environmental measures	1,931.9	2,005.3	2,151.7			
Less-favored areas	1,051.8	1,123.7	1,192.4			
Early retirement	196.0	182.5	246.7			
Forestry	401.2	363.8	380.6			
Investment aid	229.8	252.7	358.1			
Young farmers program	107.4	126.2	123.6			
Market structure improvement	186.9	183.0	284.7			
Adjustment and development of rural areas	584.9	612.1	842.8			
Others	59.0	65.4	42.7			
Rural development (guarantee) EU-15	**4,748.9**	**4,914.7**	**5,623.3**	**799.9**	**803.8**	**940.4**
Rural development (guarantee) EU-10	**628.9**	**1,931.0**	**2,096.0**			
Total section "Guarantee" of EAGGF	**43,355.4**	**48,913.0**	**49,848.7**	**6,033.7**	**6,502.9**	**6,543.7**
EAGGF-Adjustment	3,437.8	3,495.3	3,311.5			
Total rural development	**8,815.6**	**10,341.0**	**11,031.2**			
Financial instruments for fisheries	537.2	555.2	596.6			
Other agricultural measures	59.0	67.0	43.0			
Other fishery measures	84.0	93.0	93.0			
Total agricultural and fishery expenditures	**47,473.4**	**53,123.5**	**53,893.2**			
Total EU budget expenditures	**101,806.6**	**105,684.0**	**107,378.5**			
Total agricultural and fishery budget for EU-25 in % of total	**46.6**	**50.3**	**50.2**			

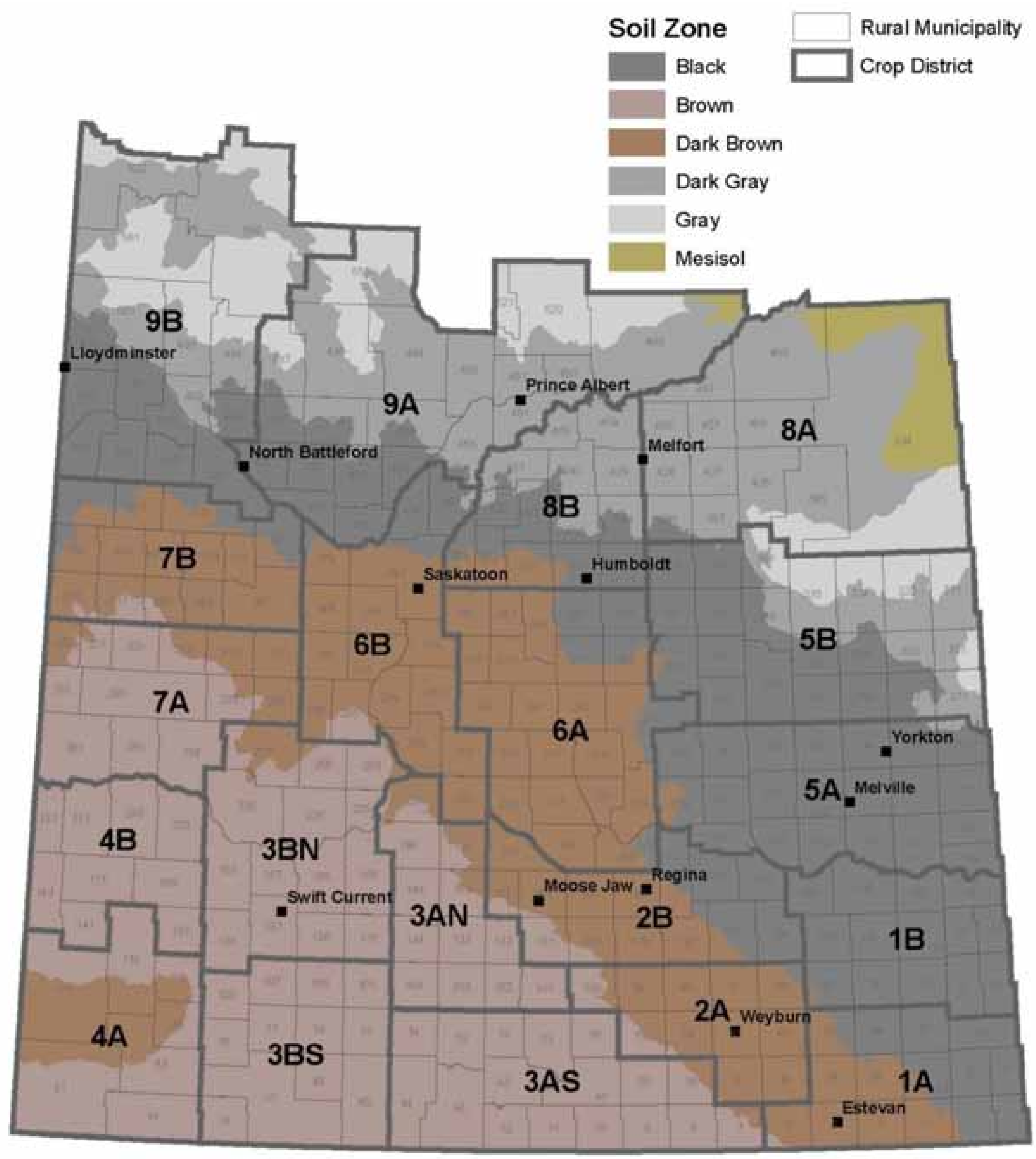
Source: BMELV, Agrarpolitischer Bericht, 2005 - 2007, own illustration.

Figure A6: Soil zones and agricultural regions in Alberta



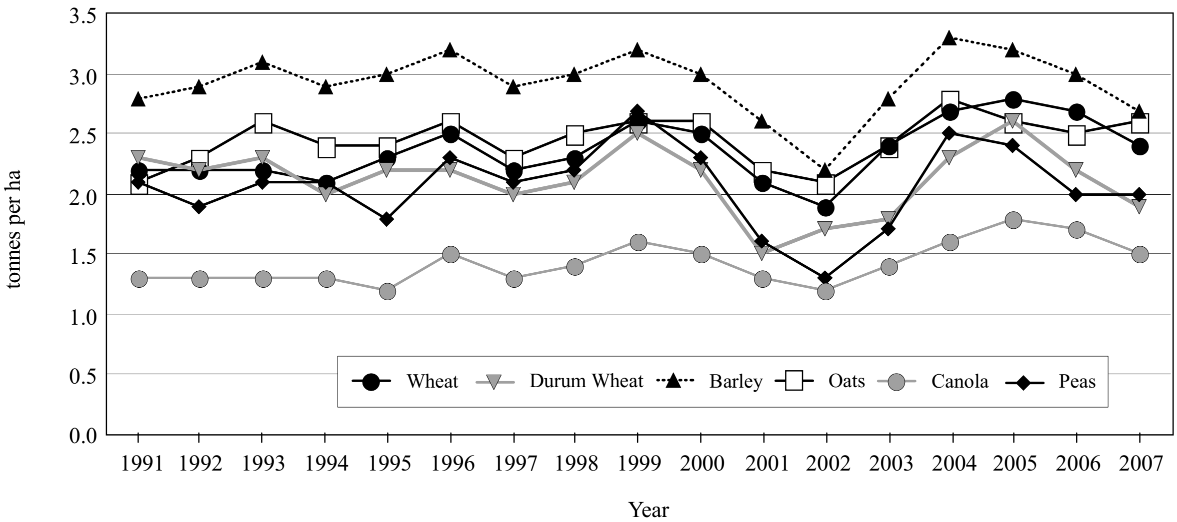
Source: Alberta Agriculture and Food and Rural Development, Conservation and Development Branch (2007).

Figure A7: Soil zones and crop districts in Saskatchewan



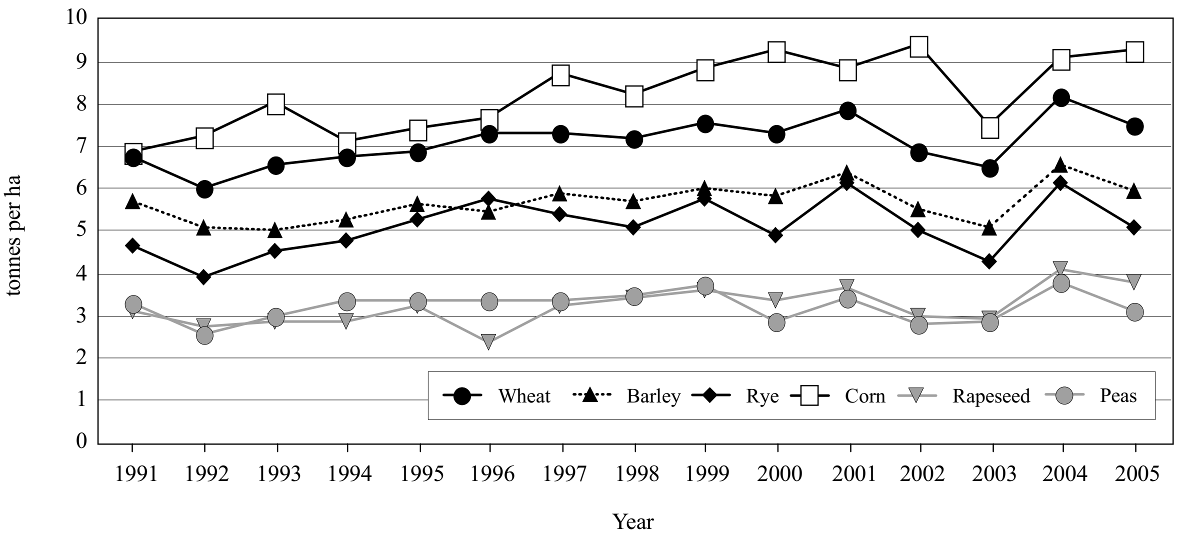
Source: Saskatchewan Agriculture and Food, Geomatics Unit (2005).

Figure A8: Yields (t/ha) of major cash crops in Canada from 1991 to 2007



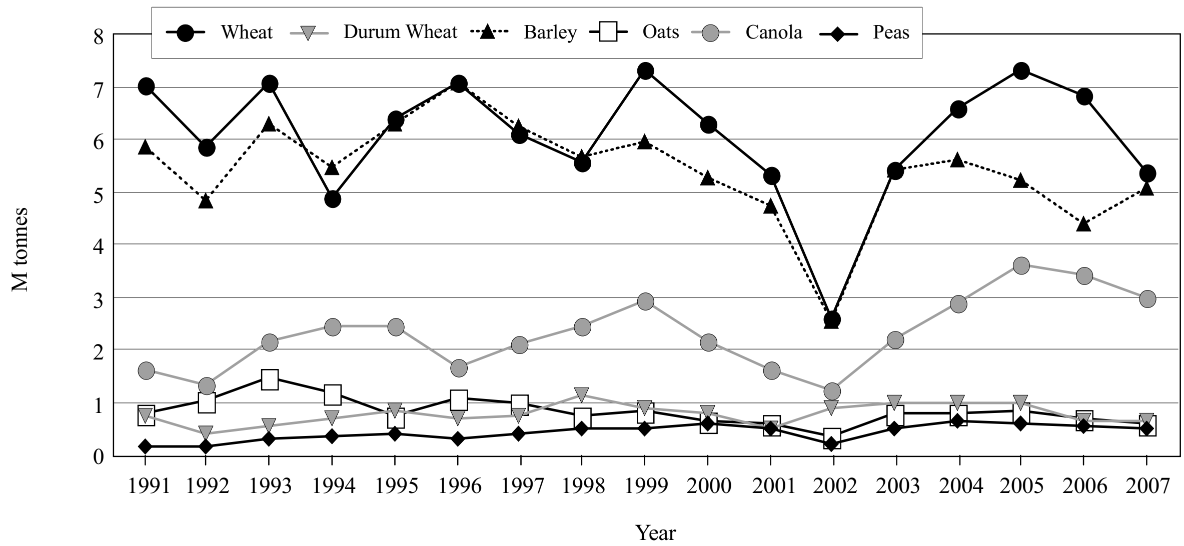
Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

Figure A9: Yields (t/ha) of major cash crops in Germany from 1991 to 2005



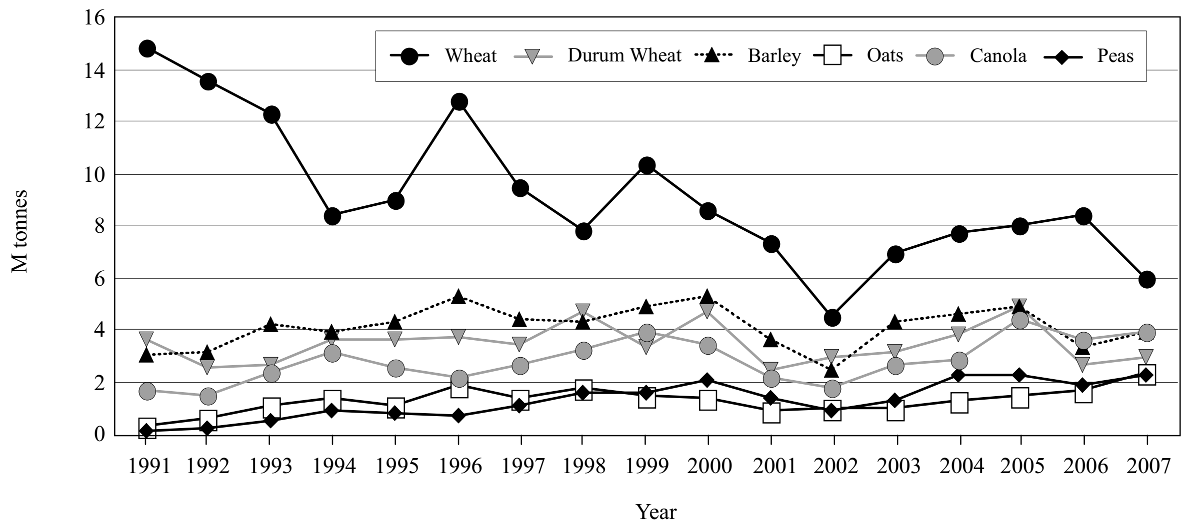
Notes: Corn includes Corn-Crop-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

Figure A10: Production (M tonnes) of major cash crops in Alberta from 1991 to 2007



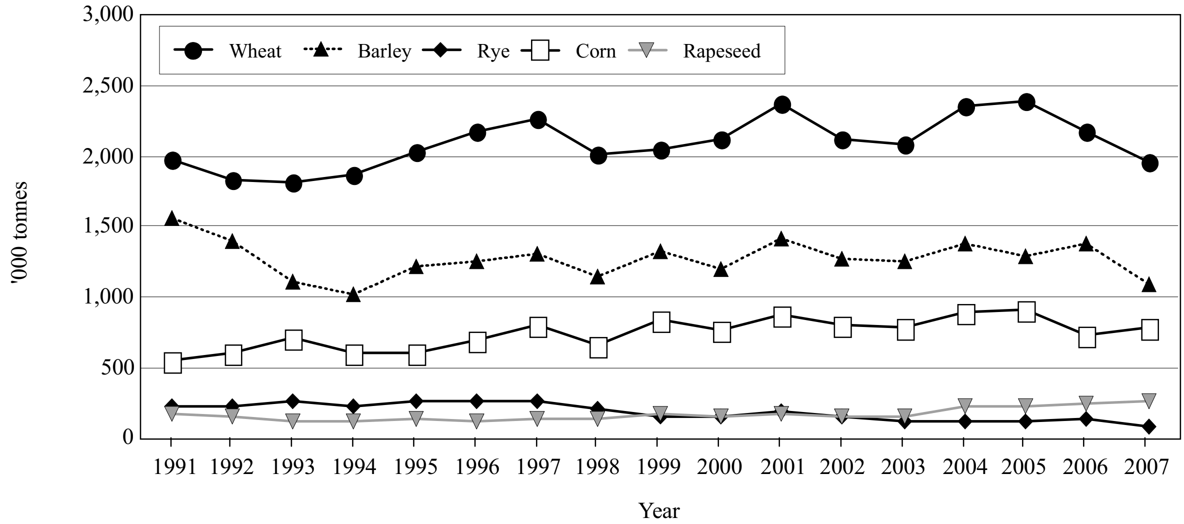
Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

Figure A11: Production (M tonnes) of major cash crops in Saskatchewan from 1991 to 2007



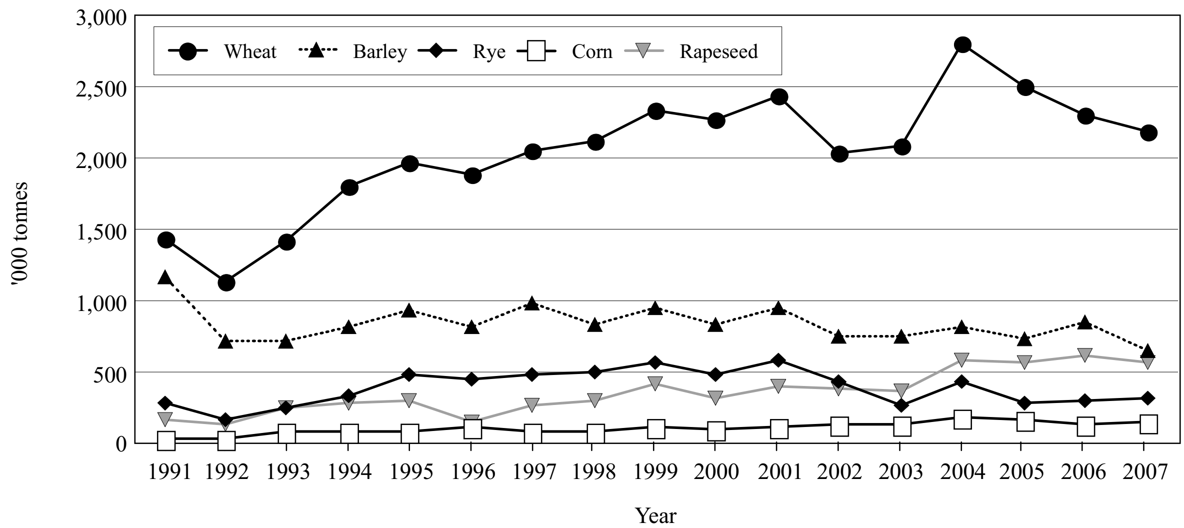
Note: Wheat includes all wheat excluding durum.
Source: CANSIM (Canadian Socio-economic Information Management System).

Figure A12: Production ('000 t) of major cash crops in North Rhine-Westphalia from 1991 to 2007



Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

Figure A13: Production ('000 t) of major cash crops in Saxony-Anhalt from 1991 to 2007



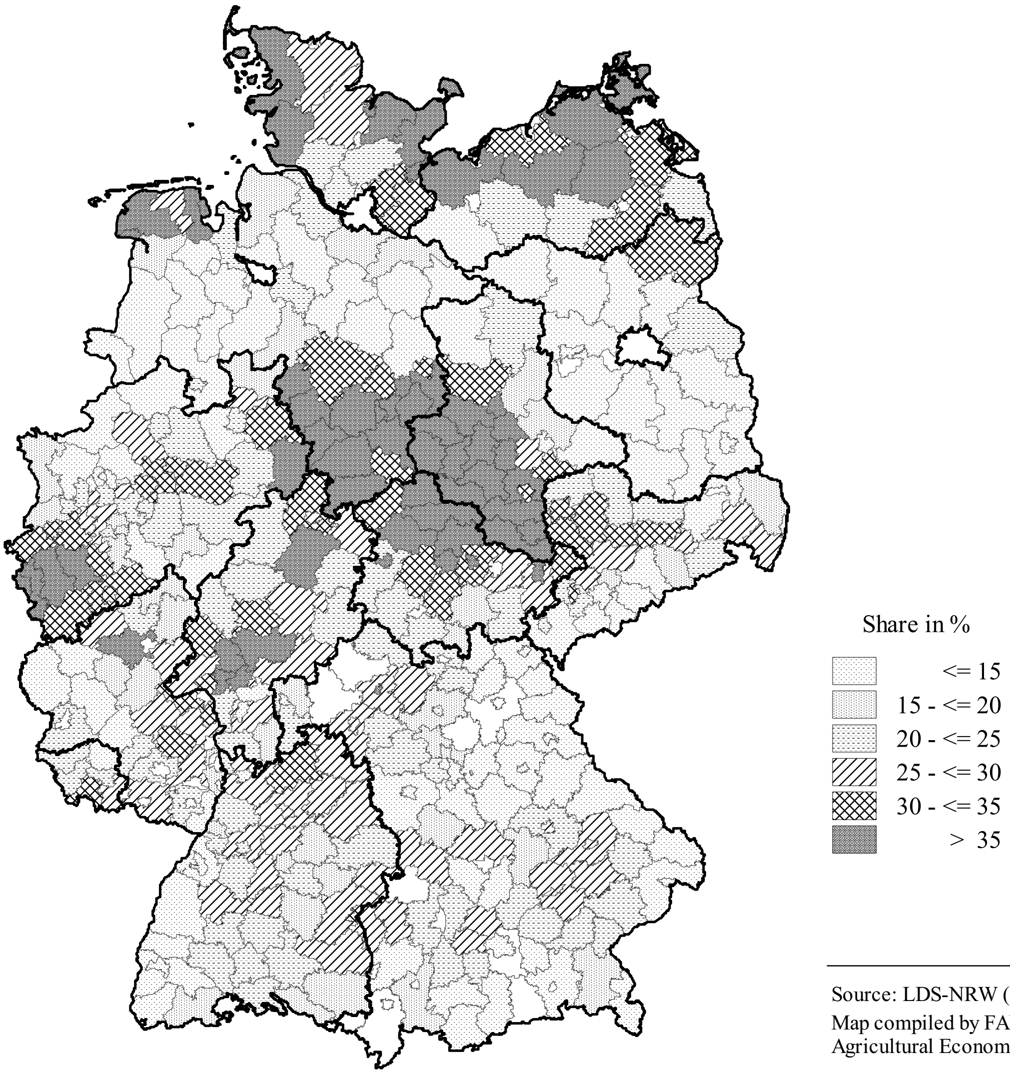
Note: Corn includes Corn-Cob-Mix (CCM).
Source: Statistisches Bundesamt, Fachserie 3, Reihe 3, various years.

Table A19: Regional distribution of major cash crops in Canada by Census Agricultural Regions (ha)

Agricultural Region	Crop Acreage (ha)								
	Total Wheat	**Spring Wheat (excluding durum)**	**Durum Wheat**	**Barley**	**Oats**	**Canola**	**Flaxseed**	**Field Peas**	**Lentils**
Alberta									
1	436,737	336,268	89,739	90,414	48,010	39,785	2,539	38,803	1,638
2	749,014	614,619	111,691	391,567	24,962	241,947	11,419	69,347	1,257
3	242,102	217,723	13,370	345,984	34,068	107,637	804	14,111	-
4A	287,830	281,911	4,736	138,727	69,687	175,938	2,291	28,961	-
4B	319,252	316,125	1,603	184,436	66,726	320,492	1,625	34,540	223
5	186,501	180,721	3,661	243,218	67,205	225,186	891	10,439	538
6	95,980	93,935	1,497	148,725	101,132	145,924	482	7,902	-
7	300,033	293,293	4,694	114,049	101,868	389,617	4,382	33,563	-
Saskatchewan									
1A	215,893	170,737	35,800	57,101	44,785	112,333	72,750	33,698	12,376
1B	147,379	133,538	8,459	57,229	69,484	85,957	53,914	17,686	1,587
2A	221,615	122,363	97,882	30,951	26,685	47,972	66,160	24,843	29,363
2B	326,498	163,273	158,171	63,412	38,386	84,538	93,183	75,439	101,886
3AN	194,976	122,157	69,878	25,484	16,235	24,366	18,520	48,070	24,785
3AS	354,583	184,556	163,492	33,060	28,475	28,344	35,806	88,777	31,359
3BN	371,271	160,749	205,969	61,045	18,640	36,731	14,926	104,436	76,878
3BS	252,669	136,457	111,122	50,068	16,894	9,502	7,276	75,641	24,111
4A	145,862	81,499	60,057	30,664	12,926	11,617	1,780	27,939	3,811
4B	206,229	88,213	116,529	17,135	5,879	9,788	1,894	29,895	9,238
5A	285,811	253,007	17,129	119,367	106,491	212,428	55,997	36,081	7,882
5B	274,704	-	-	119,597	130,195	291,280	29,093	27,300	2,018
6A	362,357	299,207	47,127	141,394	63,626	273,722	88,764	81,722	35,074
6B	348,036	307,298	37,862	92,112	58,149	155,556	20,205	62,724	51,670
7A	366,795	214,510	150,841	71,190	10,829	69,610	11,421	36,757	89,486
7B	283,880	270,595	11,520	69,864	27,057	135,269	4,174	53,151	7,766
8A	197,419	195,285	851	65,166	70,474	209,565	18,162	29,779	-
8B	252,543	247,769	3,348	110,549	48,597	240,557	16,414	34,523	1,796
9A	260,021	-	-	128,566	82,919	226,004	11,050	49,249	-
9B	207,263	203,059	3,685	81,607	60,879	153,863	3,722	45,896	2,520
Manitoba									
1	186,880	169,929	1,590	35,771	38,731	105,657	26,767	10,141	0
2	163,246	150,454	885	54,699	33,046	88,331	25,188	9,115	278
3	140,275	131,607	293	54,847	37,918	114,762	23,590	9,148	-
4	59,997	58,572	-	16,592	14,332	51,605	2,928	2,408	0
5	74,255	73,931	-	5,046	8,718	70,005	1,189	-	0
6	106,515	103,959	685	24,908	25,809	79,439	6,571	1,100	-
7	183,422	156,729	1,383	41,870	76,095	127,742	19,519	1,274	0
8	234,469	210,253	689	42,980	50,225	153,880	26,428	930	-
9	78,229	56,838	702	18,574	44,945	48,357	11,029	510	-
10	9,226	7,712	0	2,731	8,183	6,377	1,808	-	0
11	56,966	47,341	251	21,388	28,202	41,786	4,299	1,412	-
12	41,310	38,797	603	19,636	16,582	34,224	5,891	904	-

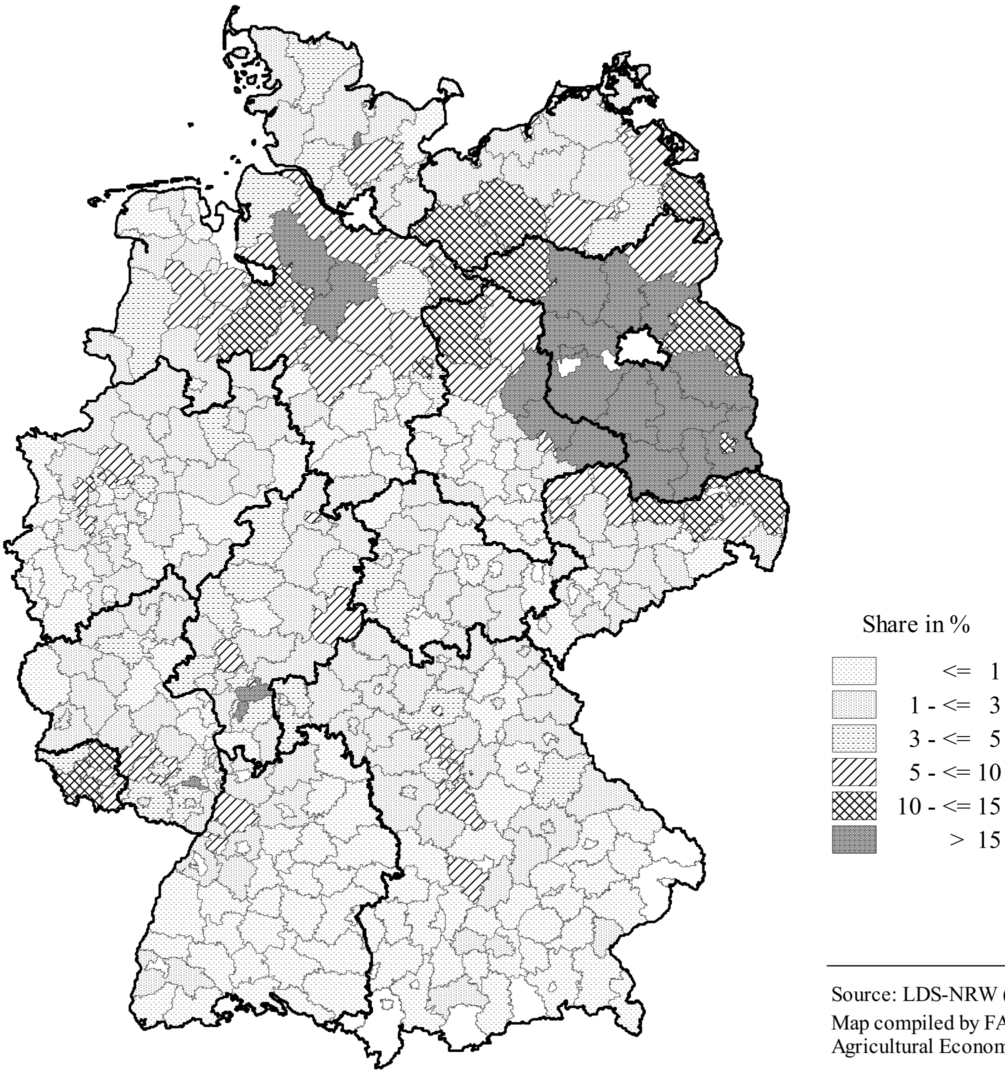
Source: Statistics Canada, Census 2006.

Figure A14: Share of wheat on total crop land by rural district in Germany



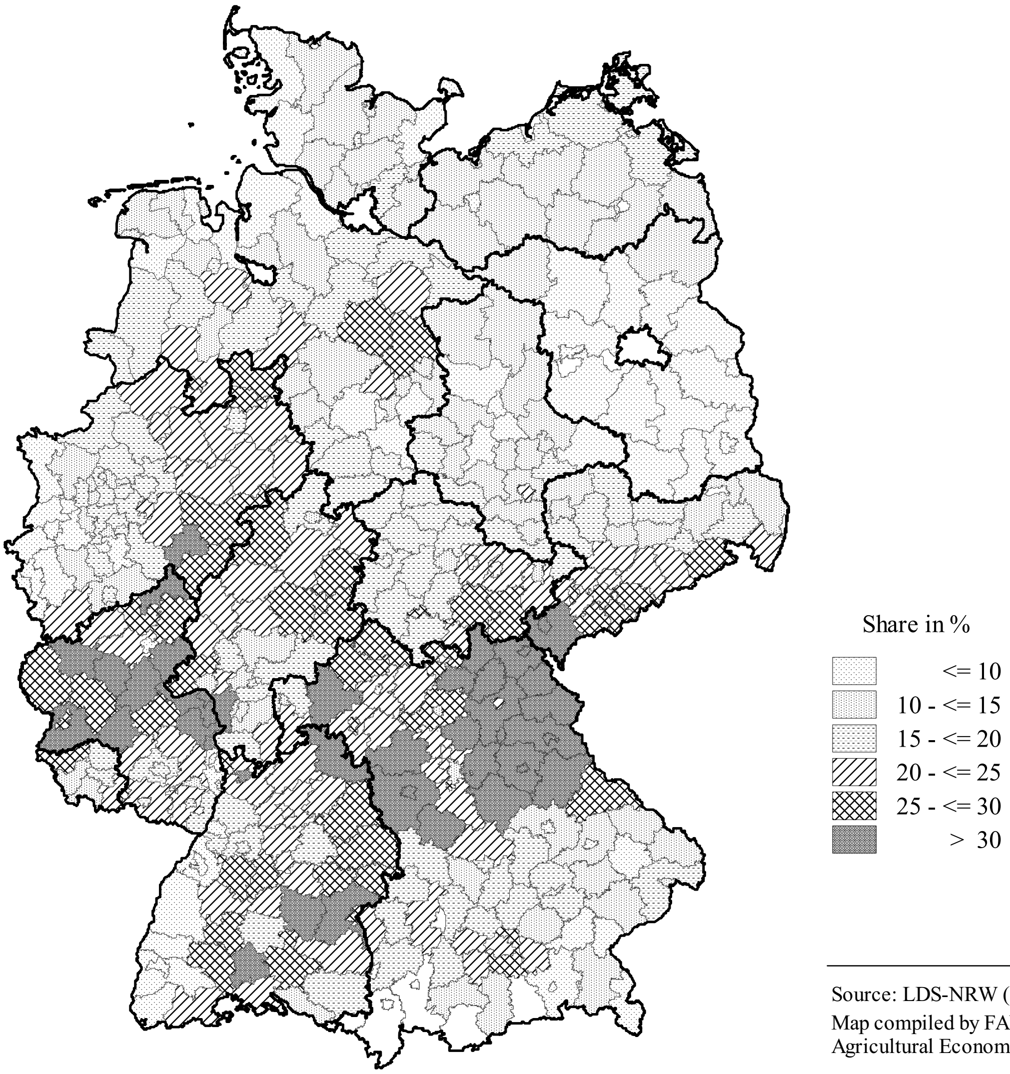
Source: LDS-NRW (2005).
Map compiled by FAL-Braunschweig, Agricultural Economics Division.

Figure A15: Share of rye on total crop land by rural district in Germany



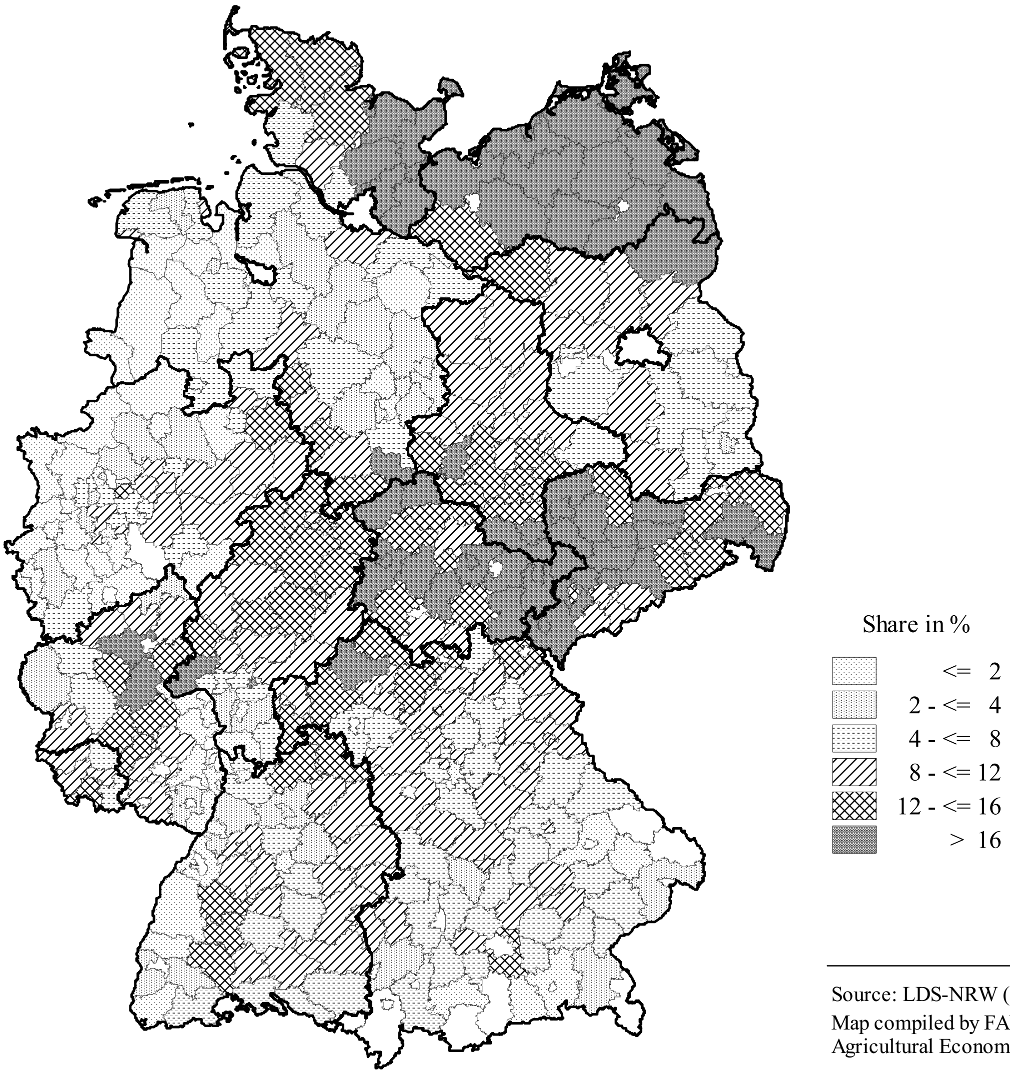
Source: LDS-NRW (2005).
Map compiled by FAL-Braunschweig, Agricultural Economics Division.

Figure A16: Share of barley on total crop land by rural district in Germany



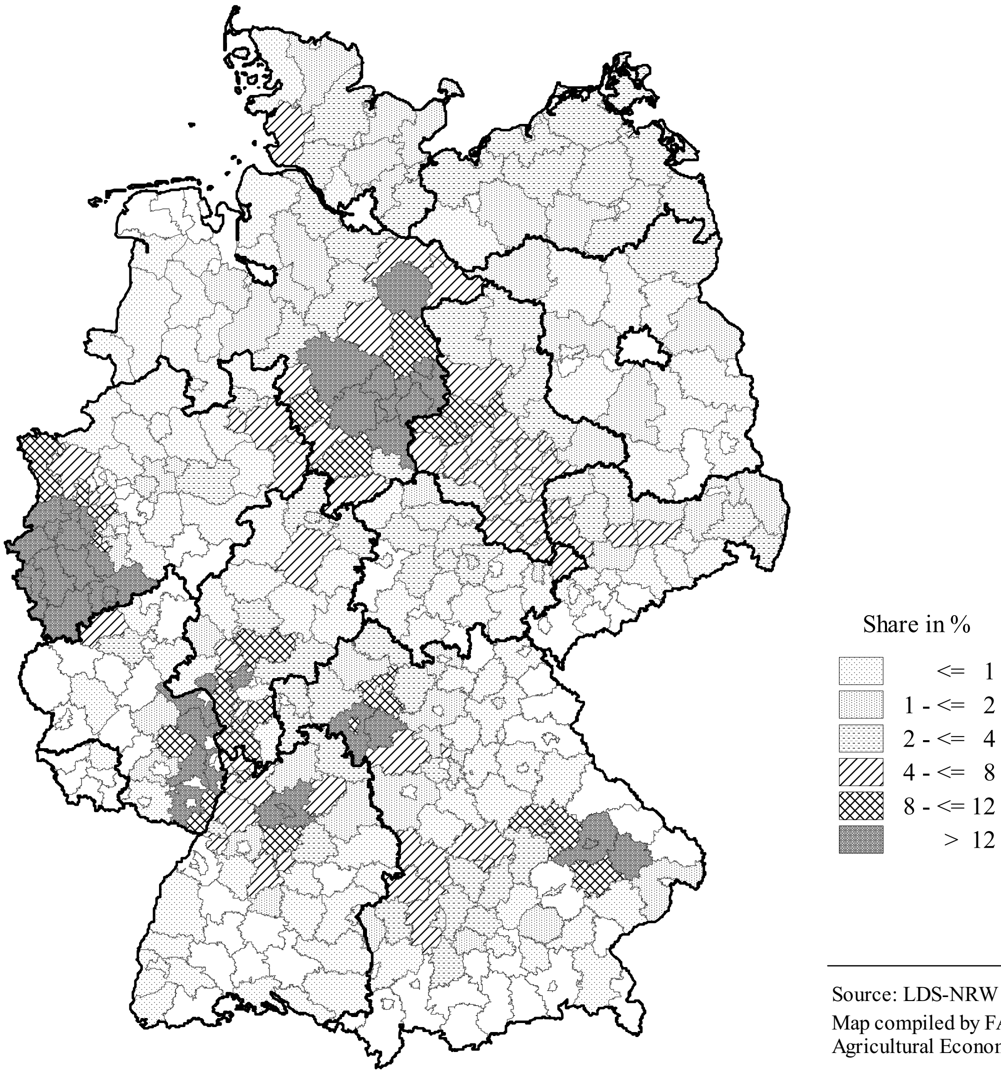
Source: LDS-NRW (2005).
Map compiled by FAL-Braunschweig, Agricultural Economics Division.

Figure A17: Share of rapeseed on total crop land by rural district in Germany



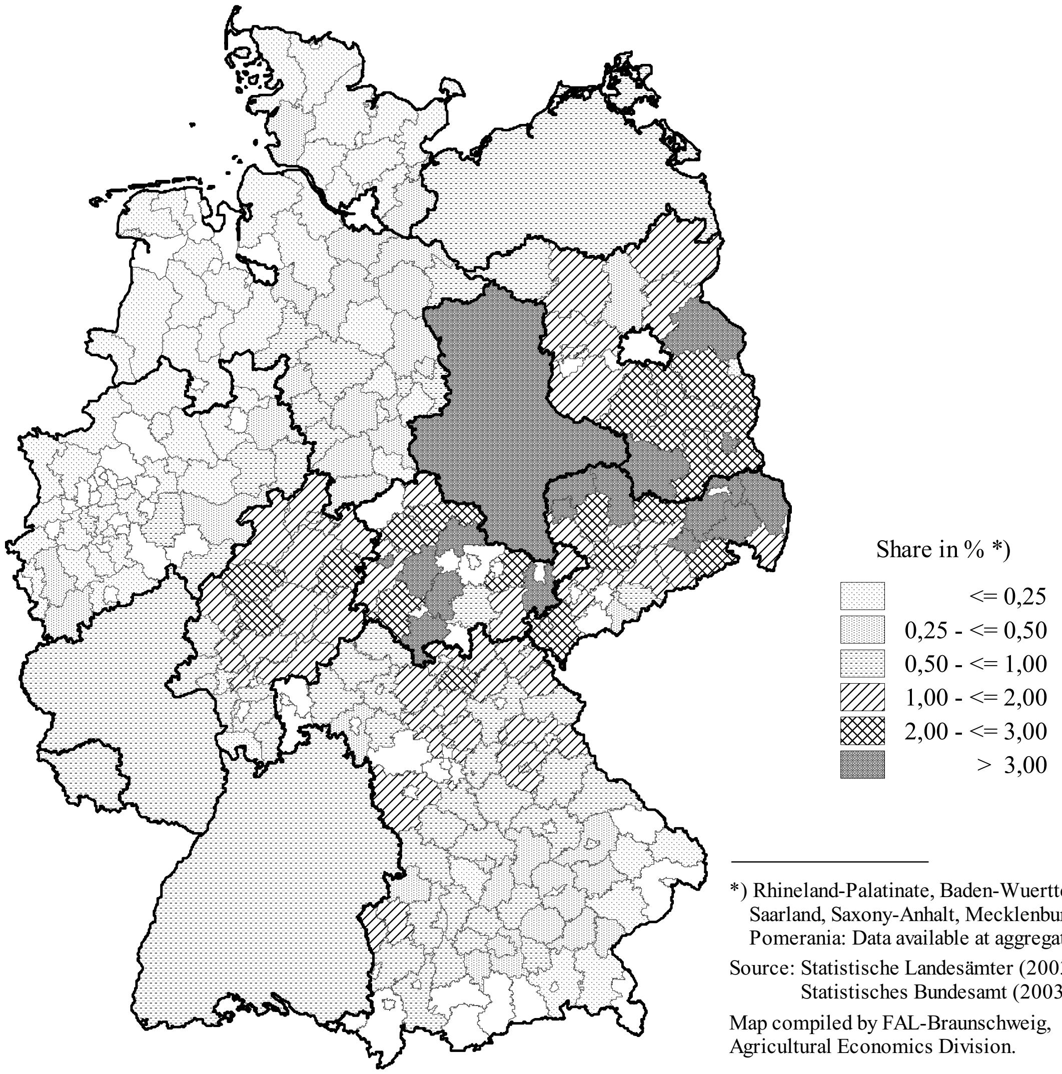
Source: LDS-NRW (2005).
Map compiled by FAL-Braunschweig, Agricultural Economics Division.

Figure A18: Share of sugar beets on total crop land by rural district in Germany



Source: LDS-NRW (2005).
Map compiled by FAL-Braunschweig, Agricultural Economics Division.

Figure A19: Share of field peas on total crop land by rural district in Germany

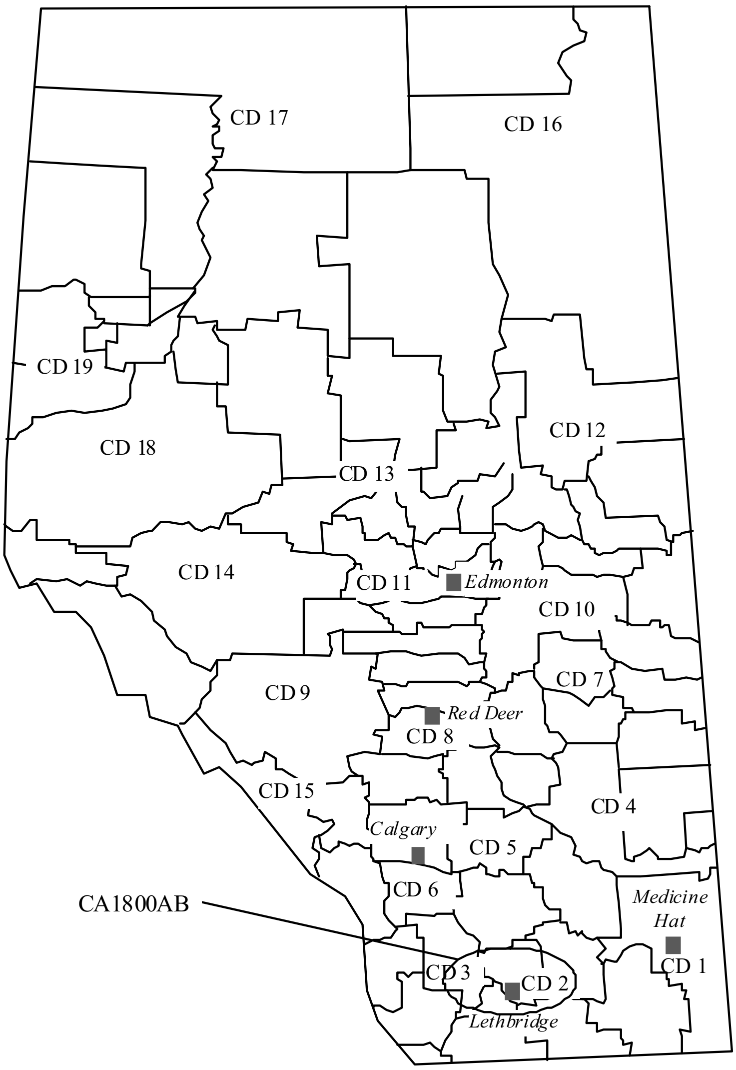


*) Rhineland-Palatinate, Baden-Wuerttemberg, Saarland, Saxony-Anhalt, Mecklenburg-Western Pomerania: Data available at aggregated level only.

Source: Statistische Landesämter (2003); Statistisches Bundesamt (2003).

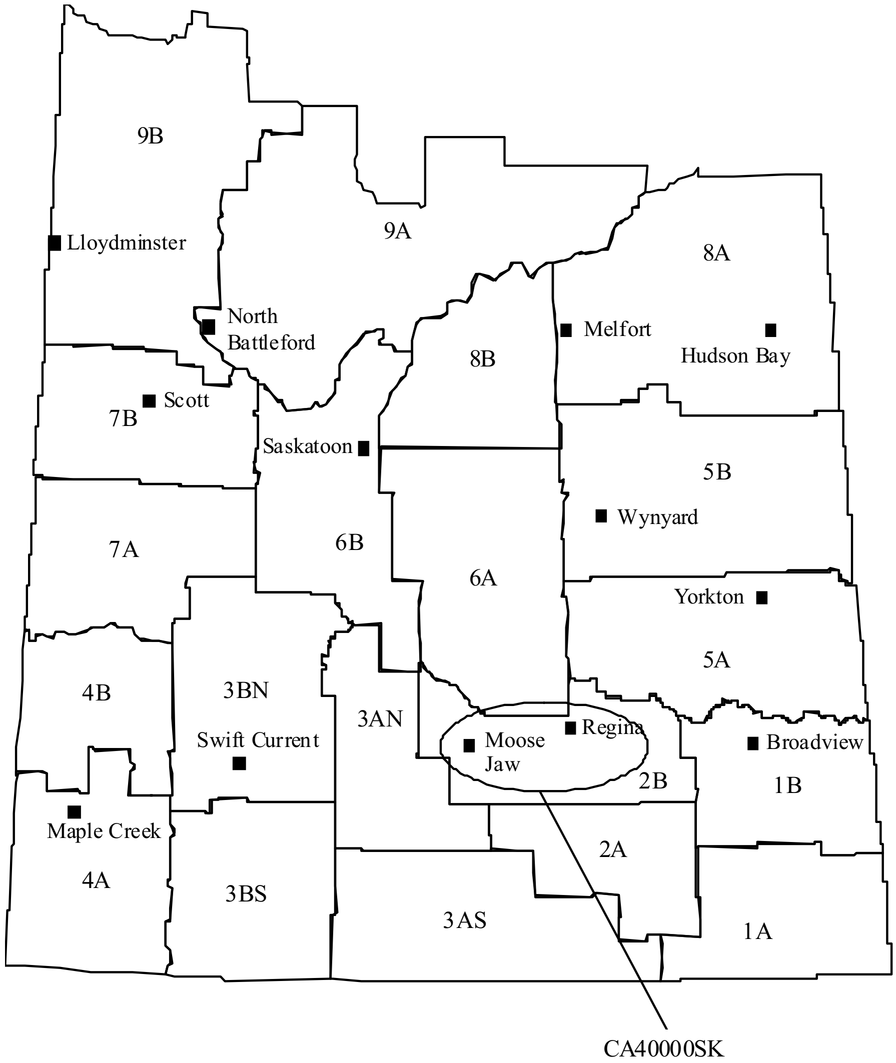
Map compiled by FAL-Braunschweig, Agricultural Economics Division.

Figure A20: Location of the representative farm and census divisions in Alberta



Source: Map compiled by FAL-Farm Economics.

Figure A21: Location of the representative farm and agricultural regions in Saskatchewan



Source: Map compiled by FAL-Farm Economics.

Table A20: Machinery and equipment of farm CA1800AB

CA1800AB	Machinery List									
Item	hp, width, capacity	Amount of lease (Can$)	Historical Purchase Price (Can$)	Age at purchase	Current Age	Years kept/ Lease period	Salvage Value (Can$)	Current Replace-ment Price (Can$)	Current Value (Can$)	Hours/ acre/bu, per year
Tractors										
4WD	400 hp		180,000	0	4	10	90,000	250,000	180,000	300
MFD with loader (pulls sprayer)	150 hp		180,000	0	2	10	90,000	180,000	120,000	500
2WD, auger and minor jobs	80 hp		50,000	5	10	15	20,000	50,000	30,000	200
Tillage										
Land roller - rented										
Seeding										
Airseeder	40'		160,000	0	2	7	60,000	200,000	120,000	
Fertilizing and Spraying										
Sprayer pull-type, high clearance	100'		45,000	0	2	5	20,000	60,000	35,000	12,000
Harvest and Transport										
Combine	350 hp		200,000	0	2	5	90,000	250,000	150,000	300
Pickup			15,000	0	2	5	10,000	20,000	15,000	
Draper platform	30'		40,000	0	2	5	20,000	50,000	30,000	
Swather, self-propelled, 85 hp, used	30'		50,000	5	8	10	30,000	65,000	40,000	
Semi - Truck, 425 hp, used			30,000	4	6	20	5,000	30,000	27,000	450
Semi - Trailer, 32t	1200 bu		45,000	0	2	20	30,000	50,000	45,000	450
Old tandem truck, 350 hp, used	500 bu		50,000	10	15	30	10,000	50,000	30,000	100
Pickup			35,000	0	2	5	10,000	40,000	30,000	
Old Pickup - used			10,000	10	12	30	0	10,000	6,000	
Old Pickup service and fuel - used			10,000	10	12	30	0	10,000	6,000	
Truck, used	120 bu		12,000	5	20	30	0	12,000	5,000	50
Other Equipment										
Shop equipment			15,000					30,000	15,000	

Source: Own illustration based on panel-approach.

Table A21: Machinery and equipment of farm CA4000SK

CA4000SK	Machinery List									
Item	**hp, width, capacity**	**Amount of lease (Can$)**	**Historical Purchase Price (Can$)**	**Age at purchase**	**Current Age**	**Years kept/ Lease period**	**Salvage Value (Can$)**	**Current Replacement Price (Can$)**	**Current Value (Can$)**	**Hours/ acre/bu, per year**
Tractors										
4WD - owned	375 hp		230,000	0	5	10	80,000	300,000	190,000	250
4WD - 5 year lease	375 hp	25,000		0	3	5				300
MFD with loader - lease	160 hp	20,000		0	1	5				400
2WD, auger and minor jobs	130 hp		40,000	5	18	30		40,000	18,000	150
2WD, auger and minor jobs	130 hp		40,000	5	21	30		40,000	15,000	150
Small tractor for farmstead care	25 hp		20,000	0	2	4	12,000	30,000	15,000	150
Tillage										
Land roller	45'		30,000	0	3	15	10,000	30,000	20,000	3.000-4,000
Seeding										
Airseeder	50'		140,000	0	6	12	40,000	180,000	90,000	5,000
Airseeder	50'		140,000	0	6	12	40,000	180,000	90,000	5,000
Fertilizing and Spraying										
Sprayer, self-prop., high-clearance, 220 hp, lease	100'	30,000		0	2	5				32,000
Harvest and Transport										
Combine 1 - lease	350 hp	30,000		0	2	5				3,300
Combine 2 - lease	350 hp	30,000		0	2	5				3,300
Combine 3 - lease	350 hp	30,000		0	2	5				3,300
3 x Pickup - owned			54,000	0	2	5	24,000	84,000	30,000	
3 x Straight cut header flex - owned	35'		210,000	0	2	5	135,000	240,000	180,000	
Swather, self-propelled, 180 hp - lease	30'	18,000		0	2	5				
Semi truck, used			40,000	3	5	10	5,000	40,000	30,000	100
Semi trailer, new	1000 bu		20,000	0	5	10	3,000	20,000	8,000	
3 x Tandem truck - used			45,000	10	15	25	15,000	54,000	24,000	300
Pickup truck, diesel, used			15,000	2	3	10	3,000	18,000	6,000	200
Pickup truck, gas, used			10,000	4	6	10	1,000	12,000	3,000	200
Pickup			35,000	0	2	5	10,000	40,000	30,000	
Other Equipment										
Shop equipment			30,000	0	7	15		50,000		
Miscellaneous			20,000	0	7	15		30,000		

Source: Own illustration based on panel-approach.

Table A22: Machinery and equipment of farm DE300EW

DE300EW	Machinery List							
Item	Historical Purchase Price (EUR)	New	Used	Current Replace-ment Price (EUR)	Salvage Value (EUR)	Year of Commissioning	Economic Lifetime (Years)	Hours/ ha/km, per year
Tractors								
Tractor 190 hp	90,000	X		95,000	35,000	2001	16	600
Tractor 160 hp	75,000	X		82,000	20,000	2004	16	600
Tractor + frontend loader	10,000		X	22,000	5,000	1998	10	200
Tillage								
Plow, 5-furrow, 2.25 m	15,000	X		15,500	3,000	2005	12	180
Packer	3,500	X		3,750	1,000	2005	12	170
Field cultivator, 4.2m	12,000	X		14,500	2,500	2001	8	600
Ripper	2,000	X		2,500	500	1999	15	35
Seeding								
Seed drill with rotary harrow, 3m	16,000	X		21,000	4,000	1998	12	250
Front wheel packer, 1.4 m	3,000	X		3,500	1,500	1998	12	250
Fertilizing and Spraying								
Sprayer, pull type, 27m, 3,500 l	35,000	X		40,000	8,000	2001	10	1,400
Fertilizer spreader, 12-36 m, 3t	7,000	X		8,000	1,000	1998	10	300
Chopper mower, 3.5m	6,000		X	6,000	500	2002	10	35
Small spreader	1,000	X		1,000		2000	10	50
Land roller, 6m	2,000		X	2,000		1993	15	50
Harvest and Transport								
Trailer, new, 16 t	15,000	X		15,000	0	1999	20	800
Trailer, new, 16 t	15,000	X		15,000	0	1999	20	800
Trailer, used, 16 t	8,000		X	5,000	0	1995	15	
Trailer, used, 16 t	8,000		X	5,000	0	1995	15	
Trailer, used, 8 t	2,000		X	2,000	0	1990	20	
Trailer, used, 8 t	2,000		X	2,000	0	1990	20	
Water tank, 5000 l	1,000		X	1,000	0	1994	20	
Other Equipment								
Pressure washer	1,500	X		2,000	0	2003	5	
Auger for seed and fertilizer	600	X		1,000	0	2000	10	
Grain meter	900	X		900	0	1994	15	
Office equipment	2,000	X		2,000	0	2003	8	
Farm vehicle, Share	12,000	X		12,000	1,000	2002	7	
Custom work	**ha**			**EUR/ha**				
Grain & oilseed harvest	246			120				
Sugar beet planting	36			50				
Sugar beet harvest	36			250				

Source: Own illustration based on panel-approach.

Table A23: Machinery and equipment of farm DE1300SA

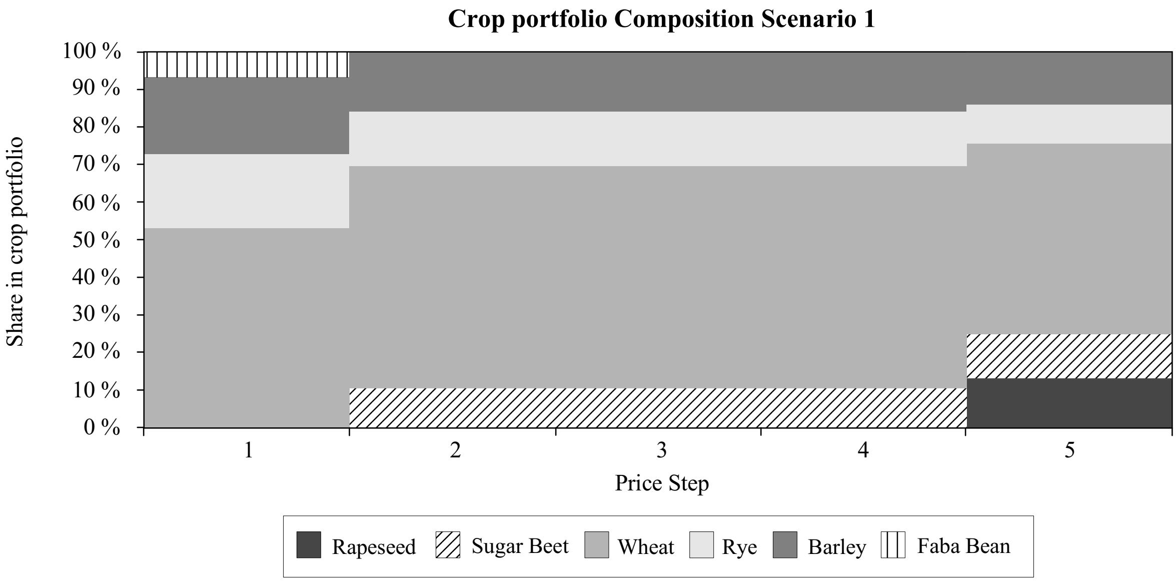
DE1300SA	Machinery List							
Item	Historical Purchase Price (EUR)	New	Used	Current Replacement Price (EUR)	Salvage Value (EUR)	Year of Commissioning	Economic Lifetime (Years)	Hours/ ha/km, per year
Tractors								
Tractor 250 hp (Tillage)	117,000	X		124,200	32,800	2003	13	
Tractor 250 hp (Seeding)	123,000	X		125,500	32,800	2005	12	
Tractor 185 hp (Sprayer)	87,000	X		96,100	27,600	2001	10	
Tillage								
Plow, 7-furrow	32,252	X		37,800	3,000	1998	92	
Packer (2.95 m)	5,722	X		6,700	900	1998	92	
Disc harrow (7.5 m)	29,300	X		29,900	6,500	2005	7	
Field cultivator (5.8 m, 8 beams)	26,700	X		30,700	4,500	1999	15	
Land roller (12 m)	16,600			20,200	2,800	1996	40	
Seeding								
Seed drill Väderstadt 6 m	53,100	X		58,600	15,800	2001	7	
Sugar beet planter, 12 rows	13,900			16,600	600	1997	15	
Fertilizing and Spraying								
Fertilizer spreader	9,500	X		9,700	3,500	2005	20	
Small spreader	1,069	X		1,200	200	2001	13	
Sprayer, pull type, 5000 l, 30m	50,000	X		55,200	3,800	2001	4	
Harvest and Transport								
Farm loader	43,000			49,400	13,800	1999	20	
Combine with header, 9 m	258,621	X		263,800	58,000	2005	9	
Header adapter for rapeseed	7,400	X		8,200	2,000	2001	7	
2 x Trailer, 16 t	24,700	X		31,300	5,500	1994	20	
2 x Trailer, 18 t	26,200	X		29,500	6,600	2000	21	
2 x Trailer, 18 t	26,200	X		29,500	6,600	2000	21	
Other Equipment								
Chopper mower 1	6,100			7,000	1,000	1999	40	
Chopper mower 2	6,900			8,100	1,000	1998	40	
Water tank 10,000 l + trailer	2,800	X		3,300	0	1998	40	
Farm Pickup (90 hp)	18,700	X		20,600	2,500	2001	6	
Auger for seed and fertilizer	3,600	X		4,200	0	1998	20	

Source: Own illustration based on panel-approach.

Figure A22: Crop portfolio composition, output prices and price ratios for scenario 1

Scenario		1	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	▼	118	141	165	188	212	235					
2	Sugar Beet	▼	16	20	23	26	29	33					
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet	12	15	17	20	22	25					
Price Ratio	Wheat	Rapeseed	0.94	1.13	1.32	1.50	1.69	1.88					
	Wheat	Sugar Beet	0.13	0.16	0.18	0.21	0.23	0.26					
	Rapeseed	Sugar Beet						0.14					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
1	-50%	-50%	=	76,342	-24%	-	0%	0%	53%	20%	20%	7%	-100%	-100%	9%	150%	55%
	-40%	-40%	=	76,354	-24%	12	0%	11%	59%	15%	15%	0%	-100%	-9%	20%	88%	19%
	-30%	-30%	=	82,724	-17%	6,370	0%	11%	59%	15%	15%	0%	-100%	-9%	20%	88%	19%
	-20%	-20%	=	89,094	-11%	6,370	0%	11%	59%	15%	15%	0%	-100%	-9%	20%	88%	19%
	-10%	-10%	=	88,006	-12%	-1,088	13%	12%	50%	11%	13%	0%	-28%	0%	3%	38%	3%



Source: Own calculations based on panel-approach.

Table A24: Cropping activity gross margins and shares in crop portfolio for scenario 1

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
1	1	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-313	-259	-98	-341	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	0	0	60	0	60	60	60	40	20
Share in crop portfolio		100%	0%	0%	0%	0%	20%	0%	20%	20%	20%	13%	7%
Total Gross Margin (EUR)		76,342	0	0	0	0	22,924	0	14,559	11,334	15,946	10,298	1,280
Rotation Index			18	17									
Rotation Acreage (ha)			200	100									
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	0	160	60	60	20					
Share in crop portfolio		100%	0%	0%	53%	20%	20%	7%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
1	2	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-221	-154	97	-195	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	0	39	33	65	46	45	39	0
Share in crop portfolio		100%	0%	0%	11%	0%	13%	11%	22%	15%	15%	13%	0%
Total Gross Margin (EUR)		76,354	0	0	3,184	0	14,977	11,602	15,821	8,664	12,013	10,092	0
Rotation Index			11	12	13	18							
Rotation Acreage (ha)			24	60	20	196							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	33	176	45	46	0					
Share in crop portfolio		100%	0%	11%	59%	15%	15%	0%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
1	3	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-130	-48	292	-49	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	0	39	33	65	46	45	39	0
Share in crop portfolio		100%	0%	0%	11%	0%	13%	11%	22%	15%	15%	13%	0%
Total Gross Margin (EUR)		82,724	0	0	9,554	0	14,977	11,602	15,821	8,664	12,013	10,092	0
Rotation Index			11	12	13	18							
Rotation Acreage (ha)			24	60	20	196							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	33	176	45	46	0					
Share in crop portfolio		100%	0%	11%	59%	15%	15%	0%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
1	4	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-38	58	487	97	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	0	39	33	65	46	45	39	0
Share in crop portfolio		100%	0%	0%	11%	0%	13%	11%	22%	15%	15%	13%	0%
Total Gross Margin (EUR)		89,094	0	0	15,924	0	14,977	11,602	15,821	8,664	12,013	10,092	0
Rotation Index			11	12	13	18							
Rotation Acreage (ha)			24	60	20	196							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	33	176	45	46	0					
Share in crop portfolio		100%	0%	11%	59%	15%	15%	0%					

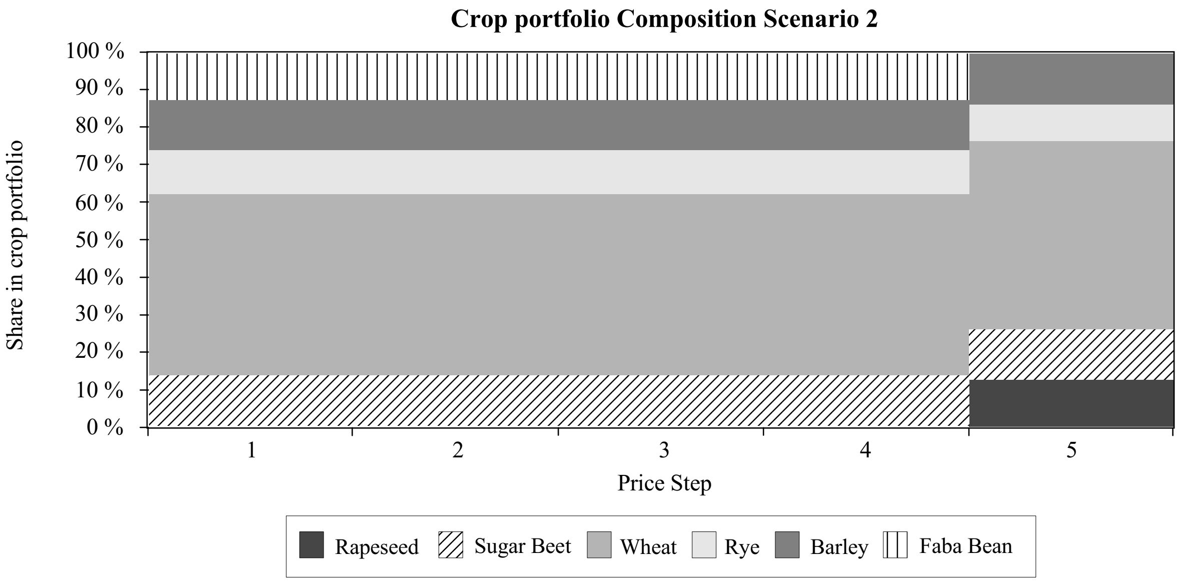
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
1	5	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			54	164	682	244	382	355	243	189	266	257	64
Crop Acreage (ha)		300	40	0	33	3	40	36	76	40	33	0	0
Share in crop portfolio		100%	13%	0%	11%	1%	13%	12%	25%	13%	11%	0%	0%
Total Gross Margin (EUR)		88,006	2,124	0	22,521	731	15,156	12,786	18,361	7,556	8,770	0	0
Rotation Index			3	1	10	11	12	15					
Rotation Acreage (ha)			59	100	80	40	9	12					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	40	36	151	33	40	0					
Share in crop portfolio		100%	13%	12%	50%	11%	13%	0%					

Source: Own calculations based on panel-approach.

Figure A23: Crop portfolio composition, output prices and price ratios for scenario 2

Scenario		2	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	▼	113	135	158	180	203	235					
2	Sugar Beet	=						33					
3	Wheat	▼	63	75	88	100	113	125					
4	Barley	As Wheat	58	69	81	92	104	115					
5	Rye	As Wheat	58	69	81	92	104	115					
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Sugar Beet	Rapeseed	3.41	4.09	4.77	5.46	6.14	6.82					
	Wheat	Rapeseed						1.80					
	Sugar Beet	Wheat	1.90	2.27	2.65	3.03	3.41	3.79					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
2	-50%	=	-50%	-12,397	-112%	-	0%	14%	49%	12%	14%	12%	-100%	13%	0%	48%	9%
	-40%	=	-40%	9,715	-90%	22,113	0%	14%	49%	12%	14%	12%	-100%	13%	0%	48%	9%
	-30%	=	-30%	31,828	-68%	22,113	0%	14%	49%	12%	14%	12%	-100%	13%	0%	48%	9%
	-20%	=	-20%	53,941	-46%	22,113	0%	14%	49%	12%	14%	12%	-100%	13%	0%	48%	9%
	-10%	=	-10%	74,380	-26%	20,440	12%	14%	51%	10%	13%	0%	-33%	13%	4%	25%	4%



Source: Own calculations based on panel-approach.

Table A25: Cropping activity gross margins and shares in crop portfolio for scenario 2

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
2	1	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-332	-282	907	427	-149	-157	-257	-259	-211	-242	64
Crop Acreage (ha)		300	0	0	33	7	36	41	70	42	36	0	36
Share in crop portfolio		100%	0%	0%	11%	2%	12%	14%	23%	14%	12%	0%	12%
Total Gross Margin (EUR)		-12,397	0	0	30,249	3,135	-5,300	-6,386	-17,892	-10,962	-7,519	0	2,278
Rotation Index			12	13	16	17							
Rotation Acreage (ha)			80	20	22	178							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	146	36	42	36					
Share in crop portfolio		100%	0%	14%	49%	12%	14%	12%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
2	2	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-245	-180	907	427	-43	-54	-157	-170	-116	-142	64
Crop Acreage (ha)		300	0	0	33	7	36	41	70	42	36	0	36
Share in crop portfolio		100%	0%	0%	11%	2%	12%	14%	23%	14%	12%	0%	12%
Total Gross Margin (EUR)		9,715	0	0	30,249	3,135	-1,515	-2,216	-10,928	-7,168	-4,119	0	2,278
Rotation Index			12	13	16	17							
Rotation Acreage (ha)			80	20	22	178							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	146	36	42	36					
Share in crop portfolio		100%	0%	14%	49%	12%	14%	12%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
2	3	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-157	-79	907	427	64	48	-57	-80	-20	-42	64
Crop Acreage (ha)		300	0	0	33	7	36	41	70	42	36	0	36
Share in crop portfolio		100%	0%	0%	11%	2%	12%	14%	23%	14%	12%	0%	12%
Total Gross Margin (EUR)		31,828	0	0	30,249	3,135	2,269	1,955	-3,964	-3,375	-719	0	2,278
Rotation Index			12	13	16	17							
Rotation Acreage (ha)			80	20	22	178							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	146	36	42	36					
Share in crop portfolio		100%	0%	14%	49%	12%	14%	12%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
2	4	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			-69	22	907	427	170	151	43	10	75	58	64
Crop Acreage (ha)		300	0	0	33	7	36	41	70	42	36	0	36
Share in crop portfolio		100%	0%	0%	11%	2%	12%	14%	23%	14%	12%	0%	12%
Total Gross Margin (EUR)		53,941	0	0	30,249	3,135	6,054	6,126	3,000	419	2,681	0	2,278
Rotation Index			12	13	16	17							
Rotation Acreage (ha)			80	20	22	178							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	146	36	42	36					
Share in crop portfolio		100%	0%	14%	49%	12%	14%	12%					

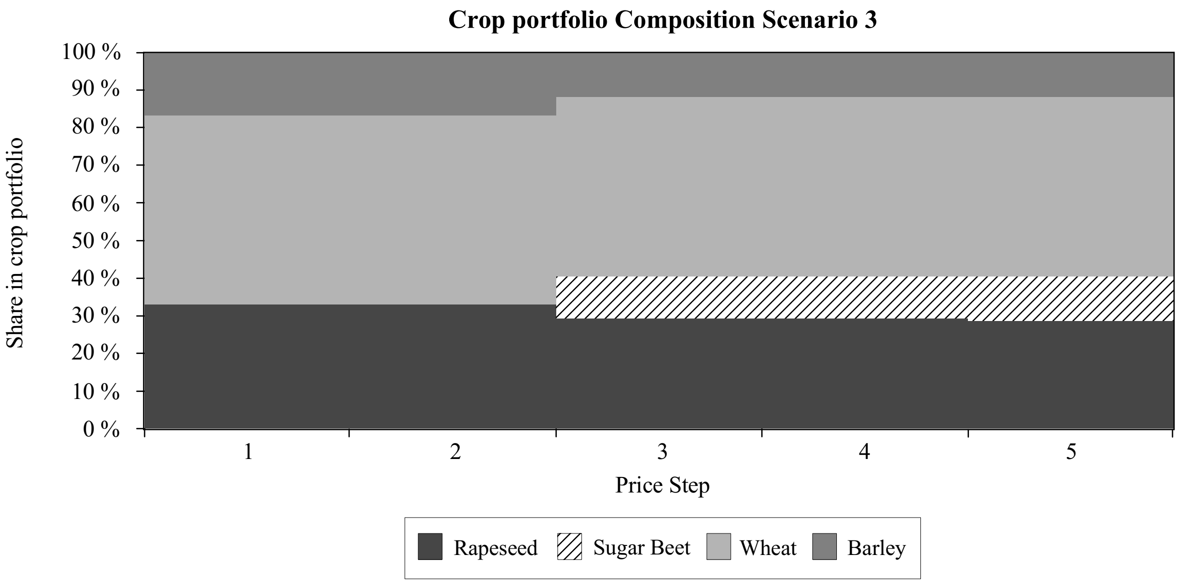
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
2	5	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed Sugar Beet Wheat	▼ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Gross Margin (EUR/ha)			19	123	907	427	276	253	143	100	171	158	64
Crop Acreage (ha)		300	37	0	33	7	37	41	74	40	30	0	0
Share in crop portfolio		100%	12%	0%	11%	2%	12%	14%	25%	13%	10%	0%	0%
Total Gross Margin (EUR)		74,380	690	0	30,249	3,135	10,225	10,296	10,641	4,019	5,124	0	0
Rotation Index			2	1	1	12	13	16					
Rotation Acreage (ha)			28	150	150	90	10	22					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	37	41	152	30	40	0					
Share in crop portfolio		100%	12%	14%	51%	10%	13%	0%					

Source: Own calculations based on panel-approach.

Figure A24: Crop portfolio composition, output prices and price ratios for scenario 3

Scenario		3	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	=						235					
2	Sugar Beet	▼	18	21	25	28	32	33					
3	Wheat	▼	66	79	92	105	118	125					
4	Barley	As Wheat	61	73	85	97	109	115					
5	Rye	As Wheat	61	73	85	97	109	115					
6	Sugar Beet Ind.	As Sugar Beet	13	16	19	21	24	25					
Price Ratio	Wheat	Sugar Beet						0.27					
	Rapeseed	Sugar Beet	0.08	0.09	0.11	0.12	0.14	0.15					
	Rapeseed	Wheat	0.28	0.34	0.39	0.45	0.50	0.56					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
3	=	-50%	-50%	-15,967	-116%	-	33%	0%	50%	0%	17%	0%	82%	-100%	3%	-100%	29%
	=	-40%	-40%	5,205	-95%	21,172	33%	0%	50%	0%	17%	0%	82%	-100%	3%	-100%	29%
	=	-30%	-30%	40,338	-60%	35,133	30%	11%	47%	0%	12%	0%	62%	-8%	-3%	-100%	-7%
	=	-20%	-20%	66,340	-34%	26,001	30%	11%	47%	0%	12%	0%	62%	-8%	-3%	-100%	-7%
	=	-10%	-10%	92,896	-7%	26,556	29%	12%	47%	0%	12%	0%	56%	0%	-3%	-100%	-7%



Source: Own calculations based on panel-approach.

Table A26: Cropping activity gross margins and shares in crop portfolio for scenario 3

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
3	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	-15	-279	-121	-130	-231	-236	-186	-216
Crop Acreage (ha)		300	60	40	0	0	100	0	50	50	0	0
Share in crop portfolio		100%	20%	13%	0%	0%	33%	0%	17%	17%	0%	0%
Total Gross Margin (EUR)		-15,967	8,712	10,778	0	0	-12,113	0	-11,548	-11,796	0	0
Rotation Index			3	4	7							
Rotation Acreage (ha)			30	150	120							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	100	0	150	0	50	0				
Share in crop portfolio		100%	33%	0%	50%	0%	17%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
3	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	196	-121	-9	-22	-126	-141	-86	-111
Crop Acreage (ha)		300	60	40	0	0	100	0	50	50	0	0
Share in crop portfolio		100%	20%	13%	0%	0%	33%	0%	17%	17%	0%	0%
Total Gross Margin (EUR)		5,205	8,712	10,778	0	0	-927	0	-6,284	-7,074	0	0
Rotation Index			3	4	7							
Rotation Acreage (ha)			30	150	120							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	100	0	150	0	50	0				
Share in crop portfolio		100%	33%	0%	50%	0%	17%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
3	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	408	38	103	86	-20	-47	15	-6
Crop Acreage (ha)		300	56	33	33	0	89	33	20	36	0	0
Share in crop portfolio		100%	19%	11%	11%	0%	30%	11%	7%	12%	0%	0%
Total Gross Margin (EUR)		40,338	8,131	8,891	13,463	0	9,131	2,823	-408	-1,694	0	0
Rotation Index			3	4	14							
Rotation Acreage (ha)			60	108	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	142	0	36	0				
Share in crop portfolio		100%	30%	11%	47%	0%	12%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
3	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	619	196	214	193	85	47	115	100
Crop Acreage (ha)		300	56	33	33	0	89	33	20	36	0	0
Share in crop portfolio		100%	19%	11%	11%	0%	30%	11%	7%	12%	0%	0%
Total Gross Margin (EUR)		66,340	8,131	8,891	20,442	0	19,086	6,385	1,698	1,706	0	0
Rotation Index			3	4	14							
Rotation Acreage (ha)			60	108	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	142	0	36	0				
Share in crop portfolio		100%	30%	11%	47%	0%	12%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
3	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	831	355	326	301	190	142	216	205
Crop Acreage (ha)		300	53	33	33	3	86	36	20	36	0	0
Share in crop portfolio		100%	18%	11%	11%	1%	29%	12%	7%	12%	0%	0%
Total Gross Margin (EUR)		92,896	7,695	8,891	27,422	1,065	28,063	10,850	3,803	5,106	0	0
Rotation Index			3	4	16	14						
Rotation Acreage (ha)			51	108	9	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	86	36	142	0	36	0				
Share in crop portfolio		100%	29%	12%	47%	0%	12%	0%				

Source: Own calculations based on panel-approach.

Figure A25: Crop portfolio composition, output prices and price ratios for scenario 4

Scenario		4	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	=						235					
2	Sugar Beet	=						33					
3	Wheat	▼	66	79	92	105	118	125					
4	Barley	As Wheat	61	73	85	97	109	115					
5	Rye	As Wheat	61	73	85	97	109	115					
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Rapeseed	Wheat	0.28	0.34	0.39	0.45	0.50	0.56					
	Sugar Beet	Wheat	1.99	2.39	2.79	3.19	3.59	3.99					
	Rapeseed	Sugar Beet						0.14					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
4	=	=	-50%	20,885	-79%	-	27%	14%	48%	0%	11%	0%	48%	13%	-1%	-100%	-14%
	=	=	-40%	39,906	-60%	19,021	27%	14%	48%	0%	11%	0%	48%	13%	-1%	-100%	-14%
	=	=	-30%	58,926	-41%	19,021	27%	14%	48%	0%	11%	0%	48%	13%	-1%	-100%	-14%
	=	=	-20%	77,947	-22%	19,021	27%	14%	48%	0%	11%	0%	48%	13%	-1%	-100%	-14%
	=	=	-10%	94,024	-6%	16,077	22%	14%	48%	5%	11%	0%	20%	13%	-1%	-35%	-14%

Crop portfolio Composition Scenario 4

Source: Own calculations based on panel-approach.

Table A27: Cropping activity gross margins and shares in crop portfolio for scenario 4

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
4	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	-121	-130	-231	-236	-186	-216
Crop Acreage (ha)		300	48	33	33	8	81	41	23	33	0	0
Share in crop portfolio		100%	16%	11%	11%	3%	27%	14%	8%	11%	0%	0%
Total Gross Margin (EUR)		20,885	7,018	8,891	29,946	3,277	-9,852	-5,297	-5,235	-7,864	0	0
Rotation Index			3	4	16	14						
Rotation Acreage (ha)			45	100	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	81	41	145	0	33	0				
Share in crop portfolio		100%	27%	14%	48%	0%	11%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
4	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	-9	-22	-126	-141	-86	-111
Crop Acreage (ha)		300	48	33	33	8	81	41	23	33	0	0
Share in crop portfolio		100%	16%	11%	11%	3%	27%	14%	8%	11%	0%	0%
Total Gross Margin (EUR)		39,906	7,018	8,891	29,946	3,277	-754	-909	-2,849	-4,716	0	0
Rotation Index			3	4	16	14						
Rotation Acreage (ha)			45	100	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	81	41	145	0	33	0				
Share in crop portfolio		100%	27%	14%	48%	0%	11%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
4	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	103	86	-20	-47	15	-6
Crop Acreage (ha)		300	48	33	33	8	81	41	23	33	0	0
Share in crop portfolio		100%	16%	11%	11%	3%	27%	14%	8%	11%	0%	0%
Total Gross Margin (EUR)		58,926	7,018	8,891	29,946	3,277	8,344	3,479	-462	-1,568	0	0
Rotation Index			3	4	16	14						
Rotation Acreage (ha)			45	100	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	81	41	145	0	33	0				
Share in crop portfolio		100%	27%	14%	48%	0%	11%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
4	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	214	193	85	47	115	100
Crop Acreage (ha)		300	48	33	33	8	81	41	23	33	0	0
Share in crop portfolio		100%	16%	11%	11%	3%	27%	14%	8%	11%	0%	0%
Total Gross Margin (EUR)		77,947	7,018	8,891	29,946	3,277	17,442	7,868	1,924	1,580	0	0
Rotation Index			3	4	16	14						
Rotation Acreage (ha)			45	100	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	81	41	145	0	33	0				
Share in crop portfolio		100%	27%	14%	48%	0%	11%	0%				
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
4	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	326	301	190	142	216	205
Crop Acreage (ha)		300	48	18	33	8	66	41	38	33	16	0
Share in crop portfolio		100%	16%	6%	11%	3%	22%	14%	13%	11%	5%	0%
Total Gross Margin (EUR)		94,024	7,018	4,715	29,946	3,277	21,482	12,256	7,258	4,728	3,343	0
Rotation Index			3	4	11	16	14					
Rotation Acreage (ha)			45	100	62	23	70					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	66	41	145	16	33	0				
Share in crop portfolio		100%	22%	14%	48%	5%	11%	0%				

Source: Own calculations based on panel-approach.

Figure A26: Crop portfolio composition, output prices and price ratios for scenario 5

Scenario		5	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	=						235					
2	Sugar Beet	▼	16	20	23	26	29	33					
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet	12	15	17	20	22	25					
Price Ratio	Rapeseed	Sugar Beet	0.07	0.08	0.10	0.11	0.12	0.14					
	Wheat	Sugar Beet	0.13	0.16	0.18	0.21	0.23	0.26					
	Wheat	Rapeseed						1.88					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
5	=	-50%	=	79,852	-20%	-	25%	0%	51%	12%	12%	0%	38%	-100%	4%	50%	-7%
	=	-40%	=	79,852	-20%	0	25%	0%	51%	12%	12%	0%	38%	-100%	4%	50%	-7%
	=	-30%	=	84,816	-15%	4,964	25%	11%	50%	7%	7%	0%	38%	-8%	3%	-17%	-48%
	=	-20%	=	91,251	-9%	6,435	25%	11%	50%	7%	7%	0%	38%	-8%	3%	-17%	-48%
	=	-10%	=	92,148	-8%	898	18%	12%	49%	8%	13%	0%	0%	0%	0%	0%	0%

Crop portfolio Composition Scenario 5

Source: Own calculations based on panel-approach.

Table A28: Cropping activity gross margins and shares in crop portfolio for scenario 5

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
5	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	-98	-341	382	355	243	189	266	257
Crop Acreage (ha)		300	36	40	0	0	76	0	76	36	36	0
Share in crop portfolio		100%	12%	13%	0%	0%	25%	0%	25%	12%	12%	0%
Total Gross Margin (EUR)		79,852	5,227	10,778	0	0	29,038	0	18,441	6,800	9,568	0
Rotation Index			7	1								
Rotation Acreage (ha)			120	180								
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	76	0	152	36	36	0				
Share in crop portfolio		100%	25%	0%	51%	12%	12%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
5	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	97	-195	382	355	243	189	266	257
Crop Acreage (ha)		300	36	40	0	0	76	0	76	36	36	0
Share in crop portfolio		100%	12%	13%	0%	0%	25%	0%	25%	12%	12%	0%
Total Gross Margin (EUR)		79,852	5,227	10,778	0	0	29,038	0	18,441	6,800	9,568	0
Rotation Index			7	1								
Rotation Acreage (ha)			120	180								
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	76	0	152	36	36	0				
Share in crop portfolio		100%	25%	0%	51%	12%	12%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
5	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	292	-49	382	355	243	189	266	257
Crop Acreage (ha)		300	43	33	33	0	76	33	43	20	20	0
Share in crop portfolio		100%	14%	11%	11%	0%	25%	11%	14%	7%	7%	0%
Total Gross Margin (EUR)		84,816	6,195	8,891	9,651	0	28,910	11,721	10,353	3,778	5,315	0
Rotation Index			3	1	14							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	76	33	151	20	20	0				
Share in crop portfolio		100%	25%	11%	50%	7%	7%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
5	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	487	97	382	355	243	189	266	257
Crop Acreage (ha)		300	43	33	33	0	76	33	43	20	20	0
Share in crop portfolio		100%	14%	11%	11%	0%	25%	11%	14%	7%	7%	0%
Total Gross Margin (EUR)		91,251	6,195	8,891	16,086	0	28,910	11,721	10,353	3,778	5,315	0
Rotation Index			3	1	14							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	76	33	151	20	20	0				
Share in crop portfolio		100%	25%	11%	50%	7%	7%	0%				

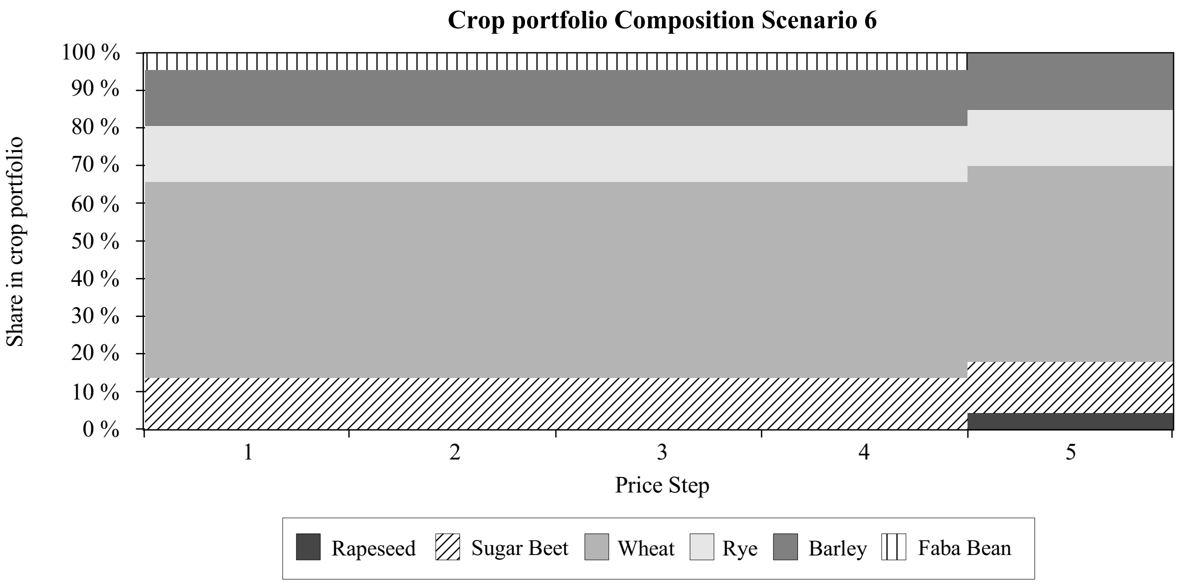
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
5	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	682	244	382	355	243	189	266	257
Crop Acreage (ha)		300	55	0	33	3	55	36	55	39	24	0
Share in crop portfolio		100%	18%	0%	11%	1%	18%	12%	18%	13%	8%	0%
Total Gross Margin (EUR)		92,148	7,986	0	22,521	731	21,014	12,786	13,427	7,304	6,379	0
Rotation Index			3	4	10	11	13	15				
Rotation Acreage (ha)			85	80	12	84	27	12				
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	55	36	146	24	39	0				
Share in crop portfolio		100%	18%	12%	49%	8%	13%	0%				

Source: Own calculations based on panel-approach.

Figure A27: Crop portfolio composition, output prices and price ratios for scenario 6

Scenario		6	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	▼	118	141	165	188	212	235					
2	Sugar Beet	=						33					
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Wheat	Rapeseed	0.94	1.13	1.32	1.50	1.69	1.88					
	Sugar Beet	Rapeseed	3.56	4.27	4.98	5.70	6.41	7.12					
	Wheat	Sugar Beet						0.26					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
6	-50%	=	=	102,082	2%	-	0%	14%	52%	15%	15%	4%	-100%	13%	7%	90%	16%
	-40%	=	=	102,082	2%	0	0%	14%	52%	15%	15%	4%	-100%	13%	7%	90%	16%
	-30%	=	=	102,082	2%	0	0%	14%	52%	15%	15%	4%	-100%	13%	7%	90%	16%
	-20%	=	=	102,082	2%	0	0%	14%	52%	15%	15%	4%	-100%	13%	7%	90%	16%
	-10%	=	=	101,946	2%	-136	4%	14%	52%	15%	15%	0%	-76%	13%	7%	90%	16%



Source: Own calculations based on panel-approach.

Table A29: Cropping activity gross margins and shares in crop portfolio for scenario 6

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
6	1	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed	▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Sugar Beet	=												
Wheat	=												
Gross Margin (EUR/ha)			-313	-259	907	427	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	8	33	41	62	45	46	20	13
Share in crop portfolio		100%	0%	0%	11%	3%	11%	14%	21%	15%	15%	7%	4%
Total Gross Margin (EUR)		102,082	0	0	30,098	3,277	12,608	14,503	15,085	8,438	12,093	5,149	832
Rotation Index			11	12	13	16	17	18					
Rotation Acreage (ha)			50	27	35	23	65	100					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	156	46	45	13					
Share in crop portfolio		100%	0%	14%	52%	15%	15%	4%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
6	2	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed	▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Sugar Beet	=												
Wheat	=												
Gross Margin (EUR/ha)			-221	-154	907	427	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	8	33	41	62	45	46	20	13
Share in crop portfolio		100%	0%	0%	11%	3%	11%	14%	21%	15%	15%	7%	4%
Total Gross Margin (EUR)		102,082	0	0	30,098	3,277	12,608	14,503	15,085	8,438	12,093	5,149	832
Rotation Index			11	12	13	16	17	18					
Rotation Acreage (ha)			50	27	35	23	65	100					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	156	46	45	13					
Share in crop portfolio		100%	0%	14%	52%	15%	15%	4%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
6	3	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed	▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Sugar Beet	=												
Wheat	=												
Gross Margin (EUR/ha)			-130	-48	907	427	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	8	33	41	62	45	46	20	13
Share in crop portfolio		100%	0%	0%	11%	3%	11%	14%	21%	15%	15%	7%	4%
Total Gross Margin (EUR)		102,082	0	0	30,098	3,277	12,608	14,503	15,085	8,438	12,093	5,149	832
Rotation Index			11	12	13	16	17	18					
Rotation Acreage (ha)			50	27	35	23	65	100					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	156	46	45	13					
Share in crop portfolio		100%	0%	14%	52%	15%	15%	4%					

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
6	4	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed	▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Sugar Beet	=												
Wheat	=												
Gross Margin (EUR/ha)			-38	58	907	427	382	355	243	189	266	257	64
Crop Acreage (ha)		300	0	0	33	8	33	41	62	45	46	20	13
Share in crop portfolio		100%	0%	0%	11%	3%	11%	14%	21%	15%	15%	7%	4%
Total Gross Margin (EUR)		102,082	0	0	30,098	3,277	12,608	14,503	15,085	8,438	12,093	5,149	832
Rotation Index			11	12	13	16	17	18					
Rotation Acreage (ha)			50	27	35	23	65	100					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	0	41	156	46	45	13					
Share in crop portfolio		100%	0%	14%	52%	15%	15%	4%					

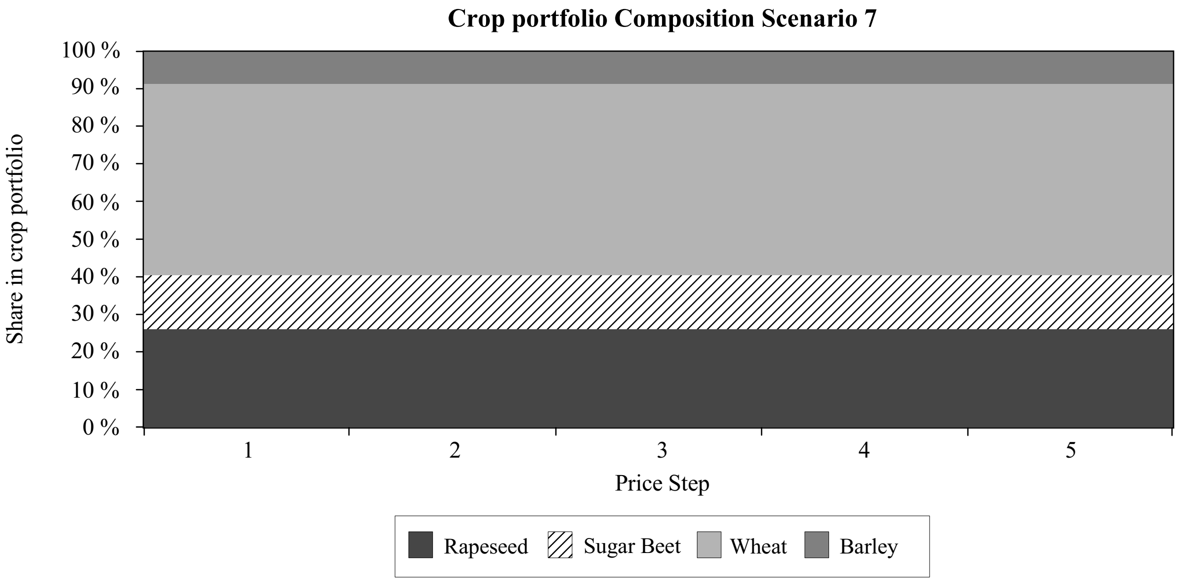
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14	19
6	5	Crop Index	1	1	2	6	3	3	3	4	5	3	7
Rapeseed	▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)	Faba Beans (Min-Till, 4.3 t/ha)
Sugar Beet	=												
Wheat	=												
Gross Margin (EUR/ha)			54	164	907	427	382	355	243	189	266	257	64
Crop Acreage (ha)		300	13	0	33	8	33	41	62	45	46	20	0
Share in crop portfolio		100%	4%	0%	11%	3%	11%	14%	21%	15%	15%	7%	0%
Total Gross Margin (EUR)		101,946	696	0	30,098	3,277	12,608	14,503	15,085	8,438	12,093	5,149	0
Rotation Index			1	11	12	13	16	17	18				
Rotation Acreage (ha)			65	50	27	35	23	0	100				
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other					
Crop Acreage (ha)		300	13	41	156	46	45	0					
Share in crop portfolio		100%	4%	14%	52%	15%	15%	0%					

Source: Own calculations based on panel-approach.

Figure A28: Crop portfolio composition, output prices and price ratios for scenario 7

Scenario		7	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	▲						235	259	282	306	329	353
2	Sugar Beet	▲						33	36	39	42	46	49
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet						25	27	29	32	34	37
Price Ratio	Wheat	Rapeseed						1.88	2.07	2.26	2.44	2.63	2.82
	Wheat	Sugar Beet						0.26	0.29	0.31	0.34	0.36	0.39
	Rapeseed	Sugar Beet						0.14					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
7	+10%	+10%	=	121,641	21%	21,517	26%	14%	50%	0%	9%	0%	44%	19%	3%	-100%	-31%
	+20%	+20%	=	137,244	37%	15,603	26%	14%	50%	0%	9%	0%	44%	19%	3%	-100%	-31%
	+30%	+30%	=	152,848	53%	15,603	26%	14%	50%	0%	9%	0%	44%	19%	3%	-100%	-31%
	+40%	+40%	=	168,451	68%	15,603	26%	14%	50%	0%	9%	0%	44%	19%	3%	-100%	-31%
	+50%	+50%	=	184,054	84%	15,603	26%	14%	50%	0%	9%	0%	44%	19%	3%	-100%	-31%



Source: Own calculations based on panel-approach.

Table A30: Cropping activity gross margins and shares in crop portfolio for scenario 7

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
7	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			237	375	1072	536	382	355	243	189	266	257
Crop Acreage (ha)		300	46	33	33	10	79	43	29	27	0	0
Share in crop portfolio		100%	15%	11%	11%	3%	26%	14%	10%	9%	0%	0%
Total Gross Margin (EUR)		121,641	10,895	12,381	35,391	5,362	30,184	15,272	7,118	5,037	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			58	80	132	30						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	79	43	151	0	27	0				
Share in crop portfolio		100%	26%	14%	50%	0%	9%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
7	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			328	481	1267	682	382	355	243	189	266	257
Crop Acreage (ha)		300	46	33	33	10	79	43	29	27	0	0
Share in crop portfolio		100%	15%	11%	11%	3%	26%	14%	10%	9%	0%	0%
Total Gross Margin (EUR)		137,244	15,111	15,871	41,826	6,825	30,184	15,272	7,118	5,037	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			58	80	132	30						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	79	43	151	0	27	0				
Share in crop portfolio		100%	26%	14%	50%	0%	9%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
7	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			420	587	1462	829	382	355	243	189	266	257
Crop Acreage (ha)		300	46	33	33	10	79	43	29	27	0	0
Share in crop portfolio		100%	15%	11%	11%	3%	26%	14%	10%	9%	0%	0%
Total Gross Margin (EUR)		152,848	19,327	19,361	48,261	8,287	30,184	15,272	7,118	5,037	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			58	80	132	30						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	79	43	151	0	27	0				
Share in crop portfolio		100%	26%	14%	50%	0%	9%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
7	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			512	692	1657	975	382	355	243	189	266	257
Crop Acreage (ha)		300	46	33	33	10	79	43	29	27	0	0
Share in crop portfolio		100%	15%	11%	11%	3%	26%	14%	10%	9%	0%	0%
Total Gross Margin (EUR)		168,451	23,543	22,850	54,696	9,750	30,184	15,272	7,118	5,037	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			58	80	132	30						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	79	43	151	0	27	0				
Share in crop portfolio		100%	26%	14%	50%	0%	9%	0%				

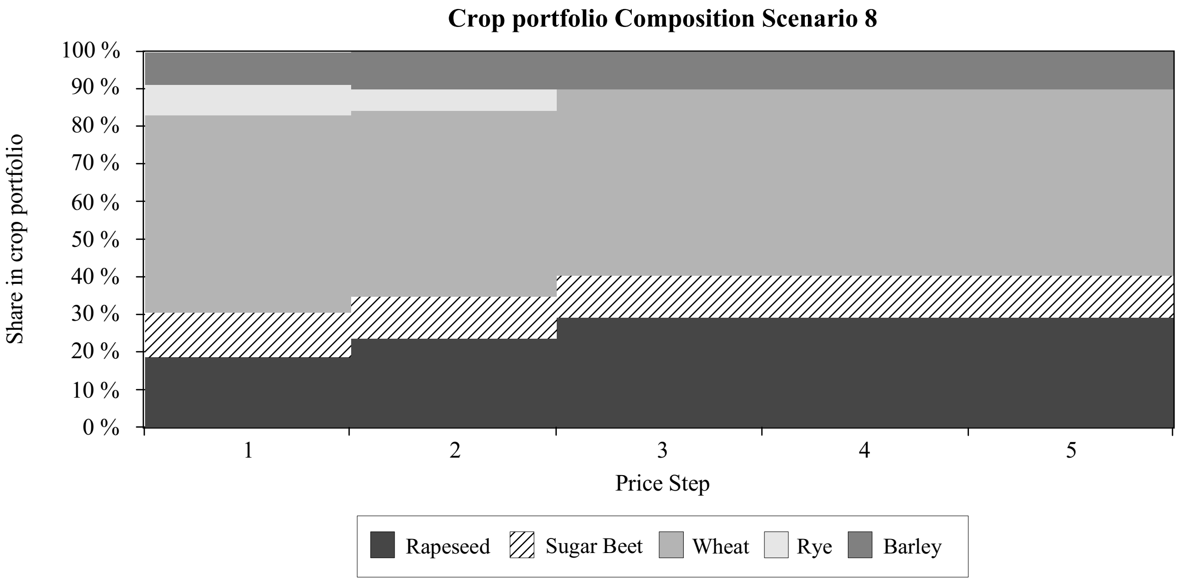
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
7	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			603	798	1852	1121	382	355	243	189	266	257
Crop Acreage (ha)		300	46	33	33	10	79	43	29	27	0	0
Share in crop portfolio		100%	15%	11%	11%	3%	26%	14%	10%	9%	0%	0%
Total Gross Margin (EUR)		184,054	27,758	26,340	61,131	11,212	30,184	15,272	7,118	5,037	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			58	80	132	30						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	79	43	151	0	27	0				
Share in crop portfolio		100%	26%	14%	50%	0%	9%	0%				

Source: Own calculations based on panel-approach.

Figure A29: Crop portfolio composition, output prices and price ratios for scenario 8

Scenario		8	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	▲						235	248	270	293	315	338
2	Sugar Beet	=						33					
3	Wheat	▲						125	138	150	163	175	188
4	Barley	As Wheat						115	127	138	150	161	173
5	Rye	As Wheat						115	127	138	150	161	173
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Sugar Beet	Rapeseed						6.82	7.50	8.18	8.87	9.55	10.23
	Wheat	Rapeseed						1.80					
	Sugar Beet	Wheat						3.79	4.17	4.55	4.93	5.31	5.69

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
8	+10%	=	+10%	124,583	24%	24,459	19%	12%	53%	8%	9%	0%	2%	0%	8%	0%	-33%
	+20%	=	+20%	152,317	52%	27,734	24%	11%	50%	6%	10%	0%	29%	-8%	2%	-29%	-23%
	+30%	=	+30%	180,837	81%	28,520	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%
	+40%	=	+40%	207,284	107%	26,447	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%
	+50%	=	+50%	233,731	133%	26,447	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%



Source: Own calculations based on panel-approach.

Table A31: Cropping activity gross margins and shares in crop portfolio for scenario 8

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
8	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲											
Sugar Beet	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Wheat	▲											
Gross Margin (EUR/ha)			194	326	907	427	489	458	343	279	362	358
Crop Acreage (ha)		300	56	0	33	3	56	36	66	26	24	0
Share in crop portfolio		100%	19%	0%	11%	1%	19%	12%	22%	9%	8%	0%
Total Gross Margin (EUR)		124.583	10.875	0	29.946	1.282	27.383	16.499	22.656	7.258	8.683	0
Rotation Index			3	4	11	12	16					
Rotation Acreage (ha)			90	78	96	27	9					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	56	36	158	24	26	0				
Share in crop portfolio		100%	19%	12%	53%	8%	9%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
8	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲											
Sugar Beet	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Wheat	▲											
Gross Margin (EUR/ha)			282	427	907	427	595	561	443	369	457	458
Crop Acreage (ha)		300	52	19	33	0	71	33	45	30	17	0
Share in crop portfolio		100%	17%	6%	11%	0%	24%	11%	15%	10%	6%	0%
Total Gross Margin (EUR)		152.317	14.663	8.118	29.946	0	42.265	18.508	20.097	10.944	7.774	0
Rotation Index			3	4	6	11	14					
Rotation Acreage (ha)			76	80	12	68	64					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	71	33	149	17	30	0				
Share in crop portfolio		100%	24%	11%	50%	6%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
8	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲											
Sugar Beet	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Wheat	▲											
Gross Margin (EUR/ha)			370	529	907	427	702	663	543	459	553	558
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		180.837	19.227	19.027	29.946	0	61.741	21.893	15.396	13.607	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
8	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲											
Sugar Beet	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Wheat	▲											
Gross Margin (EUR/ha)			458	630	907	427	808	766	643	548	648	658
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		207.284	23.791	22.673	29.946	0	71.096	25.277	18.231	16.269	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

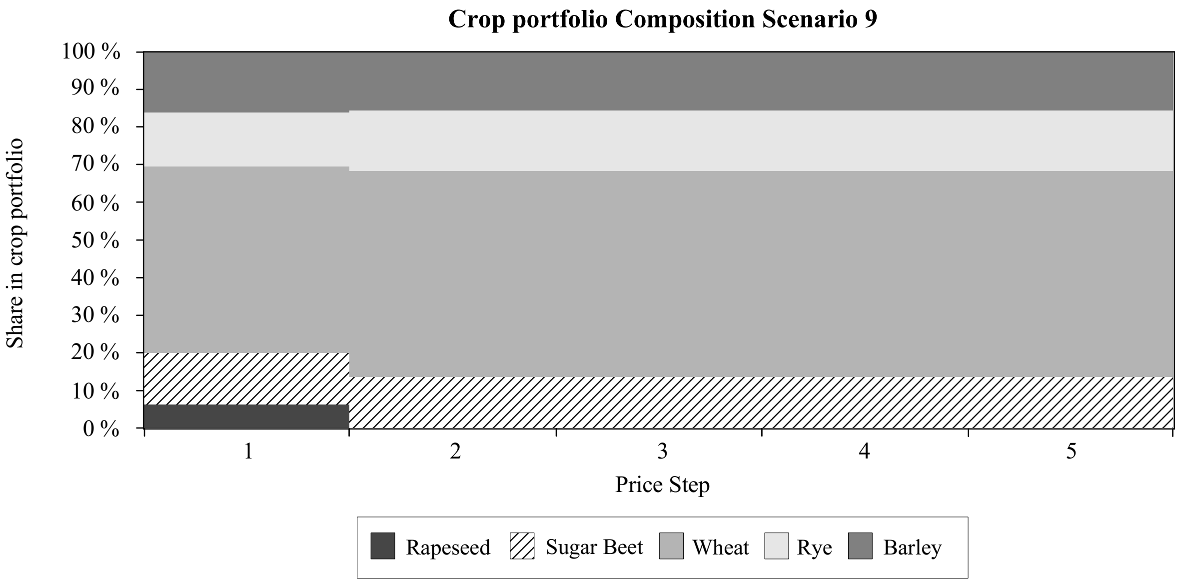
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
8	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	▲											
Sugar Beet	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Wheat	▲											
Gross Margin (EUR/ha)			545	731	907	427	914	869	743	638	744	758
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		233.731	28.355	26.319	29.946	0	80.451	28.662	21.066	18.932	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

Source: Own calculations based on panel-approach.

Figure A30: Crop portfolio composition, output prices and price ratios for scenario 9

Scenario		9	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	=						235					
2	Sugar Beet	▲						33	39	42	46	49	53
3	Wheat	▲						125	145	158	171	184	197
4	Barley	As Wheat						115	133	145	157	170	182
5	Rye	As Wheat						115	133	145	157	170	182
6	Sugar Beet Ind.	As Sugar Beet						25	29	32	34	37	40
Price Ratio	Wheat	Sugar Beet						0.27					
	Rapeseed	Sugar Beet						0.15	0.17	0.18	0.20	0.21	0.23
	Rapeseed	Wheat						0.56	0.62	0.67	0.73	0.78	0.84

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
9	=	+10%	+10%	153,010	53%	52,886	6%	14%	49%	15%	16%	0%	-65%	13%	1%	81%	25%
	=	+20%	+20%	192,123	92%	39,113	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	=	+30%	+30%	227,154	127%	35,031	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	=	+40%	+40%	262,185	162%	35,031	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	=	+50%	+50%	297,216	197%	35,031	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%



Source: Own calculations based on panel-approach.

Table A32: Cropping activity gross margins and shares in crop portfolio for scenario 9

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
9	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	▲											
Gross Margin (EUR/ha)			145	269	1254	672	550	517	401	331	417	416
Crop Acreage (ha)		300	19	0	33	8	35	41	57	48	44	16
Share in crop portfolio		100%	6%	0%	11%	3%	12%	14%	19%	16%	15%	5%
Total Gross Margin (EUR)		153,010	2,807	0	41,381	5,043	19,435	20,947	22,641	15,984	18,125	6,648
Rotation Index			4	10	11	15	18					
Rotation Acreage (ha)			58	52	80	30	80					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	19	41	148	44	48	0				
Share in crop portfolio		100%	6%	14%	49%	15%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
9	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	▲											
Gross Margin (EUR/ha)			145	269	1465	831	662	625	506	425	517	521
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		192,123	0	0	48,360	6,232	18,268	25,317	34,459	20,236	24,875	14,374
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
9	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	▲											
Gross Margin (EUR/ha)			145	269	1677	990	774	733	611	520	618	626
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		227,154	0	0	55,340	7,422	21,356	29,688	41,629	24,732	29,708	17,280
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
9	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	▲											
Gross Margin (EUR/ha)			145	269	1888	1148	886	841	717	614	718	731
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		262,185	0	0	62,319	8,612	24,443	34,058	48,798	29,227	34,542	20,186
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

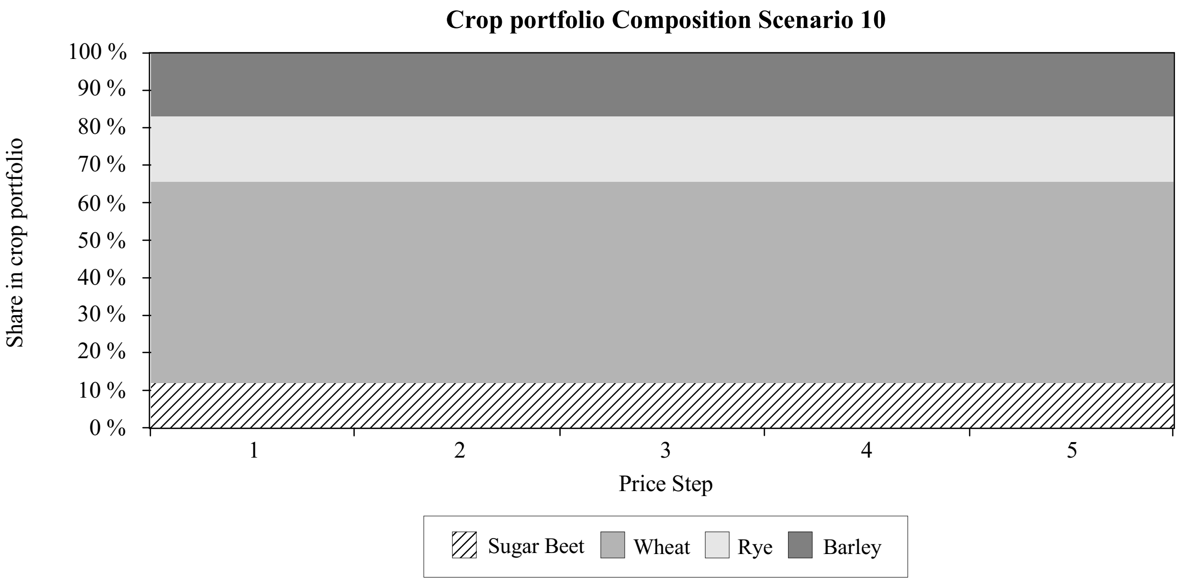
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
9	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	▲											
Gross Margin (EUR/ha)			145	269	2100	1307	997	949	822	708	819	837
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		297,216	0	0	69,299	9,801	27,530	38,429	55,968	33,722	39,376	23,092
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Source: Own calculations based on panel-approach.

Figure A31: Crop portfolio composition, output prices and price ratios for scenario 10

Scenario		10	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1 -50%	2 -40%	3 -30%	4 -20%	5 -10%		1 +10%	2 +20%	3 +30%	4 +40%	5 +50%
1	Rapeseed	=						235					
2	Sugar Beet	=						33					
3	Wheat	▲						125	145	158	171	184	197
4	Barley	As Wheat						115	133	145	157	170	182
5	Rye	As Wheat						115	133	145	157	170	182
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Rapeseed	Wheat						0.56	0.62	0.67	0.73	0.78	0.84
	Sugar Beet	Wheat						3.99	4.39	4.79	5.18	5.58	5.98
	Rapeseed	Sugar Beet						0.14					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
10	=	=	+10%	143,893	44%	43,768	0%	12%	54%	17%	17%	0%	-100%	0%	11%	114%	31%
	=	=	+20%	171,203	71%	27,310	0%	12%	54%	17%	17%	0%	-100%	0%	11%	114%	31%
	=	=	+30%	198,513	98%	27,310	0%	12%	54%	17%	17%	0%	-100%	0%	11%	114%	31%
	=	=	+40%	225,822	126%	27,310	0%	12%	54%	17%	17%	0%	-100%	0%	11%	114%	31%
	=	=	+50%	253,132	153%	27,310	0%	12%	54%	17%	17%	0%	-100%	0%	11%	114%	31%



Source: Own calculations based on panel-approach.

Table A33: Cropping activity gross margins and shares in crop portfolio for scenario 10

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
10	**1**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	550	517	401	331	417	416
Crop Acreage (ha)		300	0	0	33	3	33	36	60	51	51	33
Share in crop portfolio		100%	0%	0%	11%	1%	11%	12%	20%	17%	17%	11%
Total Gross Margin (EUR)		143.893	0	0	29.946	1.282	18.151	18.619	24.044	16.783	21.354	13.712
Rotation Index			10	11	13	15	18					
Rotation Acreage (ha)			35	61	27	12	165					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	36	162	51	51	0				
Share in crop portfolio		100%	0%	12%	54%	17%	17%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
10	**2**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	662	625	506	425	517	521
Crop Acreage (ha)		300	0	0	33	3	33	36	60	51	51	33
Share in crop portfolio		100%	0%	0%	11%	1%	11%	12%	20%	17%	17%	11%
Total Gross Margin (EUR)		171.203	0	0	29.946	1.282	21.843	22.504	30.361	21.576	26.504	17.187
Rotation Index			10	11	13	15	18					
Rotation Acreage (ha)			35	61	27	12	165					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	36	162	51	51	0				
Share in crop portfolio		100%	0%	12%	54%	17%	17%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
10	**3**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	774	733	611	520	618	626
Crop Acreage (ha)		300	0	0	33	3	33	36	60	51	51	33
Share in crop portfolio		100%	0%	0%	11%	1%	11%	12%	20%	17%	17%	11%
Total Gross Margin (EUR)		198.513	0	0	29.946	1.282	25.534	26.389	36.677	26.368	31.654	20.661
Rotation Index			10	11	13	15	18					
Rotation Acreage (ha)			35	61	27	12	165					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	36	162	51	51	0				
Share in crop portfolio		100%	0%	12%	54%	17%	17%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
10	**4**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	886	841	717	614	718	731
Crop Acreage (ha)		300	0	0	33	3	33	36	60	51	51	33
Share in crop portfolio		100%	0%	0%	11%	1%	11%	12%	20%	17%	17%	11%
Total Gross Margin (EUR)		225.822	0	0	29.946	1.282	29.225	30.274	42.994	31.161	36.804	24.135
Rotation Index			10	11	13	15	18					
Rotation Acreage (ha)			35	61	27	12	165					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	36	162	51	51	0				
Share in crop portfolio		100%	0%	12%	54%	17%	17%	0%				

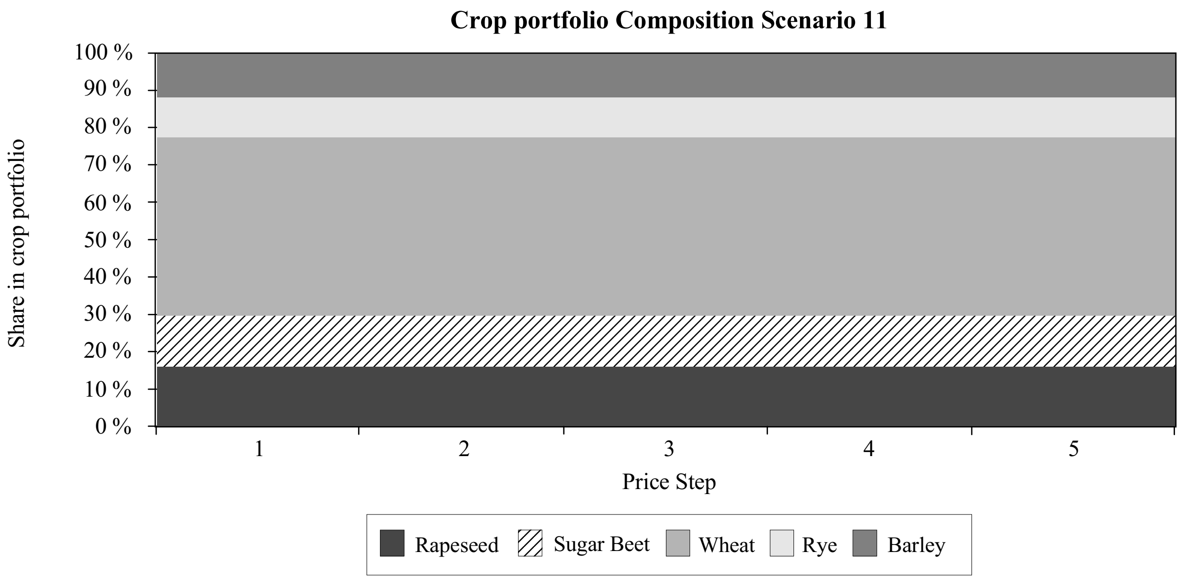
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
10	**5**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= = ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	907	427	997	949	822	708	819	837
Crop Acreage (ha)		300	0	0	33	3	33	36	60	51	51	33
Share in crop portfolio		100%	0%	0%	11%	1%	11%	12%	20%	17%	17%	11%
Total Gross Margin (EUR)		253.132	0	0	29.946	1.282	32.917	34.159	49.311	35.954	41.954	27.609
Rotation Index			10	11	13	15	18					
Rotation Acreage (ha)			35	61	27	12	165					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	36	162	51	51	0				
Share in crop portfolio		100%	0%	12%	54%	17%	17%	0%				

Source: Own calculations based on panel-approach.

Figure A32: Crop portfolio composition, output prices and price ratios for scenario 11

Scenario		11	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+10%	+20%	+30%	+40%	+50%
1	Rapeseed	=						235					
2	Sugar Beet	▲						33	36	39	42	46	49
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet						25	27	29	32	34	37
Price Ratio	Rapeseed	Sugar Beet						0.14	0.15	0.17	0.18	0.19	0.21
	Wheat	Sugar Beet						0.26	0.29	0.31	0.34	0.36	0.39
	Wheat	Rapeseed						1.88					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
11	=	+10%	=	107,806	8%	7,682	16%	14%	48%	11%	12%	0%	-11%	13%	-2%	31%	-8%
	=	+20%	=	115,338	15%	7,532	16%	14%	48%	11%	12%	0%	-11%	13%	-2%	31%	-8%
	=	+30%	=	122,870	23%	7,532	16%	14%	48%	11%	12%	0%	-11%	13%	-2%	31%	-8%
	=	+40%	=	130,402	30%	7,532	16%	14%	48%	11%	12%	0%	-11%	13%	-2%	31%	-8%
	=	+50%	=	137,933	38%	7,532	16%	14%	48%	11%	12%	0%	-11%	13%	-2%	31%	-8%



Source: Own calculations based on panel-approach.

Table A34: Cropping activity gross margins and shares in crop portfolio for scenario 11

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
11	**1**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			145	269	1072	536	382	355	243	189	266	257
Crop Acreage (ha)		300	49	0	33	8	49	41	54	36	32	0
Share in crop portfolio		100%	16%	0%	11%	3%	16%	14%	18%	12%	11%	0%
Total Gross Margin (EUR)		107,806	7,115	0	35,391	4,022	18,722	14,385	13,063	6,738	8,372	0
Rotation Index			3	4	11	13	15					
Rotation Acreage (ha)			67	80	96	27	30					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	49	41	143	32	36	0				
Share in crop portfolio		100%	16%	14%	48%	11%	12%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
11	**2**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			145	269	1267	682	382	355	243	189	266	257
Crop Acreage (ha)		300	49	0	33	8	49	41	54	36	32	0
Share in crop portfolio		100%	16%	0%	11%	3%	16%	14%	18%	12%	11%	0%
Total Gross Margin (EUR)		115,338	7,115	0	41,826	5,119	18,722	14,385	13,063	6,738	8,372	0
Rotation Index			3	4	11	13	15					
Rotation Acreage (ha)			67	80	96	27	30					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	49	41	143	32	36	0				
Share in crop portfolio		100%	16%	14%	48%	11%	12%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
11	**3**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			145	269	1462	829	382	355	243	189	266	257
Crop Acreage (ha)		300	49	0	33	8	49	41	54	36	32	0
Share in crop portfolio		100%	16%	0%	11%	3%	16%	14%	18%	12%	11%	0%
Total Gross Margin (EUR)		122,870	7,115	0	48,261	6,215	18,722	14,385	13,063	6,738	8,372	0
Rotation Index			3	4	11	13	15					
Rotation Acreage (ha)			67	80	96	27	30					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	49	41	143	32	36	0				
Share in crop portfolio		100%	16%	14%	48%	11%	12%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
11	**4**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			145	269	1657	975	382	355	243	189	266	257
Crop Acreage (ha)		300	49	0	33	8	49	41	54	36	32	0
Share in crop portfolio		100%	16%	0%	11%	3%	16%	14%	18%	12%	11%	0%
Total Gross Margin (EUR)		130,402	7,115	0	54,696	7,312	18,722	14,385	13,063	6,738	8,372	0
Rotation Index			3	4	11	13	15					
Rotation Acreage (ha)			67	80	96	27	30					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	49	41	143	32	36	0				
Share in crop portfolio		100%	16%	14%	48%	11%	12%	0%				

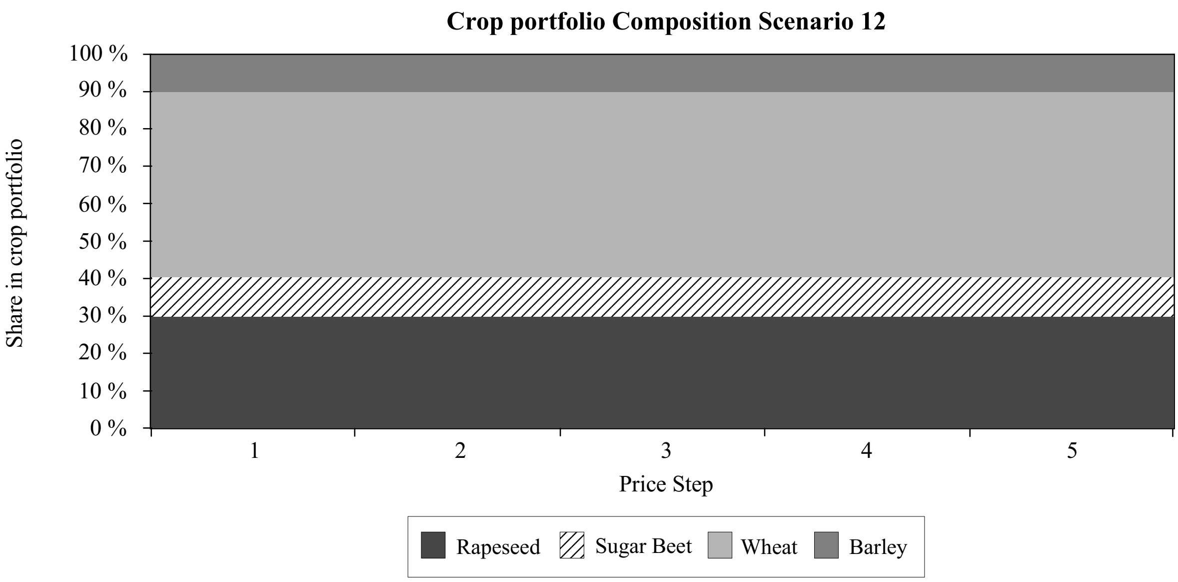
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
11	**5**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	=	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	▲											
Wheat	=											
Gross Margin (EUR/ha)			145	269	1852	1121	382	355	243	189	266	257
Crop Acreage (ha)		300	49	0	33	8	49	41	54	36	32	0
Share in crop portfolio		100%	16%	0%	11%	3%	16%	14%	18%	12%	11%	0%
Total Gross Margin (EUR)		137,933	7,115	0	61,131	8,409	18,722	14,385	13,063	6,738	8,372	0
Rotation Index			3	4	11	13	15					
Rotation Acreage (ha)			67	80	96	27	30					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	49	41	143	32	36	0				
Share in crop portfolio		100%	16%	14%	48%	11%	12%	0%				

Source: Own calculations based on panel-approach.

Figure A33: Crop portfolio composition, output prices and price ratios for scenario 12

Price Index	Crop	Price Development	Price Steps / Price (EUR/t) 1 -50%	2 -40%	3 -30%	4 -20%	5 -10%	Initial Price (EUR/t)	Price Steps / Price (EUR/t) 1 +10%	2 +20%	3 +30%	4 +40%	5 +50%
Scenario		12											
1	Rapeseed	▲						235	259	282	306	329	353
2	Sugar Beet	=						33					
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Wheat	Rapeseed						1.88	2.07	2.26	2.44	2.63	2.82
	Sugar Beet	Rapeseed						7.12	7.83	8.55	9.26	9.97	10.68
	Wheat	Sugar Beet						0.26					

Scenario	Change in Price Ratios: Rapeseed	Sugar Beet	Wheat	Change in Total Gross Margin: Total EUR	Change from Total in %	Change by Price Step in EUR	Share in Crop Portfolio: Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Change in Acreage in %: Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
12	+10%	=	=	113,592	13%	13,467	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%
	+20%	=	=	122,164	22%	8,573	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%
	+30%	=	=	130,737	31%	8,573	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%
	+40%	=	=	139,310	39%	8,573	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%
	+50%	=	=	147,883	48%	8,573	29%	11%	50%	0%	10%	0%	60%	-8%	2%	-100%	-23%



Source: Own calculations based on panel-approach.

Table A35: Cropping activity gross margins and shares in crop portfolio for scenario 12

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
12	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			237	375	907	427	382	355	243	189	266	257
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		113,592	12,316	13,507	29,946	0	33,623	11,721	6,875	5,604	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
12	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			328	481	907	427	382	355	243	189	266	257
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		122,164	17,082	17,314	29,946	0	33,623	11,721	6,875	5,604	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
12	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			420	587	907	427	382	355	243	189	266	257
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		130,737	21,848	21,121	29,946	0	33,623	11,721	6,875	5,604	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
12	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			512	692	907	427	382	355	243	189	266	257
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		139,310	26,613	24,928	29,946	0	33,623	11,721	6,875	5,604	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

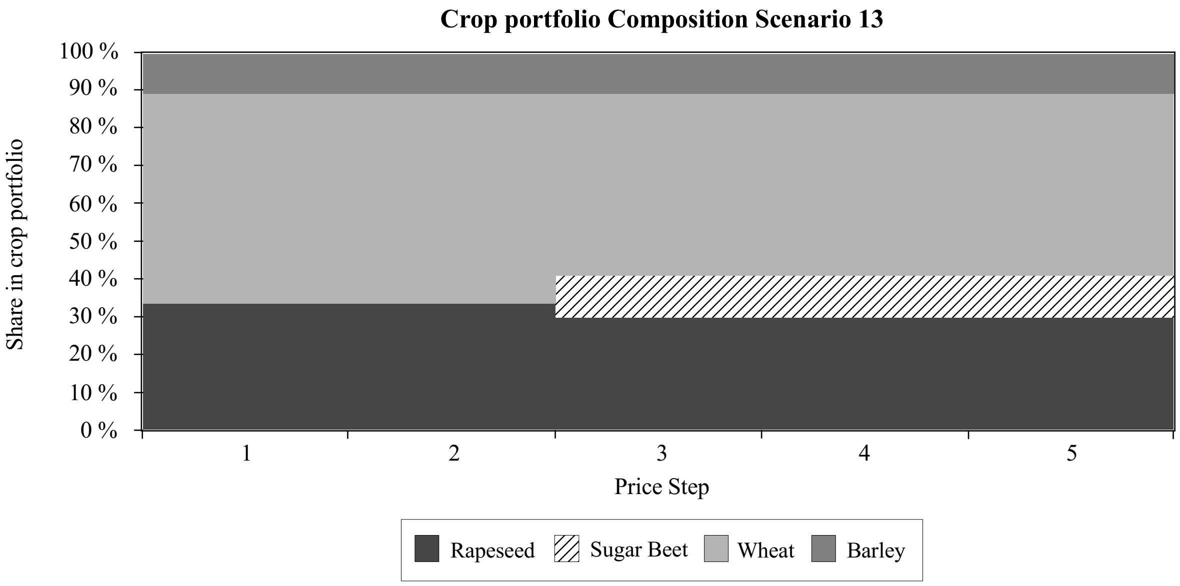
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
12	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			603	798	907	427	382	355	243	189	266	257
Crop Acreage (ha)		300	52	36	33	0	88	33	28	30	0	0
Share in crop portfolio		100%	17%	12%	11%	0%	29%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		147,883	31,379	28,735	29,946	0	33,623	11,721	6,875	5,604	0	0
Rotation Index			3	4	6	14						
Rotation Acreage (ha)			76	80	12	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	88	33	149	0	30	0				
Share in crop portfolio		100%	29%	11%	50%	0%	10%	0%				

Source: Own calculations based on panel-approach.

Figure A34: Crop portfolio composition, output prices and price ratios for scenario 13

Scenario		13	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+50%	+40%	+30%	+20%	+10%
1	Rapeseed	▲						235	353	329	306	282	259
2	Sugar Beet	▼	16	20	23	26	29	33					
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet	12	15	17	20	22	25					
Price Ratio	Wheat	Rapeseed						1.88	2.82	2.63	2.44	2.26	2.07
	Wheat	Sugar Beet	0.13	0.16	0.18	0.21	0.23	0.26					
	Rapeseed	Sugar Beet						0.14					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
13	+50%	-50%	=	129,594	29%	29,470	33%	0%	56%	0%	11%	0%	82%	-100%	14%	-100%	-14%
	+40%	-40%	=	119,809	20%	-9,785	33%	0%	56%	0%	11%	0%	82%	-100%	14%	-100%	-14%
	+30%	-30%	=	110,063	10%	-9,746	30%	11%	48%	0%	11%	0%	62%	-8%	-1%	-100%	-14%
	+20%	-20%	=	107,875	8%	-2,187	30%	11%	48%	0%	11%	0%	62%	-8%	-1%	-100%	-14%
	+10%	-10%	=	105,688	6%	-2,187	30%	11%	48%	0%	11%	0%	62%	-8%	-1%	-100%	-14%



Source: Own calculations based on panel-approach.

Table A36: Cropping activity gross margins and shares in crop portfolio for scenario 13

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
13	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			603	798	-98	-341	382	355	243	189	266	257
Crop Acreage (ha)		300	56	44	0	0	100	0	67	33	0	0
Share in crop portfolio		100%	19%	15%	0%	0%	33%	0%	22%	11%	0%	0%
Total Gross Margin (EUR)		129,594	33,793	35,120	0	0	38,207	0	16,177	6,297	0	0
Rotation Index			3	4	7							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	100	0	167	0	33	0				
Share in crop portfolio		100%	33%	0%	56%	0%	11%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
13	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			512	692	97	-195	382	355	243	189	266	257
Crop Acreage (ha)		300	56	44	0	0	100	0	67	33	0	0
Share in crop portfolio		100%	19%	15%	0%	0%	33%	0%	22%	11%	0%	0%
Total Gross Margin (EUR)		119,809	28,661	30,467	0	0	38,207	0	16,177	6,297	0	0
Rotation Index			3	4	7							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	100	0	167	0	33	0				
Share in crop portfolio		100%	33%	0%	56%	0%	11%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
13	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			420	587	292	-49	382	355	243	189	266	257
Crop Acreage (ha)		300	56	33	33	0	89	33	23	33	0	0
Share in crop portfolio		100%	19%	11%	11%	0%	30%	11%	8%	11%	0%	0%
Total Gross Margin (EUR)		110,063	23,528	19,361	9,651	0	34,005	11,721	5,500	6,297	0	0
Rotation Index			3	4	14							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	145	0	33	0				
Share in crop portfolio		100%	30%	11%	48%	0%	11%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
13	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			328	481	487	97	382	355	243	189	266	257
Crop Acreage (ha)		300	56	33	33	0	89	33	23	33	0	0
Share in crop portfolio		100%	19%	11%	11%	0%	30%	11%	8%	11%	0%	0%
Total Gross Margin (EUR)		107,875	18,396	15,871	16,086	0	34,005	11,721	5,500	6,297	0	0
Rotation Index			3	4	14							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	145	0	33	0				
Share in crop portfolio		100%	30%	11%	48%	0%	11%	0%				

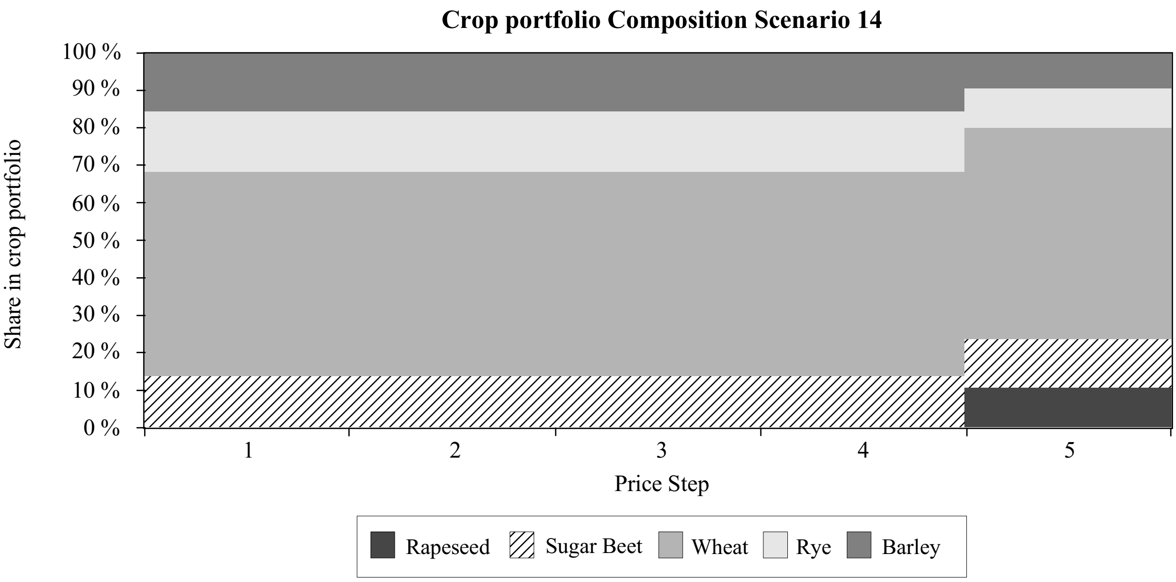
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
13	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ ▼ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			237	375	682	244	382	355	243	189	266	257
Crop Acreage (ha)		300	56	33	33	0	89	33	23	33	0	0
Share in crop portfolio		100%	19%	11%	11%	0%	30%	11%	8%	11%	0%	0%
Total Gross Margin (EUR)		105,688	13,263	12,381	22,521	0	34,005	11,721	5,500	6,297	0	0
Rotation Index			3	4	14							
Rotation Acreage (ha)			68	100	132							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	145	0	33	0				
Share in crop portfolio		100%	30%	11%	48%	0%	11%	0%				

Source: Own calculations based on panel-approach.

Figure A35: Crop portfolio composition, output prices and price ratios for scenario 14

Scenario		14	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+50%	+40%	+30%	+20%	+10%
1	Rapeseed	▼	118	141	165	188	212	235					
2	Sugar Beet	▲						33	49	46	42	39	36
3	Wheat	=						125					
4	Barley	As Wheat						115					
5	Rye	As Wheat						115					
6	Sugar Beet Ind.	As Sugar Beet						25	37	34	32	29	27
Price Ratio	Wheat	Rapeseed	0.94	1.13	1.32	1.50	1.69	1.88					
	Wheat	Sugar Beet						0.26	0.39	0.36	0.34	0.31	0.29
	Rapeseed	Sugar Beet						0.14					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
14	-50%	+50%	=	139,876	40%	39,752	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-40%	+40%	=	132,344	32%	-7,532	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-30%	+30%	=	124,812	25%	-7,532	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-20%	+20%	=	117,280	17%	-7,532	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-10%	+10%	=	106,033	6%	-11,247	10%	14%	57%	10%	10%	0%	-45%	13%	16%	25%	-23%



Source: Own calculations based on panel-approach.

Table A37: Cropping activity gross margins and shares in crop portfolio for scenario 14

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
14	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▼ ▲ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			-313	-259	1852	1121	382	355	243	189	266	257
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		139,876	0	0	61,131	8,409	10,545	14,385	16,524	8,992	12,784	7,106
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
14	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▼ ▲ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			-221	-154	1657	975	382	355	243	189	266	257
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		132,344	0	0	54,696	7,312	10,545	14,385	16,524	8,992	12,784	7,106
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
14	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▼ ▲ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			-130	-48	1462	829	382	355	243	189	266	257
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		124,812	0	0	48,261	6,215	10,545	14,385	16,524	8,992	12,784	7,106
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
14	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▼ ▲ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			-38	58	1267	682	382	355	243	189	266	257
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		117,280	0	0	41,826	5,119	10,545	14,385	16,524	8,992	12,784	7,106
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

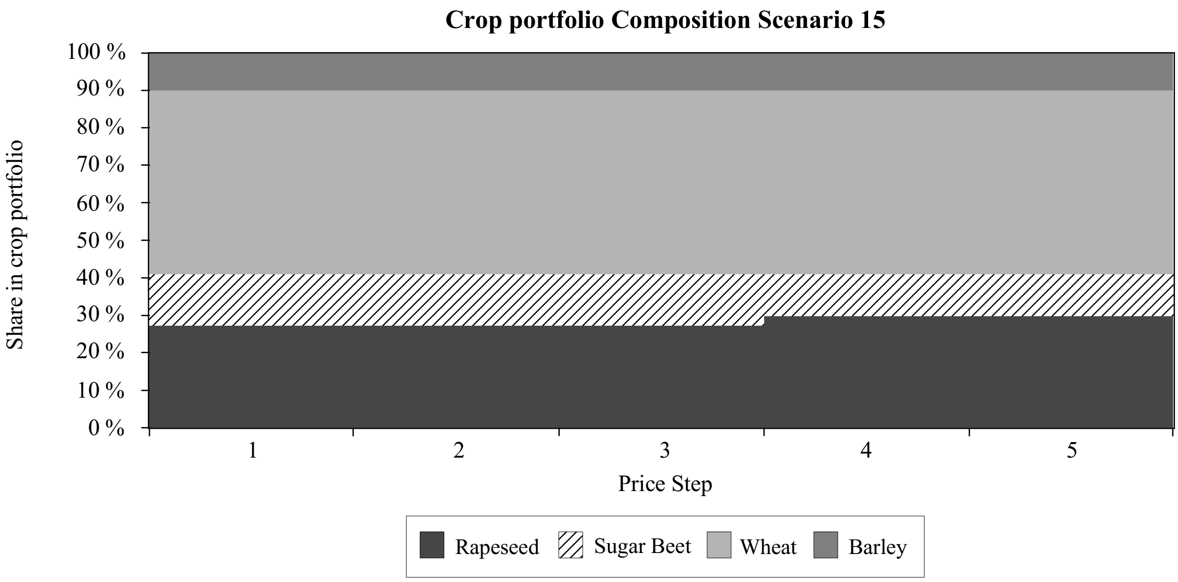
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
14	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▼ ▲ =	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			54	164	1072	536	382	355	243	189	266	257
Crop Acreage (ha)		300	30	0	33	8	40	41	80	30	30	10
Share in crop portfolio		100%	10%	0%	11%	3%	13%	14%	27%	10%	10%	3%
Total Gross Margin (EUR)		106,033	1,606	0	35,391	4,022	15,130	14,385	19,436	5,592	8,000	2,472
Rotation Index			3	10	11	15	18					
Rotation Acreage (ha)			90	80	52	30	48					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	30	41	170	30	30	0				
Share in crop portfolio		100%	10%	14%	57%	10%	10%	0%				

Source: Own calculations based on panel-approach.

Figure A36: Crop portfolio composition, output prices and price ratios for scenario 15

Scenario		15	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+50%	+40%	+30%	+20%	+10%
1	Rapeseed	▲						235	338	315	293	270	248
2	Sugar Beet	=						33					
3	Wheat	▼	63	75	88	100	113	125					
4	Barley	As Wheat	58	69	81	92	104	115					
5	Rye	As Wheat	58	69	81	92	104	115					
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Sugar Beet	Rapeseed						6.82	10.23	9.55	8.87	8.18	7.50
	Wheat	Rapeseed						1.80					
	Sugar Beet	Wheat	1.90	2.27	2.65	3.03	3.41	3.79					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
15	+50%	=	-50%	53,137	-47%	-46,987	30%	11%	49%	0%	10%	0%	62%	-8%	1%	-100%	-22%
	+40%	=	-40%	62,916	-37%	9,779	30%	11%	49%	0%	10%	0%	62%	-8%	1%	-100%	-22%
	+30%	=	-30%	72,695	-27%	9,779	30%	11%	49%	0%	10%	0%	62%	-8%	1%	-100%	-22%
	+20%	=	-20%	82,326	-18%	9,632	27%	14%	49%	0%	10%	0%	48%	13%	1%	-100%	-22%
	+10%	=	-10%	92,853	-7%	10,527	27%	14%	49%	0%	10%	0%	48%	13%	1%	-100%	-22%



Source: Own calculations based on panel-approach.

Table A38: Cropping activity gross margins and shares in crop portfolio for scenario 15

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
15	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			545	731	907	427	-149	-157	-257	-259	-211	-242
Crop Acreage (ha)		300	48	41	33	0	89	33	26	30	0	0
Share in crop portfolio		100%	16%	14%	11%	0%	30%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		53,137	26,356	29,731	29,946	0	-13,250	-5,182	-6,684	-7,780	0	0
Rotation Index			3	4	7	14						
Rotation Acreage (ha)			55	90	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	148	0	30	0				
Share in crop portfolio		100%	30%	11%	49%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
15	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			458	630	907	427	-43	-54	-157	-170	-116	-142
Crop Acreage (ha)		300	48	41	33	0	89	33	26	30	0	0
Share in crop portfolio		100%	16%	14%	11%	0%	30%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		62,916	22,114	25,613	29,946	0	-3,789	-1,798	-4,082	-5,088	0	0
Rotation Index			3	4	7	14						
Rotation Acreage (ha)			55	90	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	148	0	30	0				
Share in crop portfolio		100%	30%	11%	49%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
15	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			370	529	907	427	64	48	-57	-80	-20	-42
Crop Acreage (ha)		300	48	41	33	0	89	33	26	30	0	0
Share in crop portfolio		100%	16%	14%	11%	0%	30%	11%	9%	10%	0%	0%
Total Gross Margin (EUR)		72,695	17,871	21,494	29,946	0	5,673	1,587	-1,481	-2,395	0	0
Rotation Index			3	4	7	14						
Rotation Acreage (ha)			55	90	23	132						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	89	33	148	0	30	0				
Share in crop portfolio		100%	30%	11%	49%	0%	10%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
15	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			282	427	907	427	170	151	43	10	75	58
Crop Acreage (ha)		300	48	33	33	8	81	41	26	30	0	0
Share in crop portfolio		100%	16%	11%	11%	3%	27%	14%	9%	10%	0%	0%
Total Gross Margin (EUR)		82,326	13,629	14,100	29,946	3,277	13,831	6,126	1,121	297	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			55	90	132	23						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	81	41	148	0	30	0				
Share in crop portfolio		100%	27%	14%	49%	0%	10%	0%				

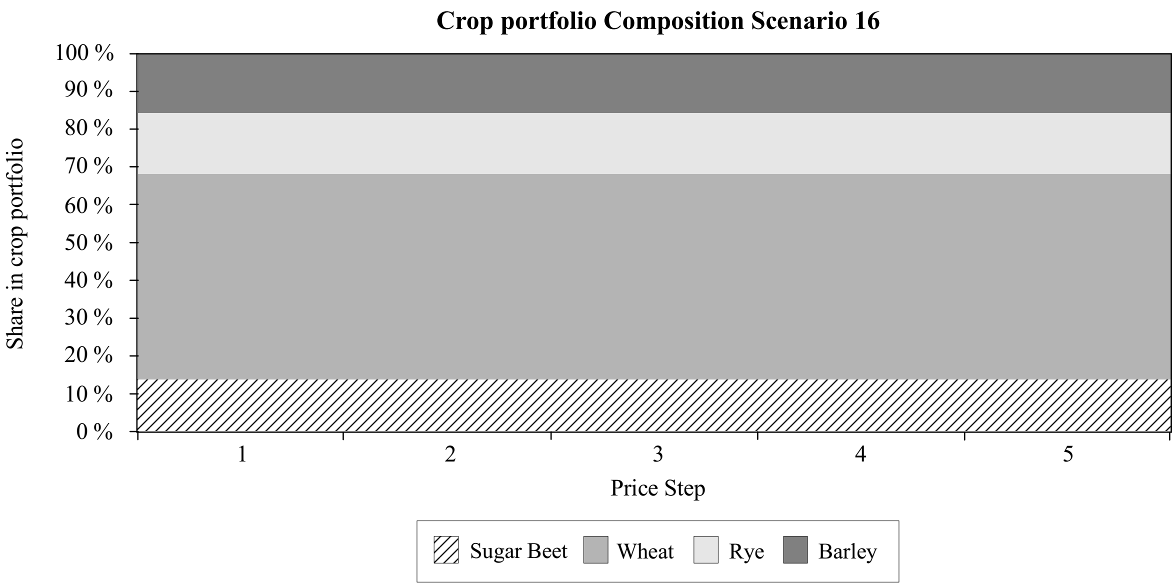
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
15	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	▲ = ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			194	326	907	427	276	253	143	100	171	158
Crop Acreage (ha)		300	48	33	33	8	81	41	26	30	0	0
Share in crop portfolio		100%	16%	11%	11%	3%	27%	14%	9%	10%	0%	0%
Total Gross Margin (EUR)		92,853	9,386	10,758	29,946	3,277	22,477	10,296	3,722	2,990	0	0
Rotation Index			3	4	14	16						
Rotation Acreage (ha)			55	90	132	23						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	81	41	148	0	30	0				
Share in crop portfolio		100%	27%	14%	49%	0%	10%	0%				

Source: Own calculations based on panel-approach.

Figure A37: Crop portfolio composition, output prices and price ratios for scenario 16

Scenario		16	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+50%	+40%	+30%	+20%	+10%
1	Rapeseed	▼	113	135	158	180	203	235					
2	Sugar Beet	=						33					
3	Wheat	▲						125	188	175	163	150	138
4	Barley	As Wheat						115	173	161	150	138	127
5	Rye	As Wheat						115	173	161	150	138	127
6	Sugar Beet Ind.	As Sugar Beet						25					
Price Ratio	Sugar Beet	Rapeseed	3.41	4.09	4.77	5.46	6.14	6.82					
	Wheat	Rapeseed						1.80					
	Sugar Beet	Wheat						3.79	5.69	5.31	4.93	4.55	4.17

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
16	-50%	=	+50%	231,275	131%	131,151	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-40%	=	+40%	205,746	105%	-25,529	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-30%	=	+30%	180,217	80%	-25,529	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-20%	=	+20%	154,688	54%	-25,529	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%
	-10%	=	+10%	129,160	29%	-25,529	0%	14%	55%	16%	16%	0%	-100%	13%	12%	100%	23%



Source: Own calculations based on panel-approach.

Table A39: Cropping activity gross margins and shares in crop portfolio for scenario 16

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
16	**1**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	▼	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	=											
Wheat	▲											
Gross Margin (EUR/ha)			-332	-282	907	427	914	869	743	638	744	758
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		231,275	0	0	29,946	3,206	25,232	35,176	50,632	30,376	35,778	20,929
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
16	**2**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	▼	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	=											
Wheat	▲											
Gross Margin (EUR/ha)			-245	-180	907	427	808	766	643	548	648	658
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		205,746	0	0	29,946	3,206	22,298	31,022	43,818	26,104	31,184	18,167
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
16	**3**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	▼	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	=											
Wheat	▲											
Gross Margin (EUR/ha)			-157	-79	907	427	702	663	543	459	553	558
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		180,217	0	0	29,946	3,206	19,364	26,869	37,004	21,832	26,590	15,406
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
16	**4**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	▼	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	=											
Wheat	▲											
Gross Margin (EUR/ha)			-69	22	907	427	595	561	443	369	457	458
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		154,688	0	0	29,946	3,206	16,430	22,715	30,190	17,560	21,997	12,644
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

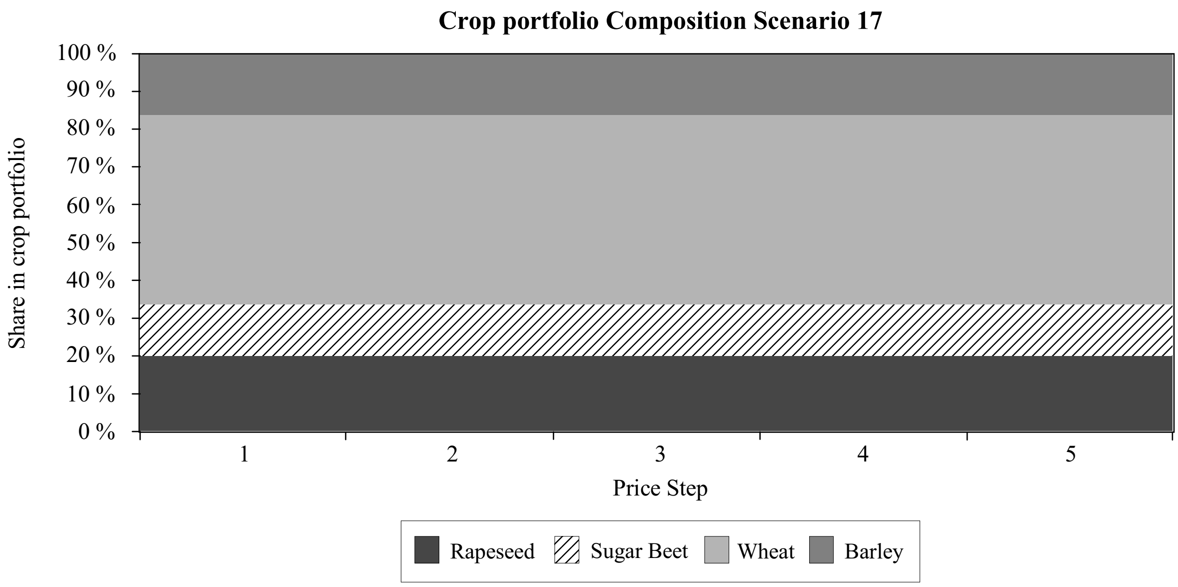
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
16	**5**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed	▼	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Sugar Beet	=											
Wheat	▲											
Gross Margin (EUR/ha)			19	123	907	427	489	458	343	279	362	358
Crop Acreage (ha)		300	0	0	33	8	28	41	68	48	48	28
Share in crop portfolio		100%	0%	0%	11%	3%	9%	14%	23%	16%	16%	9%
Total Gross Margin (EUR)		129,160	0	0	29,946	3,206	13,496	18,561	23,376	13,288	17,403	9,883
Rotation Index			10	11	15	18						
Rotation Acreage (ha)			80	52	30	138						
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	41	164	48	48	0				
Share in crop portfolio		100%	0%	14%	55%	16%	16%	0%				

Source: Own calculations based on panel-approach.

Figure A38: Crop portfolio composition, output prices and price ratios for scenario 17

Scenario		17	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+50%	+40%	+30%	+20%	+10%
1	Rapeseed	=						235					
2	Sugar Beet	▲						33	53	49	46	42	39
3	Wheat	▼	66	79	92	105	118	125					
4	Barley	As Wheat	61	73	85	97	109	115					
5	Rye	As Wheat	61	73	85	97	109	115					
6	Sugar Beet Ind.	As Sugar Beet						25	40	37	34	32	29
Price Ratio	Wheat	Sugar Beet						0.27					
	Rapeseed	Sugar Beet						0.15	0.23	0.21	0.20	0.18	0.17
	Rapeseed	Wheat	0.28	0.34	0.39	0.45	0.50	0.56					

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
17	=	+50%	-50%	52,754	-47%	-47,370	20%	14%	50%	0%	17%	0%	7%	14%	3%	-100%	29%
	=	+40%	-40%	65,498	-35%	12,744	20%	14%	50%	0%	17%	0%	7%	14%	3%	-100%	29%
	=	+30%	-30%	78,242	-22%	12,744	20%	14%	50%	0%	17%	0%	7%	14%	3%	-100%	29%
	=	+20%	-20%	90,985	-9%	12,744	20%	14%	50%	0%	17%	0%	7%	14%	3%	-100%	29%
	=	+10%	-10%	103,729	4%	12,744	20%	14%	50%	0%	17%	0%	7%	14%	3%	-100%	29%



Source: Own calculations based on panel-approach.

Table A40: Cropping activity gross margins and shares in crop portfolio for scenario 17

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
17	1	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▲ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	2100	1307	-121	-130	-231	-236	-186	-216
Crop Acreage (ha)		300	59	0	33	8	59	41	50	50	0	0
Share in crop portfolio		100%	20%	0%	11%	3%	20%	14%	17%	17%	0%	0%
Total Gross Margin (EUR)		52,754	8,567	0	69,999	10,019	-7,146	-5,341	-11,548	-11,796	0	0
Rotation Index			3	4	12	13	16					
Rotation Acreage (ha)			77	100	50	50	23					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	59	41	150	0	50	0				
Share in crop portfolio		100%	20%	14%	50%	0%	17%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
17	2	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▲ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	1888	1148	-9	-22	-126	-141	-86	-111
Crop Acreage (ha)		300	59	0	33	8	59	41	50	50	0	0
Share in crop portfolio		100%	20%	0%	11%	3%	20%	14%	17%	17%	0%	0%
Total Gross Margin (EUR)		65,498	8,567	0	62,949	8,803	-547	-916	-6,284	-7,074	0	0
Rotation Index			3	4	12	13	16					
Rotation Acreage (ha)			77	100	50	50	23					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	59	41	150	0	50	0				
Share in crop portfolio		100%	20%	14%	50%	0%	17%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
17	3	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▲ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	1677	990	103	86	-20	-47	15	-6
Crop Acreage (ha)		300	59	0	33	8	59	41	50	50	0	0
Share in crop portfolio		100%	20%	0%	11%	3%	20%	14%	17%	17%	0%	0%
Total Gross Margin (EUR)		78,242	8,567	0	55,899	7,587	6,053	3,508	-1,020	-2,352	0	0
Rotation Index			3	4	12	13	16					
Rotation Acreage (ha)			77	100	50	50	23					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	59	41	150	0	50	0				
Share in crop portfolio		100%	20%	14%	50%	0%	17%	0%				

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
17	4	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▲ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	1465	831	214	193	85	47	115	100
Crop Acreage (ha)		300	59	0	33	8	59	41	50	50	0	0
Share in crop portfolio		100%	20%	0%	11%	3%	20%	14%	17%	17%	0%	0%
Total Gross Margin (EUR)		90,985	8,567	0	48,849	6,371	12,653	7,932	4,244	2,370	0	0
Rotation Index			3	4	12	13	16					
Rotation Acreage (ha)			77	100	50	50	23					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	59	41	150	0	50	0				
Share in crop portfolio		100%	20%	14%	50%	0%	17%	0%				

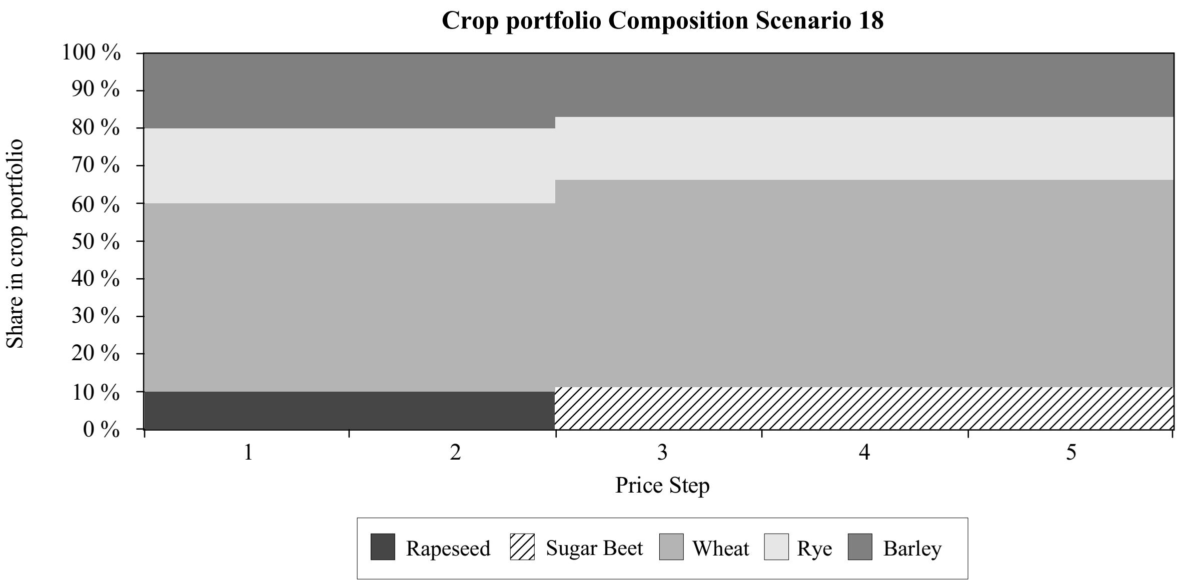
Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
17	5	Crop Index	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▲ ▼	Cropping Activity	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	1254	672	326	301	190	142	216	205
Crop Acreage (ha)		300	59	0	33	8	59	41	50	50	0	0
Share in crop portfolio		100%	20%	0%	11%	3%	20%	14%	17%	17%	0%	0%
Total Gross Margin (EUR)		103,729	8,567	0	41,799	5,155	19,253	12,357	9,508	7,091	0	0
Rotation Index			3	4	12	13	16					
Rotation Acreage (ha)			77	100	50	50	23					
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	59	41	150	0	50	0				
Share in crop portfolio		100%	20%	14%	50%	0%	17%	0%				

Source: Own calculations based on panel-approach.

Figure A39: Crop portfolio composition, output prices and price ratios for scenario 18

Scenario		18	Price Steps / Price (EUR/t)					Initial Price (EUR/t)	Price Steps / Price (EUR/t)				
Price Index	Crop	Price Development	1	2	3	4	5		1	2	3	4	5
			-50%	-40%	-30%	-20%	-10%		+50%	+40%	+30%	+20%	+10%
1	Rapeseed	=						235					
2	Sugar Beet	▼	18	21	25	28	32	33					
3	Wheat	▲						125	197	184	171	158	145
4	Barley	As Wheat						115	182	170	157	145	133
5	Rye	As Wheat						115	182	170	157	145	133
6	Sugar Beet Ind.	As Sugar Beet	13	16	19	21	24	25					
Price Ratio	Wheat	Sugar Beet						0.27					
	Rapeseed	Sugar Beet	0.08	0.09	0.11	0.12	0.14	0.15					
	Rapeseed	Wheat						0.56	0.84	0.78	0.73	0.67	0.62

Scenario	Change in Price Ratios			Change in Total Gross Margin			Share in Crop Portfolio						Change in Acreage in %				
	Rapeseed	Sugar Beet	Wheat	Total EUR	Change from Total in %	Change by Price Step in EUR	Rapeseed	Sugar Beet	Wheat	Rye	Barley	Faba Bean	Rapeseed	Sugar Beet	Wheat	Rye	Barley
Status Quo				100,124	100%		18%	12%	49%	8%	13%	0%					
18	=	-50%	+50%	233,966	134%	133,841	10%	0%	50%	20%	20%	0%	-45%	-100%	3%	150%	55%
	=	-40%	+40%	206,083	106%	-27,882	10%	0%	50%	20%	20%	0%	-45%	-100%	3%	150%	55%
	=	-30%	+30%	182,398	82%	-23,685	0%	11%	56%	17%	17%	0%	-100%	-8%	14%	110%	29%
	=	-20%	+20%	161,742	62%	-20,656	0%	11%	56%	17%	17%	0%	-100%	-8%	14%	110%	29%
	=	-10%	+10%	141,086	41%	-20,656	0%	11%	56%	17%	17%	0%	-100%	-8%	14%	110%	29%



Source: Own calculations based on panel-approach.

Table A41: Cropping activity gross margins and shares in crop portfolio for scenario 18

Scenario	Price Step	Activity Index	1	2	3	4	5	6	7	8	9	14
18	**1**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	-15	-279	997	949	822	708	819	837
Crop Acreage (ha)		300	0	30	0	0	60	0	60	60	60	30
Share in crop portfolio		100%	0%	10%	0%	0%	20%	0%	20%	20%	20%	10%
Total Gross Margin (EUR)		233,966	0	8,083	0	0	59,848	0	49,311	42,507	49,117	25,099
Rotation Index			5	18								
Rotation Acreage (ha)			150	150								
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	30	0	150	60	60	0				
Share in crop portfolio		100%	10%	0%	50%	20%	20%	0%				
Scenario	**Price Step**	**Activity Index**	1	2	3	4	5	6	7	8	9	14
18	**2**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	196	-121	886	841	717	614	718	731
Crop Acreage (ha)		300	0	30	0	0	60	0	60	60	60	30
Share in crop portfolio		100%	0%	10%	0%	0%	20%	0%	20%	20%	20%	10%
Total Gross Margin (EUR)		206,083	0	8,083	0	0	53,137	0	42,994	36,841	43,088	21,941
Rotation Index			5	18								
Rotation Acreage (ha)			150	150								
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	30	0	150	60	60	0				
Share in crop portfolio		100%	10%	0%	50%	20%	20%	0%				
Scenario	**Price Step**	**Activity Index**	1	2	3	4	5	6	7	8	9	14
18	**3**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	408	38	774	733	611	520	618	626
Crop Acreage (ha)		300	0	0	33	0	34	33	67	50	50	34
Share in crop portfolio		100%	0%	0%	11%	0%	11%	11%	22%	17%	17%	11%
Total Gross Margin (EUR)		182,398	0	0	13,463	0	25,998	24,190	40,712	25,901	31,098	21,037
Rotation Index			10	11	18							
Rotation Acreage (ha)			65	67	168							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	33	167	50	50	0				
Share in crop portfolio		100%	0%	11%	56%	17%	17%	0%				
Scenario	**Price Step**	**Activity Index**	1	2	3	4	5	6	7	8	9	14
18	**4**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	619	196	662	625	506	425	517	521
Crop Acreage (ha)		300	0	0	33	0	34	33	67	50	50	34
Share in crop portfolio		100%	0%	0%	11%	0%	11%	11%	22%	17%	17%	11%
Total Gross Margin (EUR)		161,742	0	0	20,442	0	22,240	20,629	33,700	21,193	26,038	17,499
Rotation Index			10	11	18							
Rotation Acreage (ha)			65	67	168							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	33	167	50	50	0				
Share in crop portfolio		100%	0%	11%	56%	17%	17%	0%				
Scenario	**Price Step**	**Activity Index**	1	2	3	4	5	6	7	8	9	14
18	**5**	**Crop Index**	1	1	2	6	3	3	3	4	5	3
Rapeseed Sugar Beet Wheat	= ▼ ▲	**Cropping Activity**	Rapeseed (Plow, 3.9 t/ha)	Rapeseed (Plow, 4.5 t/ha)	Sugar Beets Quota (Plow, 60 t/ha)	Sugar Beets Industrial (Plow, 60 t/ha)	Wheat on Rapeseed (Min-Till, 8.5 t/ha)	Wheat on Sugar Beets (Plow/Min-Till, 8.2 t/ha)	Wheat on Wheat (Plow, 8.0 t/ha)	Winter Barley (Plow, 7.8 t/ha)	Winter Rye (Plow, 8.3 t/ha)	Wheat on Wheat (Min-Till, 8.0 t/ha)
Gross Margin (EUR/ha)			145	269	831	355	550	517	401	331	417	416
Crop Acreage (ha)		300	0	0	33	0	34	33	67	50	50	34
Share in crop portfolio		100%	0%	0%	11%	0%	11%	11%	22%	17%	17%	11%
Total Gross Margin (EUR)		141,086	0	0	27,422	0	18,481	17,068	26,689	16,485	20,979	13,962
Rotation Index			10	11	18							
Rotation Acreage (ha)			65	67	168							
Crop Total			Rapeseed	Sugar Beets	Wheat	Rye	Barley	Other				
Crop Acreage (ha)		300	0	33	167	50	50	0				
Share in crop portfolio		100%	0%	11%	56%	17%	17%	0%				

Source: Own calculations based on panel-approach.

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