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Analyzing the environmental effects of agricultural trade policies

A case study for the Marchfeld region in Austria

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Vienna, March 2011

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This master thesis analyzes the environmental effects of different trade policy scenarios for the Marchfeld region in Austria.

Acknowledgements

I am sincerely thankful to my supervisor, Professor Dr. Erwin Schmid. His kindness and enthusiasm accompanied me from the very beginning to the very end. His excellent advice, valuable feedbacks and patience - qualities one usually rarely finds - made it possible for me to write this thesis.

I owe many thanks and a lot of gratitude to my co-supervisor, Kathryn Bicknell (PhD), who continuously provided me with a lot of valuable feedback and comments under extraordinary circumstances.

Finally, I am most grateful to my parents. Without their generous support throughout the years all of this would have not been possible.

Abstract - English

The relationship between trade and environment has received considerable attention in the last decades. Although studied by many, it remains disputed if trade enhances or decreases the production of negative externalities, especially at the regional and local level. This thesis aims to contribute to this field of study by analyzing the environmental effects of different trade policy scenarios for the Marchfeld region in Austria. The research focus is put on nitrate pollution of groundwater. I developed a linear land use optimization model that integrates environmental outcomes (nitrate leaching) from the bio-physical simulation model EPIC (Environment Policy Integrated Climate).

The model results show that tariff reductions are not likely to influence nitrate pollution of groundwater in the Marchfeld region. But, if trade liberalization is accompanied by the abolishment of single farm payments (SFP) this would reduce nitrate pollution moderately. In contrast, producer support is rather likely to increase than decrease nitrate pollution. I was also able to show that domestic policies, in particular agri-environmental payments, have a far more significant effect on reducing nitrate pollution than trade policies. This means that policy makers should concentrate on identifying efficient domestic environmental policies that are in accordance with WTO trade rules.

Abstract – German/Deutsch

Das Verhältnis zwischen internationalem Handel und Umwelt ist seit Jahrzehnten ein Thema in der wissenschaftlichen Literatur. Das liegt vor allem daran, dass bis dato keine umfassenden und eindeutigen empirischen Ergebnisse publiziert wurden. Vor allem auf regionaler und lokaler Ebene können die Folgen einer neuen Handelspolitik sehr heterogen ausfallen. Diese Masterarbeit versucht zu diesem Thema beizutragen, in dem mögliche Umweltauswirkungen von verschiedenen Handelspolitiken in der Region Marchfeld untersucht werden. Dabei werden speziell die Auswirkungen verschiedener Politiken auf die Nitratkonzentration im Grundwasser analysiert. Dazu entwickelte ich ein lineares Landnutzungsoptimierungsmodell, das simulierte Umweltdaten des biophysikalischen Prozessmodells EPIC (Environment Policy Integrated Climate) integriert.

Die Ergebnisse zeigen, dass eine Senkung oder Abschaffung von Handelstarifen kaum signifikante Auswirkungen auf die Nitratauswaschung im Grundwasser hat. Wenn zusätzlich zur Handelsliberalisierung die Betriebsprämie abgeschafft wird, könnte dies zu einer geringen Verbesserung der Grundwasserverschmutzung in der Region Marchfeld führen. Hingegen würde eine zunehmende Produktionsunterstützung zu einer Verschlechterung der Grundwasserqualität führen. Ich konnte aufzeigen, dass nationale Umweltpolitiken, wie z.B. ÖPUL, eine viel größere und signifikantere Auswirkung auf die Verringerung der Nitratauswaschung haben als Veränderungen in der Handelspolitik. Die Herausforderung wird in Zukunft also darin bestehen, nationale Umweltpolitiken zu finden, die mit den internationalen Handelsregeln der WTO übereinstimmen.

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1 Introduction

According to economic theory, trade liberalization will ideally result in a win-win situation where both exporting and importing countries gain in total welfare from mutual trade[1]. But, if production and/or consumption creates environmental externalities[2] the empirical result cannot be drawn straight forward. On the one hand, agricultural trade liberalization could increase negative externalities such as deforestation or nitrate leaching, or may decrease the production of positive externalities such as maintaining cultural landscapes amenities. On the other hand, agricultural trade liberalization could decrease environmental degradation due to the diffusion and development of 'greener' technologies, or shifts in agricultural production to low-income countries where less agro-chemical inputs are being used.

The aim of this Master's thesis is to analyze the question of *how agricultural trade policies may influence the environment*. Although a lot of research has been conducted to study the relationship between trade and environment "a consensus view does not exist" (Antweiler, Copeland, & Taylor, 2001, p. 880) and no clear-cut results can be derived from either economic theory or from empirical evidence. The only 'consensus' one may find in the literature is that the environmental effects can be both positive and negative and can differ largely between regions. And even if the net gains from agricultural trade liberalization are positive, it is still important to know how it may affect the environment (especially given the difficulties of valuing externalities). Since the early 1990's, there is a "growing demand for a better understanding" of the relationship between international trade and the environment as argued by Anderson (1992, p. 25) and this issue "continues to be of significant policy concern" (Cooper, 2005, p. 1) until the present.

Moreover, it is precisely the environmental effects of agricultural trade policies in rural areas which have not been addressed sufficiently. There is a lack of clear-cut results from economic theory and only a few studies have addressed the impact on a regional or local level in the agricultural sector. Therefore, it seems reasonable to suggest that more research is needed on this issue.

A prerequisite to linking trade policy scenarios with environmental effects is to show how trade policies will affect agricultural production in a specific region (and thus the environment) through changes in input and output price ratios. Only then can it be shown how the change in production (may it be quantitative or a shift in production) will influence the environmental outcomes.

For example, agricultural production in a specific region may generate externalities such as CO_2 emissions which would contribute to global warming or it may increase nitrate concentrations in groundwater. Trade policies can affect the agricultural production that creates these environmental externalities. A quantitative change in production would consequently lead to a quantitative change in environmental externalities. A shift in production may even create new environmental externalities.

A **regional land use optimization model** has been developed using the General Algebraic Modeling System GAMS. The GAMS model integrates outputs from the bio-physical simulation model EPIC

[1] An increase in total welfare does not imply that everybody wins. There will be distributional differences between consumers and producers (and the state).

[2] An externality "is said to occur when the production or consumption decisions of one agent have an impact on the utility or profit of another agent in an unintended way, and when no compensation/payment is made by the generator of the impact to the affected party" (Perman, Ma, McGilvray, & Common, 2003, p. 134).

(Environmental Policy Integrated Climate). Therefore, a functional linkage between agricultural production activities and nitrate leaching has been established, which allows **comparative static** trade policy scenario analysis. The empirical analysis is carried out in the Austrian Marchfeld region in order to analyze the effects of trade policy scenarios on nitrate leaching into the groundwater.

The thesis is structured as follows. The second section will explain the specific focus of the thesis on agriculture and local assessments. Section 2.1 will show how agriculture can affect the environment in numerous ways (positively and negatively) and that trade distortions in the agricultural sector are still substantial. Section 2.2 draws attention to the importance of environmental studies.

Section 3 is an introduction to the trade-environment issue which has become of interest to both economists and environmentalists since the global economic crisis from 1973-82 (Anderson & Blackhurst, 1992, p. 3). It will:

- establish a theoretical basis for understanding trade-environment linkages;
- address the important issue of sustainability;
- provide an extensive review of empirical studies.

The key objective of section 3 is to see if theory and empirical findings suggest that local environmental assessments of agricultural trade policies are in fact needed.

Section 3 is divided into four parts. The first part, section 3.1, demonstrates how trade-environment linkages can be derived from economic theory (more specifically: from environmental economics and international trade theory). It also addresses more policy oriented linkages between trade and environment. Sustainability issues enter the theoretical debate in section 3.2. Then, a review of empirical studies and consequent findings will be presented in section 3.3. The last part, section 3.4, summarizes and discusses the above findings and shows what implications they have for the case study analysis.

Section 4 will provide a local case study for estimating the potential effects of trade policies on nitrate pollution of groundwater. The case study will be conducted for the region Marchfeld in Austria. This section will begin by outlining the objectives and hypotheses of the study (section 4.1). This will be followed by a description of Marchfeld with a focus on its environmental problems, particularly groundwater contamination with nitrates (section 4.2). The following two sections present the data (section 4.3) and the methodological framework and models (section 4.4) for the empirical analysis. The next section presents and discusses the policy scenarios with respect to current national and international agricultural policy developments (section 4.5). The model results are presented and discussed in section 4.6.

The concluding fifth section will discuss the empirical results with respect to the findings from section 3. At the end I will provide some recommendations for future research.

2 Focus of the study

This study has two related foci: First, the role of agriculture in the trade-environment debate and second, the local environmental impacts of agricultural trade liberalization. The subsequent sections will show that agricultural production has important implications for the environment and trade policies can significantly influence agricultural production.

2.1 The reasons for focusing on the agricultural sector

There are two main reasons why it would make sense to focus on agriculture when studying the environmental effects of trade liberalization. Firstly, there are many important direct and indirect links between agricultural production, resource use and environmental quality (CEC Secretariat, 2000, p. 35). For example, according to Kletzan, Sinabell, & Schmid (2004, p. 3) "agriculture is the most important type of land use in Austria". It comprises 44% percent of the total Austrian territory. Consequently, it significantly affects the environment. Secondly, persistently high trade distortions in agricultural trade make it likely that freer trade will lead to substantial production shifts across the globe (Ferrantino, 2000; Sullivan & Ingram, 2005; Cooper, Johansson, & Peters, 2005). These two statements will now be elaborated in more detail.

2.1.1 The environmental effects of agriculture

Agricultural production creates many environmental externalities (see Table 1). These externalities can be negative such as soil erosion or nitrogen runoff, or positive such as open space or cultural landscapes values. The effects depend on factors such as technology, crop mix, domestic policies or characteristics of a region/country but also on the change in volume and in the mix of production caused by trade policies (Morrisey, te Velde, Gillson, & Wiggins, 2005). Further, whether an impact is assumed to be positive or negative is also influenced by societal values and public opinion. For example, the maintenance of cultural landscapes plays a much more important role in Europe than in the U.S. where wilderness has a higher priority instead (Glebe, 2006).

Table 1. Externalities of agriculture (Cooper, Bernstein, Vasavada, & Bureau, 2005, p. 19)

By-Product	Positive Impact	Negative Impact
Water Quality	Watershed protection	Nutrient/pesticide runoff
Water Quantity	Flood control	Reduced flood control
Siltation/sedimentation	Soil conservation	Soil erosion
Landscape	Scenic vistas	Odor and noise
Biodiversity	Biodiversity gain	Biodiversity loss
Ecosystem impacts	Wildlife habitat gain	Wildlife habit loss

These – desired or not desired – externalities are of policy concern. This can be seen in the high level of expenditures on agri-environmental issues in member countries of the Organization of Economic Co-operation and Development (OECD) (Cooper, Bernstein, Vasavada, & Bureau, 2005). While negative externalities are being over-produced (since their cost is not being accounted for in the market), positive externalities are likely to be under-produced (since farmers do not receive any financial benefits from them). Negative environmental externalities have traditionally received much more attention.

Maltais, Nilsson, & Persson (2002, p. 17) warn that "the baseline conditions in the agricultural sector are often far from sustainable today" due to "land scarcities, overgrazing, deforestation, excessive use of agrochemicals, and in other ways inappropriate agricultural practices". In Europe agricultural production is typically associated with the following negative environmental externalities (Abler & Shortle, 1998, p. 52):

- nonpoint surface water & groundwater pollution by fertilizers, pesticides & animal manure;
- sedimentation of surface waters by eroded soils;
- loss of flora and fauna due to pesticide runoff and overspray;
- acidification of the atmosphere due to nitrogen in fertilizers and manure;
- soil and water pollution from heavy metals in fertilizers and manure;
- loss of biodiversity due to conversion of forests and wetlands to farm land;
- salinization and waterlogging from irrigation;
- and greenhouse gas emissions from deforestation and livestock.

In recent times, the concept of multifunctionality of agriculture has received considerable attention from both politicians and researches (e.g. it has become an integral part of the CAP) (Maltais, Nilsson, & Persson, 2002, p. 142). This concept focuses on the multi-functional role of agriculture in society and has its origins in the 1960s. It gained political prominence during the negotiations on the Uruguay Round Agreement on Agriculture (URAA; entered force in 1995). Some countries, notably Norway, Japan and the Republic of Korea put forward the argument that agriculture produces many desirable amenities, such as the preservation of rural landscapes, flood prevention or cultural heritage (Cooper, Bernstein, Vasavada, & Bureau, 2005). The contribution of agriculture to food security and environmental, social and rural development was used as an argument to include more exemptions into the URAA. Most studies concerned about these amenities of agriculture focus on landscape and open space (Cooper, Bernstein, Vasavada, & Bureau, 2005). Since many positive environmental externalities have a non-use value (i.e. people receive satisfaction just from knowing 'it' exists) it remains very difficult, if not impossible, to value them accurately.

Sinabell (1995) provides an extensive list of both negative and positive externalities of Austrian agriculture. Selected examples are shown in Table 2. It becomes evident that agricultural activities can often produce negative and positive externalities at the same time. It is thus crucial to ensure a fair and cost-effective trade-off between those externalities. For example, Sinabell (1995) noted that agriculture can have ambiguous effects on biodiversity. On the one hand, it certainly contributed heavily to the massive losses in biodiversity in the past. On the other hand, it now also provides habitats for species which have adapted to the abundant cultural landscape in Austria.

It is generally recommended to concentrate on the four environmental media of air, water, land and biodiversity when analyzing environmental externalities (CEC Secretariat, 2000). Indicators for environmental externalities within these media could be for example: carbon dioxide emissions, nitrogen leakage from fertilizers, depletion of water resources, landscape values, different landscape types in ha and % of changes, deforestation rates, soil quality, soil erosion, averages annual fertilizer use in kg/ha, biodiversity management or number of threatened and extinct species (CEC Secretariat, 2000; Ervin, 2000; Maltais, Nilsson, & Persson, 2002).

Table 2. Positive and negative external effects of Austrian agriculture (Sinabell (1995, p. 165f); own translation)

Factor of influence	Negative effects	Victims	Positive effects	Beneficiary
land use	clearing of landscapes	visitors	opening of landscapes	visitors
	confinement of habitats – loss of biodiversity	society	creation of habitats – conservation of biodiversity	society
	soil loss due to erosion	society, storage power plant owner	wild meadows	hunters, wildlife watcher
	increase of water runoff	users of flood-prone land	decrease of water runoff	users of flood-prone land
	CO_2 emissions due to ploughing up of grassland	society	regulating pollutant immissions	society
			regulating CO_2	society
plant protection	impact on soil, water & air	water users	decrease of pest pressure	neighboring farmers
	decrease in biodiversity	hunters, society		
fertilization	nutrient runoff into water	water users	conservation of soil fertility	society
	concentration of heavy metals	society		
	destruction of archeological objects	science, society		
	air pollution	forest owners, society		
	Reduction of biodiversity	hunters, society		
animal husbandry	air pollution	forest owners, society	landscape amenities	visitors, tourism industry
	odor nuisance	neighbors, visitors, tourism industry	animal welfare	consumers
	ethologically questionable animal husbandry	consumers		
drainage	reduction of biodiversity	society	change in scenery	visitors
	change in scenery	visitors	reduction of CH_4 emissions	society
	micro climate effects	inhabitants		
	Increase of water runoff	users of flood-prone land		
irrigation	use of a scarce commodity	water users	dilution of pollutants	water users
	nutrient and pesticide runoff into groundwater	water users	special land uses are still profitable	visitors, tourist industry
	soil degradation	society		
	noise	neighbors		
alpine pasture	overexploitation of fragile habitats	society	conservation of fragile habitats	society
	abandoning of alpine pasture	society, visitors, tourism industry	protection against natural disasters	vulnerable land users
	forest meadows	forest owner, society	conservation of recreational space	visitors, tourism industry
socio-cultural and economic impacts			innovations (technology and products)	agriculture, consumers
			maintenance of rural population	inhabitants
			country atmosphere	society

Maltais, Nilsson, & Persson (2002, p. 153f) propose the following selection criteria for indicators used in sustainable impact assessments:

- Direct link to potential sustainability impacts;
- Relevance in the long run;
- Clear definitions;
- Relevant for as many countries as possible;
- Based on existing data.

Since it is often impossible to study all externalities, one should concentrate on those which are considered to be significant (Ervin, 2000). Selecting only a small set of indicators is said to be more effective than including many (Maltais, Nilsson, & Persson, 2002). Markandya (2000, p. 102) calls for more "user-friendly" environmental indicators which integrate and trade-off the dimension of sustainability, namely the impacts on the society, the economy, the environment and its time-aspect of intergenerational equity. The remaining paragraphs will show why **the focus of this thesis will be solely on nitrate pollution**.

One particular environmental effect of agriculture has been of considerable concern globally as well as in Austria: water scarcity. Typically, there are two types of resource scarcity with regard to water: quantitative and qualitative. Irrigation can cause quantitative water scarcity by lowering groundwater levels. Due to the abundant water availability in Austria this is only a regional concern (e.g. in the Marchfeld; see section 4.2). A qualitative water scarcity refers to a state where water may be abundant but cannot be used due to contamination of pollutants (e.g. high levels of nitrate concentrations). Qualitative water scarcity will be of major interest for the case study.

Many researches (e.g. Cooper, Bernstein, Vasavada, & Bureau (2005) or Brouwer & van Berkum (1998)) state that agricultural production is one of the main causes of water pollution in industrialized countries. It is especially nitrogen and phosphorus which lead to eutrophication of ground and surface waters. Not surprisingly, Morrisey, te Velde, Gillson, & Wiggins (2005) state that estimating water and chemical input intensity are of highest importance for estimating the environmental effects of agricultural production. If trade liberalization leads to more intensive production, and thus more use of agro-chemicals, it may intensify environmental pressure. This may be the reason why most studies, including this one, are concerned about water pollution (Cooper, Bernstein, Vasavada, & Bureau, 2005).

What is generally assumed for most industrialized countries is also true for Austria. Agricultural production is seen as the main source of pesticide and nitrogen emissions into waters in Austria (Sinabell, 2004). Nitrogen leaching into groundwater aquifers contaminates drinking water and can lead to eutrophication. A report on groundwater quality in 2006 by the Austrian Environmental Agency (Umweltbundesamt, 2006) provides data on the development of average nitrate concentrations in Austria from 1992 to 2004. Figure 1 depicts this temporal development. The dotted line gives average concentration levels and the triangle line median values. No significant changes can be noticed until 1996. Then nitrate concentration levels began to steadily decline until 2000, most likely due to less usage of fertilizers (more efficient production techniques), the implementation of agri-environmental programs in 1995, the EU nitrate directive (Council Directive 91/676/EEC) and efforts to reduce nitrate emission from municipal sources (Sinabell, 2009, p. 64f) . The current development seems to be stagnant with some short-term fluctuations.

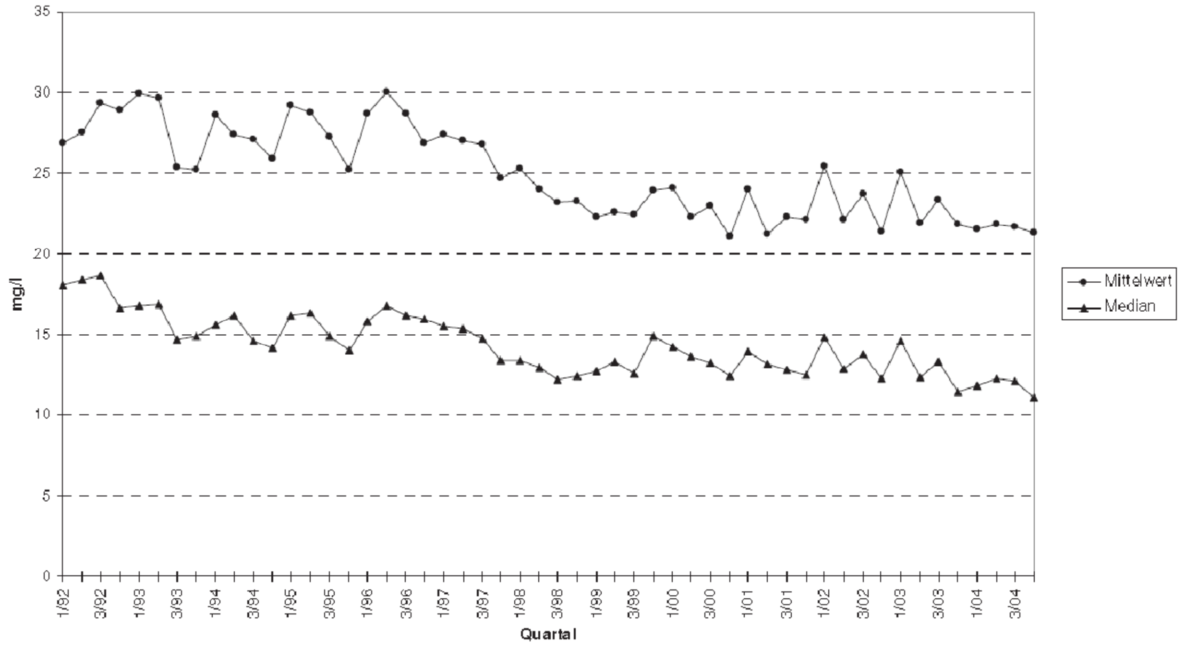

Figure 1. Temporal development of average and median nitrate concentration levels in Austria (Umweltbundesamt, 2006, p. 39)

In addition, there are substantial differences across municipalities in Austria and the critical threshold level for nitrate concentration (45 mg/l) is exceeded in some (Wick, Heumesser, & Schmid, 2010). On a disaggregated level, the temporal development may deviate from the general trend shown in Figure 1 (Umweltbundesamt, 2006).

The environmental externalities discussed above may be affected by the outcome of current trade agreements. Whalley (2004, p. 390f) provides a list of externalities that may play role in future negotiations:

1. Generalized existence value for agricultural-rural activities within countries (i.e. the multi-functionality of agriculture);
2. Generalized existence value across countries for country-specific resources (e.g. OECD-based non-governmental organizations concerned about deforestation in low-income countries);
3. Soil erosion;
4. The use of fertilizers and pesticides;
5. Open-access resources (e.g. higher exports from local fisheries may increase overexploitation);
6. Waste and degradation;
7. Allocation of water resources;
8. Global environmental considerations (e.g. greenhouse gas emissions);

As it will be been shown in the subsequent sections, trade liberalization changes the scale, composition and location of both environmentally harmful and environmentally friendly commodities at the same time (see section 3.1.2). Thus, the net outcome remains unclear (Whalley, 2004).

2.1.2 Trade distortions in the agriculture sector

At the international level, agricultural support policies which had led to production surpluses and depressed world prices remained largely unchallenged until WTO members started to implement the Uruguay Round Agreement on Agriculture (URAA). This important step created a rule-based agricultural trade regime with the objective of liberalizing global agricultural trade. The targets agreed in the Uruguay Round are shown in Table 3.

Table 3. Numerical targets of the URAA (http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm3_e.htm; retrieved at 2011-02-19)

	Developed countries 6 years: 1995-2000	Developing countries 10 years: 1995-2004
Tariffs		
average cut for all agricultural products	-36%	-24%
minimum cut per product	-15%	-10%
Domestic support		
total AMS[3] cuts for sector (base period: 1986-88)	-20%	-13%
Exports		
value of subsidies	-36%	-24%
subsidized quantities (base period: 1986-90)	-21%	-14%

But despite the URAA, "world agricultural trade is still highly distorted" (Maltais, Nilsson, & Persson, 2002, p. 30), especially among OECD countries. For example, the total nominal rate of assistance (NRA - an estimate for producer support used by the World Bank) was 13.6% in 2007 for the EU-25, 13% for the EU-15 and 14.3% for Austria (Anderson & Valenzuela, 2008).

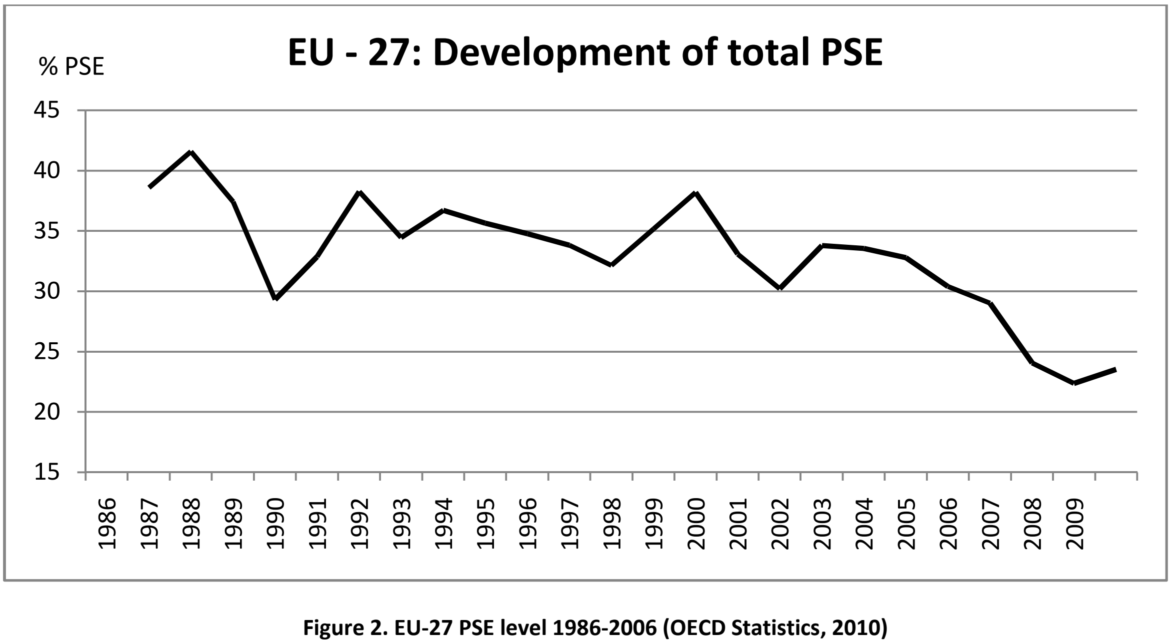

Figure 2. EU-27 PSE level 1986-2006 (OECD Statistics, 2010)

The development of producer support estimate[4] (PSE – used by the OECD) levels in the EU-27 can be seen in Figure 2. Total PSE has steadily declined from 38.6% in 1986 to 23.5% in 2009. The sharp

[3] AMS = Aggregate Measurement of Support; includes all product-specific support and non-product-specific support in one single figure; for more see http://www.wto.org/english/tratop_e/agric_e/ag_intro03_domestic_e.htm#box

drops in PSE in 1993, 2001 and then from 2004 onwards mark the adoption of the three large market oriented reforms of the Common Agricultural Policy (CAP), namely the MacSherry reform, the Agenda 2000 and the 2003 reform, respectively (see section 4.5.1 for more information). The most recent decline in PSE has not only resulted from concrete policy changes but, according to the OECD-FAO Agricultural Outlook (2010), has also been the result of the high agricultural commodity price peaks in the years 2007 and 2008.

It is important to note that the composition of total PSE in the EU has changed profoundly over the past decades (OECD Statistics, 2010). The share of support aimed directly at commodity output has been almost steadily declining since 1986 (it now makes up 25.3% of total PSE compared to 91.8% in 1986). Direct payments now account[5] for the biggest share of total PSE, namely 58.7% in 2009 (in 1986 their share was only 3%). The remaining share is comprised of support based on inputs (14.4% in 2009; 5% in 1986) and payments based on non-commodity criteria (1.7% in 2009; 0% in 1986).

Price support measures are declining but the EU still applies tariffs to some agricultural commodities. The simple average (both bound and most-favorite nation applied - MFN) tariff rate applied to all agricultural products in the EU-27 was 13.5%[6] in 2009 according to the WTO (2010b). 2010 tariff rates applied to individual crops included in the case study range from 9.6% for onions to 13.6% for carrots (for detailed information see section 7.4 in the appendix).

A new round of WTO negotiations started in November 2001, the Doha Development Agenda (DDA). So far, negotiations have been unsuccessful in reaching a new agreement. This time, even more than in the URAA, agriculture seems to be the issue of highest controversy among WTO members and one of the main reasons why no agreement has been reached (Fergusson, 2008). However, if an agreement were to be reached, one can expect substantial reductions in the three pillars of agricultural support (i.e. tariffs, export support and domestic support). According to Fergusson (2008), the EU may commit itself to a reduction of its agricultural support of up to 70%. However, the OECD-FAO agricultural outlook (2010) finds the outcome of the DDA to be unpredictable so far. Despite these drawbacks in WTO negotiations the move towards freer trade seems to continue (Fraser, 2006). The European Commission (2010b) seems to assume that agricultural trade is likely to be more liberalized in the future.

Since current trade distortions in agriculture are said to be profound (Laird, Peters, & Vanzetti, 2004) possible reduction commitments in the future are likely to lead to large shifts in agricultural production with many different environmental impacts across countries. It is usually assumed that WTO member will commit themselves to a 40% reduction of the three pillars of agricultural support. Morrisey, te Velde, Gillson, & Wiggins (2005) reviewed the results of such studies that analyzed the effects of possible DDA agreements. They conclude that most studies show that the gain in welfare from agricultural trade liberalization is very marginal, about 0.1-0.2% of World GDP. These gains, however, are not evenly distributed across countries. The effect on world prices for agricultural commodities will be moderate. It is assumed that world prices for wheat (and other cereals) will not

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[4] PSE is defined by the OECD as "an indicator of the annual monetary value of gross transfers from consumers and taxpayers to support agricultural producers, measured at farm gate level, arising from policy measures, regardless of their nature, objectives or impacts on farm production or income". (http://stats.oecd.org/glossary/detail.asp?ID=2150 retrieved at 2011-02-19)

[5] Direct payments comprise both coupled direct payments and single farm payments (SFP). If disaggregated, SFP make up 39.6% of total PSE and coupled direct payments 19.1% (OECD Statistics, 2010b).

[6] The simple average tariff for non-agricultural product in turn was only 4% in 2009.

increase more than 6%, those for beef and other meats will increase 2-4%, the increase for rice and vegetable will be below 2%, cotton world prices will increase by 10-20%, sugar only 4%.

Morrisey, te Velde, Gillson, & Wiggins (2005) explicitly point out that the changes in world prices are far less than the typical world price volatility (which ranges between 20-50%). This makes it extremely difficult to predict future world prices. Hence, producers may not even notice the changes in prices caused by trade liberalization. What they will notice is the changes in export opportunities or import competition.

Table 4. Bound and applied tariffs on agricultural products, 2001 (ad valorem equivalents in per cent) (Laird, Peters, & Vanzetti, 2004, p. 6)

		Bound	Applied
Agriculture	High-income countries	51	48
	Middle-income countries	57	20
	Low-income countries	79	17
Non-Agriculture	High-income countries	4	3
	Low & Middle-income countries	20	13

The effects of trade liberalization are said to be potentially larger in the agricultural sector than in the manufacturing sector (Ferrantino, 2000, p. 133). According to Maltais, Nilsson, & Persson (2002, p. 19). Some analysts estimate that tariffs in the agricultural sector are up to ten times higher. Figures based on a United Nations Committee on Trade and Development (UNCTAD) database are depicted in Table 4. The reason for these differences is that agricultural policies have been exempt from GATT disciplines in the past (Laird, Peters, & Vanzetti, 2004). According to Reed (2001, p. 86) "agriculture has always been viewed as a special case"[7]. This explains that agricultural issues remain to be the most disputed in current DDA negotiations (Bouët, Bureau, Decreux, & Jean, 2004). Further, agricultural trade barriers are higher in high-income countries such as the EU or the US than in middle- or low-income countries (Maltais, Nilsson, & Persson, 2002).

Ferrantino (2000) argues that on the one hand abatement costs in heavy polluting industries are very small (ca. 1% of total production costs) and that tariffs in the manufacturing sector have already been substantially reduced and remain only high in low-income countries. On the other hand, agricultural trade liberalization could lead to a large shift in production (due to trade distortions that are currently relatively high) thereby affecting the environment in numerous ways (e.g. deforestation in developing countries or soil erosion).

Schmid, Sinabell and Hofreither (2007, p. 596) show that subsidies play a special role in agriculture because:

- the volume of subsidies to this sector is significant (OECD countries make up 30% of all subsidies being paid globally);

[7] Sensitive issues such as national food sufficiency and rural development certainly made agriculture a 'special case'. To a certain extend the concept of rent seeking may have also played an important role. While the potential benefits of freer trade will be distributed among many people the potential costs will be felt by relatively few farmers. Since the incentive to free ride is larger the more people are in a group farmers will have it relatively easy to gather together and lobby against disciplines that may hurt their income (Baye, 2003). According to Hofreither (2007) this may explain, inter alia, the CAP's bias towards the supply side.

- support measures are applied to attain quite heterogeneous and sometimes conflicting objectives, which may result in highly complex and frequently inconsistent and contradictory incentives (e.g., production premiums and extensification programs at the same time);
- the influence of interest groups, among them farmers, is substantial, and
- agricultural production usually takes place in a natural environment and, therefore, spillovers are hard to prevent.

The last point makes it clear that (trade distorting) production subsidies are likely to have environmental effects. The OECD classifies production subsidies as environmentally harmful (Schmid, Sinabell, & Hofreither, 2007). Therefore, it seems interesting to analyze the environmental effect of a move towards freer trade or, put differently, to a more market based approach.

Section 2.1 has thus shown that the agricultural trade policies, to the extent that they influence patterns of agricultural production, can have an important effect on the environment. Agricultural trade today is still distorted to a large extend, especially in relative terms if compared to trade distortions in the manufacturing sector. Why it makes sense to address these environmental effects at a local level will be addressed in the following section.

2.2 Reasons for assessing local environmental impacts

Global assessments have the advantage that many linkages are included. This reduces the risk of omitting linkages that would have been left out in a regional analysis but are of significant importance. Hence economic assessments are often better at a macro/global level (Ervin, 2000). In some cases, it is most appropriate to make a global assessment, if one wants to study the effects of trade policies on climate change for example (Ervin, 2000). Use of aggregate data and models is also the most logical choice if policy issues at the regional and national are to be addressed (Antle, Lekakis, & Zanias, 1998).

But conducting global assessments comes at the cost of losing important information for regional or local impacts and often the “geographic level is too aggregative to assess environmental effects” (Ervin, 2000, p. 122). Large heterogeneous characteristics between regions and the site-specific environmental effects of agriculture make it difficult to infer local or regional effects from aggregate results (Maltais, Nilsson, & Persson, 2002; Antle, Lekakis, & Zanias, 1998). Early assessments of the environmental impacts of agricultural trade have already found that a central theme in most studies is that “the environmental impacts of agriculture are location specific and highly variable over the landscape” (Antle, Lekakis, & Zanias, 1998, p. 1). Brouwer & van Berkum (1998) conclude similarly when analyzing the environmental effects of the CAP. Special focus should be given to potential ‘hot-spot’ regions (Maltais, Nilsson, & Persson, 2002). The environmental impacts will also vary by product (Morrisey, te Velde, Gillson, & Wiggins, 2005). In addition, environmental assessments usually work better the more local and the more homogenous a region is (Ervin, 2000).

Perrin (2000) as well as Maltais, Nilsson, & Persson (2002) point out that a macroeconomic overview needs additional understanding of micro-level impacts, since even if the overall effect is positive severe damage may occur at local levels. Thus there is often a “need for more than one type of analysis” (Markandya, 2000, p. 103). Macro-level studies are thus only able to “provide a framework for discussion” (Maltais, Nilsson, & Persson, 2002, p. 152). So far, little is known about the effects of trade liberalization at the farm level (Fraser, 2006). Consequently, there is a strong call in the literature to complement already available aggregate studies with site-specific local field studies (see also section 3.3).

It has been demonstrated that agriculture provides a good example for studying trade-environment linkages: First, agriculture produces many externalities (negative as well as positive ones) and second, trade distortions are still persistently high in agriculture, especially in OECD countries. Conducting a local environmental assessment is sensible because there is a strong call for location specific case studies in the literature (as will also be shown in section 3.3). This can be explained by the fact that environmental effects of agriculture are very site-specific and that regional characteristics are very heterogeneous. It is thus not possible to infer any potential impacts on local regions from aggregate studies.

The next section will now give a thorough introduction to the trade-environment issue from an environmental economics perspective. The theoretical and empirical findings of section 3 will further support the arguments elaborated above.

3 The trade-environment issue

The environmental effects of international trade have been of concern since the 1970s (Copeland & Taylor, 2004; WTO, 2004) when many high-income countries started to adopt more stringent environmental regulations. At the beginning, researchers were mainly focusing on industrial pollution (Jayadevappa & Chhatre, 2000) or on normative issues, such as gains from trade or optimal environmental policies (Copeland & Taylor, 2004). These issues have also led to the United Nations Stockholm Conference on Development and Environment in 1972 (WTO, 2004). Trans-boundary environmental issues and the concept of sustainability gained importance in the 1980s. Hence, the trade and environment debate was extended to a debate on trade and sustainability in the 1980s (Antle & Capalbo, 1998), especially once the 'Brundtland report' came out in 1987 (WTO, 2004). At the Earth Summit in 1992 the participating nations agreed to ensure that trade and environment are mutually supportive. A similar, more recent, statement can also be found in the Cartagena Protocol on Biosafety (Secretariat of the Convention on Biological Diversity, 2000). Since the 1990s, researches became interested in how environmental regulations may affect trade patterns or the competitiveness of countries (Jayadevappa & Chhatre, 2000). Currently, testing and creating hypotheses concerned with the effects of trade on the environment are the focus of most studies (Copeland & Taylor, 2004).

The link between environmental concerns and international trade was addressed in the original text of the General Agreement on Tariffs and Trade (GATT) in 1947 (GATT, 1986)[8]. Still, environmental issues were not a major concern during the Uruguay Round negotiations in the late 1980s and early 1990s (Whalley, 2004). One important effect was the creation of the 'green box'[9]

[8] Environmental issues were addressed Article XX which deals with general exemptions. This article allows restricting trade *inter alia* if it is "necessary to protect human, animal or plant life or health" or if it is "relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption" (GATT, 1986, p. 37).

[9] Policies listed in the green box are exempted from reduction measures in the Uruguay Round commitments (e.g. costs of general services, public stockholding, decoupled income support, crop insurance, income safety nets, and conservation programs). Support measures which would normally have to be reduced can be listed in the blue box if they require farmers to limit production and are thus also exempt. All other trade distorting support measures, which are target for the reduction commitments, are listed in the amber box (Reed, 2001).

(WTO, 2004). The impact of environmental discussions was more significant for the North American Free Trade Agreement (NAFTA)[10] (Jayadevappa & Chhatre, 2000) which triggered an enormous interest in trade and environment issues in the 1990s (Fousekis, 1998). The rise of sustainability issues, increasing concerns about trade and environment and especially the discussion on the relationship between multilateral environmental agreements (MEAs) and the GATT have led to the creation of the Committee on Trade and Environment (CTE) in 1994 (WTO, 2004). The CTE's broad objective is to enhance the understanding of trade and environment relationships and to promote sustainable development.

Environmental issues continue to be of concern in the current negotiations of the WTO, the Doha Development Agenda (DDA). For example, paragraph 33 of the Doha Declaration in 2001 encourages member countries to carry out environmental reviews of trade agreements (WTO, 2004). Paragraphs 30-33 of the latest Ministerial Declaration signed by WTO members at the sixth Ministerial Conference in Hong Kong in 2005 provide evidence that the issue will continue to be of concern in future negotiation rounds (WTO, 2005). The CTE plays an important role in the trade and environment negotiations of the Doha Development Agenda (DDA) (WTO, 2010a). Together with the Committee on Trade and Development it should act as a forum for trade-environment debates (WTO, 2004). Whalley (2004) identifies three concerns that are likely to emerge during these negotiations:

1. Multifunctionality concerns;
2. Links between agricultural export subsidies and the environment;
3. The inclusion of credits for tariff cuts that improve environmental quality and penalties for those that deteriorate the environment;

Increasing concerns about the environment (globally, nationally and locally) show that conducting further assessments on the environmental effects of trade liberalization is inevitable (Copeland & Taylor, 2004).

The subsequent section will now establish a theoretical basis for a better understanding of trade-environment linkages.

3.1 Deriving trade-environment linkages from economic theory

The aim of this section is to construct a **theoretical basis for understanding trade-environment linkages**. These linkages will be derived by applying the concept of externalities from environmental economics to standard international trade theory. Externalities accrue when one agent imposes costs or benefits to another agent, but the latter is either not being reimbursed for bearing these costs or does not pay for receiving these benefits. Most commonly, trade policies which liberalize trade are analyzed. This approach will also be applied in this section.

First, the effects of freer trade on individual countries' production and environment will be derived using a simple partial-equilibrium analysis. This is the typical approach used in environmental economics to address the trade-environment issue theoretically. Second, the environmental effects

[10] Environmental concerns raised during the NAFTA negotiations have lead to the creation of the Commission on Environmental Cooperation (CEC). The CEC's objectives are to address regional environmental concerns, help prevent potential trade and environmental conflicts, and to promote the effective enforcement of environmental law (CEC Secretariat, 2010).

of trade policies will be decomposed into their different compounds. Finally, other more policy oriented theories about trade-environment linkages, which have been left out in the preceding sections will be presented.

3.1.1 Individual countries liberalizing trade

Partial-equilibrium modeling is often used to evaluate policy decisions because they are "particularly useful for studying the consequences of terms-of-trade effects, and for indicating how such factors as […] the type of the externality problem, affect the normative properties of environmental policy actions" (Krutilla, 1999, p. 404). This modeling approach is different from the land use optimization model which will be used for the case study. Still, it is important to know how the trade and environment linkages are generally being addressed and what implications might follow from such an analysis for the case study.

Thus a very simple partial-equilibrium, comparative-static analysis, will now be applied to show how trade can affect a country's welfare when there is a negative production externality. Most of the analysis is based on Anderson (1992), Krutilla (1999) and Reed (2001).

Such an analysis, of course, requires making some necessary assumptions, such as (Anderson, 1992, p. 26; Krutilla, 1999, p. 404):

- The 'rest of the world' does not respond strategically when a country initiates environmental regulation or trade-policy reform;
- The production of just one good creates an externality on others by influencing the environment;
- Property rights are not defined clearly enough or/and high transaction costs prevent the full internalization of externalities;
- There are no administrative or by-product distortionary costs of collecting taxes or disbursing subsidies and the income distributional effects of such transfer policies can be neglected;
- Producers, consumers and policy makers are well-informed and can value the externality;
- The production activity itself and not a particular production process creates the externality. Hence a tax on production is equivalent to a tax on the source of the externality;
- There are no distortionary policies affecting other markets in the economy;
- Changes in tastes and technological changes are not considered, nor is international factor mobility.

Further, the usual neo-classical assumptions, such as perfect information, zero transaction costs[11], the existence of perfectly competitive markets and rational decision-making as maximizing individual utility (*homo economicus*) are also applied.

On a macro level one can look at the issue from two perspectives. One can either focus on the environmental effects of just a single individual country or one focuses at all countries together, thus

[11] Transaction costs are costs associated with carrying out (environmental) policies. They comprise of the following costs (Perman, Ma, McGilvray, & Common, 2003, p. 261): acquiring relevant information; creating, monitoring and enforcing contracts; establishing, implementing and revising the instruments it employs; monitoring performance, and ensuring compliance.

taking into account the aggregate environmental effects of trade liberalization (Perman, Ma, McGilvray, & Common, 2003).

A distinction can be made between small economies, where international prices are given, and large economies which are able to influence international prices. Since our case study takes place in Austria this analysis will focus on the small country case scenario only. Such an assumption is reasonable since the Austria agricultural sector only plays a minor role within the EU-25 (Sinabell & Schmid, 2004).

A small country in autarchy which opens its markets can either become an importer or an exporter of a good whose production creates a negative externality such as, for example, nitrate concentrations in groundwater. Those two cases will now be discussed.

3.1.1.1 The case of a small importing country

Figure 3 illustrates the case for a small importing country. The S and D curves are the marginal costs of producing and the marginal private benefits of consuming, respectively. S' represents the marginal social costs of production (thus it takes into account the negative externality caused by production).

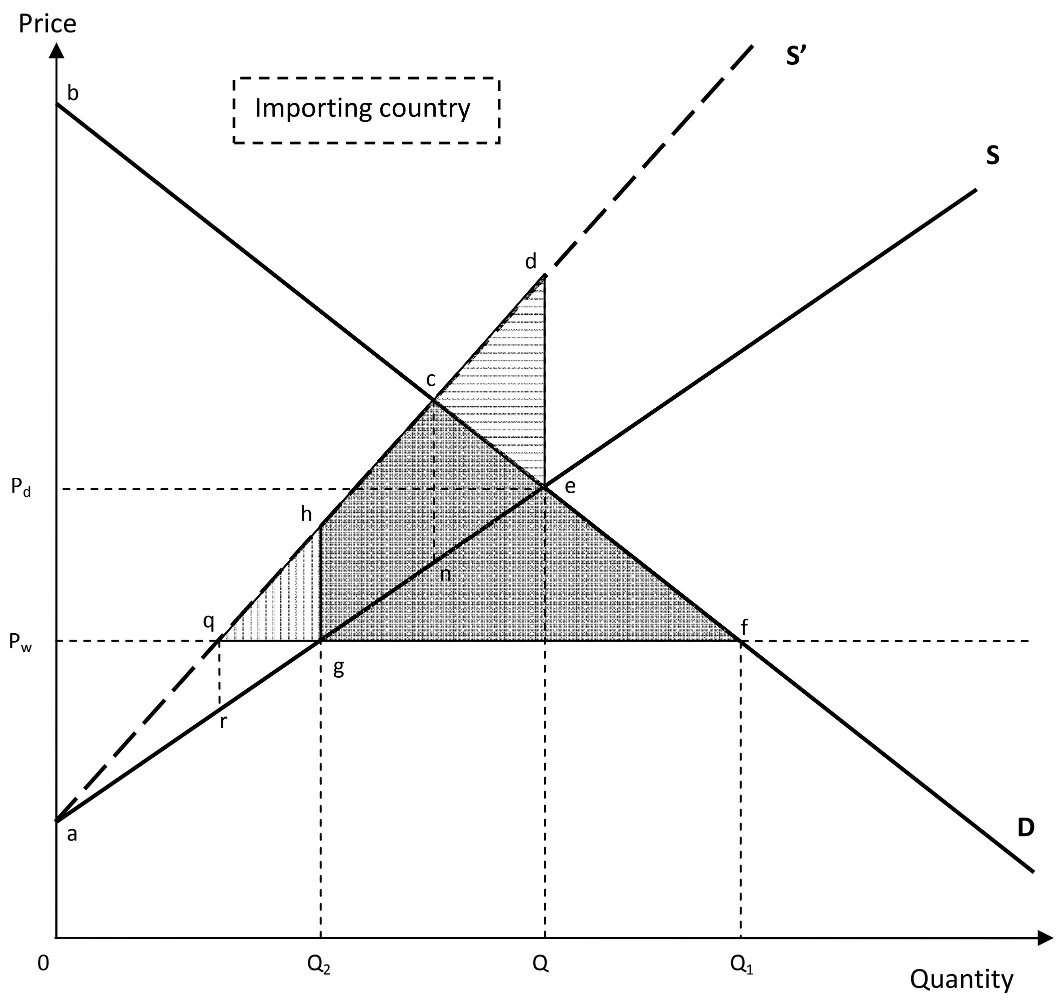

Figure 3. Effects of trade liberalization on the environment in a small importing country (after Anderson (1992, p. 28) and Reed (2001, p. 145))

In autarchy and without any environmental policies in place, the equilibrium price and quantity can be found where supply (= marginal costs of producing) equals private demand (= marginal private benefits of consuming) which is P_d and Q, respectively. In this case total welfare is producer surplus plus consumer surplus (= abe) minus pollution (= ade).

Now assume that the country is opening its market. How does it change social welfare when the externality is not internalized through environmental policies? The price of the good will change from P_d to P_w. Since P_w is lower than P_d the small country now imports a quantity of $\overline{Q_2 Q_1}$. Consumption increases to Q_1 and domestic supply is reduced to Q_2. The net gain from trade liberalization in a small country without environmental policies is $defgh$ (= the grey shaded area plus the vertically striped triangle). It comprises of the gain in consumer surplus (efg) and the losses of pollution due to decreased production ($degh$).

An optimal environmental tax[12] could guarantee that the production of the good takes into account its social cost (which is polluting the environment). In autarchy the optimal tax is cn[13] which enhances social welfare by dec (= the vertically striped triangle). If trade is liberalized the optimal environmental tax changes to qr and this will gain additional social welfare by the area hgq (= the horizontally striped triangle). The total welfare gain through trade liberalization for an importing small country is thus cfq (= the grey shaded plus the horizontally striped triangle) if the environmental tax has already been implemented before liberalizing trade.

It has therefore been shown that, under the given assumptions, an importing small country will always increase its social welfare when opening its economy to international trade.

3.1.1.2 The case of a small exporting country

As one might suspect the outcome of trade liberalization for a small exporting country will be more ambiguous since it will increase production of a good that creates negative environmental externalities.

Figure 4 illustrates the case of a small exporting country. If this country starts participating in the world market it will face a new price for the product, namely P_w. How does welfare change?

If the social costs are not being taking into account prior to the trade opening consumption decreases from Q to Q_3 while production increase from Q to Q_1. A quantity of $\overline{Q_3 Q_1}$ will be exported. The net outcome in terms of welfare will be ambiguous since one has to compare the gains in producer surplus (= ike or the areas with grey shade, vertical stripes and dots) to the increase in pollution due to increased production (=$mked$ or the vertically striped area plus the dotted area). Trade will only be welfare enhancing if producer surplus is greater than the increase of social costs due to pollution.

Economically efficient pollution control could guarantee that the cost of pollution abatement is less than the gain of producers. Again, a pollution tax equal to S' minus S is the most efficient pollution control instrument. Consumption will stay the same, but production will now accrue at the social optimal level of Q_2. A trade liberalization after such a tax has been implemented would lead to an unambiguous gain in welfare of the area ijc (= the vertically striped area) which is the increase in

[12] An environmental policy is economically efficient if it achieves a given target at least cost (Perman, Ma, McGilvray, & Common, 2003).

[13] In fact, an economically efficient tax would always be the difference between S‘ and S.

producer surplus. The smaller the difference between S' and S the more likely will it be that trade is welfare enhancing.

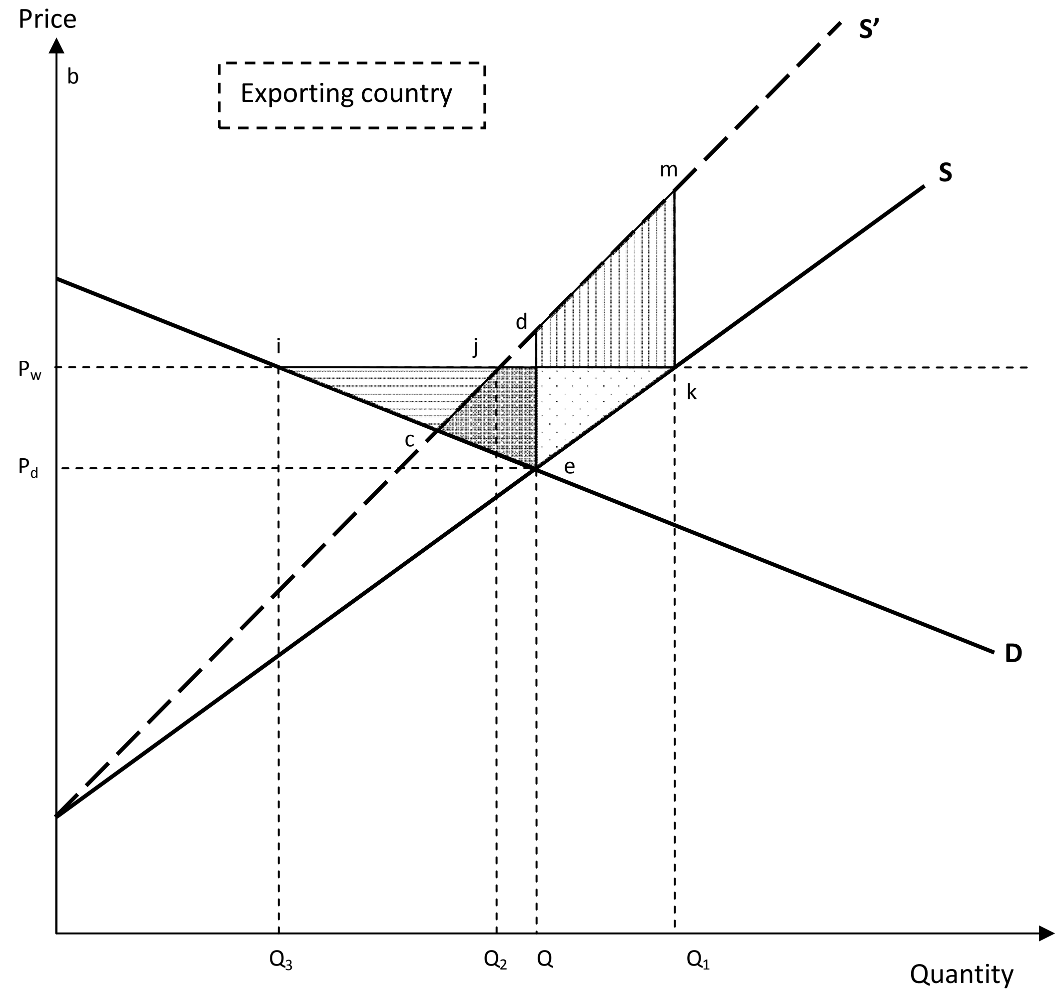

Figure 4. Effects of trade liberalization on the environment in a small exporting country (after Anderson (1992, p. 28) and Reed (2001, p. 146))

The two simple analyses above have shown that there is a linkage between trade and the environment when trade affects production that is linked to a negative environmental externality.

Given the assumptions, it was concluded that:

- An importing country will always enhance social welfare through participating in international trade, whether it has economically efficient environmental policies implemented or not. It will reduce domestic production and hence, if this production creates environmental externalities, it also reduces environmental externalities.
- Although an exporting country will clearly gain if it has adopted optimal environmental taxes the outcome becomes ambiguous if an environmental policy is not in place. It then depends on whether the increase in the net gain of produces is higher than the increase in negative environmental externalities.

The same analysis can be applied to where consumption creates an externality (e.g. cigarette smoke). The above conclusion are then just reversed (Krutilla, 1999).

Further, Siebert (1992) has found similar results in a general equilibrium analysis. His analysis showed that a small country with insufficient environmental regulations will specialize in pollution-intensive products thus decreasing environmental quality.

Fousekis (1998) applied a comparative static analysis of a two-country, one-commodity, two-factor agricultural trade model. His model results suggest that pollution will increase in exporting countries and decrease in importing countries while the net outcome remains ambiguous. The net environmental effect will depend on the following factors: relative size of each trading partners, product demand elasticities, input supply elasticities and the characteristic of the production process in each country. The most flexible trading partner in terms of production can be expected to determine the outcome of net environmental effects.

3.1.1.3 Policy response

From an economic point of view, one has to analyze to which extent trade policies may affect externalities associated with agricultural production (Whalley, 2004). The most advocated approach among economists in dealing with externalities is to implement a Pigouvian tax[14] which ideally corrects for this market failure. Another way to internalize externalities is to enforce secure property rights ('Coase theorem'). In an ideal situation (that is, for example, zero transaction costs and zero information costs) agents can then internalize the externality through bargaining.

The question has been raised whether trade measures may be an adequate way to deal with environmental externalities (Whalley, 2004). The underlying theme of this question is that if trade openness causes an increase in negative (environmental) externalities could this justify trade restrictions? According to Whalley (2004) the best solution would be to first enforce secure property rights and then to implement an environmental tax. Many economists share the view that the lack of adequate environmental policies is the root cause of potential welfare losses through free trade and not free trade itself (Krutilla, 1999; WTO, 2004). Free trade just enhances already existing externalities.

Such an argument assumes that it is generally possible to implement efficient and effective environmental policies. Specifically, it means that transaction costs need to be low enough (i.e. the benefits of implementing a policy need to be higher than its transaction costs) and that enough information is available to both consumers and producers to value the externality accurately. These conditions may not necessarily hold in reality. It is therefore not surprising when Perman, Ma, McGilvray, & Common (2003, p. 341) state that 'the world is one in which distortions are pervasive, environmental pollution problems are rarely if ever fully internalised, and it is almost impossible to design fully efficient pollution control programmes'.

If it is thus not possible to come up with an economically efficient[15] environmental policy, the 'case for free trade' is undermined (Perman, Ma, McGilvray, & Common, 2003). The argument for free trade is further weakened if one includes trans-boundary or international pollution issues (Jayadevappa & Chhatre, 2000). This changes the issue to the following question: Are trade measures

[14] The purpose of a Pigouvian tax is to internalize a negative externality by closing the gap between private and social costs of production (or private and social benefits of consumption). See also the application of an optimal environmental tax in section 3.1.1.1.

[15] It should to be noted that more criteria than just economic efficiency can applied to environmental control programs, such as equity, dynamic effects or dependability (see Perman, Ma, McGilvray, & Common (2003, p. 203)).

justified as ‘second-best’ policy instruments if no other policies are implemented in order to internalize externalities?

There are different views on how to approach such a case. On the one hand, some argue that under such conditions trade restriction measures as a ‘second-best policy’ option may be justified (Krutilla, 1999) and that they may lead to improved resource allocation (Jayadevappa & Chhatre, 2000). Borregaard & Bradley (2000) believe it may be better to postpone trade liberalization in sectors where the environment may be severely affected. Barbier and Rauscher (1994) show that nations which import timber may use trade restrictions as a ‘second-best policy’ to encourage conservation of forests in the exporting nations[16]. Nevertheless, they also find that, under certain conditions, trade measures may even be counterproductive. They conclude that more simple, less trade distorting measures should be used if they are available. Copeland & Taylor (2004) argue that it is very difficult to achieve environmental targets by using trade policies because of the complicated general equilibrium effects of trade liberalization.

On the other hand, free trade proponents may argue that in many cases trade barriers can lead to relatively poor environmental outcomes when compared to a free trade scenario[17] (Copeland & Taylor, 2004). The root cause of environmental degradation is often seen in the absence of adequate domestic environmental policies (Strutt & Anderson, 2000). Therefore, trade itself is not to blame. Eglin (1995, p. 777), former Director of the Trade and Environment Division of the GATT Secretariat, warns that it would be a “tragic mistake” to draw the conclusion that trade restrictions can be an appropriate tool to address environmental issues. He does not dispute that freer trade may increase environmental pressure in the presence of weak environmental policies, but believes that a more appropriate response would then be to actually implement better domestic environmental policies. However, low-income countries may lack the institutional capacity to deal optimally with accompanying problems of trade liberalization.

Chichilnisky (1994) addressed the issue of weak institutional capacity in low-income countries. According to her findings, weak institutions may hinder the ability of low-income countries to secure property rights and to internalize externalities which in turn will lead to under-pricing and overproduction of natural resources. This effect is made even worse when a country with weak property rights starts trading with one that has well defined ones. The North-South trade is assumed to represent this pattern. Strong proponents of free trade, such as Bhagwati (1996; in Cooper (2005, p. 3))[18] argue instead that this is not a good reason for protectionism but instead calls for improving the efficiency of markets.

From what has been elaborated above it can be seen that trade restrictions are at best only seen as ‘second-best’ policy options. Still, it might be interesting to compare the environmental (and welfare) outcomes of trade distorting policies to those policies which liberalize trade. Carefully constructed case studies may indicate whether trade barriers may lead to an improvement of environmental

[16] For example, if the timber exporting country is import dependent, a tariff on timber will deteriorate the terms of trade and will thus reduce the long-run equilibrium forest stock (Barbier & Rauscher, 1994).
[17] e.g. it may create perverse incentives by reducing the value of natural resources thus leading to more extraction and environmental problems.
[18] Unfortunately, I was not able to access this study. The full reference is: Bhagwati, Jagdish. (1996) “Diversity of Environmental Standards” in J. Bhagwati and R. Hudec (eds). Fair Trade and Harmonization: Prerequisites for Free Trade? MIT Press: Cambridge, Massachusetts and American Society of International Law: Washington, DC.

indicators. If that is the case it has to be further investigated if they are in fact the most efficient and effective policy option available.

One has to carefully interpret the conclusions made in the preceding section with regard to the, sometimes strong, assumptions outlined at the beginning. Nevertheless, three important implications can already be drawn:

1. the presence of externalities (positive or negative) creates a linkage between trade and the environment if trade affects production that is linked to an externality;
2. it is the absence of adequate (or perfect) environmental policies that provides the economic justification for the empirical assessment of the environmental effects of trade policies (Martin, 2000; Strutt & Anderson, 2000);
3. welfare effects can be ambiguous if trade increases production that creates negative environmental externalities.

3.1.2 Decomposing the environmental effects of trade liberalization

Trade liberalization can be expected to change global production patterns significantly (Abler & Shortle, 1998). The environmental effects caused by these changes in production patterns will come in manifold ways and are generally decomposed into three basic categories (Antweiler, Copeland, & Taylor, 2001; Perman, Ma, McGilvray, & Common, 2003; CEC Secretariat, 2000; Huda, 2000; Ervin, 2000; Strutt & Anderson, 2000; Cooper, 2005):

i) Scale effect (negative)

This effect explains the scalar change in economic growth induced by trade liberalization. Put differently, it refers to the increase in economic activity (and thus pollution) caused by freer trade.

ii) Technique effect (may be positive or negative)

There are many ways through which trade liberalization may alter production methods:

a) It may improve economies of scale (Abler & Shortle, 1998);
b) It may spread 'green' technologies across the globe (Cooper, 2005; Abler & Shortle, 1998)
c) The change in relative output prices may give an incentive to change production techniques (Cooper, 2005) or it changes the technological path by affecting research and development decisions (Abler & Shortle, 1998). In order to induce the right incentives it is necessary that the environmental effects are being internalized (Ervin, 2000);
d) The changes in relative output prices can also create the Stolper-Samuelsen effect on factor prices[19] (Abler & Shortle, 1998). This can also lead to changes production technologies.

With increased incomes due to higher economic activity, production techniques are expected to become more efficient and less polluting because consumers are expected to demand more 'environmentally friendly' products. This is seen as a necessary but insufficient condition for improving environmental quality (Ervin, 2000, p. 120). In some studies, this effect is distinguished from the technological effect and called the *'political effect'* (Maltais, Nilsson, & Persson, 2002) or *'policy effect'* (Abler & Shortle, 1998; Ervin, 2000).

[19] The Stolper-Samuelsen theorem says that "an increase in the price of a good will cause an increase in the price of the factor used intensively in that industry and a decrease in the price of the other factor" (Suranovic, 2006).

iii) Composition/Mix effect (may be positive or negative)

This effect relates to the assumption that trade liberalization may change the economic structure of an economy. Resources will be devoted to products with a comparative advantage. This may change the mix of commodities and thus may favor products with different environmental impacts.

It is important to note that the partial-equilibrium analysis in the previous section, for reasons of simplicity, only considered one good. No attention was drawn to what happens if a shift in production occurs (i.e. the composition effect). The importing country may specialize in the production of a different good (which it could export) that also produces a (perhaps different) externality. This has implications when we look at the regional/local scale. For example, if Austria becomes an importer of corn (due to trade liberalization), production of corn in the Marchfeld will be reduced. Some other production activity may replace this reduction. Whatever farmers do to compensate for the reduction in corn production one has to analyze if the new production activity is more or less polluting for the environment (e.g. if it will decrease or increase nitrate concentrations in groundwater). This is an important implication for the Marchfeld case study.

Abler and Shortle (1998) as well as Ervin (2000) add one more important category (with special regard to agricultural trade liberalization):

- **Externality effects (may be positive or negative)**

These effects refer to the feedback effects on production and/or consumption of environmental externalities caused by trade liberalization. Externality effects are seen as “the heart of any analysis” (Ervin, 2000, p. 128) and can be either positive or negative and need to be included in full social benefit and cost accounting. Changes in fertilizer and pesticide use and landscape are most commonly used. Unfortunately, the majority of studies do not include all externalities due to missing data.

The CEC (Commission for Environmental Cooperation) Secretariat[20] (2000) also includes *spatial effects*[21] (e.g. how freer trade may affect peripheral or transitional regions) and *resource allocation effects* (e.g. freer trade may create disincentives to use marginal agricultural land).

Morrisey, te Velde, Gillson, & Wiggins (2005, p. 19f) further identify *product effects*, which refer to impacts related to the flow of products (or services) between countries (e.g. transportation). Due to trade liberalization increased transportation activity is likely to occur with increased agricultural production and trade (Cooper, Johansson, & Peters, 2005). Given the current transportation technologies this will potentially harm the environment.

Finally, it is the sum of all effects which gives the total environmental effect. The effects themselves can of course be off-setting or reinforcing (Ervin, 2000; Maltais, Nilsson, & Persson, 2002; Abler & Shortle, 1998). The net outcome is thus ambiguous and needs to be empirically determined. Ervin (2000) argues that studies which take not into account technological effects are thought to overestimate the environmental and economic effects of trade liberalization. Abler and Shortle (1998, p. 68) go as far as saying that “technology, in particular, is the ‘wild card’ that has the potential to dominate all other effects”.

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[20] see also footnote 10 on page 20.

[21] But analyzing such effects is said to be “complex and uncertain” (CEC Secretariat, 2000, p. 32).

This latter argument can be depicted in the concept of the environmental Kuznets curve (EKC). The EKC assumes that environmental degradation increases at the beginning of economic growth but starts to decrease when a certain threshold level (T* in Figure 5) has been reached. This can be depicted as an inverse-U-relationship, as shown in Figure 5. Positive technique effects (e.g. more environmentally friendly technology and stricter environmental regulations) are expected to offset negative scale (and/or perhaps composition) effects. This threshold level will of course vary depending on the type of environmental pollution.

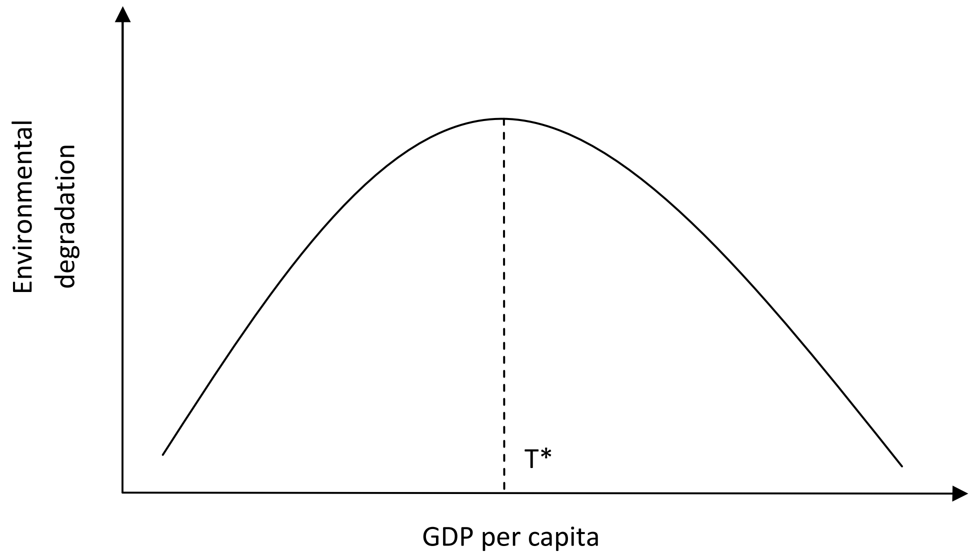

Figure 5. The environmental Kuznets curve (based on Cooper (Cooper, 2005, p. 5)

There is evidence for the EKC for some air pollutants (especially SO_2), but the estimated figures often range widely, for example from \$5000 per capita to far over \$8000 per capita for SO_2 emissions (Jayadevappa & Chhatre, 2000). Many concerns have been raised about the theory, methodology and empirical evidence of the EKC. Currently, it is not clear if this concept also applies to agriculture, according to Cooper (2005, p. 6). Further, other factors than economic growth such as policies, technology, market structure, literacy, political rights and civil liberties are said to influence environmental patterns. Linking environmental quality only to income levels is thus seen to be an insufficient approach (Copeland & Taylor, 2004). Drawing their conclusion on an in-depth literature review Jayadevappa & Chhatre (2000, p. 182) state that "the EKC relation offers no information about the actual chemistry of the interactions between development and environment that is crucial for policy measures".

As it will be shown in section 3.3 the net environmental outcomes of trade liberalization are ambiguous and current empirical findings do not allow for a generalization. Not surprisingly, how trade might affect the environment becomes thus "largely an empirical question" (Maltais, Nilsson, & Persson, 2002, p. 16).

3.1.3 Other trade-environment linkages

Many other trade-environment-hypotheses have been proposed in the literature such as (Perman, Ma, McGilvray, & Common, 2003; Antweiler, Copeland, & Taylor, 2001; Vaughan, 2000):

- the pollution haven hypothesis;
- the factor endowment hypothesis;
- race to the bottom;
- regulatory chill;
- accelerated transfer of environmentally sound technologies and;
- positive effects of foreign direct investment (FDI) on environmental quality.

These hypotheses are not being addressed in the case study. Nevertheless, since they have significantly shaped the discussion on the trade-environment issue the most noteworthy ones will be briefly addressed in order to provide a holistic overview of the topic. For more in-depth studies see recent discussion papers such as Jayadevappa & Chhatre (2000); Eckersley (2004); Eglin (2001); McCormick (2006); Yu, Sutherland, & Clark (2002) or Oberthür & Gehring (2006).

The 'pollution haven hypothesis' claims that heavily polluting production will move from countries with high environmental standards to countries that have weak environmental protection. It is assumed that higher-income countries generally have higher environmental standards. Low-income countries in turn have lower environmental standards. If production costs for heavily polluting commodities are lower when environmental standards are poor, low-income countries are thus assumed to become a haven for polluting industries (Perman, Ma, McGilvray, & Common, 2003; Cooper, 2005). In addition, Copeland & Taylor (2004) distinguish the pollution haven hypothesis from the 'pollution haven effect'. The latter hypothesis says that more stringent environmental regulation will, at the margin, affect location decisions of industries and trade patterns. Copeland & Taylor (2004) argue that there is more theoretical support for the latter hypothesis: Given that international plant location decisions are much more dependent on other factors than environmental costs, it can be the case that a pollution haven effect exists, while at the same time no evidence is found for the pollution haven hypothesis.

The 'race to the bottom' hypothesis is similar and assumes that trade liberalization will give countries an incentive to lower their environmental standards in order to attract industries. This may lead to a global decrease in environmental standards (which is not the case in the 'pollution haven' hypothesis). Despite its rational appeal there is hardly any empirical evidence for the 'race to the bottom' hypothesis (Cooper, 2005; Jayadevappa & Chhatre, 2000; Eglin, 1995). Markandya (2000, p. 109) concludes that "in several cases the adoption of stricter standards not only decreased environmental damage, it also increased firms' efficiency and profits". It has been shown that trade has not been significantly influenced by tighter environmental regulation (Jayadevappa & Chhatre, 2000). It is also argued that in turn environmental regulations do not significantly influence location decisions of multi-national corporations (Markandya, 2000). A reason for such findings is that abatement costs often only constitute a small fraction of total production costs. A further increase of these costs due to environmental regulation leads therefore only to a marginal cost increase for producers (Jayadevappa & Chhatre, 2000). This argument also speaks against the 'pollution haven' hypothesis.

Another linkage is assumed in 'the factor endowment hypothesis'. Traditional trade theory assumes that factor abundance determines comparative advantage. If one now assumes that heavily polluting production is capital-intensive such production will move to countries where capital is abundant. On the contrary, less polluting labor-intensive production will move to countries where labor is abundant. This would mean that, in contrast to the 'pollution haven hypothesis', polluting industries will stay in high-income countries where capital is abundant (Perman, Ma, McGilvray, & Common, 2003).

Refering to recent empirical studies Perman, Ma, McGilvray & Common (2003, p. 341) conclude "that trade seems to reflect factor endowments, not differing emissions abatement costs". Antweiler, Copeland & Taylor (2001, p. 896) also find that „factor endowment motives are offsetting tighter pollution policy in relatively rich countries". But although the pollution haven hypothesis is said to be insignificant in its effect (Aggarwal, 2006; Antweiler, Copeland, & Taylor, 2001; Copeland & Taylor, 2004) it could be expected that further tightening of environmental regulations will increase the incentive to move to low-standard countries. With regard to the pollution haven effect Copeland & Taylor (2004) find that many recent studies do find empirical evidence for this distinct hypothesis.

With regard to environmental regulations Anderson & Blackhurst (1992, p. 5) identify the two issues of concern:

1. Environmental policies of one set of countries can impact on other countries through international trade.
2. Many people feel that trade policies are a way to force countries into discussions about environmental issues and agree to environmental aspects of trade agreements.

This reveals that the trade and environment issue is also one about policy integration. It is about the conflict of finding a mutual agreement on pursuing environmental and economic goals at the same time, internationally and domestically (Perman, Ma, McGilvray, & Common, 2003). One can find manifold discussions among the scientific community on the relationship between the World Trade Organization (WTO) and Multilateral Environmental Agreements (MEAs) with highly divergent opinions and conclusions. On the one hand, for example, the WTO is blamed for diminishing the capacities of MEAs to deal efficiently with environmental problems and for strongly influencing the outcomes of new MEAs negotiations. Eckersley claims (2004) that this has led to a 'regulatory chill' which has limited the scope and application of measures included in MEAs. On the other hand, proponents of free trade such as Eglin (2001) believe that the current WTO rules allow for enough environmental regulation and that the WTO should stick to its main objective, namely enhancing free trade. It is quite unlikely that the, sometimes heated, discussion will cease in the future.

A theoretical basis for understanding trade-environment linkages has been established. The following section will extend the debate to the important concept of sustainbility.

3.2 Trade and sustainability

Given the high importance of sustainability in our society today (see for example European Commission (2010a; 2010b)) it seems reasonable to now address trade and sustainability in a separate section.

The World Commission on Environment and Development (WCED, 1987, p. 54) defines 'sustainable development' as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". If trade policies are to be analyzed from a sustainable development point of view, one has to look at how the three dimensions of sustainability are being affected at the same time. More precisely, it is not only the environmental effects, such as soil erosion, nitrogen leaching into groundwater, or the preservation of cultural landscapes that are of concern. One has to view these effects also in a societal and economic perspective and include factors such as ‘rural livelihood’ and economic welfare effects. Being an exploratory study and due to the lack of data on social indicators the extent of the case study will be limited to the economic and environmental dimension.

To ensure sustainable development all three dimensions need to develop in a way which ensures that the needs of current and future generations are being met. In operative terms, this could mean, for example, that land needs to be managed without degrading the environment (thus ensuring that it can be used by future generations), that the welfare of a region is non-decreasing or that rural society enjoys a peaceful and secure life. Optimal land use/management is assumed to be one of the key issues for the sustainable development of agriculture (Sinabell, 1995). That the current agricultural activities are assumed to be unsustainable has already been addressed in section 2.

A more precise formulation of this concept with regard to agriculture is the term sustainable land management which evolved after the United Nations Conference on Environment and Development in 1992 and can be defined as “a system of technologies and/or planning that aims to integrate ecological with socio-economic and political principles in the management of land for agricultural and other purposes to achieve intra- and intergenerational equity” (Hurni, 2000, p. 85). It is characterized by (Hurni, 2000, p. 85f):

- A multi-actor perspective and multi-level stakeholder approach to include farmers as well as administrators or scientists;
- A participatory approach where the various views and dimensions of sustainability have to be weighed against each other in a non-discriminatory way among all stakeholders;
- A land use management that conforms to the five major pillars of sustainability: (1) ecologically protective; (2) socially acceptable; (3) economically productive; (4) economically viable; (5) effective in reducing risk;
- Transdisciplinarity, which is a scientific approach that combines the internal (indigenous) and external (scientific) knowledge systems.

It is within this concept that sustainability impact assessments (SIAs) of trade policies are being conducted, especially by the EC and the World Wide Fund for Nature (WWF).

It is argued that “there is an inherent danger in implementing wide-ranging trade agreements without first assessing the likely social and environmental consequences that may arise from them” (Perrin, 2000, p. 68). Therefore such assessments, of course, are in need of a holistic approach in which social, development and ecological issues are fully incorporated into the assessment. If one is concerned about the agricultural sector an SIA should include, for example (Perrin, 2000, p. 68):

- potential effects of increased and freer trade on land use (land management, land use policies and practices);
- food (food security, national food-self-reliance, production surplus);
- the environment (ecological processes, biodiversity maintenance, forest and freshwater resources) and;
- rural communities (rural wages and income, traditional knowledge, etc.).

One of the objectives of the SIAs conducted by the WWF is to identify either ‘trigger’ (e.g. inflow of cheap food imports) or ‘magnifier’ (e.g. expansion of production and consumption) effects of trade liberalization.

An important distinction made by the WWF is one between process-focused (institutional mechanisms) and substance-focused (quantitative, sectoral) methodologies (Perrin, 2000). While the first ones are more concerned about finding the appropriate policy response the latter try to determine the environmental effects. Clearly, the approach taken in the case study here is ‘substance-focused’. Nevertheless, in a holistic assessment both may be needed (Markandya, 2000) but this demands a lot of available resources.

The EC has been conducting several SIAs of proposed trade agreements in the DDA since 1999. Their objectives are to (European Commission, 2010a): (1) analyze the issues covered by a trade negotiation from a sustainable development perspective; (2) inform negotiators of the possible social, environmental and economic consequences of a trade agreement; (3) and to provide guidelines for the design of possible flanking (complementary) measures.

The EC states that “trade liberalization is not an end in itself; rather, it is an essential element of sustainable development. It is necessary to measure the non-trade impact of trade liberalization as well as its economic impact” (Plijter, 2000, p. 83). Similarly, Ervin (2000, p. 124) believes that trade liberalization is a necessary but insufficient step to sustainable development. In order to promote sustainable development producers and consumers need to take into account the full social costs of their decisions (Borregaard & Bradley, 2000).

The theoretical basis for these SIAs is the same as the one outlined in section 3.1.2. To get a more precise picture of the complex interactions through which trade may affect sustainable development, Maltais, Nilsson, & Persson (2002) developed a Conceptual Framework for Sustainability Impact Assessments of Trade Negotiations in the Agricultural Sector. This framework is depicted in Figure 6. While it is recognized that no generalization can be made on the relationship between trade and environment this framework should nevertheless “enhance our understanding of the generic cause-effect relationships” (Maltais, Nilsson, & Persson, 2002, p. 18). It is possible to adapt their framework to the agricultural sector in any region of the world. The establishment of baseline sustainability conditions is a key prerequisite for any analysis (e.g. agrochemical use per ha as an environmental indicator).

Figure 6 shows that, at the beginning, trade reforms (1) will affect the economic structure through reduction of trade barriers.

These economic impacts are likely to change relative prices or terms of trade (2; see Figure 6). How the economic structure will change exactly can be analyzed by applying partial or general equilibrium models (see 7.1). The results of such models will rely on a country’s economic characteristics, its domestic policies, resource allocations, trade balance and of course on the underlying assumptions of the model. Countries with high trade barriers will face lower domestic prices, whereas world market prices are expected to generally increase (Morrisey, te Velde, Gillson, & Wiggins, 2005). Maltais, Nilsson, & Persson (2002) note that low-income countries that are food net-importers may suffer from deteriorating terms of trade since world food prices are expected to increase with further trade liberalization.

The changes of the economic structure may lead to changes in agricultural production (3; see Figure 6), such as scale and structure of agricultural activities, production techniques or crop mixes (see also section 3.1.2). Production is expected to shift from high-income countries to low-income countries due to the reduction of high trade barriers in the former (Maltais, Nilsson, & Persson, 2002). Farmers are predicted to respond differently to given price changes. Whereas large-scale commercial farmers may be able to adapt to these changes, small-scale poorer farmers may need assistance to adjust to short-term shocks (Morrisey, te Velde, Gillson, & Wiggins, 2005).

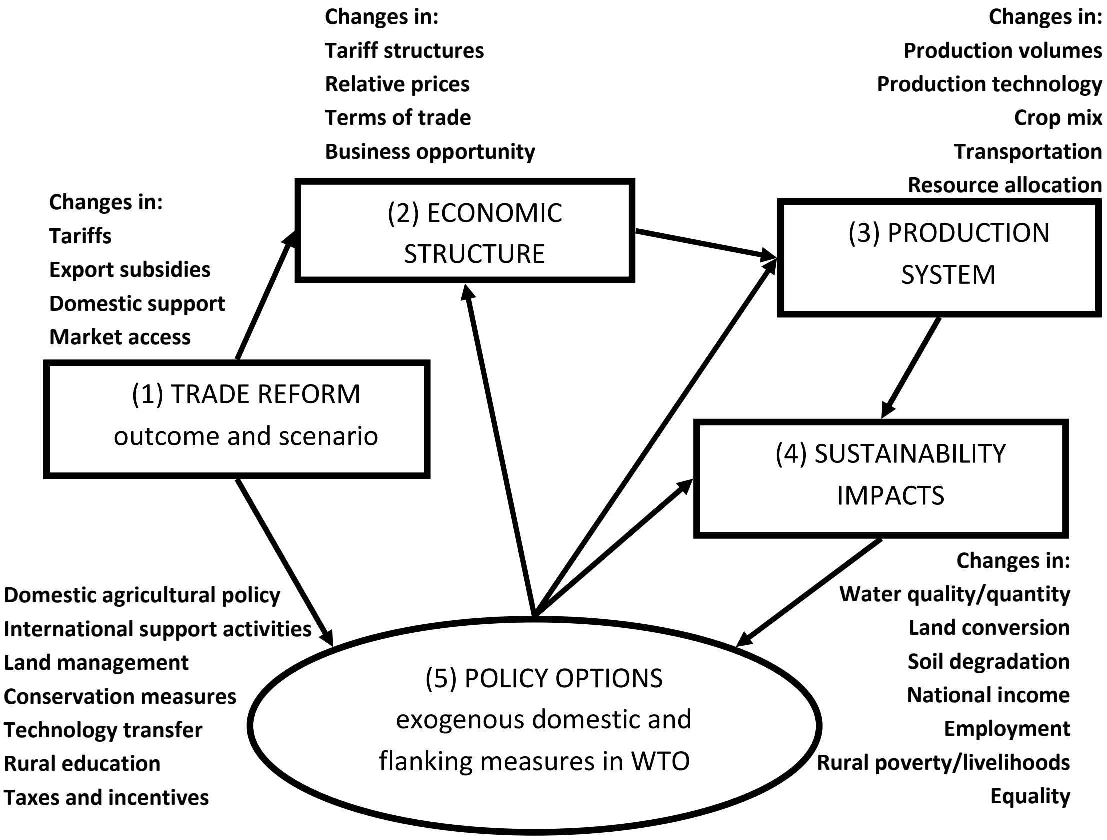

Figure 6. Conceptual Framework for Sustainable Impact Assessment of Trade Negotiations in the Agricultural Sector (adopted from Maltais, Nilsson, & Persson (2002, p. 18)

Changes in the production system will have an impact on sustainability indicators (4; see Figure 6) such as land and agrochemical use, impacts on poverty and welfare. Maltais, Nilsson, & Persson (2002) address three key sustainability issues with regard to agriculture.

With regard to the environment, land and agrochemical use are of high concern (Maltais, Nilsson, & Persson, 2002). Due to the shift of agricultural production from high-income to low-income countries the environmental impacts will differ in those countries. The production decrease in high-income countries may decrease environmental pressure but it may also lead to a deterioration of cultural landscape or semi-natural habitats (especially if former agricultural land is abandoned). Because agricultural production is less intensive in low-income countries the production increases are expected to only have modest environmental effects (in terms of agrochemical use). However, this may change in the long term when production becomes more modernized. But, when agricultural production is extensive an increase in production will lead to an expansion of land. Thus, trade liberalization may lead to increased rates of deforestation in low-income countries (Ferrantino, 2000) which is likely to cause loss of biodiversity, greenhouse gas emissions and soil erosion (Morrisey, te Velde, Gillson, & Wiggins, 2005). The overall environmental effect is expected to be negative in low income countries. Increased production and transport are responsible for this effect. In addition, many regions which are likely to face increased production already suffer from substantial environmental stress. This may partially be offset by better environmental/natural resource management (Morrisey, te Velde, Gillson, & Wiggins, 2005).

With regard to society, poverty is a key issue (Maltais, Nilsson, & Persson, 2002). Trade is generally assumed to decrease poverty, but regional differences can be substantial. How trade will affect the poor will depend on how it will change the prices of the goods that poor household spend most of their budget on. Moving to freer trade by reducing subsidies or tariffs may expose farmers to high price volatility (Hoekman, Ng, & Olarreaga, 2004). Adjusting to short term fluctuations is usually very costly for poor people or small farmers.

The most important issue with regard to the economic dimension is the effect of trade on welfare (Maltais, Nilsson, & Persson, 2002). Three types of global gains are expected from such trade liberalization policy reforms (Morrisey, te Velde, Gillson, & Wiggins, 2005, p. 9):

1. Exporters benefit from enhanced market access, perhaps increased prices;
2. Consumer benefit from access to an increased variety of, often cheaper, goods;
3. Increased efficiency in the allocation of resources for production in agriculture (globally and domestically).

It is acknowledged that these gains, as well as the adjustment costs are not evenly distributed globally and within countries. Thus equity/distributional issues are of concern (Maltais, Nilsson, & Persson, 2002). The elimination of export support measures is generally regarded as beneficial, but the loss in tax revenue may lead to adverse impacts, especially in low-income countries (Morrisey, te Velde, Gillson, & Wiggins, 2005). By contrast, high-income countries, such as Austria, are expected to have good institutional capacities to implement safeguard measures (Morrisey, te Velde, Gillson, & Wiggins, 2005)

The social and environmental effects will depend on three basic factors (Morrisey, te Velde, Gillson, & Wiggins, 2005, p. 20):

1. the nature of the economic changes induced by trade liberalization;
2. the social and environmental baseline conditions;
3. policies, regulations and institutions in place to safeguard any negative effects.

Therefore policies (5; see Figure 6) need to ensure that the overall-goal of sustainable development can be achieved. It is suggested that general economic development and policies have a far more significant impact on sustainable development (Maltais, Nilsson, & Persson, 2002). But the need for flanking measures to cope with the potentially high adjustment costs has been widely recognized. Of course, new trade agreements will affect domestic policies, and some countries can use the WTO exceptions noted in the green box and blue box in order to ensure a smooth adjustment. Maltais, Nilsson, & Persson (2002, p. 24) propose some additional policies that might be used:

- integrated land and resource management and conservation measures, and water management;
- sustainable agriculture technologies, such as integrated pest management;
- institutional capacity building, such as legal provisions to maintain rights;
- training to farmers, officials' higher education, research, extension, and dissemination of resource-conservation techniques.

Section 3.3 is now going to shed some light on empirical findings of trade-environment and trade-sustainability linkages.

3.3 Review of empirical studies

Having explained the theory of trade-environment linkage, attention will now be drawn to empirical findings. I will start by presenting common arguments found in the literature with regard to the environmental effects of trade liberalization. Of course, the actual environmental effects of trade policies will lie in-between those sometimes extreme positions and will be quite diverse (Ervin, 2000). Especially in the short-run a distribution of pollution levels across countries can be expected (Fousekis, 1998).

Advocates of freer agricultural trade usually put forward the argument that increased income induced by trade liberalization will improve environmental regulations and hence environmental quality (for example see the discussion on the Environmental Kuznets curve in section 3.1.2). They usually point out the positive effects of improved efficiency that are assumed to come along with trade liberalization, for example (WTO, 2004, p. 23): more efficient factor-use and consumption patterns through enhanced competition; poverty reduction through trade expansion and encouragement of a sustainable rate of natural resource exploitation; an increase in the availability of environment-related goods and services through market liberalization; and better conditions for international cooperation through a continuing process of multilateral negotiations.

Moreover the expected shift of agricultural production from high-income to low-income countries is said to offer "win-win-win" situations (WTO, 2004, p. 23)[22]. Removal of trade barriers in high-income countries is said to reduce environmental stress in high-income countries while stimulating growth in low-income countries due to new export opportunities. Higher returns from agriculture will generate more income for the rural poor thereby mitigating poverty, a presumably major cause of environmental degradation (WTO, 2004). It is also assumed that less agro-chemicals are used for production in low-income countries (Reed, 2001). In addition, the positive effect of increased economic wealth could induce a higher demand for environmentally friendly commodities (Fousekis, 1998) and it could pay for stricter environmental standards in low-income countries (Eglin, 1995). This is said to significantly decrease the use of fertilizers and thus would be beneficial for the environment. Hence, trade liberalization could potentially be a win situation for almost everyone.

The most apparent argument of critics of freer trade is that increased production will consequently increase the already high pressure on the environment (Antle, Lekakis, & Zanias, 1998). This scale effect may lead to a further deterioration of environmental quality. A second, very popular argument is that low-income countries are said to be at a high risk of experiencing environmental deterioration through freer trade (Røpke, 1994; Chichilnisky, 1994). It is especially the lack of institutional capacity in low-income countries which will make it difficult, if not impossible for some, to mitigate negative side effects of trade liberalization (Aggarwal, 2006). Without proper policies due to a lack of institutional capacity market signs may lead to the degradation of marginal lands which have high ecological value. A third argument has been often put forward by European countries, namely the loss of 'multifunctionality' attributes due to trade liberalization in the EU (WTO, 2004). Trade liberalization is expected to decrease agricultural production in the EU. Since agricultural production

[22] The potential "win-win-win" outcomes are (WTO, 2004, p. 22): (1) Benefits for the multilateral trading system; (2) Benefits for the environment; and (3) Benefits for development and social equity.

is assumed to generate many positive externalities in Europe (e.g. maintaining cultural landscape or semi-natural habitats) these benefits are said to decline with trade liberalization if they are not internalized.

This section will now provide some empirical findings on (i) general trade-environment issues and (ii) environmental impacts of agricultural trade liberalization. Because of its importance, the last part is further divided into two parts: (A) macro-level studies which assess sector wide aggregate environmental and sustainability effects; and (B) those (few) studies that tried to empirically assess the environmental impacts of agricultural trade liberalization on a more regional or even local level. A brief explanation on modeling approaches is given in section 7.1 in the appendix.

3.3.1 General trade-environment studies

In an empirical study on SO_2 concentrations, Antweiler, Copeland & Taylor (2001) find that, on an aggregate level, technique effects outweigh the increase in pollution for SO_2 concentrations in the air due to scale effects and that composition effects remain small in magnitude. They estimate that an increase in output and income by 1 percent due to freer trade will lead to a reduction of 1 percent in SO_2 concentrations.

Strutt and Anderson (2000) conducted a GTAP (Global Trade Analysis Project)[23] application (version 3) to assess the environmental effects of trade liberalization in Indonesia. To assess the environmental impacts an environmental input-output data set was included in the model. Units of economic activities were augmented by environmental coefficients (thus, a linear relationship between economic activity and environmental impact was assumed). Their key findings are that (i) the emission of air-pollutants (CO_2, SO_X, and N) only increases marginally (less than 4%), (ii) water withdrawal is reduced (due to a reduction in paddy rice output), and (iii) effect on water pollution depends on the level of liberalization (the higher the better). They conclude that their findings call for better domestic environmental policies in order to minimize the negative environmental impacts of trade liberalization.

Jayadevappa & Chhatre (2000) have conducted the only comprehensive review of studies analyzing trade and environmental quality issues to date. They show that "most of the empirical studies find conflicting evidence regarding effects of trade on environment" (ibid., p.180). Although they provide the reader with a vast list of empirical studies, they only included one study concerned with agriculture trade. This study, from the year 1993, concluded that innappropriate policy measures such as subsidies, taxes and agricultural trade barriers cause environmental degradation in the agricultural sector.

Jayadevappa & Chhatre (2000, p. 188f) do find some consenus views in their literature review:

1. Many studies emphasis the positive effects of trade liberalization on welfare and the environment;
2. Trade is seen as an important factor contributing to development, whereas inadequate environmental policies are seen as the cause of environmental problems;

[23] GTAP is a modeling framework established in 1992. It aims to help researches in conducting global trade analyses using general equilibrium models (Sullivan & Ingram, 2005). For further information see https://www.gtap.agecon.purdue.edu/default.asp

3. Appropriate environmental policy responses in an increasingly globalized world are difficult and need to take into account the existence of imperfect competition.
4. Currently, GATT rejects concern for competiveness as a basis for environmental trade measures;
5. Policy coordination between high-income and low-income countries is needed in order to minimze the negatvie environmental effects of trade (challenges differ: low-income countries want to minimze environmental degradation, whereas high-income countries want to reduce it).

The next sections will now narrow the focus to the agricultural sector.

3.3.2 Environmental impacts of agricultural trade policies

Within the large literature on trade-environment issues not many focus solely on agriculture[24] (Cooper, Johansson, & Peters, 2005), and only a few researchers have focused on the effects that trade policies may have on the use of renewable resources in rural areas (Barbier & Bulte, 2004). This section will be divided into two parts. The first presents macro level studies while the second draws attention to the few notable exceptions that also deal with the local or regional impacts of trade liberalization.

3.3.2.1 Macro level

Beghin, Dessus, Roland-Holst, & van der Mensbrugghe (1997) investigate trade and environment linkages for Mexico by applying a trade and environment equilibrium model (TEQUILA). They assess both the linkages at the aggregate and commodity levels and include vectors for pollution emissions (e.g. SO_2 and NO_2). According to their results, unilateral trade liberalization in Mexico would decrease aggregate agricultural output and pollution. But there are increases in environmental pollution for some commodities (e.g. rice, horticulture, coffee, etc.). If trade liberalization is accompanied by environmental policy reforms the environmental pollution of nearly all commodities declines (expect toxic chemicals for coffee and poultry). It is concluded that free trade offers a 'win-win' solution for the agricultural sector: joint efficiency and less pollution are achieved at the same time. A more cautious conclusion can be found in Nadal (1999). He argues that corn producer may switch to modern production technologies that will increase water and agro-chemical use. In addition a loss of genetic diversity may be expected due to a shift to corn hybrids.

Williams & Shumway (2000) estimate the effects of NAFTA on chemical input use in an agricultural sector model for the US and Mexico. Their results show that NAFTA will induce an overall increase in agro-chemical usage in the US. In Mexico, fertilizer input will increase significantly but pesticide use will decrease. Income increases for both nations. These findings contradict the findings above. It further undermines common hypotheses such as the notion of the environmental Kuznets curve (as explained in section 3.1.2) and that the elimination of producer subsidies would lead to less chemical input use. They argue that developed countries have a better capacity for chemical use. Hence, sectors that will expand in developed countries will increase their chemical input more than those that will expand in less developed countries (this would explain the decrease in fertilizer use in Mexico).

Cooper, Johansson, & Peters (2005) analyzed the environmental effects of agricultural trade liberalization for the US. Their analysis comprised three components: a trade equilibrium model to estimate the changes in world agricultural production; a spatial equilibrium model to estimate

[24] The only topic less researched in the trade and environment issue is the energy sector (Jayadevappa & Chhatre, 2000)

changes in US agricultural production technologies and a spatial environmental simulation model to finally estimate the environmental impact in the US. Environmental indicators that have been included in their modeling efforts are: nitrogen, phosphorus and pesticide loss to water; sheet, rill, and wind-related soil erosion; and manure nutrient production (Cooper, Johansson, & Peters, 2005, p. 54).

In their models, a fully liberalized agriculture world market (they also eliminated any fixed payments, direct or indirect ones) will only lead to marginal increases in aggregate US agricultural production. The aggregate environmental impacts in the US are also estimated to be small. Impacts in some regions may be more significant, such as increased pesticide use in the Northern Plains due to a likely increase in cropping. The costs of increased aggregate environmental degradation are estimated to be more than $16 million, which amounts to only 1% of the total income gains of agricultural trade liberalization. Such estimated figures need to be looked at cautiously since it still remains a difficult challenge to value nature resources ‘correctly’[25].

Sullivan & Ingram (2005) made a global assessment of the environmental effects of agricultural trade liberalization. They used a computable general equilibrium model, named Future Agricultural Resources Model (FARM), which is based on GTAP. Two major findings are derived from their results. First, the environmental effects will be greatest in Europe due to high subsidies. Second, removal of subsidies will lead to a shift of some crop and livestock production to less developed countries. Further, their findings show that trade liberalization affects the environment in both positive and negative ways globally. The effects depend on the intensity of land use and the characteristic of the different land classes used in the model.

Würtenberger, Koellner, & Binder (2006) take an interesting approach in assessing environmental as well as socio-economic impacts of trade agreements. They develop a method that uses the concept of virtual land, which is defined as “those productive areas hidden in imported or exported agricultural goods” (ibid., p.681). For assessing the impacts they combine a material flow analysis with a multi-criteria assessment of these impacts, namely MAUT (multi attribute utility theory). Their case study on wheat production in Switzerland shows that the increase in socio-economic utility is 4% as against a decrease of 11% in environmental utility[26]. When giving each criterion equal weight a total aggregation of these results “suggest to keep wheat production in Switzerland” (Würtenberger et al., 2006, p.689).

Van Meijl, van Rheenen, Tabeau, & Eickhout (2006) analyzed the effect of different trade policy scenarios on land use in the EU until the year 2030. They linked a macro-economic GTAP model with the biophysical-base modeling framework Integrated Model to Assess the Global Environment

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[25] Cooper, Johansson, & Peters (2005) recognize: that the study had an incomplete set of environmental indicators (e.g. they did not include greenhouse gas emissions or pollutants connected with fuel usage); that it did not include all agricultural products (e.g. sugar, fruit or vegetables); that environmental amenities were left out; and that no attention was given to the increase of transportation and its environmental implications.

[26] The gain in socio-economic utility is the result of an increase in rural-urban justice and real farm income, but is also influenced by a decrease in international justice. The loss in environmental utility is the result of an increase in soil degradation and a loss of biodiversity. This is somewhat compensated by an increase in nutrient balance. (Würtenberger et al., 2006, p.689)

(IMAGE) to account for the heterogeneity of land and to take into account the changes in productivity caused by land use and climate change. They distinguish four different policy scenarios:

1. Global Economy (A1): full liberalization and low regulation;
2. Global Co-operation (B1): full liberalization and high regulation;
3. Continental Market (A2): focus is on markets, but national/regional interests prevail;
4. Regional Communities (B2): trade policies remain unchanged (except export subsidies), regional/national interests are important;

Their results show that agricultural trade liberalization causes only a small negative impact on land use in the EU (under all scenarios except a very marginal increase in A2. This increase is caused by high economic growth and the persistence of protectionist measures). Two factors are assumed to be responsible for keeping the effect small. First, the loss in competitiveness will not necessarily lead to land abandonment but to extensification. Second, the decoupling of domestic support under current agricultural policy reforms already has less production effects than earlier forms of subsidies (e.g. price support, input subsidies). In their analysis changes *will not turn out to be "spectacular"* in the future (van Meijl, van Rheenen, Tabeau, & Eickhout, 2006, p. 35). The environmental effects of the estimated land use changes are said to "remain largely uncertain" (ibid., p. 21).

Maltais, Nilsson, & Persson (2002) conducted a pilot sectoral sustainability impact assessment (SIA) of WTO negotiations on wheat and edible oil crops for the European Commission (EC). Their baseline scenario assumes full implementation of the Uruguay Round Agreement on Agriculture (URAA). This scenario is compared to an intermediate scenario where a gradual move towards freer trade takes place and to a full liberalization scenario where all trade distortions are removed. While the EU exports wheat (12% share in the world market) it largely imports most of its oilseed demand (80%).

In the liberalization scenario world prices are expected to rise substantially. Together with the removal of trade barriers and reductions in direct payments the EU will experience a significant change in agricultural trade. Production will decrease and specialization increase. The expected negative trade balance should be offset by large efficiency gains and moderate real income gains. Budgetary expenditure will be significantly lowered. Overall, the effects on sustainability issues are found to be insignificant. The aggregate decrease in production is assumed to have a positively moderate effect on environmental stress. But, one needs to recognize that decreased agricultural production may also decrease the positive multifunctionality attributes of agriculture, thereby negatively affecting sustainability. These effects will be very heterogeneous across regions. It thus not surprising when Maltais, Nilsson, & Persson (2002, p. 145) state that "site-specific studies are required".

In the intermediate scenario prices will change similarly to the liberalization scenario, but direct payments (those included in the green and blue box) are still in place. Together with reductions in border tariffs and export subsidies this will lead to some production increases. In this scenario more opportunities are given to mitigate potential adverse effects of trade liberalization.

Maltais, Nilsson, & Persson (2002, p. 145) conclude that "the weight of evidence does *not* [original emphasis] suggest that production changes from trade liberalization and expansion will cause broad sustainability impacts in developed countries".

Morrisey, te Velde, Gillson, & Wiggins (2005) conducted a SIA of proposed WTO negotiations for the agricultural sector. Their study is an overall qualitative assessment with focus on products that are most likely affected by current negotiations (i.e. wheat, rice, beef, cotton, sugar and green vegetables). They are only concerned about impacts that are a direct effect of trade liberalization.

The baseline scenarios represents status quo, i.e. how trade would continue without any new WTO negotiations. This scenario is compared to a partial liberalization scenario, which recognizes that countries are not going to fully liberalize trade. This partial liberalization scenario represents "the strongest probable implementation of the negotiations agreed at the Doha Ministerial Conference" (Morrisey, te Velde, Gillson, & Wiggins, 2005, p. 12) and comprises the 'three pillars of liberalization':

- **Tariff reductions** – Developed countries: 36% reduction applied to all products; developing countries: 24% reduction applied to all products (maximum tariff 40%); no requirements for less developed countries (LDC);
- **Reduction of export support** – Developed countries: elimination of all forms of export support; developing countries: reduction by 50%; no commitments by LDC;
- **Reform of trade-related domestic support** – Developed countries: 60% reduction of trade-distorting policies; developing countries: 40% reduction; no reductions for LDC;

To study the effects of trade liberalization, Morrisey, te Velde, Gillson, & Wiggins (2005) apply a causal chain analysis to study the impacts in the long term. First, the short-run first order (adjustment) effects need to be identified. This initial 'shock' is referred to as the price change induced by trade policy reforms. This effect might be especially significant for countries with relatively high protection (such as the EU, and therefore Austria), since it will probably change their domestic prices. Countries with minimal trade barriers would only be affected if world prices changed. Then, the next step is to identify the cause-effect linkages between this scenario and its impact on sustainability.

Table 5. Percent change in production due to trade liberalization (Morrisey, te Velde, Gillson, & Wiggins, 2005, p. 55)

	Netherlands	France	Germany	Rest of EU15	CEEC new member states
Cereals	-19	-10	-12	-12	2
Horticulture	-1	4	4	4	2
Sugar	0	0	0	0	-4
Intensive livestock	1	2	-1	1	1
Cattle	-2	-8	-5	-8	0
Dairy	0	0	0	0	3
Other agriculture	0	2	0	0	6
Processed foods	8	3	-3	-1	1

In the EU, the reduction of trade barriers ('the three pillars') will lead to a decrease in domestic prices, more trade (exports will increase by 10%) and all member countries will gain economically due to the reduction in support (but only in the order of 0.1% of GDP). Consumer will benefit from lower domestic prices. Trade within the EU is expected to decline. Freer trade will on the one hand increase export opportunities for EU producer, but on the other hand they will face stiffer competition from increased imports. The net result (if production decreases or increases) will of course vary significantly in each member country and is shown in Table 5. Unfortunately, the data is too aggregate to provide individual estimates for Austria (which is part of the 'Rest of EU15' group).

Current reforms of the CAP in the EU are expected to have positive distributional effects since a shift from less support to more direct payments shifts the cost bearing from consumers to tax payer thus benefiting poor people. However, a decrease in production may negatively affect rural livelihood due to unemployment.

No large environmental effects are expected due to the small economic impact of agricultural trade liberalization in the EU. They argue that the most likely effect will be a more extensive farming system with less use of agro-chemical inputs. But, Morrisey, te Velde, Gillson, & Wiggins (2005, p. 56) note that effects may occur at the farm level and that "diverse impacts are expected in different areas". Their conclusions support the application of studies on a more regional or local level.

The next section reviews empirical findings of micro level studies.

3.3.2.2 Micro level

One of the first studies that tried to link trade policies with land use decisions has been conducted by López (1997). His study had two goals. First, to see if environmental resources (i.e. biomass) are an important factor in agricultural production in Western Ghana and second if trade policies affect agricultural income while accounting for environmental effects. He assumed that "environmental and conventional effects of trade policies may have conflicting impacts on national income" (López, 1997, p. 19). Land in western Ghana is mostly owned by communities (villages) and the predominant form of agricultural production is shifting cultivation. Ideally, communal controls should guarantee that each individual does not overexploit the common resource pool. But empirical analyses showed that biomass is an important factor of agricultural production and that the tradeoff between cultivated land and fallow land is not optimal (i.e. too much land is cultivated).

Following this conclusions, a land cultivation model was adapted to a situation where externalities are only partially internalized by each community farmer. Important explanatory variables include wages, farmers' capital, family size, village fallow area and a dummy variable for taking into account ethnic background. The model results indicate that decreasing wages or increasing prices increase the fraction of cultivated land. This will be followed by a loss in biomass and finally a loss in agricultural productivity[27] (López, 1997).

Finally, López (1997) analyzed the effects of trade liberalization with a two-sector general equilibrium model. The theoretical framework indicates that the effect on welfare is ambiguous if environmental externalities are not fully internalized. The empirical findings show that the environmental distortions are greater than the decrease in price distortions due to trade liberalization. Complete liberalization may decrease national income by about 0.10%.

Barbier (2000) explores the effects of structural adjustment, trade liberalization and agricultural development and draws his conclusions based on two case studies conducted in Ghana and Mexico. According to the results, opening the domestic markets can have direct and indirect effects on rural resource degradation. If agricultural activities increase, the expansion of the cultivated area is a direct effect of trade liberalization. Indirect effects can be caused by displacement of rural

[27] In shifting cultivation agricultural productivity depends on available biomass. López (1997) showed that biomass contributes 15% to 20% to the value of agricultural output.

households due to agro industrial development. These displaced people often migrate to frontier regions which may lead to further land degradation.

For studying these effects, Barbier (2000, p. 300) developed a model of land use decisions in a rural economy to analyze "how input and output price changes may influence the rate of land use change, as well as the demand for land in agricultural production". The demand for agricultural land use is determined by the price of output, as well as input, for an agricultural activity and a competing activity, and by exogenous factors, such as population, income per capita or roads. Generally, higher returns lead to more demand in land for agricultural use. Specifications of the model show that land use will be significantly influenced by whether households rely more on inputs or on land to increase their production. This model does not take into account the possibility of household labor to work off-farm. It assumes representative households and abstracts from the choice of product mixes that households usually face (Barbier, 2000).

In Mexico trade liberalization would cause a significant drop in prices for maize and a reduction in subsidies for fertilizers. According to the model described above, this would lead to a decrease in the demand for agricultural land. Barbier (2000) also mentions the importance of indirect effects. Unemployment may force rural workers and subsistence farmers to migrate to frontier areas to convert forestland. This could potentially outweigh the direct effects. In Ghana, low input and extensive cocoa production has led to increased deforestation. Empirical data shows that "any increase in returns to cocoa led to a more rapid rate of land expansion and forest loss" (Barbier, 2000, p. 308).

Aggarwal (2006) combines models of ecosystem dynamics from ecology with models in New Institutional Economics to analyze impacts of globalization on renewable resources in rural areas. This means that he is especially concerned with the role of institutions on the management of rural resources and that he puts a lot of emphasis on the importance of resilience of local ecosystems. He finds that economic growth, caused by trade liberalization, may lead to more stress on ecosystems due to upward scale effects. This effect gets even worse when countries specialize in natural resources extraction activities and when they narrow the range of crops for exports. If this is followed by a loss of biodiversity, it decreases the resilience of the ecosystem. In a long term perspective, this will heighten the level of vulnerability of the rural poor to external shocks, such as drought.

Aggarwal (2006) concludes that on the one hand the rural poor are more exposed to fluctuating world prices and on the other hand the local ecosystem becomes less resilient to external shocks. Institutions and culture are very critical determinants of these outcomes. He believes that the current institutional set-up in most countries cannot deal adequately with these problems. They are very likely to adapt too slowly to environmental and economic changes. Aggarwal (2006) calls for drawing the attention to these underlying factors of decreasing resilience and rural poverty.

Fraser (2006) takes a new approach in linking the effects of agricultural trade policies to local management decisions. The key question of his analysis is how globalized trade may affect crop diversity. In order to determine the effect that trade liberalization had on crop diversity in British Colombia, Canada, Fraser (2006) identified commodity perceptions of local residents in order to explain how crop diversity changed over a period when policy changes led to freer trade (1984-1995). The most common perception found among residents was that trade affected farmers because of the negative impact it had on the processing industry in British Colombia. Industry statistics confirmed that the number of food processing plants declined during the period of concern. Finally, statistical analysis showed that monocultures were replaced by more diverse crops destined for the fresh market. Further, organic production increased from almost 0% in 1990 to 10% in 2000. Also, farmers who used to produce for the processing industry diversified their crops more than farmers that produced for the fresh market. Hence, it is hypothesized that the impact of trade liberalization on crop diversity will vary greatly between region and commodity. Local contextual factors play an important role in production decisions and multiple equilibria can exist. The effects of more crop diversity are seen as beneficial for the environment, especially the increase in grassland and in organic production but also the decrease in monocultures. Trade is thus said to have significant environmental impacts if it affects on-farm specialization (Fraser, 2006).

One more important implication of this study is that general international trade theory might be too prescriptive and it should take into account context-specific variables which mediate the effects of trade liberalization (Fraser, 2006).

3.3.3 Summary

From the empirical studies presented above the following findings can be identified:

- Countries with high trade barriers (e.g. the EU and thus also Austria) can quite certainly expect **economic welfare gains**, although they will be relatively small compared to total welfare (measured as GDP);
- There is **conflicting evidence** on both
  - the general environmental effects of trade liberalization, and
  - on the environmental effects of agricultural trade liberalization;
- In the EU the effects of agricultural trade liberalization on sustainability are assumed to be insignificant at the aggregate level. The overall environmental effects are expected to be *positive* at the aggregate level in a partial liberalization scenario;
- The common assumption that global shifts of agricultural production due to freer trade will lead to dramatic land use changes in the EU might be overstated;

Most importantly two reoccurring themes can be found in almost any study:

- A call for better environmental policies to mitigate externalities, especially those that will be affected by freer trade; and
- That the environmental impacts of agricultural trade liberalization will be **site-specific and very heterogeneous across countries and within countries**. Even if aggregate effects are positive severe impacts may occur on a local/regional level. Therefore, many studies point out that there is need for location specific case studies;

Other reviews, specifically Antle, Lekakis, & Zanias (1998), Barbier and Bulte (2004) and Cooper, Johansson, & Peters (2005) derive very similar conclusions:

Antle, Lekakis, & Zanias (1998, p. 8) state that “there are few generalizations or stylized facts that emerge about answers to the questions raised about trade and environment”. The only consistent pattern found among studies is that the effects will differ widely between countries and between regions in countries, especially in regions as diverse as the EU. Hence policies which address negative side effects of trade liberalization will need to fit local conditions. This in turn means that local case studies are needed to find out how to response adequately.

Whalley also finds (2004, p. 387) that the "links are unclear: research provides relatively little quantitative or qualitative information on the externalities associated with agriculture. If trade liberalization intensifies or alleviates these externalities is also unclear".

Barbier and Bulte (2004) conclude that each case has to be analyzed specifically. It is assumed that the interlinkages between economy, ecology and institutions on local renewable resources are manifold and lead to ambiguous outcomes for realistic assessments[28].

Cooper, Johansson, & Peters (2005) also come to the conclusion that no generalization can be drawn on the environmental effects of agricultural trade liberalization. Empirical studies are very limit in numbers and in their scope. This indicates again that more research on this issue is needed.

It should be noted that Ervin (2000, p. 118) gives five reasons why the current evidence is inconclusive:

1) A global assessment is necessary to assess worldwide shifts in production;
2) Different production responses in different countries will yield different environemntal outcomes;
3) We are only expierencing the first stages of liberalization and there is thus a lack of data on production adjustments;
4) There is often lack of data with which to link land use decisions and environmental conditions;
5) Temporal changes such as technology adaption have received little attention.

The next and last section of this introductory part will summarize the theoretical and empirical findings and derive a final conclusion.

3.4 Conclusion

At the beginning, a theoretical basis was established to derive and understand the most important trade-environment linkages (section 3.1). Most basically, trade will affect the environment if it affects production that is linked to a positive or negative environmental externality (see section 3.1.1). The environmental effects are typically decomposed into scale, composition and technique effects (see section 3.1.2). The sum of all effects determines the net outcome. Since the effects can offset and reinforce each other the outcome remains ambiguous and becomes an empirical question. On a local level and in the short-run, the most profound effect will be changes in relative input and output prices. These price changes, referred to as the 'initial' or 'first-order shocks' (see also section 3.2), will be central to the case study in the subsequent section.

In addition, it was pointed out that policy related issues have of course been a key element in the trade-environment debate (see section 3.1.3). But from an environmental economic point of view, the most important question is: **What is the quantitative environmental effect of agricultural trade liberalization?** Ideally, the environmental effect can be monetarized, but more often than not environmental indicators have to be used as proxies.

[28] Realistic assessments do neither assume perfect management nor open access, but for example common property management as did López (1997).

Section 3.2 introduced the concept of sustainability to the trade-environment issue. The holistic concepts presented in this section help to better understand the manifold linkages that trade can have on the three dimensions of sustainability. It demonstrated again that the net outcomes of trade policies may be ambiguous and very heterogeneous across regions. A clear disadvantage of sustainability impact assessments is their high demand in terms of data, time and costs. This is why the case study will be limited to include only the most important environmental indicators and the effects on regional producer surplus.

In section 3.3, a literature review of numerous empirical studies has confirmed the assumption that no generalizations can be made regarding the environmental effects of agricultural trade policies. In addition, it has been shown that many studies call for more site-specific assessments in order to account for the heterogeneity of impacts. Nonetheless, most literature about trade and environment only tackles this issue on a macro (global or national) level. Just a few analyze the impacts of trade liberalization on rural or local renewable resources (Barbier & Bulte, 2004) or the effect that trade liberalization has on land management (Fraser, 2006).

Thus, from the theoretical and empirical findings in the introductory part it can be concluded that:

if environmental externalities exist, unambiguous results on the environmental effects of agricultural trade policies cannot be drawn; this is especially true for local impacts.

This means that each case of interest needs to be analyzed specifically and empirically. Hence, it has been demonstrated that theoretical and empirical findings support the application of a local case study. The next part of the thesis will provide such an assessment for the Marchfeld region.

4 The Case Study

In the previous section I have established the conclusion that trade can have ambiguous effects on the environment and that large differences can be expected at a regional and local level. Therefore, I will provide an empirical case study analysis for the pannonic Marchfeld region in Austria.

Marchfeld makes a good case for examining the environmental effects of trade policies for two reasons. First, since Marchfeld is an area of intensive agricultural production it will very likely be affected by changes in trade policies. Second, many negative externalities that exist in the Marchfeld are caused by agricultural production, most notably nitrate pollution of groundwater.

This section will be organized as follows. First, I will outline the objectives of the case study analysis (4.1). Second, I will describe the characteristics of Marchfeld and address its local environmental problems, most notably nitrate pollution of groundwater (4.2). Third, I will provide information on data input (4.3). Fourth, I will address methodological issue and outline the actual model used for the analysis (4.4). The fifth section presents the policy scenarios and discusses their choice with respect to current agricultural policy developments both nationally and internationally (4.5). Finally, I will show and discuss the results obtained from the model analysis (4.6).

4.1 Objectives of the case study analysis

The main objective of the case study is to **show how changes in trade policies may influence nitrate concentration in percolation water in Marchfeld.** A further objective of interest is to see how a change in trade policies will influence regional income (i.e. producer surplus). More specifically, I will address the following research questions:

(1) Does agricultural production have a significant influence on nitrate concentration in groundwater?
(2) Can changes in trade policies significantly alter agricultural land use and management decisions?
(3) Is trade liberalization likely to decrease environmental pressure?
(4) Are support policies likely to increase environmental pressure?

Sections 4.2 will provide an answer for my first questions. If the answer is not affirmative, the other questions would be redundant since they depend on a causal relationship between agricultural production and nitrate concentration. Concrete answers for questions two to four will be derived from the scenario results of the model (section 4.6).

I need to point out that some of the scenarios depicted for the case study are rather hypothetical and so are some of the model assumptions (e.g. I have not included other factors which are likely to influence land use decisions such as: farmers' risk behavior, climate change, institutional effects, macroeconomic effects, etc). However, it is not the ultimate purpose of this exploratory case study to very accurately forecast the magnitude of the effects for the scenarios but rather to show in which direction the change is going to head. Hence, the results of the case study should be able to indicate if one can expect more or less environmental pollution in the chosen trade policy scenarios. This notion should be kept in mind while reading the remainder of the thesis.

4.2 The region Marchfeld

4.2.1 Regional characteristics

Marchfeld is a pannonic region (south-) east of Vienna and north of the Danube river (see Figure 7). Its geographical borders in the north are the hills of Weinviertel and in the east the river March. Marchfeld is basically divided into two terraces: the "Hochterrasse" or "Gänserndorfer Terrasse" in the north and the "Niederterrasse" or "Praterterrasse" in the South. Its total area is about 1,000 km² of which approximately 700 km² are being used as arable land (Kletzan, 2004). The altitude of the area ranges from 130 m in the South to 170 m in the North (Liebhard, Schmid, & Sinabell, 2004).

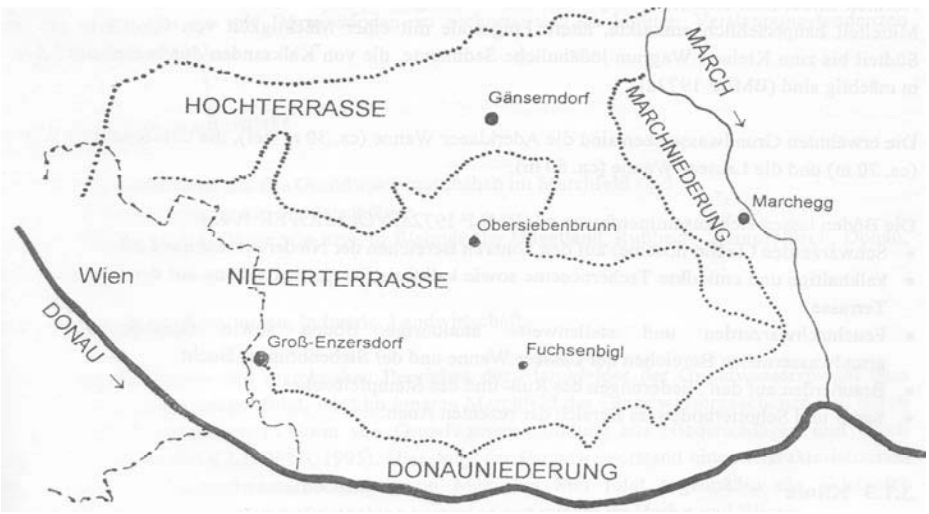

Figure 7. Marchfeld region in Austria (from Niemann (1998, p. 3))

It is “one of the most important and intensive Austrian arable production regions” according to Liebhard, Schmid & Sinabell (2004, p. 2). The main crop of production is cereal followed by root crops, alternative cultures and vegetables. Livestock unit (LU) per ha is only about 0.07 (Niemann, 1998).

Up to 312 soil types can be found in Marchfeld due to the complex geological genesis in the Vienna Basin (Liebhard, Schmid, & Sinabell, 2004), for example (Niemann, 1998, p. 4): various types of chernozem; cambisols; gley; sand and brash.

The regional climate is influenced by both semi-humid Western-European climate and continental East-European climate. Summers are hot and dry. But winters can be quite cold with occasional snowfall (Liebhard, Schmid, & Sinabell, 2004). The average precipitation rate is 500 mm per year (250-300 in dry years) thus making irrigation necessary (Kletzan, 2004).

4.2.2 Environmental problems

Marchfeld faces some environmental problems and many of them are likely to be caused by agricultural production, such as water scarcity, soil erosion and loss of biodiversity. Both quantitative and qualitative water scarcity are serious environmental threats in this region. For example, groundwater levels declined in the past due to several factors (Niemann, 1998, p. 5): regulation and deepening of the Danube river; minor groundwater inflow due to regulation of nearby streams; climatic variations and a tendency towards declining precipitation rates; and increasing water withdrawal (for drinking water, industrial water and irrigation). However, groundwater levels have started to increase steadily since 2006 (Office of the Federal State of Lower Austria, 2011) due to high precipitation rates in the past five years (MAREV, 2011).

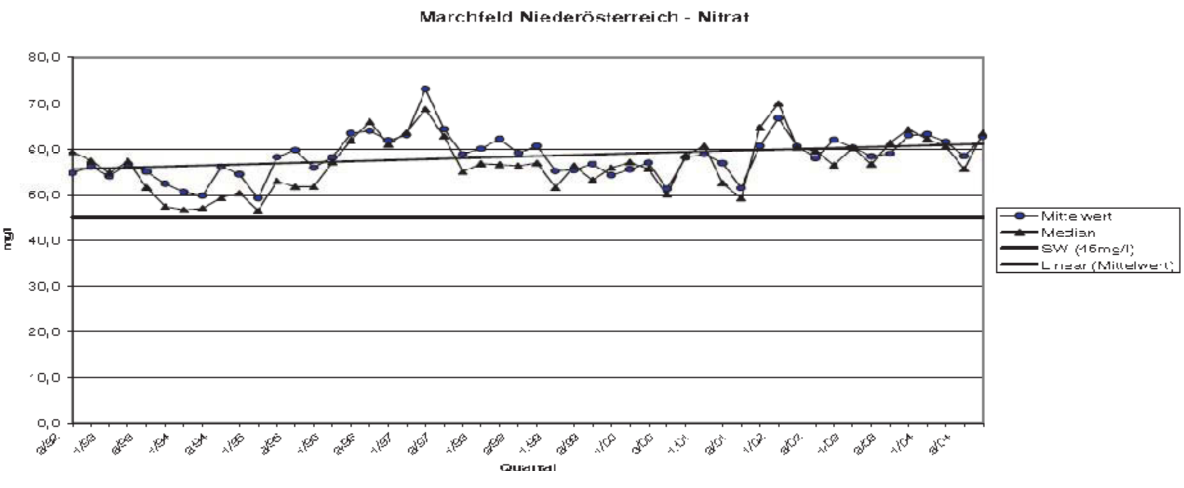

Figure 8. Nitrate concentrations in groundwater in Marchfeld (Umweltbundesamt, 2006, p. 41)

Notes: The dotted line shows the average value (“Mittelwert), the triangle line shows the median value (“Median”), the bold straight line depicts the threshold level (“SW = Schwellenwert”) and the regular up-ward sloping line depicts the linear trend of the average value (“Linear”).

Maybe even more important are various types of groundwater pollution: organic material and heavy metals (predominately from dangerous waste accumulated over the years – “Altlasten”), sewage leakage and atrazine from pesticide use. But the most severe groundwater pollution problem is said to be nitrate concentration. Local concentrations levels have reached levels that make remediation measures a legal necessity (BMLFUW, 2002a). Marchfeld has thus been labeled as a groundwater rehabilitation zone (Federal state law of Lower Austria: LGBl. Nr. 6950/22-0). According to Austrian regulation the groundwater threshold level is 45 mg/l and the drinking water limit level is 50 mg/l (Umweltbundesamt, 2006). Data on groundwater quality shows that average nitrate concentrations in Marchfeld are above the legal threshold level and have slightly increased from 1992 to 2004 (see Figure 8). Evidently, nitrate pollution is a serious concern in the Marchfeld region.

Different factors influence the level of nitrate concentration in groundwater in Marchfeld. Foremost, its climatic conditions make Marchfeld prone to nitrate contamination of groundwater (Niemann, 1998). Low precipitation rates, freezing temperatures without snow in winter, high temperatures in summer and irrigation increase the rates of mineralization (especially in autumn[29]) and thus the chance of high levels of nitrogen runoff into groundwater. In addition, only marginal nitrogen runoff can contribute relatively heavily to concentration levels due to low groundwater recharge (Vabitsch, 2000). Vabitsch (2000, p. 12) summarizes the factors that potentially influence nitrogen runoff:

- **natural factors:** groundwater recharge, dwelling time of water in the groundwater body, depth to water table, precipitation, land relief, soil characteristics, soil depth;
- **production factors:** crop rotation, fertilization management, cultivation, management of yield residue.

Natural factors determine the short-term fluctuations of nitrate concentrations in groundwater. In the middle- or long term the main contributor of nitrate pollution is said to be agriculture (Umweltbundesamt, 2006). Basically, more intensive crop farming (intensive cultivation and fertilization) has lead to higher biochemical transformations in soils and to a loss of humus (Vabitsch, 2000). High yield varieties transpire more water thereby reducing percolation water. This reduction together with increased nitrogen emissions from fertilization may have increased nitrate concentrations in groundwater (Liebhard, Schmid, & Sinabell, 2004).

Nitrate emissions from agriculture originate from four different sources (Sinabell, 2004, p. 37):

1. purchased fertilizer;
2. co-production of animal husbandry (manure);
3. co-production of plant production (nitrate fixation by legumes and nitrate as a nutrient in seeds and plant material);
4. atmospheric input;

It is only possible to accurately dose the distribution of purchased fertilizer. The effect of manure has a high range of variation and the effect of plant production can only be estimated approximately. How much nitrate is being emitted from the atmosphere is only known at specific gauge stations. The most important source of nitrate in Austria is the output of manure (Sinabell, 2004). This might not be the case for the Marchfeld since most farmers only produce crops. Hence, the contribution of purchased fertilizer input to nitrogen runoff will gain in significance here.

Wick, Heumesser, & Schmid (2010) used a regression analyses to identify influencing factors on nitrate concentrations using data from 1991 to 2008 for 1238 municipalities. They were able to show

[29] Nitrate runoff usually happens between April and May. Mineralization in autumn contributes most to this runoff (Niemann, 1998).

that, among other things[30], cropland positively contributes to nitrate concentrations. Further investigation shows that all crops have a significant positive effect on nitrate concentrations, especially oil seeds, proteins, row crops and vegetables. These results support similar findings of an earlier analysis by Hofreither & Pardeller (1996).

Sinabell (2009) analyzed the environmental effects of agricultural support policy on nitrate concentrations in groundwater in Austria. Data on nitrate concentrations per municipality that were observed during winter 2004/2005 were used to compute parameters for a regression equation. The equation with the best fit indicated which variables may explain high levels of nitrate concentrations. The results show that variables not related to agricultural activity may contribute 25% to nitrate concentrations, such as precipitation during the winter, soil quality, dry regions and population density. Significant variables which are related to agricultural activity are the withdrawal of nitrogen from soil by agricultural crops, the agri-environmental measure 31 (that is support to farmers who adopt nutrient management practices), coupled crop premiums and market price support for sugar beet and pork (but not for other products) (ibid., p.68ff). Hence, Sinabell (2009) has shown that agricultural support can exacerbate negative environmental externalities. He recommends that future research should combine empirical econometric models (such as the one above) with integrated bio-physical models to retrieve more detailed information on the flow of nutrients and to take into account spatial diversity. I will apply an integrated approach for the Marchfeld case study.

This section has thus shown that the Marchfeld is a region of high agricultural activity and that it faces many environmental problems. Further, empirical evidence suggests that nitrate pollution of groundwater is – to a significant extent - caused by agricultural production. My first research question[31] has thus been answered affirmatively. **I can conclude that agricultural production significantly influences nitrate concentration in groundwater in Marchfeld**.

The preceding section will provide extensive information on data input (section 4.3).

4.3 Data

4.3.1 Environmental data

An extensive data set from the bio-physical simulation model EPIC was available for this study. It had previously been used for similar studies that took place in Marchfeld (Schmid & Sinabell, N.A.; Liebhard, Schmid, & Sinabell, 2004). This data set provides simulated estimates on crop yield, straw yield, biomass, fertilizer application rates and irrigation, and on environmental data, for example percolation water and nitrogen run off into percolation water. The last two estimates can be used to assess how nitrate concentrations in percolation water may change under the different policy scenarios. All estimates are given per year and per hectare.

EPIC computes yield data estimates for each set of the following dimensions: region, soil type, crop rotation system, farming system, tillage system, straw measures, agri-environmental measures, crops and year. Estimates for environmental data did not include the crop dimension, only years. The next paragraphs will elaborate more on these dimensions.

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[30] Other influencing factors identifies were: precipitation (non-monotonous effect); high quality soil (positive; it is suggested that intensive agricultural production offsets the effect of less leaching in such soils).

[31] "Does agricultural production have a significant influence on nitrate concentration in groundwater?"

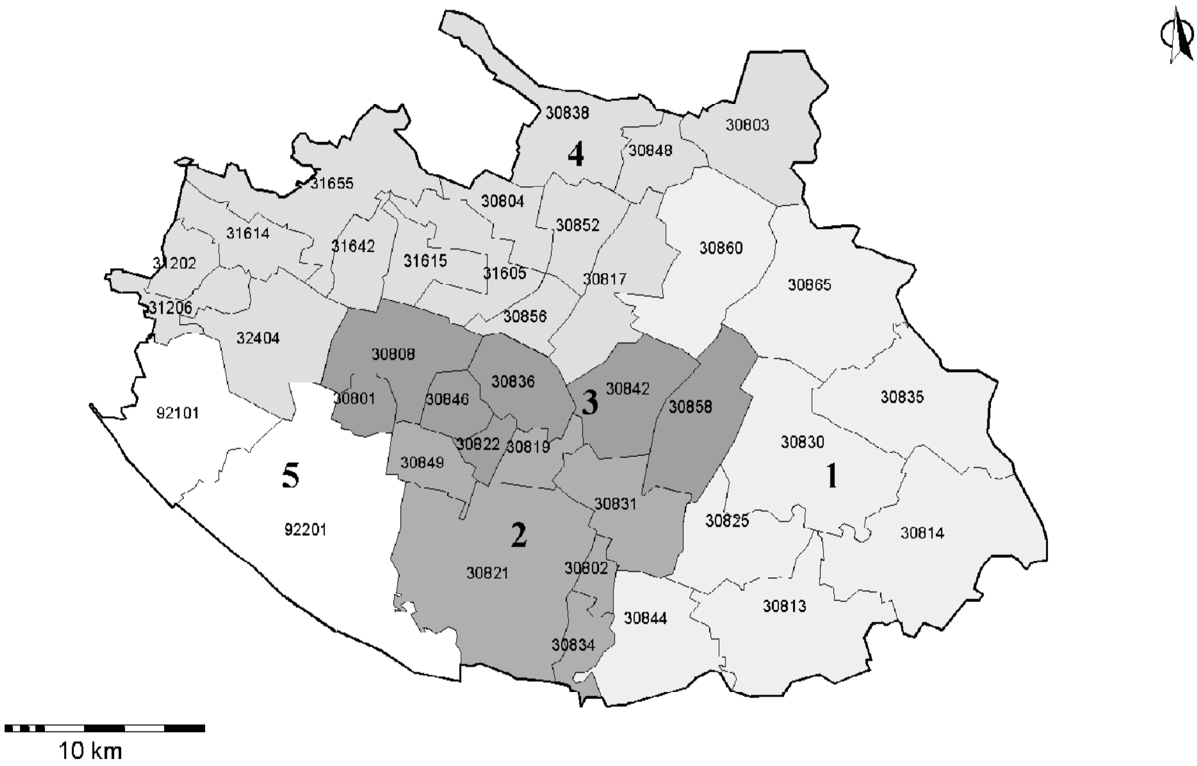

Figure 9. The five sub-regions of Marchfeld used for the analysis (Hofreither, et al., 2000, p. 8)

Land uses in Marchfeld are quite heterogeneous. In order to account for the differences similar land use characteristics (e.g. crop rotation-mixes, participation in environmental programs) are represented by five representative sub-regions (see Figure 9). These sub-regions were identified by Hofreither et al. (2000) by applying a cluster analysis.

In order to identify representative soil types (out of 138) the same analysis as above was applied. Table 6 gives a description of the different soil types.

Table 6. Soil type characteristics (Hofreither, et al., 2000, p. 41; Liebhard, Schmid, & Sinabell, 2004, p. 3)

	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5
soil type	Chernozem from chalky fine sediment formation	Chernozem from loess formation	aggrandized chalky moist black soil	Chernozem from chalky fine sediment formation	Para-Chernozem
water conditions	moderate permeability	high storage capacity	moist and some permeability disturbances in subsoil	high permeability	low storage capacity
humus in top soil (%)	2.6	2.4	5.8	2.3	1.4
available soil water capacity (mm 120 cm^{-1}	196	200	212	127	59
share in region 1	53,8%	3,5%	15,5%	15,8%	11,4%
share in region 2	67,0%	8,8%	10,2%	12,5%	1,6%
share in region 3	42,0%	2,1%	10,4%	20,1%	25,4%
share in region 4	22,8%	21,6 %	5,1%	23,4%	27,1%
share in region 5	56,8%	3,5%	10,7%	26,8%	2,2%

The following crops are included: carrots, onions, green peas, sugar beet, spinach, potatoes, early potatoes, winter barley, summer barley, corn, durum wheat, winter wheat, field peas, green peas, spinach, sunflower, winter oilseed rape, winter rye and also fallow land.

The current share of organic farms is very low in Marchfeld (about 2%) and will thus be ignored in the model. Therefore farming systems can only be conventional.

Three different kinds of tillage systems can be applied by farmers: conventional, reduced or minimum. The last two are agri-environmental measures. The dimension straw harvest has only two sub-dimensions: straw harvesting or no straw harvesting. Agri-environmental management measures comprise of four different practices: usual fertilizer regime, fertilizer splitting and reduced nitrogen fertilizer amounts, cover crop system and management measures plus cover crops.

Thirteen different crop rotation systems are included. Each crop rotation is 12 years long. Data was also available on the observed distribution of crop rotation systems across regions and soils (Schmid & Sinabell, N.A.). Additional artificial crop rotation mixes are created in order to allow for more land use choice options in the policy scenarios. The artificial mixes were not allowed to deviate more than 20% from the observed share. This is a strong constraint but I assume that in the short term one may not expect extreme variations given that farmers are usually assumed to be risk averse. Nevertheless, I will apply a sensitivity analysis which will compare my results to a case where more deviation is allowed and one where no constraints are applied (with regard to crop rotation system shares).

4.3.2 Economic data

4.3.2.1 Commodity prices

Statistics Austria (2010) offers detailed information on domestic agricultural prices in their annual reports on agricultural producer prices. To account for the high fluctuations of agricultural prices I calculated a mean value for the years 2006 to 2009.

Future world prices for (aggregate) agricultural commodities are taken from OECD Statistics[32]. It provides a forecast for world prices until the year 2019. Thus I was able to calculate a mean value for the years 2010-2019 for the following aggregate crops: coarse grains (= barley, rye and maize), oilseeds (= rapeseed and sunflower) and wheat (= winter and durum wheat).

Average MFN applied tariffs for 1996 and 2010 are taken from the WTO “Tariff Analysis Online” database (WTO, 2010c).

These data are included as tables in the appendix (see section 7.2 for commodity prices and section 7.4 for tariffs).

4.3.2.2 Production costs

The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft) has published a paper that provides valuable data on average gross margins for a wide range of crops (BMLFUW, 2008). From this document, I could derive variable production costs per hectare for

[32] http://stats.oecd.org/index.aspx?

conventional farming systems. Variable production costs include: seeds, miscellaneous fertilizers (excludes nitrogen), pesticides, insurance, variable machine costs and other variable harvest cost.

Average production costs for carrots, onions, green peas and spinach as well as the costs of applying tillage, straw and agri-environmental measures were taken from Schmid & Sinabell (N.A.).

These data are depicted in the appendix section 7.3.

4.3.2.3 Premiums

The historical reference period for single farm payments in Austria was 2000 to 2002. Basis is the amount of direct (coupled) payments received during this period (i.e. livestock premiums and crop premiums; they latter are labeled "Kulturpflanzen-Flächenzahlung" – KPF) and the amount of land that was eligible for such payments. Premiums for animal products can be disregarded for Marchfeld. It is almost solely crops and vegetables that are being produced in this region (see section 4.2). Crops included in the case study that were eligible for KPF are: winter barley, summer barley, corn, durum wheat, winter wheat, sunflower, triticale, winter oilseed rape, winter rye, fallow land, potatoes (if not used for starch), early potatoes (if not used for starch) and field peas. The annual crop premium amounted to €332 per ha for almost all crops listed above in 2002 (BMLFUW, 2002b).

In order to get per ha values for SFP one may divide the total amount of SFP received in a region by its total agricultural area. Unfortunately, data is only available for the federal state of Lower Austria and not for Marchfeld specifically. Nevertheless, such a value can be used as an approximation. In 2009 total SFP paid out in Lower Austria was about €260 million (AMA, 2010a) and total agricultural land was 689'137 ha (Statistics Austria, 2009, p. 4). This gives a per hectare payment of €377.01.

Premiums for agri-environmental measures are taken from "The Austrian Programme for Rural Development 2007-2013" (BMLFUW, 2007). Only two agri-environmental measures can be applied in the case study:

- fertilizer splitting and reduces nitrogen fertilizer amounts (€115 per ha and year);
- cover crop systems (€130 per ha and year).

These measures can be combined (which gives a premium of €245 per ha and year).

In the next section I will present the methodology which will be used to analyze the effects of the policy scenarios.

4.4 Method

This section will present and discuss the methodology used to conduct the case study. I will start by focusing on methodological challenges (4.4.1). Then I will describe my methodological framework (4.4.2) and finally provide a detailed description of the actual modeling approach – the "Marchfeld model" (4.4.3).

4.4.1 Methodological challenges

Many papers regarding trade-environment analyses have been published in the 1990ies (Markandya, 2000; Steininger, 1999). In 1999, the OECD held a workshop on methodologies for assessing environmental effects of trade policies. Back then, they concluded that methodologies for this area are still young and evolving (Tarasofsky, 2000). Nowadays, researchers seem to have made substantial progress in linking environmental simulation models to CGE models (see for example Cooper, Johansson, & Peters (2005) or Sullivan & Ingram (2005)). Nevertheless, only few notable exceptions developed methodologies for assessing the environmental effects of trade policies on a local level, i.e. López (1997), Antle & Capalbo (1998), Barbier (2000) or Fraser (2006).

Here, I will focus on methodological challenges with regard to local and static models. Comparative-static analyses are assumed to be a dominant approach (Martin, 2000)[33].

First of all, a regional/local analysis only makes sense when the environmental problem is local in nature (compared to the other two types of spatial environmental problems: trans-boundary and global). It is thus the exchange of goods and services which connects the environmental problem with trade (trans-boundary or global environmental problems are caused due to physical spillovers) (Jayadevappa & Chhatre, 2000). This case can be depicted for Marchfeld:

- Nitrogen contamination of ground water is a local environmental problem; and
- trade will affect nitrogen contamination by influencing farmers' land use decision at the extensive and intensive margin[34].

An analysis at the local/regional level "needs data on household income and expenditure as well as on the relevant environmental variables (areas under different crops, rates of soil loss in different areas, demand for water and other resources by activity)" (Markandya, 2000, p. 107). Hence there is a need for highly disaggregated data in combination with micro-economic analysis to assess the local environmental impacts of agricultural trade liberalization (Antle, Lekakis, & Zanias, 1998). However, this is a very time demanding process and data gathering may take several years (Ferrantino, 2000). Thus, lack of adequate data is often a serious problem (Ervin, 2000). Fortunately, as mentioned before (see section 4.3.1), an extensive environmental data set at field scale was available for Marchfeld as well as average standard production costs.

Usually, it is quite challenging to obtain precise causal linkages between trade policies and environmental impacts (Perrin, 2000). The CEC Secretariat (2000, p. 31) even calls it "the trickiest issue". Although it is difficult to establish linkages between trade and environment, it can be assumed that (Perrin, 2000, p. 69f):

1. this difficulty does not mean that trade liberalization has no effect on the environment;
2. integrating trade and environmental policies requires that the principles of prevention and precaution be upheld;
3. trade liberalization may or may not be the root cause of environmental problems; However, it is an important factor influencing the environment.

In the static, short-term model used for the Marchfeld case study the direct effects of trade policies will be captured by the changes in input and output prices that come along with new trade policies. In addition, the elimination of indirect support (e.g. direct payments) will also affect land use decisions. One may also include indirect feedback effects from economy-wide liberalization, such as institutional changes, allocation/distributional and management issues ('coping strategies'), supply of

[33] Poor knowledge of ecosystems dynamics is assumed to be the main reason for this.

[34] At the extensive margin farmers decide whether to use land or to set it aside. If they decide to use it, they have to decide which management measures to apply (i.e. intensive margin).

labor or value of land holdings (Ervin, 2000; Markandya, 2000). The latter effects are omitted in the case study since they are assumed to be exogenous and constant in the short-term.

Other key problems at the local/regional level are how to identify a baseline scenario and how to reconcile results to the macro-level data (Markandya, 2000; Maltais, Nilsson, & Persson, 2002). The aggregation of local data for policy relevance creates serious data problems and can often not be done (Ervin, 2000). A compromise may be found by using global analysis to identify regions which are heavily affected and then use local analyses on the identified regions (Ervin, 2000, p. 123).

Tarasofsky (2000, p. 14) adds another problem, namely “the general lack of environmental methodologies available for measuring certain kinds of impacts” and reminds us that data limitations are almost always a concern. An advantage of regional/local studies is that, as explained before, environmental analysis improves at watershed levels but this, of course, may omit the incorporation of other macro-economic forces than trade policies (Ervin, 2000).

Furthermore, whilst economic assessments generally measure quantitative effects, environmental assessments often need to analyze qualitative effects. It is argued that it is difficult to quantify such effects because (CEC Secretariat, 2000, p. 30): 1) the link between trade and environmental effects is uncertain; 2) trade agreement effects are often modest[35] and 3) necessary baseline data on the environment are ‘often unavailable’.

It is made clear by Tarasofsky (2000, p. 16) that “environmental assessments of trade agreements should not be purely theoretical exercises, but should lead to practical and policy-relevant results”. Policy recommendations should also come in a manifold way (e.g. ‘flanking’ policies) and take into account that trade measures may be delayed or slowed (Perrin, 2000, p. 69).

Having brought attention to important methodological issues it is now time to present my methodological framework in the preceding section.

4.4.2 The methodological framework

Antle & Capalbo (1998) provide so far the most interesting approach for assessing environmental impacts of trade policies at a local/regional level. I will adapt their methodological framework to my case study since it seems to be an adequate approach.

They developed “a conceptual framework for agricultural technology impact assessment that incorporates essential features of agriculture-environment interactions” (ibid., p. 26). The basic idea behind their modeling approach is that environmental impacts cannot be assessed accurately at a regional or national level. Therefore, a more disaggregated economic analysis is needed on a local/field specific level which fits better to a typical soil science analysis.

Figure 10 shows an adapted version of the static spatial model that Antle & Capalbo (1998) developed in order to assess the environmental impacts of land use and crop management decision-making at field scale. The model shows that it is essential to know the drivers of land use and management decisions. The characteristics of land, the prices for inputs and outputs, as well as the technology influence farmers’ choice of land use and their management decision (i.e. tillage, straw and agri-environmental measures). The choice of land use and management decisions (i.e. the

[35] It should be noted that even a ‘modest’ effect could have a serious and significant environmental impact, especially in regions where the environment is already highly degraded.

production decision) together with the ecological characteristics of the land will then determine crop yields and the location-specific environmental outcomes.

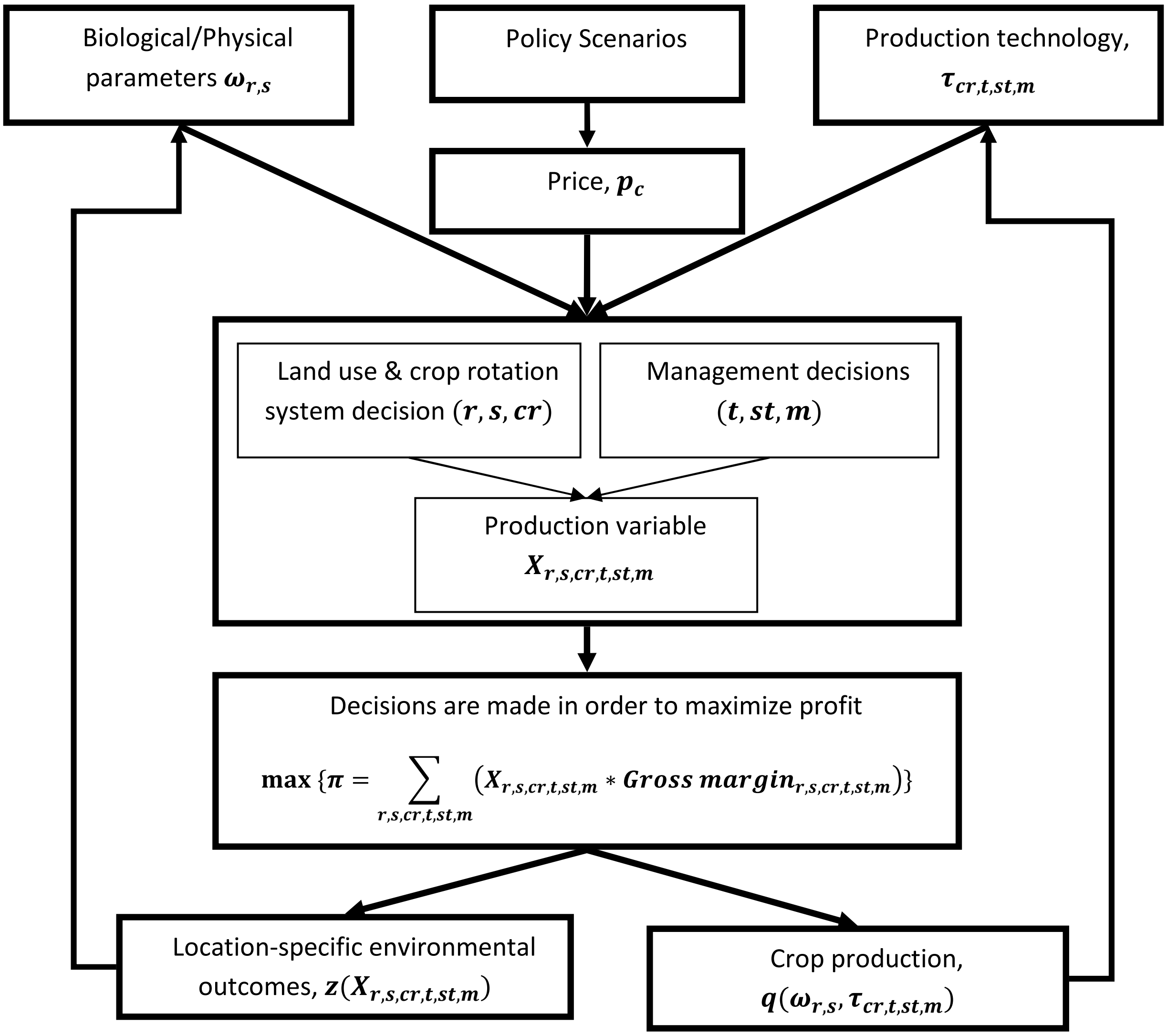

Figure 10. A static spatial model of land use and crop management decision-making (adapted from: Antle & Capalbo, 1998, p. 27)

Each field's physical attributes are represented in the vector $\boldsymbol{\omega}_{r,s}$ (which may also take into account stochastic effects due to weather), where index r is regions and s is soils. Production technology - $\boldsymbol{\tau}_{cr,t,st,m}$ - is assumed to be static and differs between crop rotation systems, cr, tillage management, t, straw management, st, agri-environmental measures, m. These two attributes – which are accounted for by EPIC (see section 4.4.3.1) - will affect crop production and thus in turn farmers' land use and management decisions. Land use and management decisions are made annually and per ha with respect to crop rotation systems. Both decisions are summarized in the production variable $\boldsymbol{X}_{r,s,cr,t,st,m}$[36]. To ensure that production decisions across fields are made according to their highest value, farmers will try to maximize the profit function. This function is defined as the production variable times its respective gross margins:

[36] Production decisions are made per hectare for region (r), soil (s), crop rotation system (cr), tillage practice (t), straw management (st) and agri-environmental measures (m).

$$\max\{\boldsymbol{\pi} = \sum_{r,s,cr,t,st,m}(\boldsymbol{X}_{r,s,cr,t,st,m} * \boldsymbol{Gross\ margin}_{r,s,cr,t,st,m})\}.$$

The crop production function is defined as $\boldsymbol{q}_{r,s,cr,t,st,m} = \boldsymbol{q}(\boldsymbol{\omega}_{r,s}, \boldsymbol{\tau}_{cr,t,st,m})$. Hence production is a function of the land unit's physical attributes and the production technology. Constant returns to scale are assumed.

The environmental impact, $\boldsymbol{z}$, is determined by $\omega_{r,s}$ as well as by the choice of management options and crop rotation systems. EPIC provides environmental estimates for each $X_{r,s,cr,t,st,m}$. The environmental impact can thus be written as a function of $z_{r,s,cr,t,st,m} = z(X_{r,s,cr,t,st,m})$.

It is noted that the static model presented here may not be useful for assessing sustainability impacts (Antle & Capalbo, 1998). In such an assessment the long-run dynamic effects are important. This means that one needs to incorporate the changes in the physical/ecological characteristics of land over time and also include temporal variability (due to seasonal dynamics).

While this framework can be used for estimating the environmental impacts of any domestic trade policy change the main concern is that "adequate data does not exist to conduct disaggregate analyses across the entire landscape of most countries. Hence, there remains a gap between the demand for information about environmental impacts at the national level and our capability to deliver scientifically sound estimates of such impacts" (Antle & Capalbo, 1998, p. 50). To fill these gaps the following three principles are suggested (Antle & Capalbo, 1998, p. 50f):

1. Specific, feasible goals for use of the agri-environmental indicators must be set before the indicators are collected.
2. Data collection must be based on a coherent theoretical framework of the process through which policy change causes environmental change. This theoretical framework must be consistent with the economic processes governing farmer behavior and the biophysical processes governing environmental change.
3. The choice of economic and environmental data to be included in a set of aggregate indicators must be guided by scientific and policy analysis requirements for meeting policy analysis goals. The indicator set must include information needed to estimate the impacts of policy on land use and management practices that affect environmental quality, and information to estimate the impacts of land use and management practices on environmental quality.

These principles can be sufficiently met in the Marchfeld case study analysis. First, I focus only on one of the most important environmental indicator in the region, i.e.: nitrogen leaching. Second, the theoretical frameworks above and in the preceding section are assumed to be an adequately enough representation of how trade policy changes may influence farmer's behavior in this region (Antle & Capalbo, 1998). And third, by integrating the environmental simulation outcomes from EPIC, I can compute the environmental effects of land use and management decisions.

The next section will present the actual modeling approach used to conduct the case study.

4.4.3 The Marchfeld model

I will now give a detailed description of the land use optimization model used for analyzing the environmental effects of different trade policy scenarios in Marchfeld. I am able to integrate estimates from the bio-physical simulation model EPIC into an economic land use optimization model. Thus, I can immediately infer environmental outputs (i.e. nitrate concentration in percolation water) to the results of the policy scenarios (which influence the land use and management decisions). My approach closely follows earlier applications of integrated economic-environmental simulation models, most notably Hofreither et al. (2000) and Schmid & Sinabell (N.A.). The model used for this case study will be referred to as the "Marchfeld model".

First, I will describe EPIC (section 4.4.3.1) and then the land use optimization model (section 4.4.3.2).

4.4.3.1 The EPIC model

EPIC (Environmental Policy Integrated Climate) was developed by J.R. Williams, C.A. Jones and P.T. Dyke in 1984 in order to analyze how soil erosion may affect soil productivity (Williams J. , 1995). Today, the application of the model has been expanded to numerous important processes of agricultural management.

It is a continuous bio-physical simulation model that can be used for simulating the long-term effects of agricultural production on plant growth as well as on three environmental media (soil, water and air). It operates on a daily time step and outputs refer to field scale (e.g. one hectare).

The following components may be included in the EPIC model (Williams J. , 1995, p. 909): weather simulation, hydrology, erosion-sedimentation, nutrient cycling, pesticide fate, plant growth, soil temperature, tillage, economics, and plant environmental control. Through these components it can "estimate crop yields, movement of nutrients and pesticides, and water and sediment yields" (Williams J. , 1995, p. 981). Most commonly, focus is put on soil erosion (e.g. through different tillage management or wind erosion), water quality (e.g. contamination through pesticide residue and/or nitrogen runoff) and greenhouse gas emissions (e.g. CO_2 emissions). A detailed description and application of the model is given in Williams J. (1995), Cepuder, Tuller, & Kastanek (1997) and Müller (2007).

EPIC has already been applied to estimate nitrogen leaching into groundwater in Marchfeld, for example, Schmid & Sinabell (N.A.), Cepuder, Tuller, & Kastanek (1997), Hofreither, et al. (2000) and Liebhard, Schmid & Sinabell (2004). The latter used the extended capabilities of the model to simulate the effects of plant growth (sugar beet and cover crop), yield response, nitrogen cycle and water balance for different tillage management and cover crop cultivation scenarios in Marchfeld. Müller (2007, p. 12) finds that "nitrogen leaching can be reasonably reproduced by the model". Liebhard, Schmid & Sinabell (2004, p. 8) , however, note that the "simulation results should be interpreted with care". Assumptions in the model may not fit to certain local conditions and/or the behavior of farmers. Therefore caution should be applied when interpreting the results.

The EPIC model is of high value to economic analyses if the stream of physical outputs on short or long-term periods can be used as an input in economic land use optimization models (Williams J. , 1995). It can thus be used to simulate the environmental effects of different land use decisions.

The following section outlines the land use optimization model which will incorporate the environmental estimates of EPIC.

4.4.3.2 The land use optimization model

The regional land use optimization model includes different input and output ratios representing different trade policy scenarios. By doing so, the model captures the composition/mix effects (see section 3.1.2) induced by the trade policy scenarios. Since the optimization model is only suitable for comparative static and short-term analysis, scalar and technique effects cannot be accounted for. Finally, by linking the estimates of the bio-physical EPIC model with the Marchfeld model, I am able to assess if the trade policy scenarios have different effects on nitrate concentration levels.

The General Algebraic Modeling System (GAMS)[37] will be used in order to solve this linear programming problem. GAMS is an optimization software package that is ideally suited for both linear and non-linear modeling problems. Its programming language is concise and easy to use and it allows integrating data from different sources (e.g. EPIC). Its application area ranges from small scale farm modeling to general equilibrium models.

The objective of the land use optimization model is to find the mix of production choices (i.e. land use and management decisions) per year that maximizes regional producer surplus given the endowment constraints. In addition crop rotation system mixes will be taken into account as constraints on the optimization problem in order to avoid extreme solutions and to obtain a more realistic result (see section 4.3.1).

The duration of all crop rotation systems is 12 years and they usually comprise of four (max. five) different crops (for an example see Table 7). An optimal crop rotation system ("RotaID") has to be found for each region ("Region"), soil ("Soil"), tillage system ("TillSyst"), straw management ("strawMan") and management measure ("ManMeas").

EPIC provides field scale estimates for each of these dimensions on crop yield, nitrogen fertilizer application and irrigation, as well as on percolation water and nitrate leaching.

Table 7. An example of a crop rotation system in Marchfeld

Region	Soil	RotaID	TillSyst	strawMan	ManMeas	Crops	Year
Reg3	Soil2	CRS09	convTill	base	covC	POTA	1
Reg3	Soil2	CRS09	convTill	base	covC	WWHT	2
Reg3	Soil2	CRS09	convTill	base	covC	PEAS	3
Reg3	Soil2	CRS09	convTill	base	covC	BARL	4
Reg3	Soil2	CRS09	convTill	base	covC	POTA	5
Reg3	Soil2	CRS09	convTill	base	covC	WWHT	6
Reg3	Soil2	CRS09	convTill	base	covC	PEAS	7
Reg3	Soil2	CRS09	convTill	base	covC	BARL	8
Reg3	Soil2	CRS09	convTill	base	covC	POTA	9
Reg3	Soil2	CRS09	convTill	base	covC	WWHT	10
Reg3	Soil2	CRS09	convTill	base	covC	PEAS	11
Reg3	Soil2	CRS09	convTill	base	covC	BARL	12

The objective function is defined as maximizing average annual regional producer surplus (PS). Regional PS is the sum of production choices times their average annual gross margin:

$$(\mathbf{1}) \qquad Regional\ PS = \sum_{r,s,cr,t,st,m} \left(X_{r,s,cr,t,st,m} * GM_{r,s,cr,t,st,m} \right)$$

[37] see www.gams.com

where X is the choice variable for production (in ha) and GM is the gross margin parameter (in €/ha). The indices depict the dimensions for sub-regions (r), soils (s), crop rotation systems (cr), tillage systems (t), straw management (st), and environmentally friendly management measures (m).

The average annual gross margin for each crop rotation mix can be derived by dividing the gross margin for each crop rotation year by the duration of the crop rotation system (i.e. 12 years). Hence it can be defined as follows:

$$(\mathbf{1.1}) \quad GM_{r,s,cr,t,st,m} = \sum_{c,y} \left(\frac{Total\ Revenue_{r,s,cr,t,st,m,c,y} - Total\ Variable\ Costs_{r,s,cr,t,st,m,c,y}}{Number\ of\ years} \right)$$

where the index c is crops and y is years. The number of years is 12 (i.e. the duration of a crop rotation system). Total revenue can be written more explicitly as:

$$(\mathbf{1.2}) \quad Total\ Revenue_{r,s,cr,t,st,m,c,y} = CWght_c * Y_{PRICE\,c} * YLD_{r,s,cr,t,st,m,c,y} + YLS_{r,s,cr,t,st,m,c,y} * 1.17 * 62.63 + CAPPrm_c + SFP_c + AgriPrm_{c,m}$$

where $CWght$ is a yield factor, Y_{PRICE} the price of crops (€/t), YLD the average annual dry crop yield (t/ha), YLS the average annual dry straw yield (t/ha), 1.17 the yield factor for straw and 62.63 the average price of straw (years 2006 to 2009). The premiums (€/ha) comprise coupled premiums ($CAPPrm$), the Single Farm Payment (SFP) and agri-environmental premiums ($AgriPrm$). The parameters for yield (YLD and YLS) are the integrated estimates from EPIC.

In turn total costs can be written as:

$$(\mathbf{1.3}) \quad Total\ Variable\ Costs_{r,s,cr,t,st,m,c,y} = SEED_c + MISCFERT_c + PEST_c + INSUR_c + HARVEST_c + VARMACH_c + FTN_{r,s,cr,t,st,m,c,y} * NPrice + IRG_{r,s,cr,t,st,m,c,y} * IRRPrice + Agricost_{c,m} + Agricost_{c,t} + Agricost_{c,st}$$

where $SEED$ are seed costs (€/ha), $MISCFERT$ are miscellaneous fertilizer costs (€/ha), $PEST$ are pesticide costs (€/ha), $INSUR$ are insurance costs (€/ha), $HARVEST$ are harvest and other costs (€/ha), $VARMACH$ are variable machine costs (€/ha), FTN is nitrogen fertilizer applications (kg/ha) and $NPrice$ is the cost of nitrogen fertilizer (€/kg), IRG is irrigation (mm/ha) and $IRRPrice$ is the cost of water (€/mm). The costs of agri-environmental measures ($Agricost$ in €/ha) are divided into the costs of applying management measures (m), tillage measures (t) and straw measures (st). Estimated application rates for FTN and IRG are taken from EPIC.

This objective function is constrained to:

(1) Land Endowments
(2) Observed crop rotation system mixes per region and farming system

The land endowment constraint is written as:

$$(\mathbf{2}) \quad \sum_{cr,t,s,m} (X_{r,s,cr,t,st,m} * LAND_{r,s,cr,t,st,m}) \leq SoilMix_{r,s} \qquad \forall\, r,s$$

where $LAND_{r,s,cr,f,t,st,m}$ is the parameter for land requirement and $SoilMix_{r,s}$ is the land available per sub-region and soil type. This equation ensures that no more land is used than available per region and soil.

The balance equations for observed and artificial crop rotation system are:

$$(\mathbf{3.1}) \qquad \sum_{x} (Mixes_{r,cr,x} * CRMIX_{r,x}) \leq \sum_{s,t,st,m} X_{r,s,cr,t,st,m} \qquad \forall\, r, cr$$

$$(\mathbf{3.2}) \qquad \sum_{s,t,st,m} X_{r,s,cr,t,st,m} \leq \sum_{x} \left(CRMIX_{r,x} * \sum_{cr} Mixes_{r,cr,x} \right) \qquad \forall\, r$$

where x is Mixes, $CRMIX$ is the choice variable and $Mixes$ is the parameter for the available mixes. These balance equations ensures a convex set of alternative crop mixes. Hence, it constrains the optimal land use decisions to the available crop mixes.

Solving this entire land use optimization model for X will yield a matrix of optimal production decisions: $\hat{X}$. Once an optimal production decision has been found it is possible to compute average annual percolation water and nitrate leaching per ha with the following equations:

$$(\mathbf{5}) \qquad average\ PRK = \frac{\sum_{r,s,cr,t,st,m} \hat{X}_{r,s,cr,t,st,m} * PRK_{r,s,cr,t,st,m}}{\sum_{r,s} BwSystMix_{r,s}}$$

$$(\mathbf{6}) \qquad average\ PRKN\ per\ ha = \frac{\sum_{r,s,cr,t,st,m} \hat{X}_{r,s,cr,t,st,m} * PRKN_{r,s,cr,t,st,m}}{\sum_{r,s} BwSystMix_{r,s}}$$

where PRK is the average annual percolation water yield (mm), $PRKN$ is the average annual nitrate load (kg/ha) and $\hat{X}$ is the matrix of optimal crop rotation systems. The numerators in equation (5) and (6) are total PRK and total PRKN, respectively, while the denominator is total land in Marchfeld (70,527 ha) in both cases. EPIC provides the simulations results for PRK and PRKN.

It is now possible to calculate average annual nitrate concentrations in percolation water by using the formula (Sommer, 1999, p. 65):

$$(\mathbf{7}) \qquad {NO_3}^- = \frac{PRKN}{PRK} * 100 * \frac{62}{14}$$

The next section will discuss the different trade policy scenarios.

4.5 Policy scenarios

The aim of this section is to determine one or more alternative scenarios that either represent scenarios of freer trade or the implementation of new (old) trade barriers. It is recommended to include two to four different scenarios on economic and policy assumptions (CEC Secretariat, 2000, p. 33). In the Marchfeld model the results of these scenarios will then be compared to the baseline scenario.

Before presenting the scenarios the next section will briefly address the developments of the Common Agricultural Policy (CAP) of the EU.

4.5.1 Development of the CAP

Austria had to adopt the CAP when in it joined the EU in 1995. Therefore, the CAP determines the political framework for agriculture in Austria and acts as the regulatory body for domestic support of agricultural producers. It is said to "heavily influence the EU's agricultural trade conditions" (Maltais, Nilsson, & Persson, 2002, p. 140) and to be "the most important land use policy within the EU" (Acs, et al., 2010, p. 550). Not surprisingly, agricultural production decisions in Austria depend to a large extend on agricultural policies (Sinabell & Schmid, 2004) and thus the CAP.

The CAP was established at the Treaty of Rome in 1955. Some of its original objectives were to increase agricultural production, stabilize markets and ensure a fair standard of living for farmers after the turmoil of the post-war area (Brouwer & van Berkum, 1998, p. 74; Hofreither, 2007). As will be shown in the following paragraphs the policy structure of the CAP has changed profoundly due to several market oriented reforms since 1992. The most important objectives of future reforms are likely to be (European Commission, 2010b, p. 7):

1. Viable food production;
2. Sustainable management of natural resources and climate action;
3. Balanced territorial development.

At the beginning the original objectives were typically achieved through price support. This led to surplus productions in the 1970ies and caused a decrease in environmental quality. It was thus assumed that if prices were lowered, surplus production would decline and less environmental damage could be expected. In addition, the Uruguay Round trade negotiations (1986-1994) pressured the EU to liberalize their agricultural market (Schmid & Sinabell, 2007). Consequently, the CAP needed to be reformed. Therefore the CAP underwent its most profound reform since it came into existence with "the MacSherry reform" in 1992. This reform aimed at improving the competitiveness of agriculture in the EU, restoring market balance and encouraging less intensive production technologies (Brouwer & van Berkum, 1998, p. 75). Hence, measures were put in place to reduce price support, decrease surplus production and to introduce more environmentally friendly production techniques, most notably: agri-environmental programs, land set-aside programs, the abolition of input subsidies and the reduction of export subsidies in order to control production (Antle, Lekakis, & Zanias, 1998). The MacSherry approach put further focus on coupled direct payments in order to reimburse farmers for their losses in income due to lower market prices. These payments depended on crop acreage or on a given number of livestock (Schmid, Sinabell, & Hofreither, 2007).

A further move towards more market orientation was the Agenda 2000 reform in 1999. This reform has led to lower administrative prices for cereals, oil prices and beef as well as substantial reductions in export subsidies (Schmid, Sinabell, & Hofreither, 2007). Its overarching aim was to contribute positively to sustainability. It also introduced the *second pillar*[38] of the CAP: the programme for rural development. It comprises of the accompanying measures of the MacSherry reform (e.g. agri-environmental payments, programs to facilitate rural adjustment …) and new measures such as modulation and cross-compliance (Schmid, Sinabell, & Hofreither, 2007). Modulation means that direct payments are reduced annually. The amount reduced is then moved to the rural development

[38] While market intervention measures together with annual direct payments are now labeled as the *first pillar* of the CAP (also known as Common Market Organizations – CMOs), the rural development programme is seen as its *second pillar*.

budget. Cross-compliance requires farmers to adopt certain environmental standards in order to be eligible for support.

The CAP reform in 2003 can be seen as the next step in the CAP's development to becoming more market orientated. It brought further reductions in prices and the introduction of decoupled 'single farm payments' (SFP) in 2005 (Schmid & Sinabell, 2007). The SFP have replaced coupled direct payments. This means that payments do not depend on crop acreage or number of livestock anymore. The level of SFP usually depends on payments received in a historical reference period (generally 2000-2002) and is reduced annually due to modulation. In 2010 the total amount of SFP in Austria was €606.72 million compared to €527.74 million agri-environmental premiums (AMA, 2010b). Due to modulation agri-environmental premiums will gain in importance in the near-term future[39].

Finally, the CAP Health Check in 2008 brought some new adjustments. The most notable changes are (European Commission, 2008):

- phasing out of milk quotas by the year 2015;
- the remaining coupled payments will be decoupled and moved into SFP (exceptions are made for suckler cow, goat and sheep premiums);
- modulation will be increased (i.e. direct payments are decreased by a higher rate (10% instead of 5% by 2012); this money is then transferred to the Rural Development budget);
- abolition of set-aside rule.

Schmid, Sinabell, & Hofreither (2007, p. 602) recognize that the "current approach of decoupling may still be a transitional solution". WTO negotiations in the DDA may make it necessary to adopt a more targeted and coherent programme. One may thus expect the SFP to be steadily reduced (through modulation) and finally phased out (Acs, et al., 2010). Cooper (2005, p. 2) even claims that agri-environmental policies with trade distorting effects in the WTO's 'green box' may be challenged in the future by some WTO members. Besides meeting the obligatory WTO commitments the CAP will also have to respond to demands from civil society and to the Sustainable Development Strategy of the EC.

Most recently the EC has held an extensive public debate and a conference in July 2010 to discuss post-2013 CAP reforms. The views expressed in this debate are summarized in a Communication Paper (European Commission, 2010b). Three likely policy options were identified (ibid., p.12):

- *gradual changes*: adjusting the distribution of direct payments so that they become more equitable;
- *major overhaul*: focus on sustainability, better targeted measures and the Europe 2020 objectives[40];
- *far reaching reform*: the CAP moves away from income support and market measures and instead focuses strongly on environmental and climate change objectives.

The effects of these different policy options still need be evaluated (European Commission, 2010b).

[39] SFPs have been reduced by 3% in 2005, 4% in 2006 and 5% in both 2007 and 2008 (Council Regulation (EC) No 1782/2003). Due to the "Health Check" review in 2008 modulation has increased to 7% in 2009, and will increase annually by one percentage point until 2012 (Council Regulation (EC) No 73/2009).

[40] see http://ec.europa.eu/europe2020/index_en.htm

It can be seen that whatever policy path the CAP will take after 2003, the measures will become more and more market oriented. It seems to be rather a question of pace: How fast will the CAP abandon market/trade distorting measures? But, given the recent price peaks in 2007 and 2008, one cannot rule out completely that countries may re-introduce trade barriers (i.e. higher tariffs or increased producer support).

This brief oversight of the development of the CAP paves the way for the final section. There, I will describe the different policy scenarios for the case study.

4.5.2 The Scenarios

Based on the findings above, I have developed following scenarios:

(1) *Base Scenario*;
(2) *Liberalization Scenario*;
  a. *Partial*
  b. *Full*
  c. *Future Outlook*
(3) *CAP Far Reaching Scenario;*
  a. *short-term*
  b. *mid-term*
(4) *Producer Support Scenario*.

The differences in assumptions between all scenarios can be seen in Table 8.

Table 8. Scenario characteristics

				Coupled direct payments	SFP	Tariffs	Price averages
1		Base		NO	YES	2010 MFN tariffs	06-09
2	a	Liberalization	partial	NO	YES	**- 40% (2010)**	06-09
	b		full	NO	YES	**- 100% (2010)**	06-09
	c		mid-term	NO	YES	**- 100% (2010)**	**10-19**
3	a	Far Reaching	short-term	NO	**NO**	**- 100% (2010)**	06-09
	b		mid-term	NO	**NO**	**- 100% (2010)**	**10-19**
4		Producer Support		**YES (2002)**	**NO**	**1996 MFN tariffs**	06-09

The base scenario (1) will represent the current budget scenario for Austrian farmers. It will include current domestic prices, tariffs and SFP payments.

The liberalization scenario (2) is assumed to depict various cases of possible CAP developments. The partial liberalization case (2a) represents a modest and realistic development of possible future CAP reforms. It assumes that currently applied MFN (most favorite nation) tariffs are cut by 40%. This should correspond to a situation where a possible DDA agreement has been reached (see section 2.1.2). Where no tariffs have been applied domestic prices will prevail (they are assumed to reflect international prices plus transmission costs[41]). SFP are still in place. The full liberalization case (2b)

[41] Without price support measure the transmission of international commodity prices can still depend on other factors such as: transaction, transport and informational costs between markets and differences in product attributes (OECD-FAO, 2010).

assumes that the EU will abolish all agricultural tariffs. The future outlook case (2c) then indicates how land use decision may change in the mid-term assuming full liberalization.

The 'CAP Far Reaching Scenario' (3) corresponds to a situation where further market oriented CAP reforms are undertaken such as the abolishment of SFP. I assume that such a reform would include tariff abolishment as well.

The producer support scenario (4) represents a case where old trade barriers, specifically coupled direct payments and higher tariffs are reintroduced. With regard to direct payments it depicts a situation prior to the CAP 2003 reform when many coupled direct payments were still in place. The year 2002 was chosen to be a reference point for this (see section 4.3.2.3). Tariff increases correspond to average tariff rates of the EU-15 in 1996 (i.e. before the URAA has been fully implemented). Domestic prices are the same as in the base scenario (1).

In addition, each general scenario will be run once with the assumption that agri-environmental premiums are eliminated (see Table 9). Such an assumption has also been made in studies by Schmid, Sinabell, & Hofreither (2007) and Acs et al. (2010). This could be helpful in order to show:

- the extent to which agri-environmental payments influence nitrate concentration and farm income;
- and if changes in trade policies have a different effect when agri-environmental payments are eliminated.

Table 9. Case study scenarios

		Agri-environmental premiums	
		YES	**NO**
Base		Scenario **1.1**	Scenario **1.2**
Liberalization	partial	Scenario **2a.1**	Scenario **2a.2**
	full	Scenario **2b.1**	Scenario **2b.2**
	mid-term	Scenario **2c.1**	Scenario **2c.2**
Far Reaching	short-term	Scenario **3a.1**	Scenario **3b.1**
	future	Scenario **3b.1**	Scenario **3b.2**
Producer Support		Scenario **4.1**	Scenario **5.2**

The next and final section of the case study part presents and discusses the results for the scenarios obtained from the Marchfeld model.

4.6 Results

I present the economic effects first (section 4.6.1). Then, I will show the results for nitrate concentration levels (section 4.6.2). Finally, I discuss the results with respect to the different land use and management decisions made in the scenarios (section 4.6.3).

4.6.1 Economic effects

The scenario results for average annual regional producer surplus (RPS) and net revenues per ha arable land are shown in Table 10.

Table 10. Scenario farm income results (own calculations)

Scenarios			Regional Producer Surplus [in Mill. €]	Net revenue per ha [in €]
Case 1: With agri-environmental premiums				
Base		1.1	56.89 (3.45)[1]	806.67 (48.87)
Liberalization	partial	2a.1	55.01 (3.73)	779.99 (52.95)
	full	2b.1	52.19 (3.94)	740.02 (55.88)
	mid-term	2c.1	55.63 (5.10)	788.83 (72.34)
Far Reaching	short-term	3a.1	25.04 (3.95)	355.04 (55.99)
	mid-term	3b.1	28.46 (5.01)	403.47 (70.97)
Producer Support		4	75.10 (9.91)	1064.84 (140.46)
Case 2: Without agri-environmental premiums				
Base		1.2	50.95 (3.25)	722.36 (46.10)
Liberalization	partial	2a.2	49.01 (3.30)	694.86 (46.73)
	full	2b.2	46.10 (3.66)	653.67 (51.83)
	future	2c.2	49.73 (5.03)	705.18 (71.27)
Far Reaching	short-term	3a.2	19.35 (3.80)	274.30 (53.89)
	mid-term	3b.2	22.74 (5.08)	322.48 (72.02)
Producer Support		4.2	70.30 (9.31)	996.72 (132.04)

[1]Standard deviations are given in parenthesis.

In the base scenario (1) RPS is €56.89 million in case 1 (with agri-environmental payments) and €50.95 million in case 2 (without agri-environmental payments). This gives net revenues per ha of €806.67 and €722.36, respectively.

Tariff reductions (2) are always accompanied by losses in farm income. A 40% tariff decrease (2a) will negatively affect RPS by 3.31% (or €1.88 million) in case 1 and by 3.81% (or €1.94 million) in case 2. This negative effect is amplified with the abolishment of all tariffs (2b). RPS then drops by 8.26% (or €4.70 million) in case 1 and by 9.51% (or €4.84 million) in case 2. This is in both cases more than double the effect of a 40% tariff reduction. However, higher future world prices will off-set the decreases of crop prices due to tariff abolishment. In the mid-term future (2c) losses in RPS will amount only to €1.26 million (or -2.21%) in case 1 and to €1.21 million (or -1.21%) in case 2.

Bigger losses in RPS could be experienced if the CAP would remove all SFP (3). RPS is cut by more than half under almost all circumstances. In the short-term (3a) RPS decreases by 55.99% (or €31.85 million) in case 1 and by 62.03% (or € 31.60 million) in case 2. Again, higher future world prices mitigate the negative effect. Therefore losses are lower in the mid-term (3b), in particular 49.98% (or € 28.44 million) in case 1 and 55.36% (or € 28.20 million) in case 2.

Not surprisingly, the introduction of producer support measures increases farm income (4). The increases caused by these support policies are quite large. In case 1 RPS grows by 32% (or €18.21 million) and in case 2 by 37.98% (or €19.35 million).

The differentiation between case 1 and case 2 shows that agri-environmental payments contribute a significant amount to farm income (see also Figure 11). In absolute terms the differences are very similar and range from €4.8 million in the support scenario (4.1 compared to 4.2) to €6.1 million in the full liberalization scenario (2b.1 compared to 2b.2). The lower total RPS the higher is the share of agri-environmental premiums in total RPS. Hence, the abolishment of agri-environmental premiums leads to income losses of more than 20% in the far reaching scenario (both in the short- and mid-term), whereas it only decrease income by 6% in the producer support scenario.

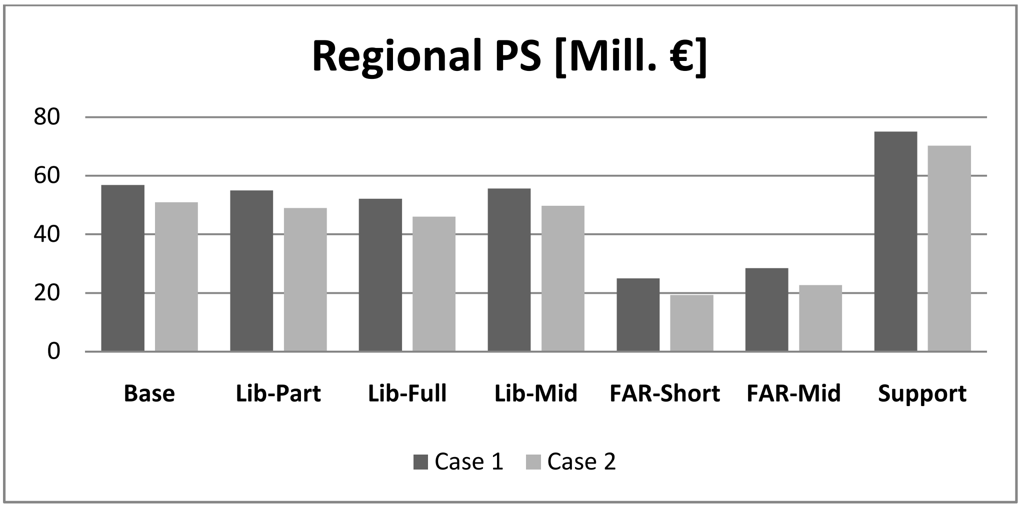

Figure 11. Average annual regional producer surplus (own calculations)

The direction of RPS effects induced by the scenarios is the same whether agri-environmental premiums are included or not. Figure 12 can illustrate this quite well by showing the percentage changes in RPS compared to the base scenarios. It also shows that the effects in the liberalization scenarios are relatively moderate whereas significant changes occur in the far reaching and support scenarios.

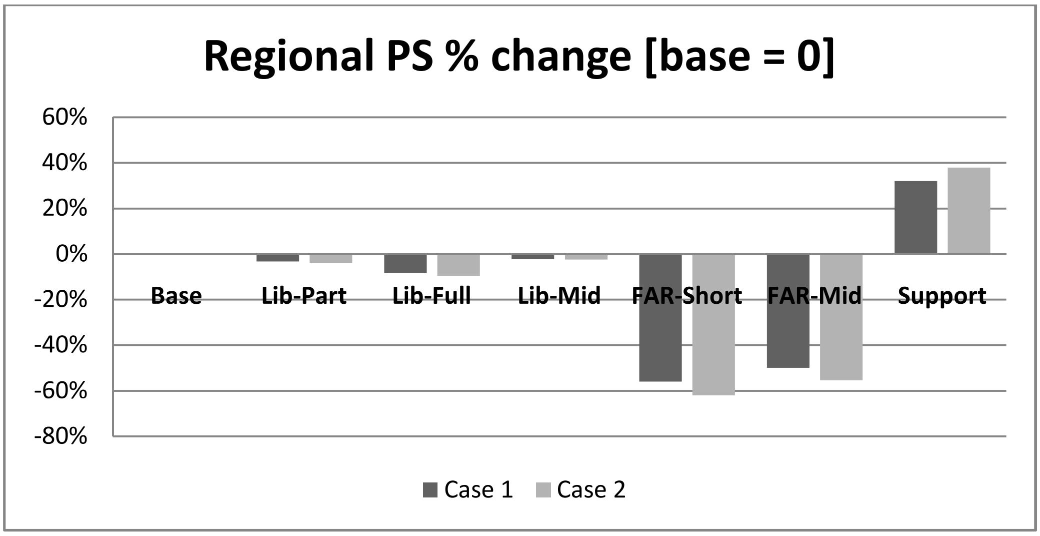

Figure 12. Change of producer surplus in percentage terms (own calculations)

4.6.2 Environmental effects

The environmental effects of the scenarios are given in Table 11.

In the base scenario (1) average annual NO_3 concentration levels in percolation water are 59.76 mg/l in case 1 and 84.60 mg/l in case 2.

Table 11. Environmental effects of the scenarios (own calculations)

Scenarios			Percolation water (mm)	Nitrate leaching (kg/ha)	NO_3 concentration (mg/l)
Case 1: With agri-environmental premiums					
Base		1.1	49.03 (26.06)[1]	4.29 (1.83)	59.76 (84.15)
Liberalization	partial	2a.1	49.03 (26.06)	4.29 (1.83)	59.76 (84.15)
	full	2b.1	49.18 (26.17)	4.43 (1.88)	61.26 (85.53)
	future	2c.1	49.08 (26.31)	4.18 (1.67)	59.23 (83.19)
Far Reaching	short-term	3a.1	46.09 (25.29)	3.74 (1.48)	56.99 (81.14)
	mid-term	3b.1	49.08 (26.31)	4.18 (1.67)	59.23 (83.19)
Producer Support		4.1	50.68 (27.34)	4.70 (1.93)	62.46 (84.97)
Case 2: Without agri-environmental premiums					
Base		1.2	56.81 (31.85)	8.10 (3.22)	84.60 (86.28)
Liberalization	partial	2a.2	56.82 (31.85)	7.98 (3.13)	83.90 (86.17)
	full	2b.2	56.82 (31.84)	7.98 (3.13)	83.88 (86.18)
	future	2c.2	56.88 (31.94)	8.01 (3.14)	83.27 (83.33)
Far Reaching	short-term	3a.2	45.72 (28.22)	5.58 (2.47)	75.07 (77.02)
	mid-term	3b.2	47.16 (28.59)	6.01 (2.55)	76.26 (72.59)
Producer Support		4.2	56.74 (31.68)	8.10 (3.21)	84.59 (86.03)

[1]Standard deviations are given in parenthesis.

Hardly any effects on NO_3 concentrations can be found in the liberalization scenarios (2). In case 1 not even a 40% tariff reduction (2a.1) is sufficient to induce changes in land use and management decisions. They are the same as in the base scenario and thus are NO_3 concentration levels. In all other variations and cases land use and management decisions do change. But they change so marginally that no actual effects can be identified.

Far reaching CAP reforms (3) seem to have positively moderate effects on the environment. In the short term (3a) they can reduce NO_3 concentrations by 4.63% in case 1 and by even 11.27% in case 2. The effects in the mid-term (3b) are insignificant in case 1 and but significant case 2 where NO_3 concentration decreases by 9.87%.

Producer support measures (4) have a significant effect in case 1. They will raise NO_3 concentration levels by about 5% to 62.49 mg/l. This is the highest level of NO_3 concentration of all scenarios. However, in case 2, NO_3 concentration levels are nearly the same as in the base scenario.

Figure 13 clearly depicts the large differences in NO_3 concentration levels between case 1 and case 2. The abolishment of agri-environmental payments has a vast effect on NO_3 concentration levels. In every scenario, except one, they increase by more than 30%. The lowest increase takes place in the far reaching mid-term scenario (3b.2) with 29% and the largest takes place in the base scenario (1.2) with 41.57% (compared to 3b.1 and 1.1, respectively).

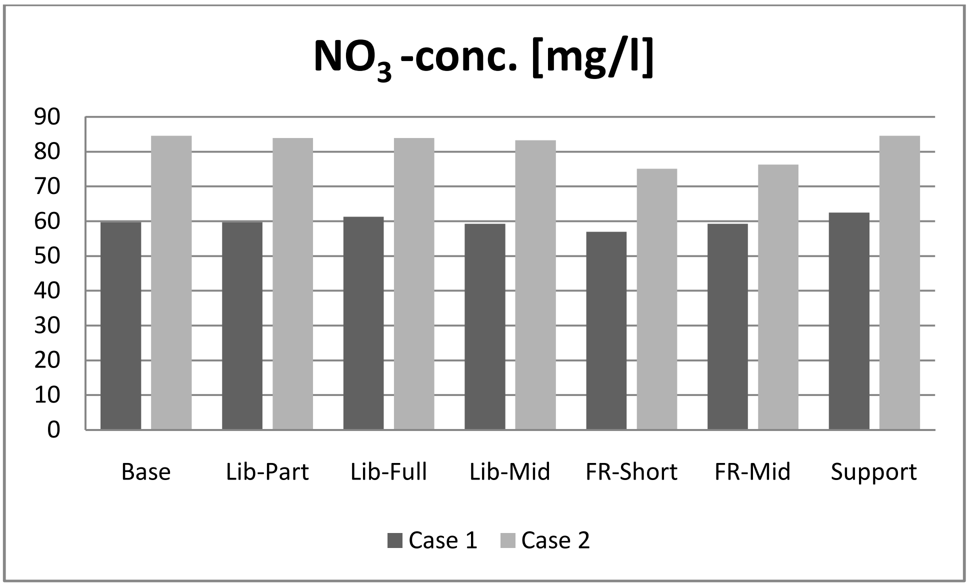

Figure 13. NO_3 concentrations in percolation water (own calculations)

Furthermore the abolishment of agri-environmental payments has some effects on the relative magnitude and the direction of impacts (see Figure 14):

- A 40% tariff reduction (2a) starts to affect NO_3 concentrations (although insignificantly);
- Full liberalization now negatively effects NO_3 concentrations (although only by about 2%);
- The positive effect on the environment of the far reaching scenarios becomes even more significant (in relative terms);
- Producer support ceases to affect NO_3 concentrations significantly.

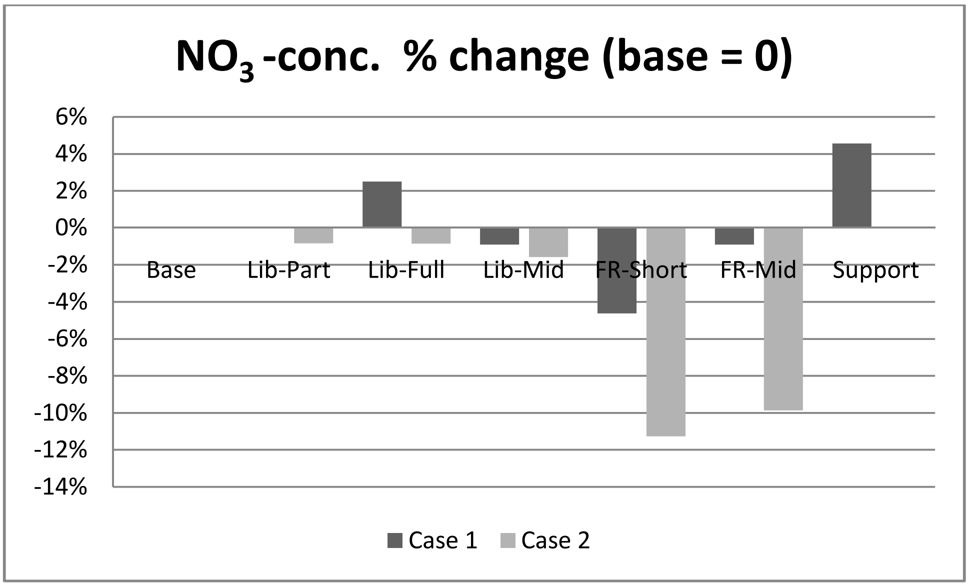

Figure 14. Change of NO_3 concentrations in percolation water (own calculations)

The next section will discuss the results with respect to land use and management decisions undertaken in the different scenarios.

4.6.3 Effects on land use and management decisions

The economic effects of the different scenarios are unambiguous and as expected. Lower prices due to tariff reductions will lower regional income whereas increased producer support will enhance the profitability of arable land.

What has to be noted in particular is that the abolishment of SFP payments does not only have a large effect on RPS but also on land use choice. The sharp decline in profitability in this scenario causes some land to be abandoned. In particular, 1573 hectares of arable land (which is 2.2% of total area) are not used for agricultural production in the far reaching short-term scenario in case 1 (3a.1). With the abolishment of agri-environmental payments (case 2) this effect is further magnified. It will increase land abandonment in the far reaching short-term scenario (3a.1) to 5367 hectare (7.6% of total area) and will also lead to land abandonment in the mid-term (3b.2), namely 4639 hectare (6.6% of total area). All land abandonment occurs solely on soil type five in region four. The reasons for this may be found in the fact that (see 4.3.1):

- soil type five has the most unfavorable conditions with respect to crop production,
- and region four has the largest share of soil type five (27%).

In order to explain the outcomes of the scenario results (both economic and environmental) it is now reasonable to take a look at the changes in land use and management decisions cause by trade policy changes.

When looking at the changes in the choice of crop rotation system mixes the most striking finding is that no changes occur in the liberalization (2) and far reaching (3) scenarios (see Table 20 in the appendix section 7.5). That is, changes in trade policies have no effect on crop rotation system mix choices (compared to the base scenario). The choice of crop rotation system mixes only changes in the producer support scenario (4) for region 2. Still, the share of crop rotation systems does change in the far reaching scenarios (3)[42] due to land abandonment. Therefore, the differences in environmental outcomes may be rather caused by different choices in management decisions than by changes in crop rotation systems.

The different shares of possible combinations of management decisions (i.e. tillage practices, straw harvest and agri-environmental measures) between the scenarios are given in Table 12. Only seven out of 16 possible combinations (see Table 21 in the appendix) can be found in the optimal solutions over all scenarios. Combinations that contain no straw harvest (labeled as base) are entirely disregarded in all scenarios. From the remaining eight possible combinations only one combination was left out of the optimal solutions among all scenarios, namely reduced tillage (redu) plus straw harvest (straw) plus fertilizer measures (meas). Table 12 also shows that if one differentiates between the two cases only five possible combinations are found in case 1 and four in case 2.

Table 12 includes a ranking of expected average annual NO_3 concentration levels between the management combinations. These averages are calculated from EPIC estimates. This ranking can only give an indication since the environmental outcomes of management decisions will further differ between soils (this can be seen in the unusually high concentration levels). Given the small variations between the scenarios further disaggregation into soils is omitted. This ranking may still be a

[42] No change occurs in the mid-term far reaching scenario in case 1 (3b.1) because no land abandonment takes place.

sufficiently useful indicator to explain the differences. While combination 1 is likely to have the highest nitrate concentration levels, combination 4 is likely to have the lowest.

For example, it may be used to explain the vast difference in NO_3 concentration between case 1 and case 2. The applied management combinations vary largely between the two cases. While combination 4 - the one with the lowest NO_3 concentration ranking - has by far the highest share in case 1 it is not being at all applied in case 2. Combination 1 – the one with the highest NO_3 concentration ranking - makes up more than 50% of the total share among all scenarios in case 2. In case 1 this combinations are rarely applied. Hence it is the choice of different land management decisions that mainly affects the differences in NO_3 concentration levels between the two cases. I will try to identify next if this can also explains that different outcomes between the scenarios.

Table 12. Share of possible management combinations in the scenarios (own calculations)

Scenarios			Comb. 1	Comb. 2	Comb. 3	Comb. 4	Comb. 5	Comb. 6	Comb. 7
Tillage (conv/mini/redu)			conv	conv	conv	conv	mini	mini	redu
Straw (base/straw)			straw	straw	straw	straw	straw	straw	straw
Agri-environmental measures (base/meas/covC/mCov)			base	meas	covC	mCov	base	meas	base
Average NO_3-conc. in mg/l (std dev)			134.32 (75.12)	110.87 (75.88)	108.13 (79.98)	80.83 (83.87)	89.95 (82.00)	103.06 (85.27)	85.96 (83.33)
Nitrate pollution ranking			(1)	(2)	(3)	(7)	(5)	(4)	(6)
Case 1: With agri-environmental premiums									
Base		1.1	-	14.73%	-	83.39%	-	1.88%	-
Liberalization	partial	2a.1	-	14.73%	-	83.39%	-	1.88%	-
	full	2b.1	-	15.98%	-	82.14%	-	1.88%	-
	future	2c.1	-	15.63%	-	83.39%	-	0.98%	-
Far Reaching	short-term	3a.1	-	17.45%	-	82.43%	-	0.12%	-
	mid-term	3b.1	-	15.63%	-	83.39%	-	0.98%	-
Producer Support		4.1	5.09%	26.58%	0.87%	65.59%	-	1.88%	-
Case 2: Without agri-environmental premiums									
Base		1.2	54.99%	0.35%	-	-	43.09%	-	1.58%
Liberalization	partial	2a.2	55.25%	0.35%	-	-	42.82%	-	1.58%
	full	2b.2	55.25%	-	-	-	43.17%	-	1.58%
	future	2c.2	54.72%	-	-	-	43.23%	-	2.05%
Far Reaching	short-term	3a.2	58.03%	-	-	-	39.59%	-	2.37%
	mid-term	3b.2	57.00%	-	-	-	39.52%	-	3.47%
Producer Support		4.2	59.60%	0.60%	-	-	35.03%	-	4.77%

conv … conventional; mini … minimum; redu … reduced;
straw … straw harvest;
base … usual fertilizer regime; meas … fertilizer splitting and reduced N fertilizer amounts; covC … cover crop system;
mCov … management measures plus cover crops;

Figure 15 (as well as Figure 22 to Figure 24 in the appendix section 7.5) shows the differences between combined management decisions for case 1. No actual differences can be observed for the liberalization scenarios (2.1). This is not surprising as it has been shown in the previous section that they do not lead to any significant changes in NO_3 concentration. A moderate change can be observed for the far reaching short-term scenario (3a.1). One would now actually expect more nitrate pollution since it increases the share of combination measures 2 (to 17.5%). Nevertheless this effect will be largely offset by land abandonment. Significant changes can be clearly identified in the producer support scenario (4.1). The share of more polluting combination measures increases (e.g. combination 2 increases by 80% to 27% and combinations 1 and 3 are also applied) while combination 4, the least polluting of all according to the ranking, drops sharply from 83% to 66%. It is thus not surprising to see that this scenario has the highest environmental impact.

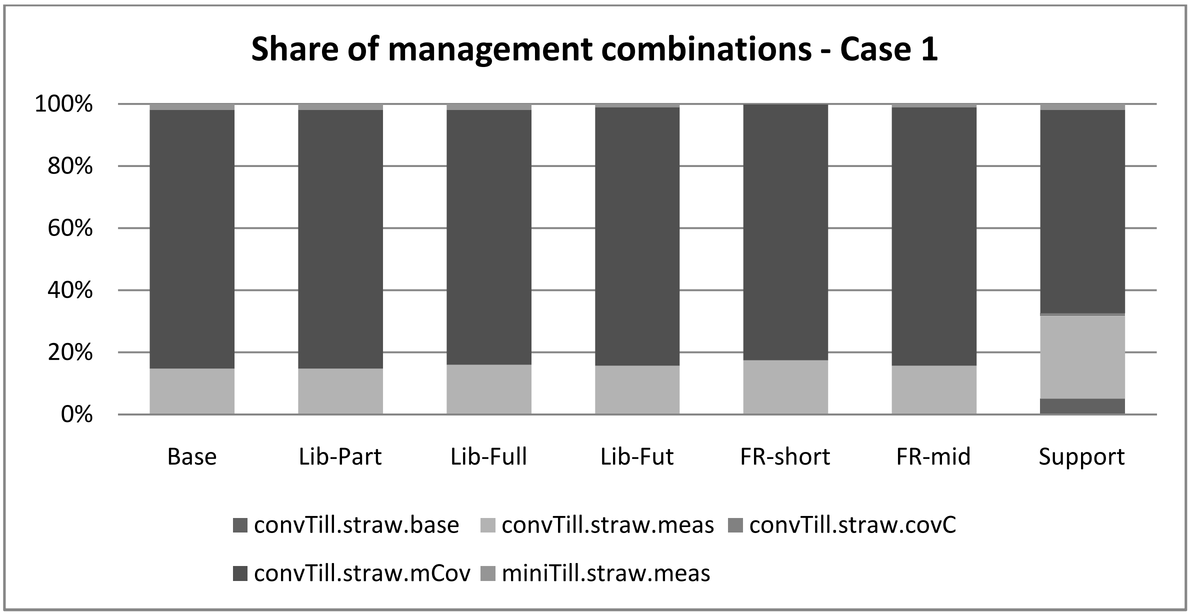

Figure 15. Share of possible measure combinations in case 1

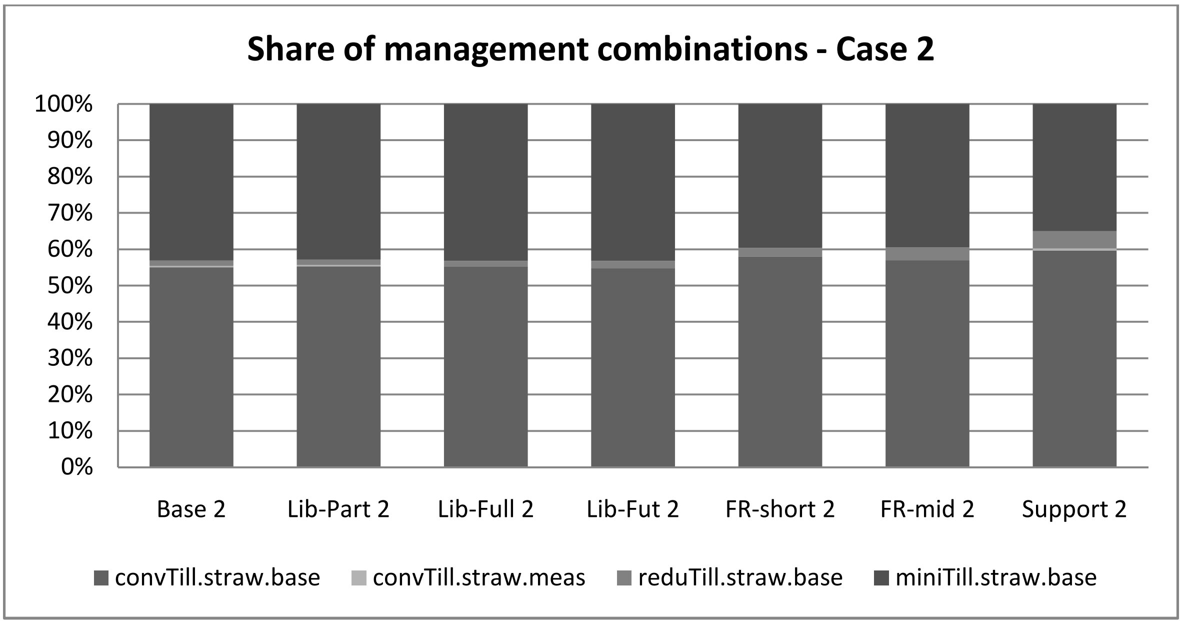

Figure 16. Share of possible measure combinations in case 2

Figure 16 (as well as Figure 25 to Figure 28 in the appendix section 7.5) depicts the differences in management combination shares for case 2. The effects in the liberalization scenario (2.2) are still insignificant. But moderate effects can be observed in the far reaching scenarios (3.2): One would expect increases in nitrate pollution due to a moderate decrease in the share of combination 5, which is usually associated with low pollution, and a moderate increase in the share of combination 1, which is likely to be have the highest NO_3 concentration. This negative effect may be mitigate by some extend by an increase in combination 6 (which is associated with lower NO_3 concentration) but the generally low nitrate concentration levels in the far reaching scenario can be mostly attributed to the significant amount of abandoned land. A similar but more significant pattern can be observed in the producer support scenario (4.2). As shown in the previous section, no significant changes in NO_3 concentration occur in the producer support scenario in case 2. It seems as if the negative effect of increases in combination 1 and the positive effect of increases in combination 6 may cancel themselves out.

These management decisions can of course be further disaggregated. It makes sense to focus on the differences in agri-environmental measures applied in the scenarios because they are more likely to influence nitrate run-off than straw or tillage practices. Especially since two of the three possible agri-environmental measures include measures that are aimed at reducing fertilization rates. Combined measures (mCov) are generally best at reducing NO_3 concentrations, followed by fertilizer measures (meas) and cover Crops (covC). Conventional measures (base) are likely to have the highest NO_3 concentration. Again, the actual outcomes may vary widely and depend on their combination with other management measures and on soil characteristics.

The abolishment of agri-environmental premiums (case 2) decreases the application of agri-environmental measures by almost 100% in all cases. In scenarios where measures are still applied there share is less than 1% and thus insignificant.

Figure 17 depicts the effects of the scenarios on agri-environmental measures for case 1. With agri-environmental premiums in place the most abundant agri-environmental measure applied is the combination of cover crops and measures to reduce fertilization rates (mCov). Its share is more than 80% in all but the producer support scenario. This is clearly a further indication why NO_3 concentration levels are so much lower in case 1 than in case 2. Not applying agri-environmental measures will very likely lead to more nitrate pollution.

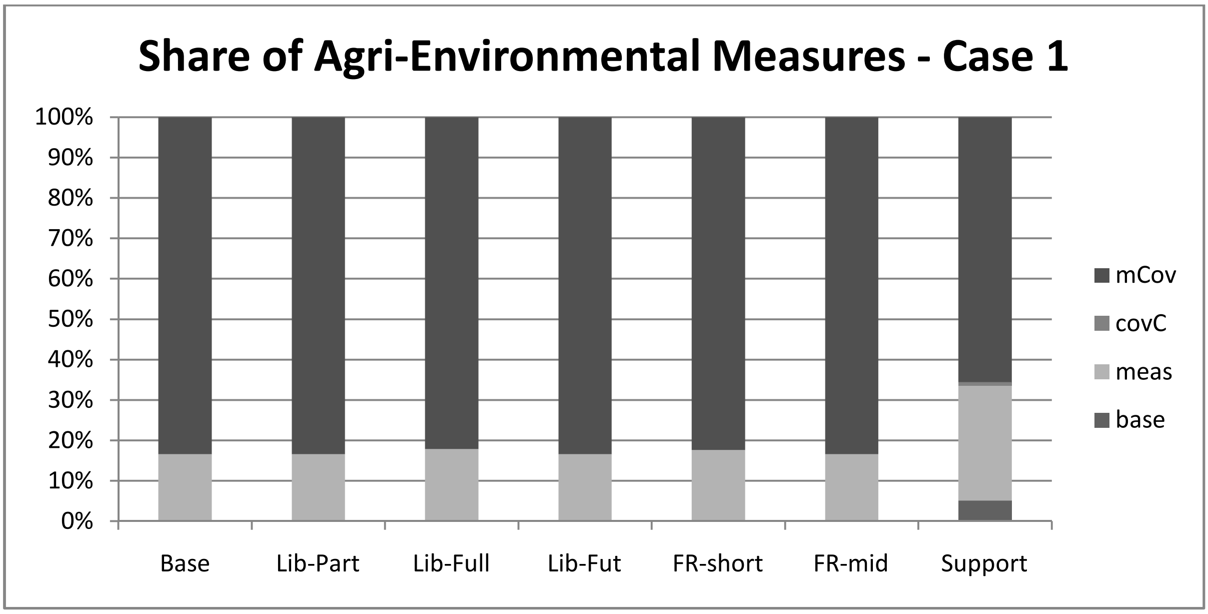

Figure 17. Share of agri-environmental measures in case 1

Some small changes occur in the full liberalization scenario (2a.1) and the far reaching short-term scenario (3a.1). In both scenarios the amount of combined measures (mCov) decreases by roughly

1.5 % whereby fertilizer measures (meas) increase by 8% in the full liberalization scenario and by 6% in the far reaching short-term scenario). The drop in combined measures may explain the high NO_3 concentration levels in the full liberalization scenario. Again, land abandonment can have offset this negative effect in the far reaching short-term scenario.

Significant changes are found in the producer support scenario (4.1) where the share of combined measures (mCov) drops to 66% (compared to 83% in the base scenario). In turn fertilizer measures (meas) increase by more than 70% to 28.46%. Producer support also leads to the application of cover crops (covC) and even to base measures, but the only make up an insignificantly small amount of the total share. Given the likely effects of the measures, it is becomes obvious why producer support has the highest NO_3 concentration levels in case 1.

4.6.4 Sensitivity Analysis

As mentioned in section 4.3.1, I have constructed artificial crop rotation system mixes for all region and soils that do not deviate more than 20% from the original observed share. In order to see if my results are robust to changes in the artificial shares, I have applied a sensitivity analysis. The allowed deviation range from the observed share is increased to 50% and the constraint is dropped.

Figure 18 and Figure 19 show how changes in the artificial crop rotation system mixes may influence regional PS. The results seem to be quite robust. Without a constraint the changes in regional PS are more moderate for the far reaching (3) as well as producer support scenarios (4), but the direction of impact is the same in all scenarios.

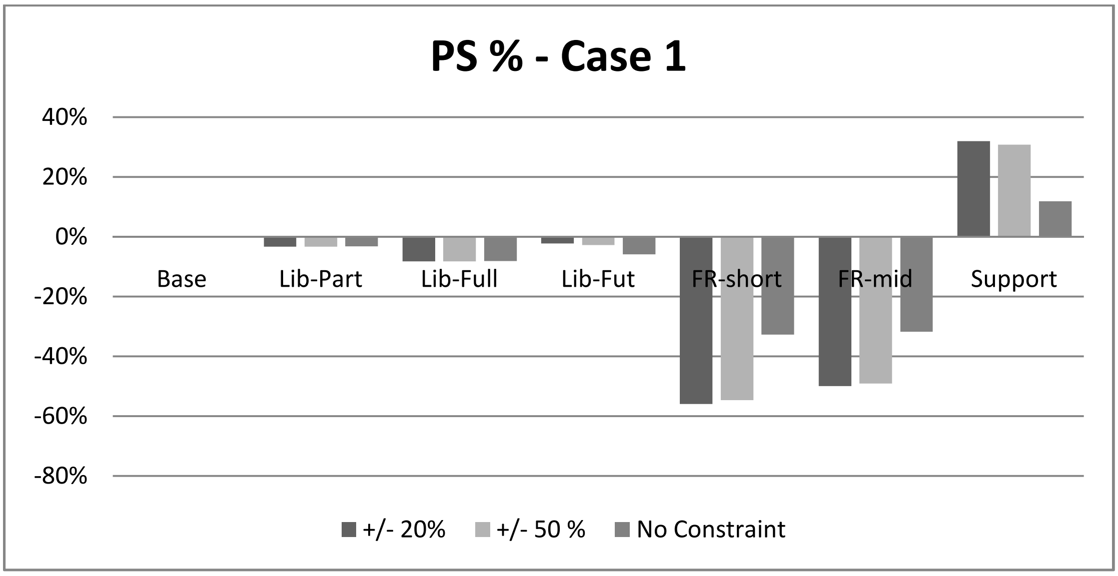

Figure 18. Sensitivity analysis for regional PS – case 1

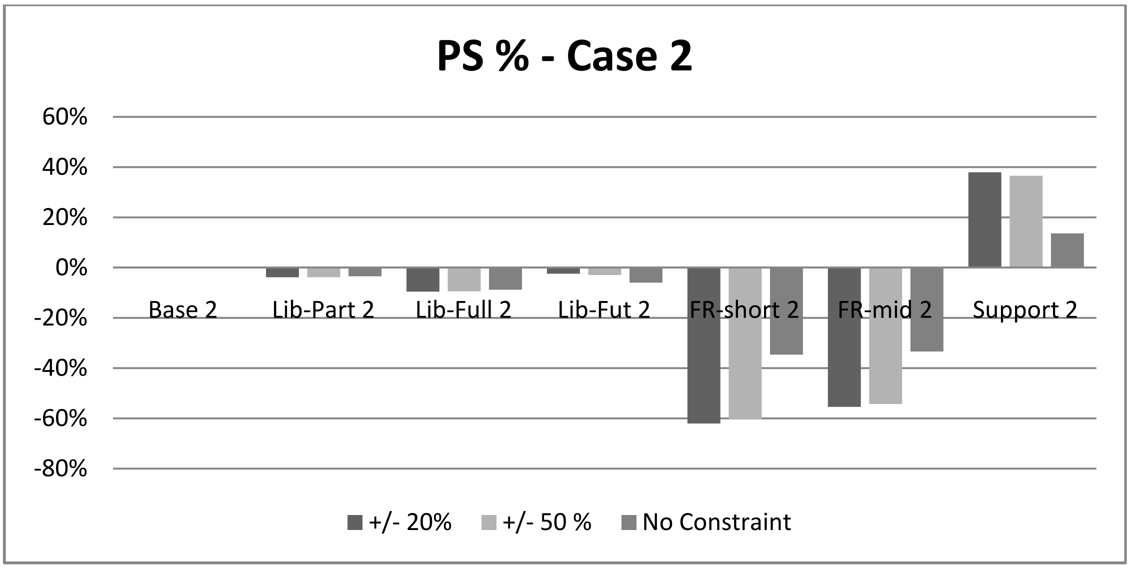

Figure 19. Sensitivity analysis for regional PS – case 2

The results are less robust for nitrate concentration levels, but still within an acceptable range. This is illustrated in Figure 20 and Figure 21. The changes in the liberalization scenarios (2) are very low in both cases. Changes in the far reaching scenario (3) are also very modest except in case 1 for the short term variation (3a.1) when no constraints are included. The change in this particular scenario is quite substantial. The direction of impact changes (i.e. it leads to more nitrate pollution) and the impact is very significant (nitrate pollution will increase by more than 13%). Eliminating the constraint magnifies the effects of the producer support scenarios but leads to no change in the direction of impact.

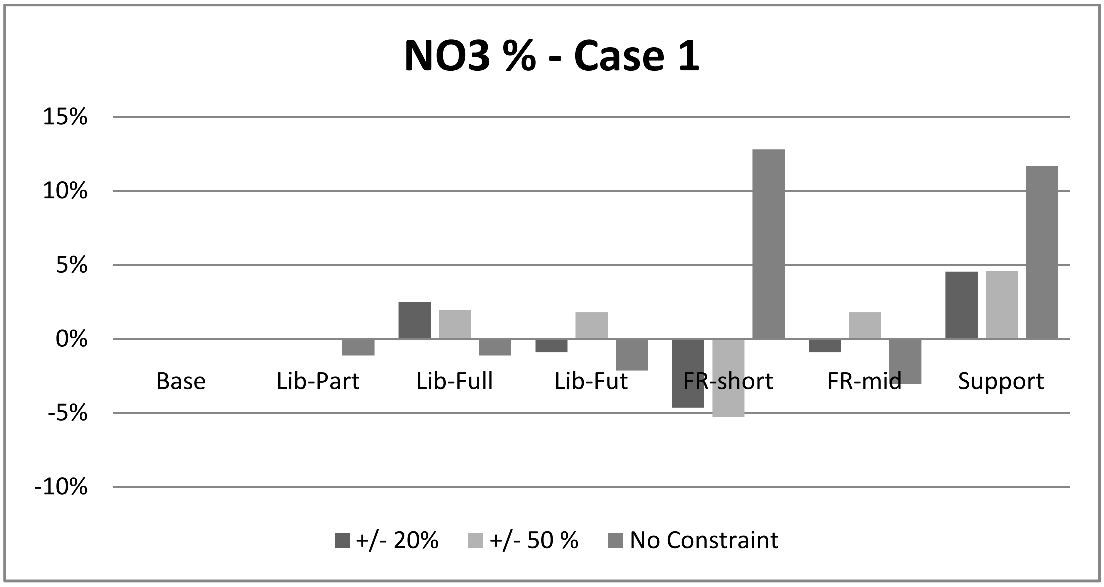

Figure 20. Sensitivity analysis for nitrate concentration – case 1

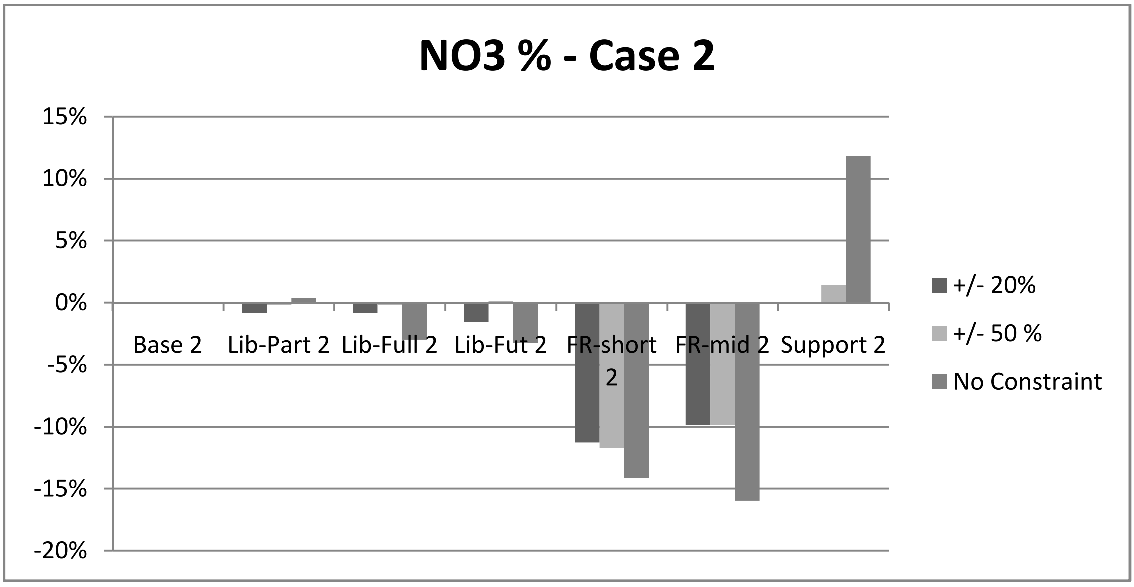

Figure 21. Sensitivity analysis for nitrate concentration – case 2

Despite the extreme outbreak in the short-term far reaching scenario, I may conclude that my results are in general quite robust. However, the sensitivity analysis indicates that if farmers are assumed to adapt quickly to prices changes (i.e. they are not risk averse), the environmental effects of trade policy changes may become more significant (especially if the changes are far reaching).

In the fifth section of this thesis, I provide answers for the research questions asked at the beginning of the case study section (4.1). This is followed by some concluding remarks and notes on future research issues.

5 Conclusion

My first research question "Does agricultural production have a significant influence on nitrate concentration in groundwater?" has already been answered in section 4.2. There, I provided enough evidence from other empirical studies in order to be able to conclude that agriculture does indeed significantly affect nitrate leaching in groundwater (in Marchfeld).

Having presented the results from the Marchfeld model analysis in the previous section, I can now begin to provide answers for the remaining three questions.

Can changes in trade policies significantly alter agricultural land use and management decisions?

The results can of course only speak for the region Marchfeld but it seems that tariff reductions will not have significant effects on land use decisions. In the most likely case, that is agri-environmental payments will continue to be provided in the future, the choice of crop rotation systems will be unaffected by trade liberalization. Changes in management decisions are also negligible.

If trade liberalization is accompanied by far reaching CAP reforms (i.e. the abolishment of SFP) this could have significant effects, depending on the development of future world prices. I have shown that the abolishment of SFP could reduce the profitability of land to a point where costs outweigh revenue. A study by Acs, et al. (2010) derived similar results[43]. Two things should be pointed out here. First, if world prices continue to rise this can offset the decline in profitability[44]. Second, given the EU policies on bioenergy and its 2020 targets[45], it could happen that farmers start to produce biomass instead of food crops in Marchfeld. It would be very interesting to include this option in future research.

The re-introduction of producer support has the most significant effects on land use decisions. This is not surprising given the high levels of tariffs and coupled direct payments.

I may conclude that *agricultural trade has in fact already been liberalized to a level where further changes will only have minor effects on land use and management decisions in Marchfeld*. However, if domestic producer support is also abolished this may indeed lead to substantial changes and perhaps also to the adoption of new agricultural products, for example, biomass for energy products.

Are support policies likely to increase environmental pressure?

In the most realistic case (i.e. agri-environmental premiums are in place) producer support leads to more nitrate pollution in Marchfeld. It will increase the incentive to use combinations of management measures that are likely to increase nitrate concentration. Without agri-environmental premiums the incentives are somewhat the same but hardly any changes occur in nitrate concentration levels. After all, *there is some indication that coupled direct payments and higher tariffs may increase nitrate pollution in the Marchfeld*. This is in accordance with the findings of Sinabell (2009) who showed in a regression analysis that support policies are linked to higher nitrate pollution in Austria (see section 4.2.2).

Is trade liberalization likely to decrease environmental pressure?

In general, tariff reductions or abolishment seem to have insignificant effects on NO_3 concentration levels. This is not surprising if one considers the very small effects of tariff changes on land use and management decisions.

Changes become more significant if trade liberalization is accompanied by the abolishment of domestic producer support measures (i.e. SFP). In this case, NO_3 concentration levels are likely to decline. While it seems that these policies do increase the incentive to adopt management measures which are likely to increase nitrate pollution, it may be offset by land abandonment. It is unlikely that abandoned land will be set aside for a long time. One will have to identify possible future land uses and their environmental effects (i.e. the production of biomass). Such an option has been omitted in the case study. In addition, agri-environmental measures (if in place) are going to make up a more significant part of total farm income. This supports to some extent the results of a study by Schmid & Sinabell (2007) who found that agri-environmental measures will play a more important role in production decisions when direct payments are decoupled.

[43] Acs, et al. (2010) analyzed the effects of six different CAP policy scenarios on marginal agricultural systems. They conducted a case study on six hill farms in the UK's Peak District National Park. The extreme scenario (no SFP and no agri-environmental payments) would lead to large land abandonment and negative farm incomes for all but one farm.

[44] However, costs may also rise.

[45] http://ec.europa.eu/europe2020/index_en.htm (retrieved at 2011-02-24)

I may conclude that *trade liberalization has negligible effects on nitrate pollution depending on the magnitude of reforms*. Therefore, it can be assumed that changes in trade policies will hardly play a significant role with regard to nitrate pollution in Marchfeld. Even if the environmental changes were negative, it is reasonable to suggest that they would be relatively low compared to possible welfare gains (see section 3.1.1).

Furthermore, by differentiating between a case with agri-environmental payments and one without, I was able to show that *domestic environmental policies have a far more significant effect on nitrate pollution*. This shows that trade policies should only be used as a substitute for environmental policies (such as agri-environmental payments or taxes on nitrogen fertilizer) if no other option is available (and externalities are influenced by freer trade). Hence, these findings show that trade policies are – at best – only 'second-best' policy options in order to mitigate nitrate pollution. This reasoning can be found in many other papers (see section 3). Markandya (2000, p. 108f) concludes that "in fact, one could argue that in all cases where negative impacts have been identified, some environmental protection policies that were acceptable from a trade point of view could have been introduced to reduce that impact."

I agree with Maltais, Nilsson, & Persson (2002) who argue that how sustainable agriculture ultimately performs may depend more on domestic EU policies than on trade agreements (for example: agri-environmental measures). They say that enough possibilities exist within the WTO trade rule system to implement domestic policies that aim to promote sustainability. This view is also supported by Glebe (2006). The focus of these policies needs to move away from production and needs to be more objective driven (e.g. based on multifunctionality demands). To do so, minimal trade distorting policies need to be put in place, as well as market-based environmental protection schemes and rural-development policies. As has been shown, the CAP seems to move further into this direction. Moreover, increased access to world markets for low-income countries is a global sustainability issues that the EU has to take into account (as well as all other OECD countries).

Recommendations for future research

Given the strong assumptions of the model, there is space for manifold improvements and the results should be interpreted carefully. After all, they are only able to give an **indication** of how the different trade policies may influence nitrate pollution. A more holistic assessment may be needed in order to derive more conclusive results. This could be done by extending the model to the following:

- Farmers' risk behavior needs to be taken into account, especially given the high price volatilities in agricultural world markets;
- Climate change effects should be included to predict more accurate results for the foreseeable future;
- Better calibration of the model to observed data by using the method of positive mathematical programming;
- The inclusion of:
    - more environmental indicators, such as soil erosion and greenhouse gas emissions, biodiversity and landscape amenities;
    - multifunctionality indicators;
    - 'new' agricultural products in Marchfeld, for example, biomass;
    - social indicators in order to be able to make sustainable impact assessments.

It may be important to keep in mind that the "limits on current knowledge of the relevant parameters are likely to require considerable humility about the ability to capture the magnitude, or even the sign, of many important impacts [of trade liberalization]" (Martin, 2000, p. 230) and that "the dynamic and intricate nature of the problem and its complex interactions pose a challenge" (Jayadevappa & Chhatre, 2000, p. 187f). But this is not to say that it is impossible. Many advances have been made in integrating bio-physical simulation models with economic models. Combining such models "results in a powerful tool to reduce uncertainties in the natural and social environment and generates sufficient information to analyze economic and environmental policy implications, efficiently" (Schmid & Sinabell, N.A., p. 8).

Focus should thus be put on further improving such integrated modeling approaches for assessing (trade) policy impacts. While I do believe that trade policies will continue to play an important role in the future, I recognize that the focus should and will shift from traditional barriers such as tariffs and (coupled) direct payments to more implicit barriers such as technical barriers to trade. 'Hidden' trade barriers will gain in significance due to the today's comparatively low levels of traditional barriers. For example, Glebe (2006) assumes that the inclusion of agri-environmental payments in the WTO's green box may be challenged by other countries in future negotiations. It is feared by some that 'green' policies may be used as disguised protectionist measures. The challenge will thus lie in finding effective and efficient environmental domestic policies that are legitimized under WTO rules. It seems reasonable to suggest that agri-environmental measures would fall into such a category. This view is also supported by Glebe (2006).

Research on the trade-environment issue should continue. I have shown that no conclusive results have been derived so far. And while most studies, including mine, indicate that domestic policies play a much more significant role than trade policies this may not be true for low- or even middle-income countries. The EU has the possibilities and the capacity to implement efficient mitigation measures where trade may magnify negative externalities. Focus in the trade-environment issue should thus be turned to countries where adequate institutional frameworks do not exist. There, trade policies likely have a far more significant impact on the environment.

6 Glossary

CAP- Common Agricultural Policy

CEC - Commission for Environmental Cooperation

CTE - Committee on Trade and Environment

DDA – Doha Development Agenda

EC – European Commission

EPIC – Environment Policy Integrated Climate

GATT - General Agreement on Tariffs and Trade

GAMS - General Algebraic Modeling System

GTAP – Global Trade Analysis Project

MEA – Multinational Environmental Agreement

NAFTA - North American Free Trade Agreement

NGO – Non-governmental organizations

LDC – Less developed countries

LU – Livestock unit

OECD - Organization of Economic Co-operation and Development

ÖPUL - Österreichischen Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft (Austrian agri-environmental programme)

RPS – Regional producer surplus

PASMA - Positive Agricultural Sector Model Austria

PSE – Production Surplus Equivalent

SFP – Single Farm Payments

SIA – Sustainable Impact Assessment

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management)

UNCTAD - United Nations Committee on Trade and Development

URAA – Uruguay Round Agreement on Agriculture

WTO – World Trade Organization

7 Appendix

7.1 Modeling approaches

Ervin (2000, p. 122) gives a good overview of models used for studying trade-environment linkages:

- **Partial equilibrium models:**

Econometric (static) supply and demand functions for agricultural commodities are used to estimate changes in inputs (e.g. fertilizer, land), outputs and prices. Changes in environmental loadings with coarse geographic resolution are generally inferred. The advantages are relatively low data demands, the high level of product disaggregation (Morrisey, te Velde, Gillson, & Wiggins, 2005) and an easy interpretation of model output. Further, partial equilibrium models can often capture the vast majority of the impact at a much lower cost with respect to analyst time (compared to micro-level studies). An apparent limitation of partial equilibrium models is their absence of linkages to other sectors of the economy.

- **General equilibrium models:**

Econometric models of the agricultural and non-agricultural sectors are constructed which incorporate the horizontal relationships between the sectors and the vertical relationships with input supply and processing. Market-clearing price and quantity adjustments are estimated and the models are usually static. Input and output effects are used to infer environmental changes. According to Morrisey, te Velde, Gillson, & Wiggins (2005) their advantages lie in capturing the interactions at a global level, but this is done at the cost of a relatively aggregate product level. Additionally, the underlying assumption can be quite strong.
Advances have been made in including environmental data in general equilibrium models, according to Markandya (2000, p. 106), but there are some limitations, and the key problem is that "the models have many parameters that cannot be determined empirically with any real accuracy" which leaves a broad area of uncertainty. Nevertheless, computable general equilibrium (CGE) models using the Global Trade Analysis Project (GTAP) [46] have made substantial progress in linking economic models with environmental indicators.

- **Mathematical programming models:**

In this approach, static or dynamic models of agricultural production and resource use for regions or a nation are developed which allocate resources based on satisfying an objective function (e.g. profit maximization) subject to a set of constraints, such as amounts of land in various classes. Prices and costs are generally determined outside the model and only few if any horizontal economic linkages are included. It is usually a static model. Environmental effects are often imputed from estimated input and output shifts.

- **Economic-environmental simulation models:**

Econometric or simulation models of production input and output choices are developed based on farmers' behavior. Prices and costs are determined external to model. There are only few

[46] GTAP is a modeling framework established in 1992. It aims to help researches in conducting global trade analyses using general equilibrium models (Sullivan & Ingram, 2005). For further information see https://www.gtap.agecon.purdue.edu/default.asp.

horizontal or vertical economic linkages. The economic model is linked to an environmental process model that estimates changes in loadings and ambient environmental conditions. It can include risk dimensions and static and dynamic environmental feedback effects on production and consumption.

The essential element of all modeling approaches listed above is that they measure policy reforms with regard to their effects on prices (Morrisey, te Velde, Gillson, & Wiggins, 2005). The most important factor is thus the price change induced by trade liberalization and the response to these changes. This short-term static effect can be also captured by a land use optimization model. Clearly, this approach has the limitation that it does not include indirect effects or dynamic effects. Nevertheless, most other studies have also not included these type of effects, according to Morrisey, te Velde, Gillson, & Wiggins (2005).

Whatever model one uses depends on the question being asked (e.g. if it is used for policy analysis or forecasting) and, according to Martin (2000, p. 220), it may make more sense to concentrate on specific trade scenarios “rather than attempting to provide a complete benchmark forecast”. If one focuses on a global or on a regional level the choice of model will be determined by the character of environmental externalities which are of concern to the researcher (Martin, 2000). For example, transnational or global environmental externalities such as global warming need to be addressed at a global level whereas groundwater quality may only be of national/regional concern. Hence, mathematical programming models or economic-environmental simulation models may be suitable approaches for analyzing local effects.

The modeling approach chosen for the case study fells into both categories of “mathematical programming models” and “economic-environmental simulation models”. I have developed a land use optimization model which will be linked to estimates from the environmental simulation model EPIC. By doing so, I can estimate nitrate run-off into percolation water for the different policy scenarios. This model will be elaborated in detail in section 4.4.3.

My approach is different from what is most commonly used in other trade-environment studies. Since many of them analyze the environmental effects of trade liberalization in agriculture on a national or global level they typically use either partial or general equilibrium models. There is disagreement between researchers on how useful these two models are for such an analysis (Martin, 2000; Steininger, 1999; Tarasofsky, 2000). The CEC Secretariat (2000, p. 30) even states that both “general or partial equilibrium models are of ‘limited use’, largely because variables such as changes in technology, FDI, regulations or public choice tend to lie outside standard CGE models”. Hence the use of both partial and general equilibrium models should be taken with caution. Maltais, Nilsson, & Persson (2002) show that even models that use the same database may derive widely different results[47]. It is assumed that results from such models generally overestimate potential gains from trade liberalization (Morrisey, te Velde, Gillson, & Wiggins, 2005). These models may be an effective instrument for predicting trends but they seem to be less effective in predicting the significance of impacts (Maltais, Nilsson, & Persson, 2002).

[47] The differences are assumed to lie in different assumption of economic behavior, baseline data and liberalization scenarios (Maltais, Nilsson, & Persson, 2002).

7.2 Commodity prices

Table 13. Crop prices in € per ton (Statistics Austria, 2010)

	Domestic 2006 - 2009	OECD-FAO Outlook 2010-2019
rapeseeds	273,0	294,2
winter barley	110,2	135,7
winter rye	126,8	135,7
winter wheat	147,2	156,1
durum wheat	199,7	156,1
summer barley	132,6	135,7
field peas	127,9	-
sunflower	217,6	294,2
maize	129,4	135,7
sugar beet	31,0	-
potatoes	140,0	-
early potatoes	217,3	-
onions	152,7	-
carrots	55,9	-
spinach	82,1	-
green peas	281,8	-

7.3 Production costs

Table 14. Average production costs in €/ha (BMLFUW, 2008; Schmid & Sinabell, N.A.)

	SEED	MISCFERT	PEST	INSUR	HARVEST	VARMACH
winter rape seed	51	84	48	17	105	165
winter barley	68	69	34	17	100	171
winter rye	68	72	34	17	100	171
winter wheat	65	74	59,5	17	100	170
durum wheat	94	68	22	17	100	170
summer barley	57	68	30	17	100	170
field peas	69	73	104	17	105	132
sunflower	152	94	88	17	105	178
maize	150	89	60	17	120	137
sugar beet	188	175	293	17	457	450
potatoes	1096	193	575	-	-	653
early potatoes	1096	193	575	-	-	653
onions	645	100	426	92	518	0,0
carrots	917	125	351	92	298	0,0
spinach	272	90	194	15	116	0,0
green peas	218	62	137	15	15	93
fallow land	218	62	137	15	15	93

Table 15. Agri-environmental costs in €/ha (Schmid & Sinabell, N.A.).

	cover crops	reduced fertilzer measuers	measuers and cover crops	reduced tillage	minimum tillage	straw harvest
winter rape seed	-	-	18.5	-14.1	-28.6	-
winter barley	-	18.5	18.5	-14.1	-28.6	150
winter rye	-	18.5	18.5	-14.1	-28.6	150
winter wheat	-	18.5	18.5	-14.1	-28.6	150
durum wheat	60.2	78.7	18.5	-14.1	-28.6	150
summer barley	60.2	78.7	18.5	-14.1	-28.6	150
field peas	60.2	78.7	-	-14.1	-28.6	-
sunflower	60.2	78.7	18.5	-14.1	-28.6	-
maize	60.2	78.7	18.5	-14.1	-28.6	-
sugar beet	60.2	78.7	18.5	-6.1	-8.3	-
potatoes	60.2	78.7	18.5	-6.1	-8.3	-
early potatoes	60.2	78.7	18.5	-6.1	-8.3	-
onions	60.2	60.7	-	-6.1	-8.3	-
carrots	60.2	60.7	-	-6.1	-8.3	-
spinach	-	-	-	-6.1	-8.3	-
green peas	60.2	60.2		-6.1	-8.3	-

7.4 Tariffs and producer support

Table 16. Average MFN applied tariffs for the EU (WTO, 2010c).

	1996	2010
rape seeds	-	-
barley	55,6%	-
rye	71,8%	-
wheat	59,3%	12,8%
peas	11,5%	9,9%
sunflower seed	-	-
maize	17,3%	-
sugar beet	73,0%	-
potatoes	12,3%	10,1%
onions	11,2%	9,6%
carrot	15,9%	13,6%
spinach	12,1%	10,4%

Table 17. EU-27 tariffs by product groups – 2009 (WTO, 2010b).

Product groups	Final bound duties – average	MFN applied duties – average
Fruit, vegetables, plants	10.3	11.3
Cereals & preparations	21.3	17.5
Oilseeds, fats & oils	5.1	5.5
Sugars and confectionery	26.4	27.5

Table 18. EU-27 tariffs for selected crops – 2010 (WTO, 2010c)

Crops	MFN tariff - average	Bound tariff - average
Fresh carrots	13.6	13.6
Fresh onions	9.6	9.6
Fresh peas	9.9	9.9
Fresh spinach	10.4	10.4
Fresh potatoes	10.1	10.1
Wheat and meslin	12.8	12.8
Maize	-	-
Rye	-	-
Raw beet or cane sugar	-	-
Rape seeds	n.a.	-
Barley	-	-
Durum wheat	-	-

The World Bank uses the concept of Nominal Rate of Assistance (NRA[48]) as an indicator of total producer support. Their database provides NRA on individual crops for almost every country from the year 1955 until 2007. A selection of crops can be seen in Table 19. Total NRA for Austria in 2007 was about 0.14 (Anderson & Valenzuela, 2008).

Table 19. NRAs for selected crops in Austria – 2007 (Anderson & Valenzuela, 2008)

Crops	Nominal Rate of Assistance
Barley	-0.0000872
Maize	0.234113
Potato	0.0967736
Rapeseed	0.0001651
Sugar	0.9904364
Sunflower	0.0002624
Wheat	-0.0000893

[48] Total NRA by product = NRA to border price support + NRA to domestic price support (e.g. direct production subsidy) + NRA to input.

7.5 Land use and management decisions

Table 20. Choice of CRS mixes in the scenarios.

Region	Mix	Base	Lib-Part	Lib-Full	Lib-Fut	FR-short	FR-mid	Support
				Case 1: With agri-environmental premiums				
Reg 1	Mix 1	YES	YES	YES	YES	YES	YES	YES
Reg 2	Mix 1	YES	YES	YES	YES	YES	YES	-
Reg 2	Mix 3	-	-	-	-	-	-	YES
Reg 3	Mix 2	YES	YES	YES	YES	YES	YES	YES
Reg 4	Mix 2	YES	YES	YES	YES	YES	YES	YES
Reg 5	Mix 3	YES	YES	YES	YES	YES	YES	YES
				Case 2: Without agri-environmental premiums				
Reg 1	Mix 1	YES	YES	YES	YES	YES	YES	YES
Reg 2	Mix 1	YES	YES	YES	YES	YES	YES	-
Reg 2	Mix 3	-	-	-	-	-	-	YES
Reg 3	Mix 2	YES	YES	YES	YES	YES	YES	YES
Reg 4	Mix 2	YES	YES	YES	YES	YES	YES	YES
Reg 5	Mix 3	YES	YES	YES	YES	YES	YES	YES

Table 21. All possible combinations of management decisions.

Included in the solutions	Number	Tillage Practices	Straw Harvest	Agri-environmental measures
NO	-	conventional (conv.)	NO (base)	base
NO	-	conventional (conv.)	NO (base)	fertilizer measure (measure)
NO	-	conventional (conv.)	NO (base)	cover crops (covC)
NO	-	conventional (conv.)	NO (base)	measures and cover crops (mCov)
YES	1	conventional (conv.)	YES (straw)	base
YES	2	conventional (conv.)	YES (straw)	fertilizer measure (measure)
YES	3	conventional (conv.)	YES (straw)	cover crops (covC)
YES	4	conventional (conv.)	YES (straw)	measures and cover crops (mCov)
NO	-	minimum (mini.)	NO (base)	base
NO	-	minimum (mini.)	NO (base)	fertilizer measure (measure)
YES	5	minimum (mini.)	YES (straw)	base
YES	6	minimum (mini.)	YES (straw)	fertilizer measure (measure)
NO	-	reduced (redu.)	NO (base)	base
NO	-	reduced (redu.)	NO (base)	fertilizer measure (measure)
YES	7	reduced (redu.)	YES (straw)	base
NO	-	reduced (redu.)	YES (straw)	fertilizer measure (measure)

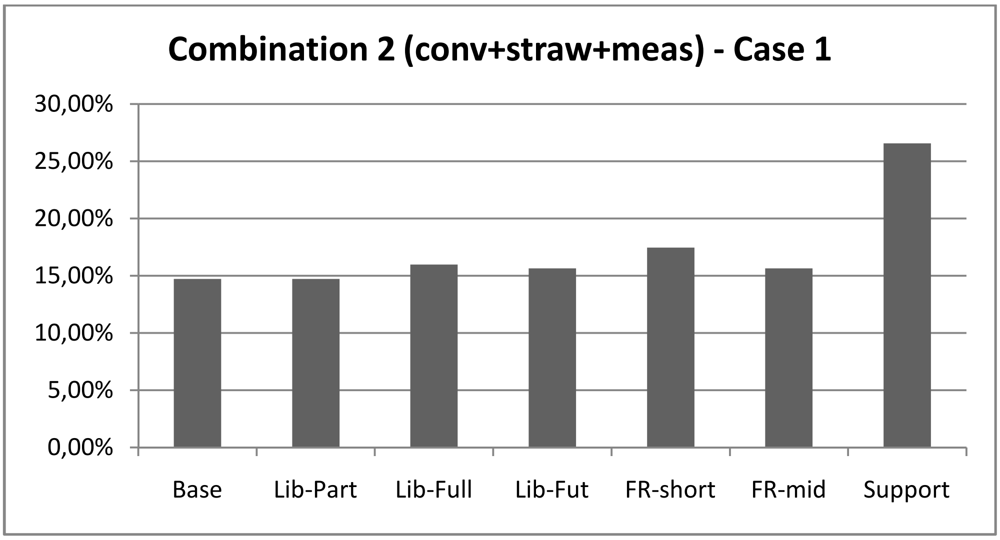

Figure 22. Share of combination 2 (case 1)

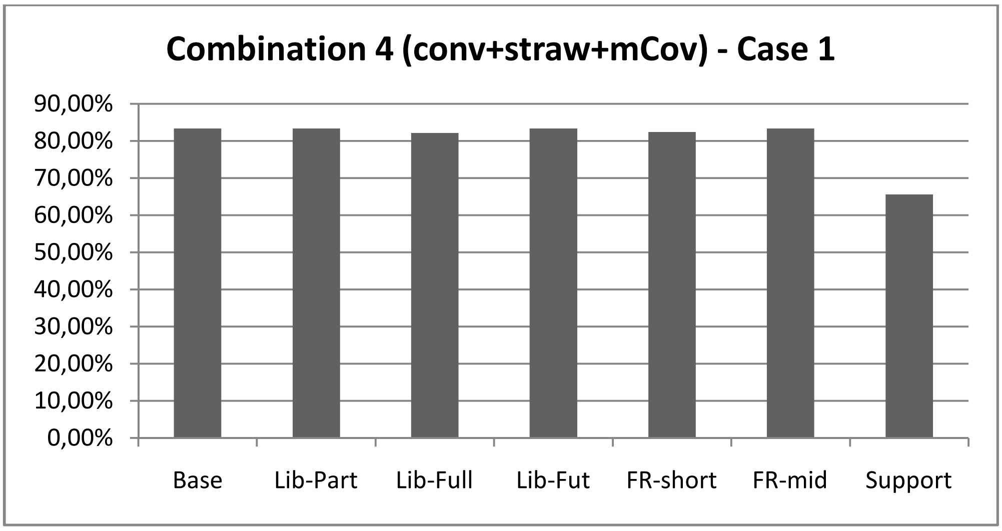

Figure 23. Share of combination 4 (case 1)

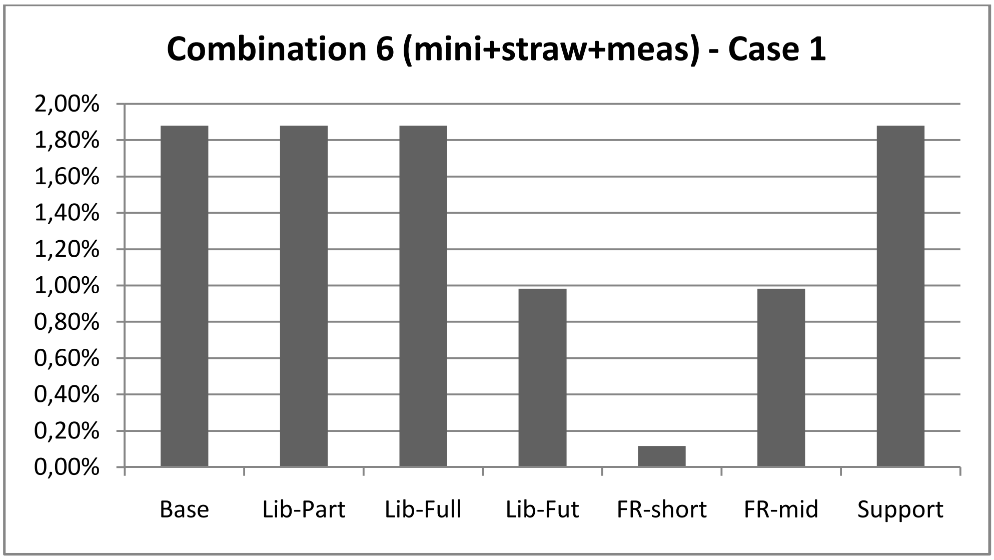

Figure 24. Share of combination 6 (case 1)

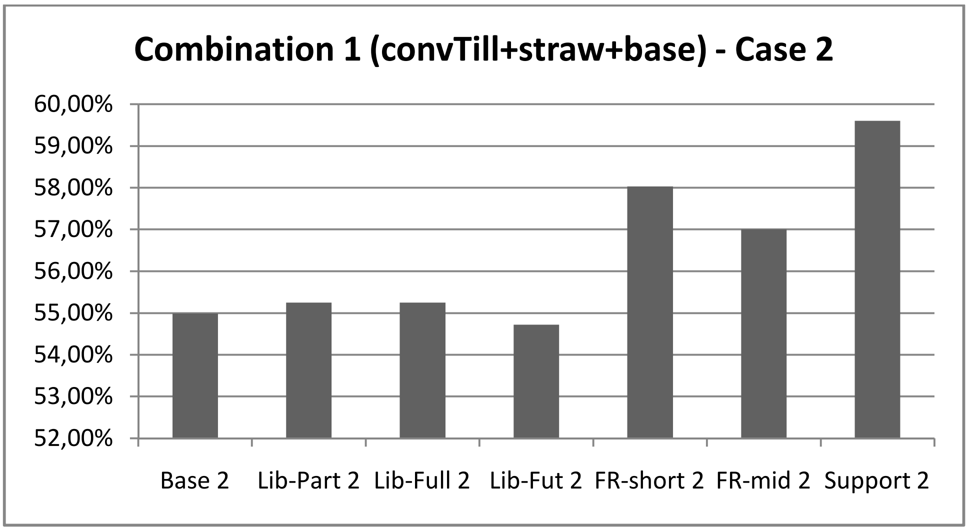

Figure 25. Share of combination 1 (case 2)

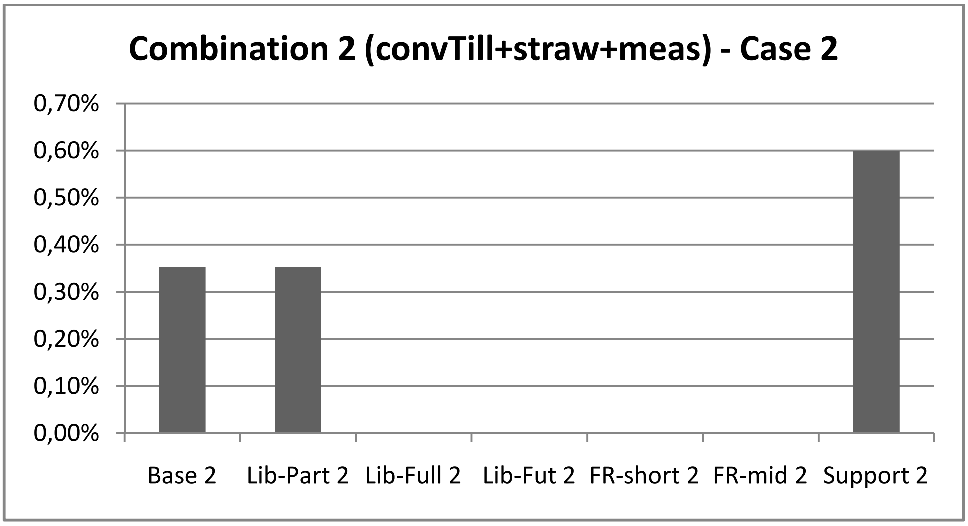

Figure 26. Share of combination 2 (case 2)

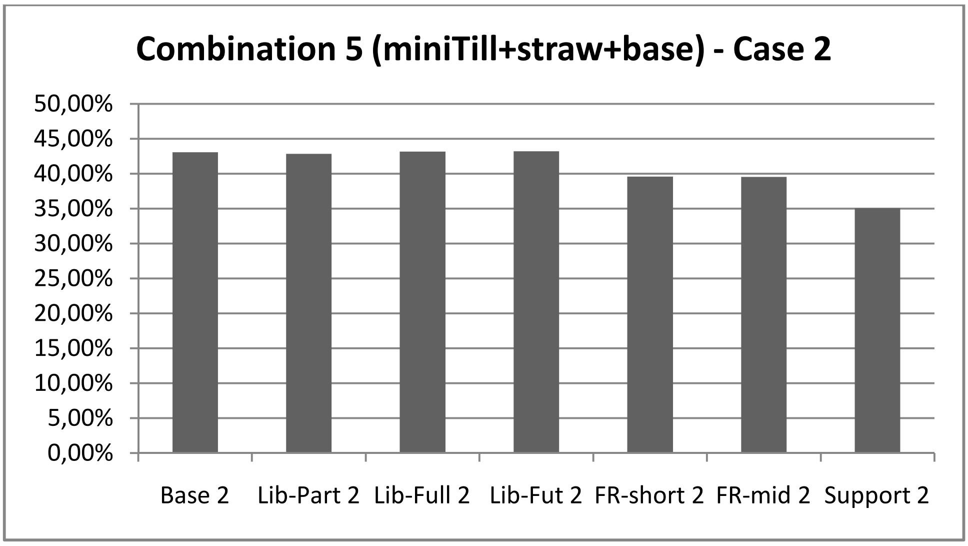

Figure 27. Share of combination 5 (case 2)

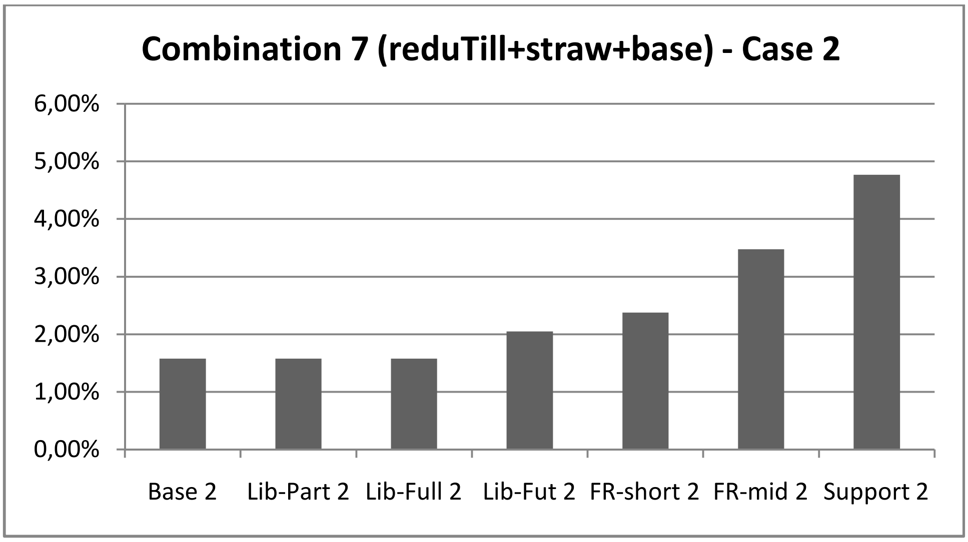

Figure 28. Share of combination 7 (case 2)

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