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The value of Neonicotinoid seed treatment in the European Union

A socio-economic, technological and environmental review

– Research Report –

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HFFA Working Paper 01/2013

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List of abbreviations

AAEA	–	Agricultural and Applied Economics Association
AWU	–	Annual Working Unit (equivalent to 1,800 annual working hours)
BMELV	–	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz
BYDV	–	Barley Yellow Dwarf Virus
CIS	–	Commonwealth of Independent States
CNV	–	Constructed Normal Value
Copa-Cogeca	–	European Farmers and European Agri-Cooperatives
CRF	–	Cabbage Root Fly
EBITDA	–	Earnings before Interest, Tax, Depreciation and Amortization
EC	–	European Commission
ECPA	–	European Crop Protection Association
EnBW	–	Energie Baden-Württemberg
ESA	–	European Seed Association
EU	–	European Union
FAO	–	Food and Agriculture Organization (of the United Nations)
FAPRI	–	Food and Policy Research Institute
FNPSMS	–	Fédération Nationale de la Production des Semences de Maïs et de Sorgho
G&A	–	General and Administrative (expenses)
GDP	–	Gross Domestic Product
GHG	–	Greenhouse Gas
ILUC	–	Indirect Land Use Changes
KTBL	–	Kuratorium für Technik und Bauwesen in der Landwirtschaft
MMM	–	Multi-region Multi-market Model
NNi	–	Neonicotinoid (seed treatment)
NPZ	–	Nordeutsche Pflanzenzucht
OECD	–	Organization for Economic Cooperation and Development
OSR	–	Oilseed rape
R&D	–	Research and Development

RFB	–	Rape Flea Beetle
SITC	–	Standard International Trade Classification
UFS	–	Union Française des Semnciers
UK	–	United Kingdom
USDA	–	United States Department of Agriculture
WFE	–	World Food Equation
WTO	–	World Trade Organization

1 Introductory remarks

Seed treatment is one of the most advanced and targeted forms of crop protection. The chemical ingredient is applied to the seed as a coating prior to planting. In the case of Neonicotinoid seed treatment (NNi), the insecticide is absorbed and distributed within the plant as it grows. This enables the plant to control pests that feed on it below or above ground. These threats to the plant can easily destroy the harvest, wasting huge amounts of natural resources (water, soil, nutrients, etc.), energy, and labour.

NNi is highly specific, and one of the most efficient forms of crop protection technology because of its targeted action and low application dose, long lasting protection against pests that destroy crops, especially when the plant is small and most vulnerable. Safe and targeted use of NNi therefore reduces the exposure to pesticide chemicals on large areas of farmland. Moreover, this technology improves crop yields and lowers farming costs. This enables farmers to improve their productivity and profitability, manage risks and adversities, reduce workload as well as operational complexity, and innovate and professionalize their businesses.

In this context, the overall objective of this research is to investigate the socio-economic and environmental contribution made by NNi technology to the European Union (EU) across major crops and key countries. More specifically, this work aims at highlighting the transformative nature of NNi technology and the catalysing role that it currently plays in modern agriculture. In addition, this study makes transparent the impact to the various stakeholders should the technology no longer be available.

The research report is structured as follows:

- In chapter 2 (corresponding author: Steffen Noleppa), the methods of the market and macro-economic analysis are explained and some background information on data and modelling assumptions is provided. A discussion of the short-term impacts and mid-term effects of a potential loss of NNi on European agriculture follows: socio-economic indicators, i.e. monetary and labour indicators as well as some environmental indicators, are used to demonstrate how EU economies would be affected by a potential ban or suspension of this technology.

- Chapter 3 (corresponding author: Thomas Hahn), then, focuses on an in-depth analysis of *hotspots*. These hotspots or focal points highlight the role of NNi from the perspective of various selected stakeholders across the value chains, the benefits this technology offers and, in consequence, the damage a loss of this technology would cause to their businesses. While not aiming at being complete, a substantial series of such hotspots is discussed; they support the market and macro-economic results by showing the significant socio-economic, technological, and/or environmental effects that would result from removing NNi technology from the market and the negative effects this would have for specific European regions, businesses, and with respect to particular crops.

- Chapter 4 contains a brief summary of the findings addressed in chapters 2 and 3. In the course of these findings, some specific challenges are highlighted.

2 Results of the market and macro-economic analyses

2.1 Methodological and data considerations

Comprehensively analysing market and macro-economic as well as some additional impacts of NNi across the EU and European key crops requires the application and combination of various sophisticated modelling techniques. Major analytical aspects to be considered and approaches to be used in this study are as described below:

- First, the analysis of NNi impacts should point at major short-term economic effects, e.g. at initial monetary and labour impacts that a ban or suspension of NNi would cause in EU agriculture. In the short run (i.e. up to one year), farmers are often not able to adjust crop production structures to changing market environments; fields might already be cultivated or foreseen to be cultivated with certain crops to maintain crop rotation schemes as necessarily planned. Taken this initial limited flexibility into account, a simple but straightforward modelling technique has been applied: a combination of the constructed normal value (CNV) approach (see, e.g., Eidman et al., 2000) with the more sophisticated so-called world food equation (WFE) approach (see, e.g., Kirschke et al., 2011). Details of the CNV and the WFE approaches can be found in the Annexes A.1 and A.2. The CNV approach allows calculating the economic effects for a particular region if (a) certain cost and/or revenue positions are subject to change and if (b) these changes can be formulated for an 'average' farmer cultivating a specific crop in the region under consideration. A ban or suspension of NNi would certainly change several cost and return positions. First of all, not applying NNi would mean saving NNi-specific cost, but at the same time, it would increase the use and cost of other plant protection products available to the farmers in the various EU member states. Furthermore, the non-application of NNi generally tends to decrease the yield per hectare in situations where farmers currently make use of this technology, hence altering production revenues. Once such cost and yield changes as well as the acreage cultivated with a particular crop in a specific region are known, the CNV approach is a powerful instrument for economic analysis. However, agricultural markets are rather volatile markets. Even small supply and/or demand changes may cause price fluctuations and, thereby, further revenue changes. The CNV approach is not an appropriate tool to endogenously take into account such potential price changes that a NNi ban or suspension might cause. In order to consider these particular short-term market adjustments, the WFE approach has been embedded into the analysis, making it possible to transfer regional production (supply) changes into price changes on (world) markets. In summary, short-term price, cost and revenue changes can be analysed with the meaningful combination of the CNV and WFE approaches. The sum of cost and revenue changes can thus be interpreted as almost immediate impacts of NNi on the agricultural value added per crop and region, i.e. on the agricultural gross domestic product (GDP).

- The aim of this study is not only to analyse economic impacts of NNi on agriculture, but on the entire value chain. In the short-term, entrepreneurs up- and downstream the various agricultural value chains plan according to the input and output structures they are used to. In such an environment, abrupt disturbances of agricultural markets, input provisions and/or output availabilities, e.g. caused by a sudden NNi ban or suspension, will almost immediately transfer to interlinked upstream and downstream markets and would, thereby, increase the initial agricultural GDP impact. Such macroeconomic effects can be included into the impact assessment by incorporating a multiplier analysis. Multipliers are quantitative factors explaining the transmission of a particular sector change into an economy-wide change. A meta-analysis has been conducted to meaningfully define agricultural multipliers for the EU member states. The references used in and the findings of this meta-analysis are displayed in Annex A.3.

- With Annex A.3 it becomes obvious that not only the GDP but also job multipliers have been gathered and defined for the purposes of this study. Indeed, the analysis not only aims at standard economic indicators measurable in monetary terms, but also at quantifying labour impacts. Labour impacts of input and output changes in agriculture can be analysed by using input-output ratios and calculator methods; corresponding data are provided by EC (2012), Handler and Blumauer (2006) and KTBL (2011) and have been used to identify agricultural labour input effects of changing production volumes in arable farming. Multiplying these agricultural impacts with the identified agricultural job multipliers (see again Annex A.3) leads to labour effects at the level of the entire economy.

- The determination of short-term economic effects enables us to point at initial impacts a NNi ban or suspension would have. Over time, however, agriculture and the other industries and stakeholders of the various value chains being entrepreneurs are able to adjust, at least partially, to changing market environments. To analyse such mid-term economic impacts in addition to the above-mentioned short-term effects, a complex and sophisticated partial equilibrium model has been applied. Partial equilibrium models are powerful tools when it comes to discussing economic impacts taking into account a time horizon of three to ten years. The time frame considered depends on the specification of data and assumptions of the modelling approach. Here we look at a time horizon for potential adjustments of five years. The details of the partial equilibrium model developed and used in this study are summarised in Annex A.4. With the modelling approach it becomes possible to analyse societal welfare effects. This basic but powerful economic concept of societal welfare analysis is standard in many scientific applications to agriculture (see, e.g., Anderson and Croser, 2010; Nomisma, 2012; Schmitz et al., 2010; von Witzke and Noleppa, 2011) and does not need to be repeated here. Changes in producer, consumer and state (budgetary) surpluses lead to societal welfare changes which are equal to costs, benefits and foreign exchange earnings of a region under consideration. The impact on societal welfare might thus be interpreted as a GDP impact, valued at the level of agricultural markets.

- Besides economic impacts of NNi (discussed by using several monetary and labour market indicators), some environmental impacts need to be analysed. Therefore, we will expand the analysis even further and quantify how much some of the important environmental indicators would change if modern crop protection technologies were discontinued. First, a ban or suspension of NNi in the EU would obviously increase virtual land imports by the EU substantially as this would cause an expansion of the production and, hence, the agricultural acreage elsewhere. This is also referred to as indirect land use changes (ILUC), which create negative environmental effects around the globe; a prominent example is increasing CO_2 emissions (see, e.g., Burney et al., 2010; Searchinger et al., 2008; Stern, 2007). Therefore, an analysis of virtual land and CO_2 emission changes is incorporated into the study. Basically, the approach allows changes in domestic EU production (due to a ban or suspension of NNi) to be converted into changes in extra-EU trade and then into the acreage expansion outside the EU territory necessary to compensate for the reduction in EU production. Using the ILUC-tool initially developed by von Witzke and Noleppa (2010) and further specified in von Witzke et al. (2011a; b), these ILUC can be quantified by world regions. Using applicable factors of carbon sequestration and carbon release per area of land in the various world regions (in accordance to Tyner et al., 2010) allows quantifying the CO_2 effect of such ILUC. In addition, the social cost of CO_2 emissions would be calculated based on their cost to society. Respective data are provided by EnBW (2011) and Ackerman and Stanton (2011). More information on the ILUC-tool can be obtained from Annex A.5 summarising major features of the approach.

The overall objective of this study is to assess (with the above-mentioned methods) the value of NNi in European agriculture. More precisely, the assessment is carried out by analysing the impacts occurring if NNi were banned or suspended in EU agriculture. Five scenarios have been defined to allow for an in-depth discussion:

(1) Scenario S1 analyses the impacts of a NNi ban or suspension for all key crops and EU member states assuming that suspensions currently in place would not have occurred and that all other crop protection tools and technologies remain available to the farmers. An effect of NNi on cereals is only considered in high-pressure geographies in the EU, i.e. in the United Kingdom, France, Ireland, Belgium, Netherlands, Germany, Austria, and the Czech Republic.

(2) Scenario S2 deals with a similar analysis as described for scenario S1, but only considers a potential NNi ban or suspension in corn in all EU member states.

(3) Similarly, scenario S3 refers to a ban or suspension of NNi in all EU member states, but this time only with respect to oilseed rape (OSR) and sunflower.

(4) Corn, OSR and sunflower mark the acreage across the EU that would be affected by a potential NNi ban or suspension in scenario S4.

(5) Finally scenario S5, similar to scenario S1, analyses the impacts of a NNi ban or suspension for all key crops and EU member states, but assuming that all classes of insecticides were withdrawn from use, meaning that no other currently available corresponding crop protection technology would be used on areas where NNi are deployed now.

In order to meaningfully fill the various methodological tools and concepts with reliable and robust data, i.e. to provide the best possible yield and cost effect estimates, an analysis of on-field effects of NNi in ten EU member states and of six focus crops has been carried out. The following Figure 2.1 provides a matrix of the case studies covering the assessment of the NNi market penetration and effects for key ('role-model') countries and focus crops. If not otherwise mentioned below, findings from these 'focus points' are extrapolated to the other EU member states.

Figure 2.1: Country-crop focus of the analysis

EU member state	Wheat	Barley	Corn	OSR	Sun-flower	Sugar beet
United Kingdom						
The Netherlands						
Germany						
Poland						
Slovenia						
Hungary						
Romania						
France						
Spain						
Italy						

Source: Own figure.

The study is based on data that was collected at a country level from a broad base of experts and practitioners. It reflects the local pest pressure situation as well as current farming practices. This allows assessing 'what would actually happen' if NNi were lost and what current value contributions and opportunities the technology 'brings to the table'. The collection of the study data was organized as a series of gathering, validation, and stress-testing steps involving stakeholders and experts from the ten focus countries:

(1) First, based on the study plan and approach, a data collection instrument (questionnaire) was designed by the authors. This questionnaire comprised sections relating to country and crop base data (acreages, pest pressure, main pests by region, plant protection toolbox available to farmers, market shares, etc.), NNi yield impact data (crop protection toolbox by pest with and without NNi, trial listings, expert estimates of yield impacts), and cost impact data (cost of plant protection, with and without NNi technology, numbers of applications based on pest situation, etc.). The instrument contained various levels of redundancies to secure data consistency and stability.

(2) The questionnaire was distributed to lead industry experts from two major members of the European Crop Protection Association (ECPA) in the various countries, who reached out to local experts or made internal study data available in order to complete the instrument.

(3) The data collected was validated against available study results, verified for self-consistency, and stress-tested with leading independent experts from research institutions and other stakeholders from farmers and industry associations in a series of interviews. The country level data was synthesized into an EU-level data set.

(4) A clean, robust, self-consistent, and stress-tested data set was prepared and used as an input to the market and macroeconomic assessment.

Some essential input data for further analyses being the outcome of the data gathering from 'focus points' need to be discussed. First, Figure 2.2 provides an overview on the EU acreage per crop and the ratio of this area treated with NNi. This reveals that NNi is a key technology for all focus crops and has been embraced by European farmers because of its favourable value-risk-cost profile. For sugar beet and OSR, the market penetration in key markets is close to 100 per cent. Additionally, NNi is used on more than half the acreage grown with sunflower, and almost 40 per cent of corn area is treated with NNi. The penetration potential for wheat and barley (summarised as 'cereals' in Figure 2.2) is about 16 per cent, but NNi use is growing rapidly, especially in some key western European markets.

Figure 2.2: EU farming area and acreage using NNi technologies

	Cereals	Corn	OSR	Sun-flower	Sugar beet
EU farming area (in million ha)	39.8	13.3	7.2	3.8	1.6
NNi penetration (in per cent)	16	36	93	58	96

Source: Own calculations.

Furthermore, the identified yield and cost impacts per 'focus point' shall be highlighted: The percentage changes (measured at country level) with respect (a) to the use of other available insecticide technologies on areas currently treated with NNi and (b) to a non-use of insecticides on areas currently treated with NNi are visualised in Annex A.6. These changes are transferred into shift factors to appropriately shock the CNV and WFE approach for short-term analysis as well as the partial equilibrium model for mid-term analysis.

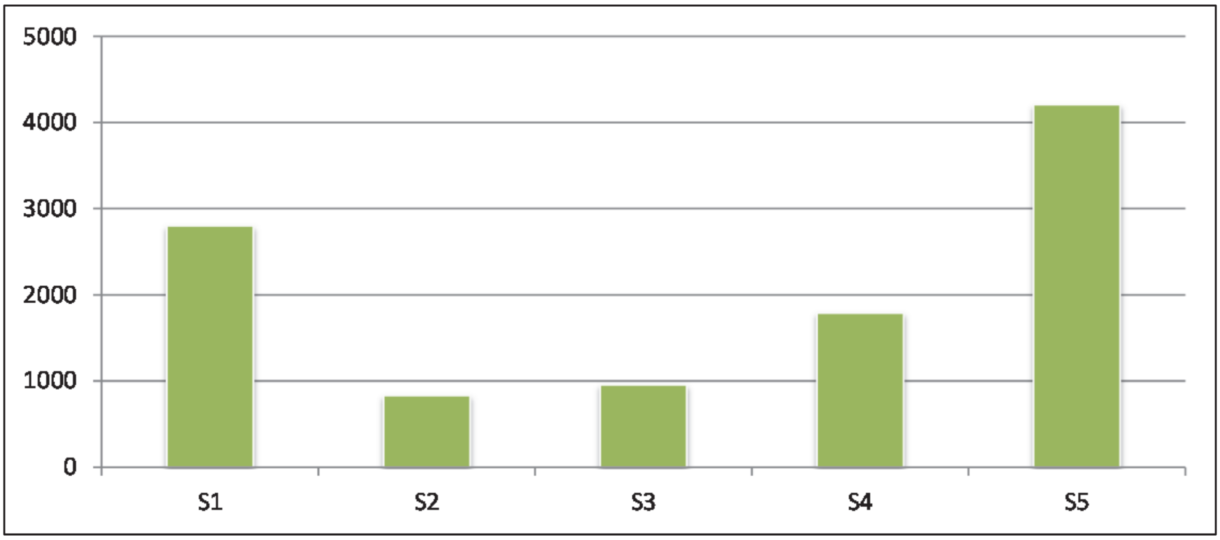
2.2 Short-term monetary and labour effects of Neonicotinoids

In this section, some major results of the short-term analysis will be discussed. All the details of the various calculations can be found in the Annexes A.7 and A.8. These scenario-specific annexes display the complete information discussed hereafter per crop and EU member state as well as in total. Note: Due to the application of the WFE, which does not take into account cross-price effects, the values for scenarios S2 to S4 are not displayed separately in the annexes. These values for corn (scenario S2), OSR and sunflower (scenario S3), and all three of these commodities (scenario S4) are exactly the same as those given in scenario S1 for the corresponding crops. All monetary indicators are valued at August 2012 market prices.

For all scenarios, the discussion starts with a debate of the monetary impacts at the agricultural grower level. According to scenario S1, NNi technology potentially contributes a total of 2.1 billion EUR to crop market revenues and lowers production cost by 0.7 billion EUR. This would result in an EU-wide gain in agricultural value added of 2.8 billion EUR, which would be lost if NNi were removed from the toolbox available to the farmers. In scenario S5, i.e. when comparing NNi to a treatment with no insecticide at all on the acreage originally treated with NNi, the gain in agricultural value added associated with the use of NNi technology would amount to 4.2 billion EUR at the grower level. In this scenario, market revenues would increase by 4.8 billion EUR, but the cost would shrink by 0.6 billion EUR. Figure 2.3 provides an overview on the monetary impacts not only for scenarios S1 and S5, but also for the other three scenarios.

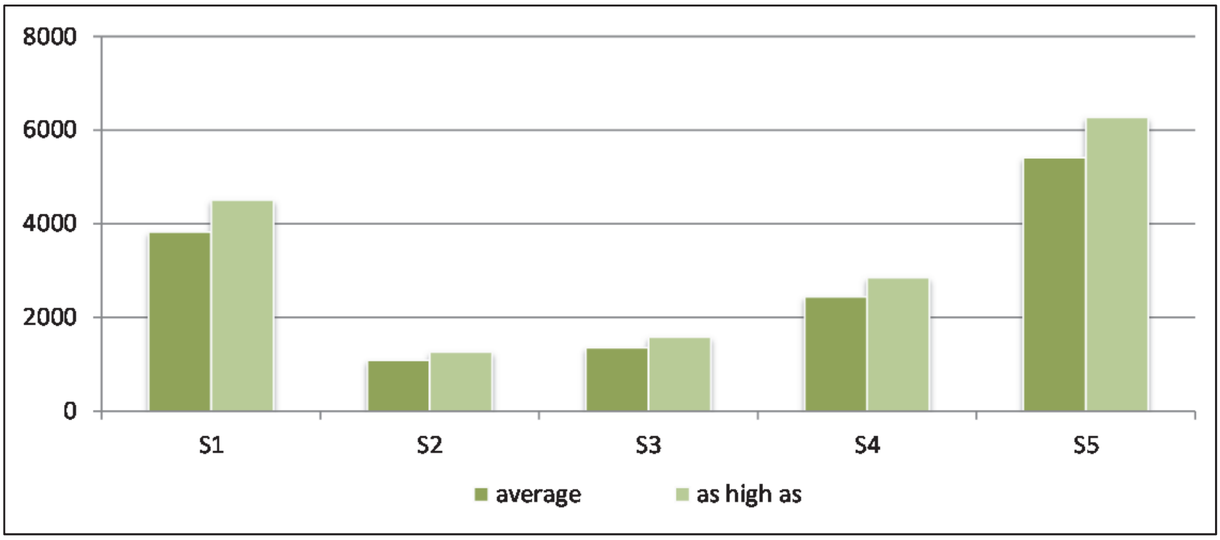
If economic impacts up- and downstream the agricultural value chains are included, the monetary impact of using NNi to protect crops is even larger. Applying the defined sets of multipliers (see again Annex A.3), it can be stated that, in total, NNi contributes between 3.8 and 4.5 billion EUR to the GDP of the EU in scenario S1, and between 5.4 and 6.3 billion EUR in scenario S5. To put these numbers into context: the immediate potential damages to the overall EU welfare if NNi were banned or their use suspended (4.5 billion EUR) are approximately as large as the entire agricultural value added of some smaller EU member states, e.g. Austria or Finland (Eurostat, 2012). The overall, i.e. economy-wide, GDP impacts at the EU level for all five scenarios can be obtained from Figure 2.4.

Figure 2.3: Short-term monetary impacts of NNi application in the EU at the grower level (in million EUR)



Source: Own calculations.

Figure 2.4: Short-term monetary impacts of NNi application in the EU on overall EU welfare (in million EUR)

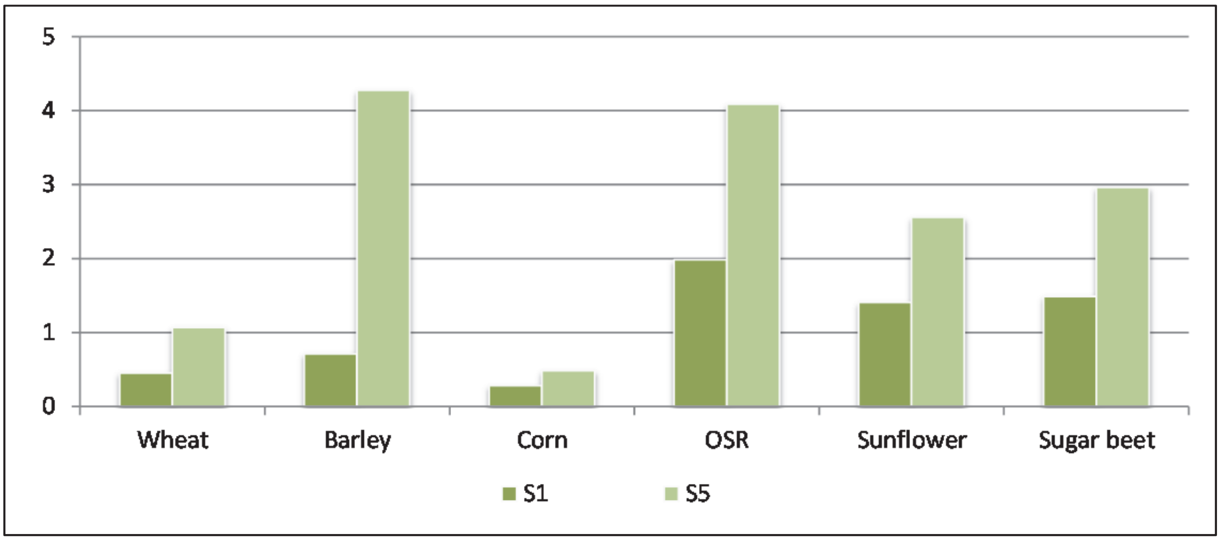


Source: Own calculations.

The agricultural and overall welfare effects would be even larger if price impacts caused by NNi were not taken into consideration. Evidently, such an approach has previously been applied by other authors, e.g. Nomisma (2012), but would lead to an apparent overestimation of monetary effects, which can and should be avoided: NNi increases yield; the yield increase shifts (increases) supply on domestic markets; the domestic supply shift (increase) automatically increases world supply; given a constant world demand, world market prices decrease (the underlying plausible assumption here is that changes in the use of NNi initially do not affect demand of agricultural products). Thus, spill-over effects between domestic and world markets need to be taken into account while analysing market effects of NNi application. These spill-over effects on world markets will feed back to domestic markets changing prices even in the short run as well as prices and quantities in the long run.

By applying the WFE approach (see above and Annex A.2), price impacts of losing NNi technology have been calculated and incorporated into the analysis. Figure 2.5 displays the potential price impacts for scenarios S1 and S5 (at world market level). It becomes obvious that in case of a complete ban or suspension of NNi across the EU, agricultural world market prices would increase (ceteris paribus) by up to 2 per cent on top of the current commodity price rally in scenario S1; for scenario S5, the impact would be even more devastating: price increases of up to 4 per cent would be the almost immediate result.

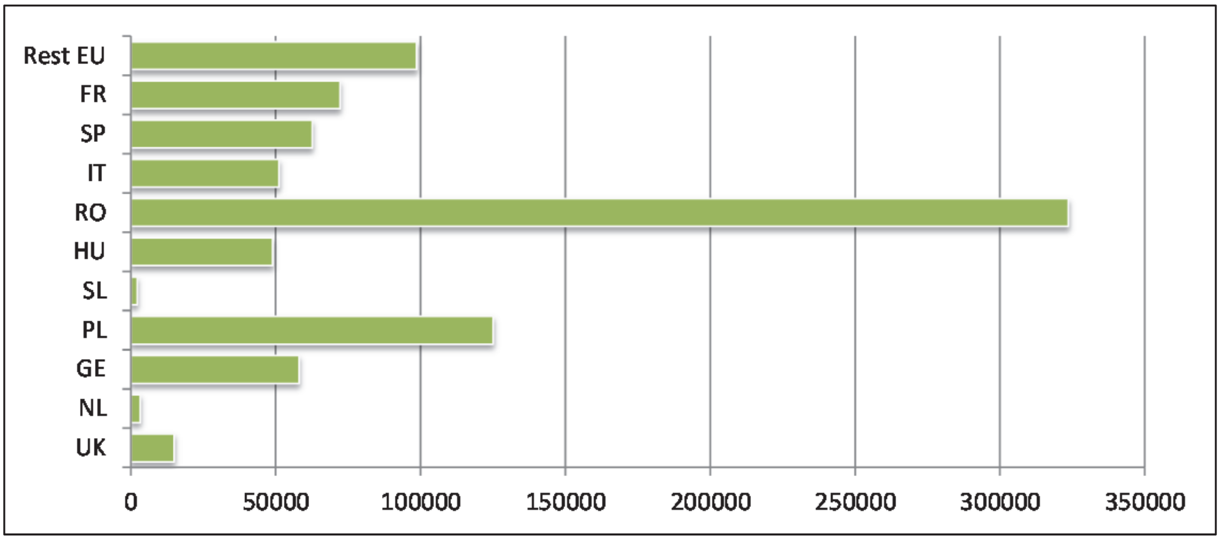
Figure 2.5: Short-term world market price impacts of NNi application in the EU (in per cent)



Source: Own calculations.

Another essential part of the economic assessment to be provided herewith is an analysis of labour effects of NNi applications across the EU. Applying meaningful output vs. (labour) input ratios, it can be stated that more than 860,000 jobs in the EU agricultural sector – measured in terms of annual working units (AWU) – would be put under stress in the absence of NNi (see Figure 2.6.). As can be seen, the relative importance of this stress is larger for countries with lower agricultural labour productivity, i.e. it is particularly high in the new EU member states and partially also in the Mediterranean countries.

Figure 2.6: Agricultural employment stressed in EU member states in case of a ban or suspension of NNi (in AWU)



Source: Own calculations.

The term 'under stress' requires clarification. It means (1) that a job is either directly lost or (2) that it is impacted by reduced wages or income. Approximately 22,000 agricultural jobs would be lost in scenario S1, or 45,000 jobs at the farm level according to scenario S5. In addition to that, still remaining arable growers would suffer an average income loss of approximately 4.7 per cent in scenario S1 and 6.3 per cent in scenario S5. This amounts to more than a two-week or a three-week average income per agricultural worker, respectively, and clearly represents a tremendous wage decline. Furthermore, it should be noted that applying the defined sets of agricultural employment multipliers leads to a situation in which between 34,000 and 41,000 jobs could be lost in the entire EU economy in scenario S1, and 69,000 to 81,000 jobs in scenario S5. The short-term labour impacts and the units of measuring these impacts for all five scenarios are summarised in Figure 2.7.

Figure 2.7: Short-term labour impacts of NNi application in the EU

Scenario	S1	S2	S3	S4	S5
Agricultural employment created by NNi (in AWU)	21,788	10,234	8,377	18,611	44,922
Economy-wide employment (up to) created by NNi (in AWU)	40,721	21,351	14,874	36,225	81,451
Agricultural income increase due to NNi (in per cent)	4.7	1.4	1.6	3.0	6.3

Source: Own calculations.

It can be concluded that, in the short-term, a potential ban or suspension of NNi technology would have tremendous economic implications:

- When assessed against a scenario without it but with other technologies intact, NNi contributes more than 2 billion EUR annually to commodity crop revenues and reduces production costs by nearly 1 billion EUR across the EU. The true value of NNi to the grower, when compared to not using insecticides at all, exceeds 4 billion EUR per year.
- If this technology was no longer available to the farmers, these productivity benefits would be lost almost immediately and prices of agricultural raw commodities would increase by up to 2 per cent on top of the current commodity price rally.
- The immediate damage to EU wealth could be as large as 6 billion EUR in the first year, more than the value-added by the agriculture of EU member states such as Austria or Finland.
- Probably, more than one million people engaged in arable production and their livelihoods would greatly suffer if this technology was lost. Farmer income would decrease by 5 per cent. However, in many areas and for many farmers the loss would be much more severe: More than 40,000 farm jobs could be lost across the EU, mainly in Eastern Europe.

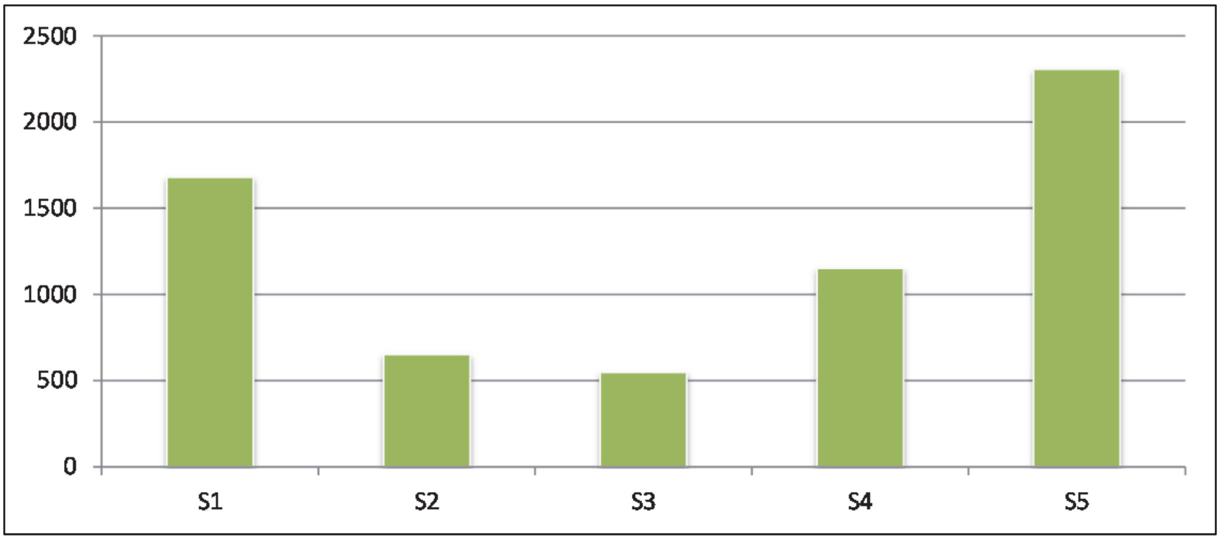
2.3 Mid-term economic and environmental effects of Neonicotinoids

Economies and their sectors are able to adapt to market shocks over time. This applies to agriculture as well. In case of continuous market interruptions, trade balances can be adjusted, cost structures will be changed and/or crop rotations might be amended, thus shifting agricultural land use towards more competitive commodities and less distorted commodity markets. At least in part, this would compensate for initial losses due to a shock. Adjusting entrepreneurial decisions to a NNi ban or suspension might result in less devastating economic effects than those detailed above for the short-term.

This section deals with the discussion of mid-term effects associated with the use or non-use of NNi in European agriculture. Again, exemplified results will be shown in the following for scenarios S1 and S5, but all the details of the various analyses and calculations can be obtained from the scenario-specific Annexes A.9 to A.13. In order to better compare short-term and mid-term results, the outcome of the modelling approach is also valued at August 2012 prices.

Within years, EU farmers are potentially able to amend input and output structures to better cope with a possible NNi ban or suspension. Having a five-year time horizon in mind, the mid-term producer surplus (to be compared with the short-term monetary impacts of NNi application in the EU at the grower level as displayed in Figure 2.3) that would be lost in the fifth year if NNi were then still banned or suspended is approximately 1.7 billion EUR for scenario S1, and it would be about 2.3 billion EUR for scenario S5. For the other three scenarios, the effect on the EU producer surplus is, of course, lower as can be seen in Figure 2.8.

Figure 2.8: Mid-term monetary impacts of NNi application in the EU at the grower level (changes of producer surplus in million EUR)

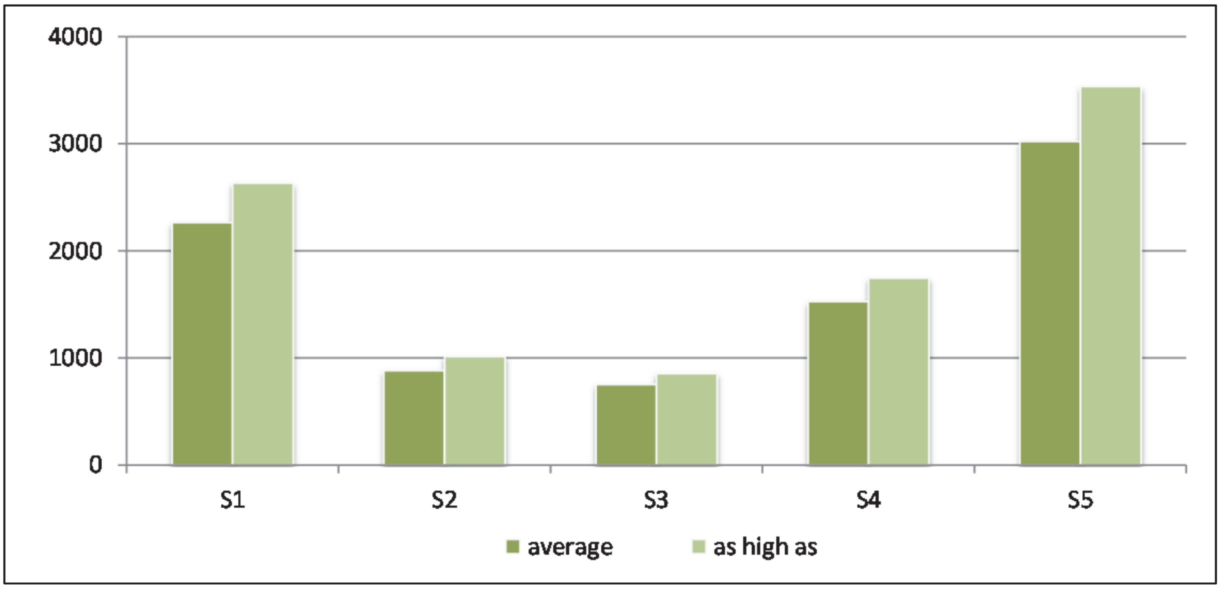


Source: Own calculations.

The changes of producer surpluses are a composite effect of changes in revenues and changes in variable cost. The occurrence of meaningful structural adjustments over time can be seen best by looking at the cost changes in the mid-term (see Annexes A.9 to A.13). For the short-term and scenario S1, for example, costs have increased because by assumption all areas remain cultivated with the crop and using crop protection toolboxes without NNi on areas that are currently treated with this technology is usually, although not always, more expensive (see also Annex 6). Over time, however, such increases in production cost per hectare combined with the associated production (i.e. revenue) losses could be so devastating in some regions that cultivating some crops under these assumptions of scenario S1 becomes non-profitable and would be stopped by farmers. They just exclude the crop from their portfolio products. Such exclusion would obviously lead to the occurrence of zero (variable) cost (per hectare). In total, country-wide costs of producing the specific commodity might thus decrease.

The applied partial equilibrium model approach allows for the determination of consumer surpluses in addition to the producer surpluses analysed above. Consumers may profit from lower prices caused by NNi. Taking this specific surplus impact into consideration and again applying the multiplier analysis, the overall monetary economic contributions of NNi are substantial, even in the mid-term. Figure 2.9 depicts the economy-wide mid-term monetary (i.e. the welfare) impacts of NNi technology in the EU. The values displayed would be lost in EU economies if NNi were banned or suspended over a longer period of time, here up to five years. In scenario S1 the loss would add to 2.3 to 2.6 billion EUR, and in scenario S5, the loss would be between 3.0 and 3.5 billion EUR, the uncertainty again being introduced by the range of likely multiplier values as determined by the meta-analysis described above.

Figure 2.9: Mid-term monetary impacts of NNi application in the EU on overall EU welfare (in million EUR)

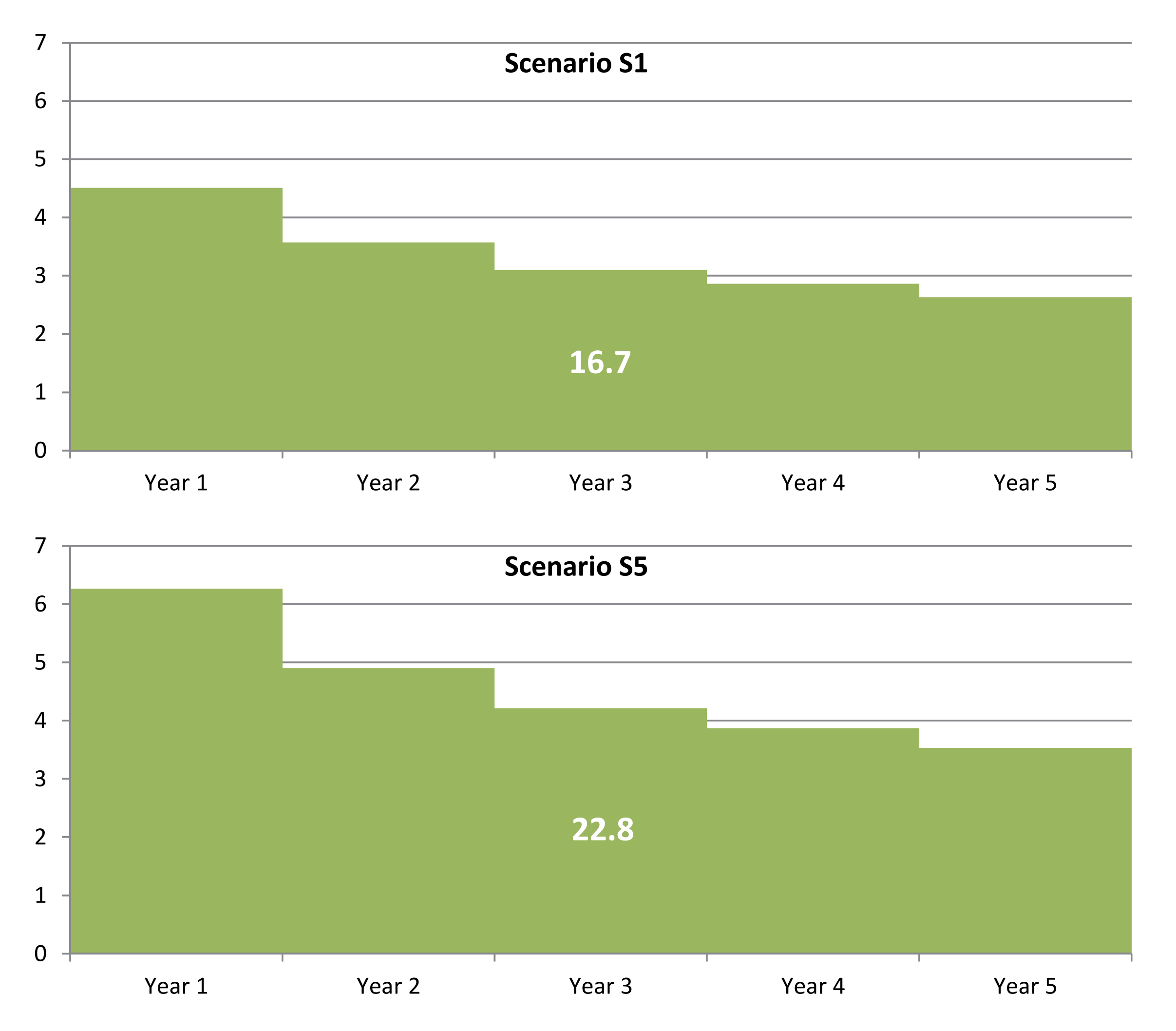


Source: Own calculations.

The societal welfare losses over five years if NNi were continuously banned or suspended over such a long period of time would be tremendous, as can be seen in Figure 2.10, which shows the accumulated losses over time for scenarios S1 and S5 and the 'as high as' multipliers. Altogether, a ban or suspension of NNi could cause a shrinking of European welfare of up to almost 17 billion EUR in scenario S1 and of up to almost 23 billion EUR in scenario S2.

The mid-term labour impacts of a continuous NNi ban or suspension remains remarkable too. Figure 2.11 shows the details. In essence, the number of jobs lost in EU agriculture in the mid-term would sum up to almost 27,000 in scenario S1 and to more than 35,000 in scenario S5. Still, an income impact must be considered: Agricultural incomes of remaining arable growers would suffer by up to 2.6 per cent, which is approximately as high as a 'ten-day wage' with respect to average paid labour and/or unpaid family labour in European agriculture.

Figure 2.10: Accumulated overall EU welfare losses within five years in case of a continuous ban or suspension of NNi (in billion EUR)



Source: Own calculations.

Figure 2.11: Mid-term labour impacts of banning or suspending NNi in EU agriculture

Scenario	S1	S2	S3	S4	S5
Agricultural jobs lost (in AWU)	26,837	12,149	11,179	23,314	35,579
Economy-wide jobs lost (up to) (in AWU)	50,393	25,674	20,046	45,689	65,395
Agricultural income decrease (in per cent)	2.0	0.9	0.6	1.4	2.6

Source: Own calculations.

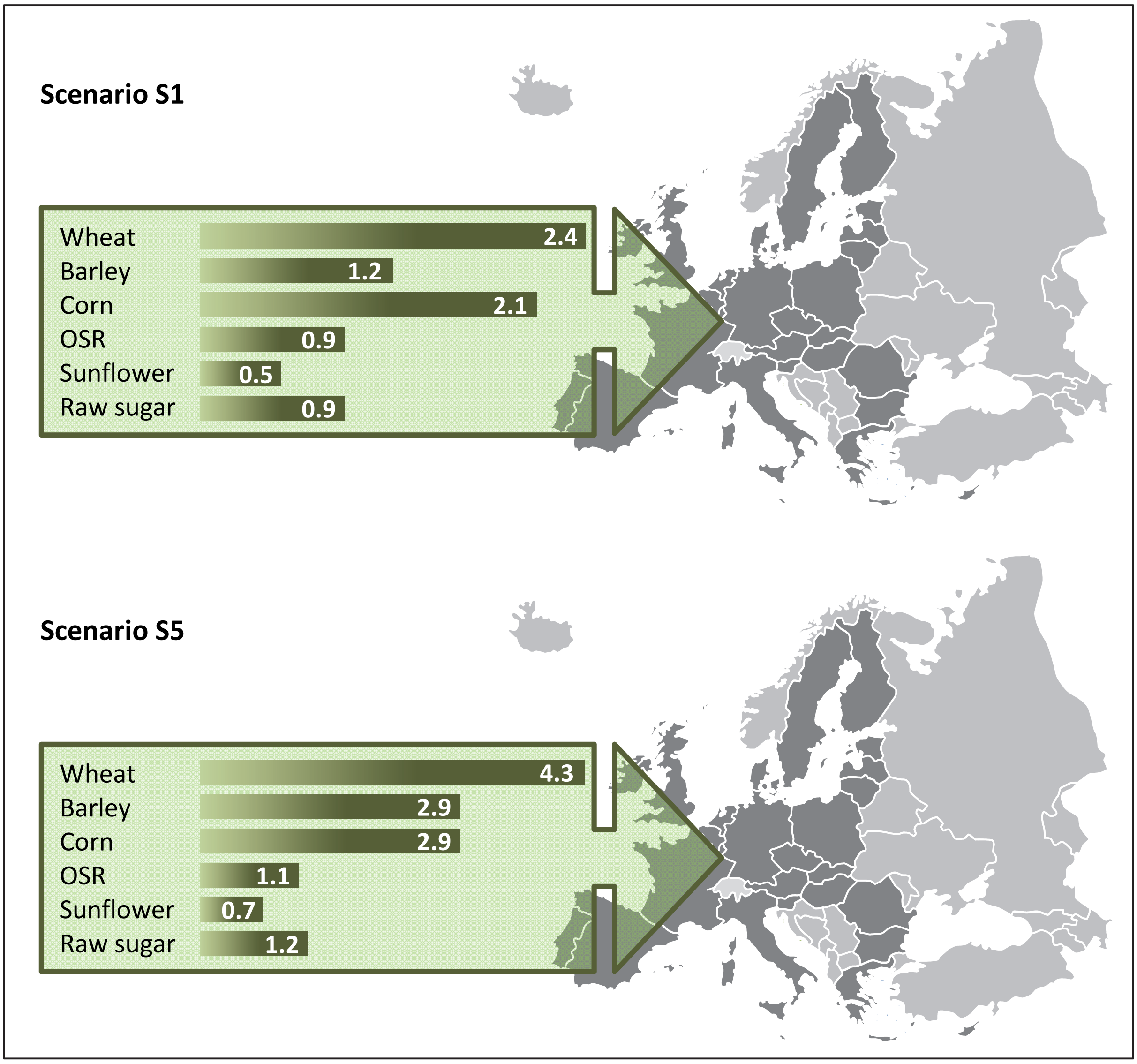
In addition to positive economic impacts, NNi provides substantial environmental benefits to European societies and even more on a global scale. The findings of the respective analyses using the ILUC-tool as specified in von Witzke et al. (2011a, b) will be discussed below.

For running the ILUC-tool the determination of changing trade patterns is essential. In the absence of NNi, less agricultural crop production will be generated in the EU. In such a situation, agricultural trade will be affected because exports will have to shrink and imports may increase if domestic demand changes only slightly (as it is the case if NNi is banned or suspended in the EU). Against this background, it makes sense to first look at changing trade balances. Figure 2.12 shows the impacts of scenarios S1 and S5, respectively. It becomes apparent that the EU trade balance with respect to all six focus crops would suffer (an arrow into the EU territory indicates negative net changes of import respectively export balances of the EU):

- In scenario S1, wheat net exports would decrease by about 16 per cent and barley net exports would shrink by more than a third (38 per cent); the already high corn net imports would further increase by 57 per cent and net imports of raw sugar would have to increase by almost a third (31 per cent). The biggest relative change can be stated for the case of sunflower seed. Here, the EU would become a net importer instead of being an actual net exporter. Together with the change in OSR trade, lower sunflower and OSR production would lead to a shortage in protein feed, thus causing even higher soybeans or soy meal imports.
- Even higher would be the change in agricultural trade in scenario S5. In this case, wheat net exports would decrease by 29 per cent and barley net exports by 93 per cent; barley would thus approach a net import situation. Net imports of corn would increase by 77 per cent, sugar imports would increase by 42 per cent. And the protein feed shortage from domestic production would be even higher than in scenario S1.

The ILUC-tool translates these changing net trade balances into changes of bilateral trade flows in such a way that the regional trade structure remains as it is. In other words: trade preferences of the EU are not subject to change. Another assumption made within the tool is the following: additional trade volumes that a particular region will import more to (or export less from) the EU in case of production shortages in the EU are generated by a change in land use and not by increasing land productivity. This allows calculating additional land cultivation for agricultural purposes per world region necessary to compensate for lower land productivity in the EU given constant land productivity in other world regions. The outcome of such an analysis is displayed in Figure 2.13.

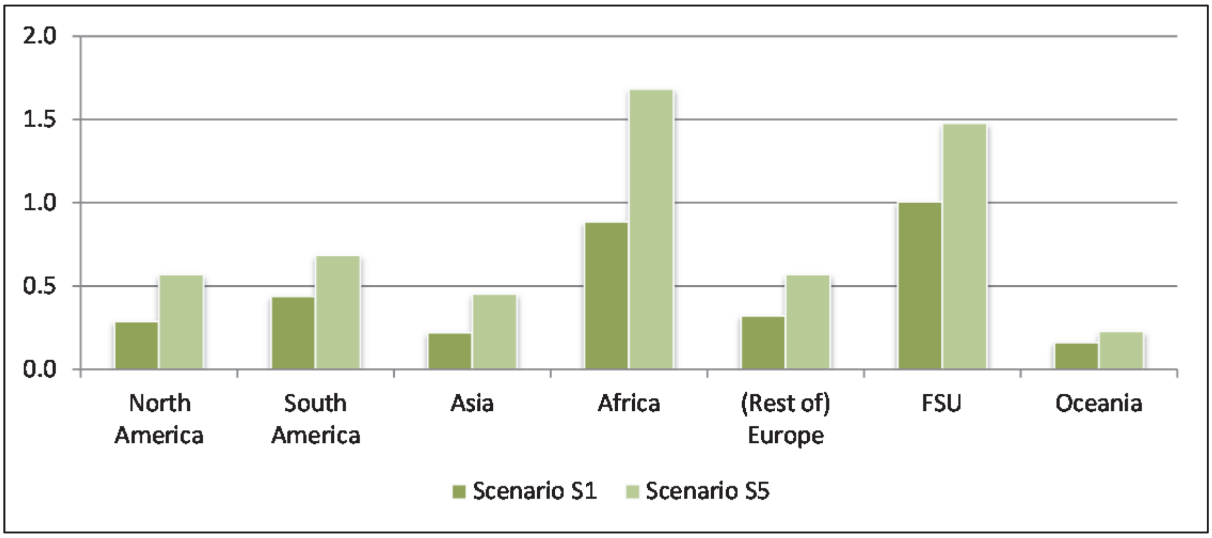
Figure 2.12: Changes in net trade balances for agricultural key commodities if NNi is banned or suspended (in million tons per year)



Source: Own calculations.

In scenario S1 and S5, more than 3.3 and almost 5.7 million hectares of land, respectively, need to be cultivated from virgin land in order to compensate for production losses due to a NNi ban or suspension in the EU. This area would have to be added to the already 'occupied' area of the EU abroad for meeting agricultural demand in the Community, which already amounts to 29 million hectares (see, e.g., von Witzke et al., 2011b).

Figure 2.13: Indirect land-use changes caused in various world regions if NNi is banned or suspended in the EU (in million ha)



Source: Own calculations.

Using applicable factors of carbon release per area of land in the various world regions if land is cultivated for agricultural purposes (in accordance to Tyner et al., 2010) allows quantifying the CO_2 effect of such additional agricultural land-uses and its cost to society (see EnBW, 2011; Ackerman and Stanton, 2011). The dimensions of both aspects, the additional CO_2 emissions and the added emission costs to society if NNi were banned or suspended in EU agriculture, are visualised in Figure 2.14.

Figure 2.14: Additional volume and costs of greenhouse gas emissions in case of a ban or suspension of NNi in EU agriculture

<table>
<tr><th colspan="3">Additional GHG emissions per world region
(in million t)</th><th colspan="4">Additional GHG emissions in total
(in million t)</th></tr>
<tr><td></td><td>Scenario S1</td><td>Scenario S5</td><td colspan="2">Scenario S1</td><td colspan="2">Scenario S5</td></tr>
<tr><td>North America</td><td>42</td><td>83</td><td colspan="2">614</td><td colspan="2">1,059</td></tr>
<tr><td>South America</td><td>66</td><td>104</td><td colspan="4" rowspan="2">Value of GHG emissions to society
(in million EUR)</td></tr>
<tr><td>Africa</td><td>173</td><td>328</td></tr>
<tr><td>Asia</td><td>65</td><td>134</td><td colspan="2">Scenario S1</td><td colspan="2">Scenario S5</td></tr>
<tr><td>Rest of Europe</td><td>54</td><td>96</td><td rowspan="2">at 10 EUR/t</td><td rowspan="2">at 25 EUR/t</td><td rowspan="2">at 10 EUR/t</td><td rowspan="2">at 25 EUR/t</td></tr>
<tr><td>Former Soviet Union</td><td>196</td><td>288</td></tr>
<tr><td>Oceania</td><td>18</td><td>26</td><td>6,143</td><td>15,358</td><td>10,591</td><td>26,478</td></tr>
</table>

Source: Own calculations.

It turns out that in scenario S1 additional greenhouse gas (GHG) emissions of approximately 600 million tons CO_2 equivalent are still avoided as long as NNi is used in EU member states. The corresponding conservative value of emission certificates assuming a liberal CO_2 emission market would be 6 to 15 billion EUR. In Scenario S5, the numbers are a bit larger. A NNi ban or suspension would cause more than 1 billion tons of additional CO_2 emissions, more than the entire GHG emissions Germany releases per year, and the value of these emissions (foregone for society) is between 11 and 26 billion EUR.

With respect to the mid-term analysis, it can be concluded that a potential ban or suspension of NNi would still have substantial economic implications:

- Over a five-year period, the EU could lose 17 billion EUR or more and over 60,000 jobs could get lost economy-wide.
- In addition, if NNi were no longer available in the EU, there would be a significant reduction of food production considerably altering the commodities trade balance. The net exports of barley and wheat would decline (where EU growers enjoy a clear competitive advantage), and the EU would need to increase the net imports of corn, raw sugar and vegetable protein sources such as soybeans to compensate among others for a shortage of protein feed from OSR. Europe would also become a net importer of sunflower.
- Any reduction in agricultural productivity in the EU would need to be compensated by making new arable land available outside of the EU. This holds true for a ban or suspension of NNi as well. Today, Europe virtually net imports already approximately 29 million hectares of land to meet its food demand. According to the model applied here, this virtual import would increase by at least additional 3.3 million hectares of (generally less productive) arable land outside the EU, which would have to be brought into production. The environmental cost of converting this land for arable use would be around 600 million tons of additional CO_2 emissions, which is equivalent to up to 15 billion EUR in emission certificate value.

3 Findings of hotspot reflections

Many farmers and industry experts across Europe have been interviewed to identify areas where NNi plays a particularly transformational and economically important role and where, in consequence, a loss of this technology would have the deepest business impact. In close collaboration with stakeholders and taking into consideration previous studies when necessary, farm and industry cases have been developed that showcase – from a stakeholder's perspective – the detailed value of NNi technology to the corresponding businesses. For these stakeholders, NNi helps to (a) increase productivity, (b) manage risk and adverse events, (c) manage workload and operational complexity, and (d) unlock new business opportunities and support professionalization of their operations. Through these levers, NNi helps secure profitability and viability of companies across the value chain and support the economy at large. To aid the reader, Annex A.14 shows a classification of these hotspots along the value chains, focus crops, and the main impact levers. Along the value chain and without order of importance, the following examples illustrate these benefits.

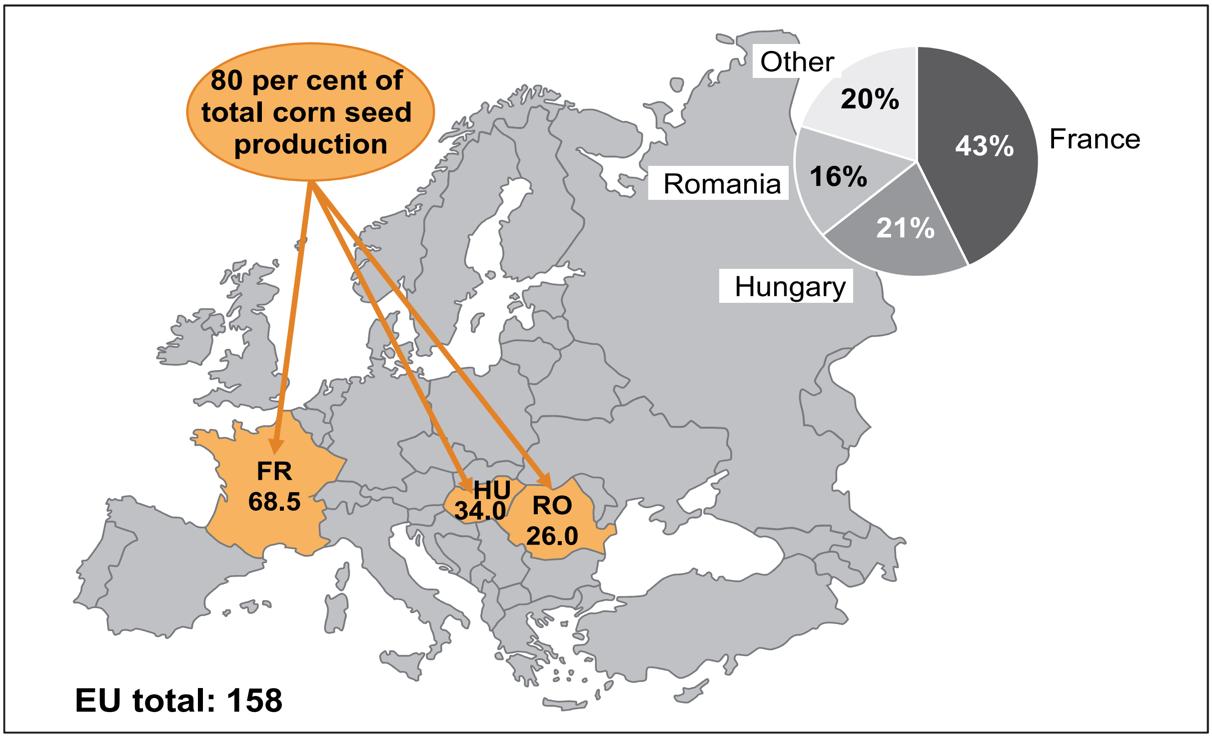
3.1 Hotspot HS1: The European corn seed industry

Over 80 per cent of corn seed production is concentrated in three EU member states: France, Hungary and Romania (see Figure 3.1). Seed producers rely on NNi to maximize the productivity of their multiplication activities. In addition, they make a margin on the application and sale of NNi. Consequently, a ban or suspension of NNi would negatively impact the productivity of the multiplication activities and eliminate the additional margins they make on the seed treatment. Figure 3.2 provides a summary of this situation, which is based on the perspective of major industry stakeholders. For the quantity of corn seeds necessary to grow one hectare of commodity corn, the average European corn seed producer would lose a net margin of about 10 EUR in case NNi were lost. Considering the entire EU-wide corn production on an area of about 11.7 million hectares (excluding areas where farm-saved seeds are used, mainly in Romania), net margins of 117 million EUR would be destroyed.

Seed production is a complex and difficult procedure and yield losses could not be easily replaced by an immediate increase in production area. NNi, thus, secures the profitability of the seed production industry. Against this background, an interviewed French seed producer pointed to the real possibility of relocating seed research and development (R&D) and production outside the EU to countries like the Ukraine and Russia.

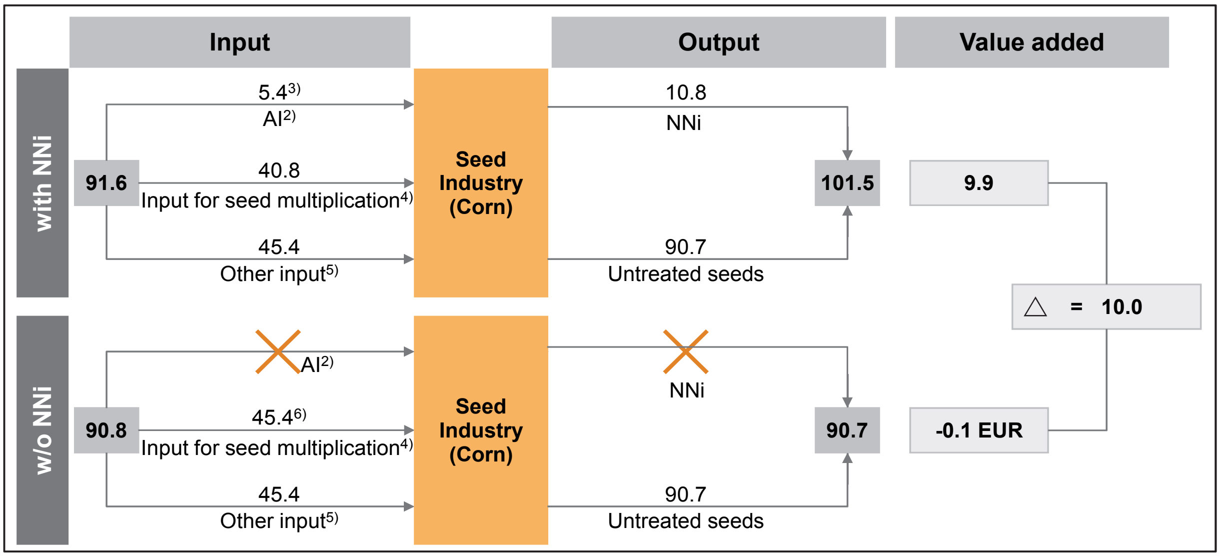
Historically, the production of corn seeds has been quite volatile with drops of 25 to 30 per cent in bad years (see Figure 3.3). With current stock levels at a critical 30 per cent level of annual demand, a possible lower production in the three key countries could further decrease stock levels (see Figure 3.4), i.e. without NNi the EU could face a critical shortage of seed supply. Given that the EU import capacity is limited (in particular due to issues related to the use respectively non-use of genetically modified organisms) and that corn is planted in spring when switching to another crop at short notice is not easily possible, this could lead some farmers to simply not plant or use farm seeds with much reduced yield potential, thus leading to an overall corn production shortage and a very disappointing season for farmers.

Figure 3.1: Main EU corn seed production areas (in 1,000 ha)



Source: Own analysis based on stakeholder interviews.

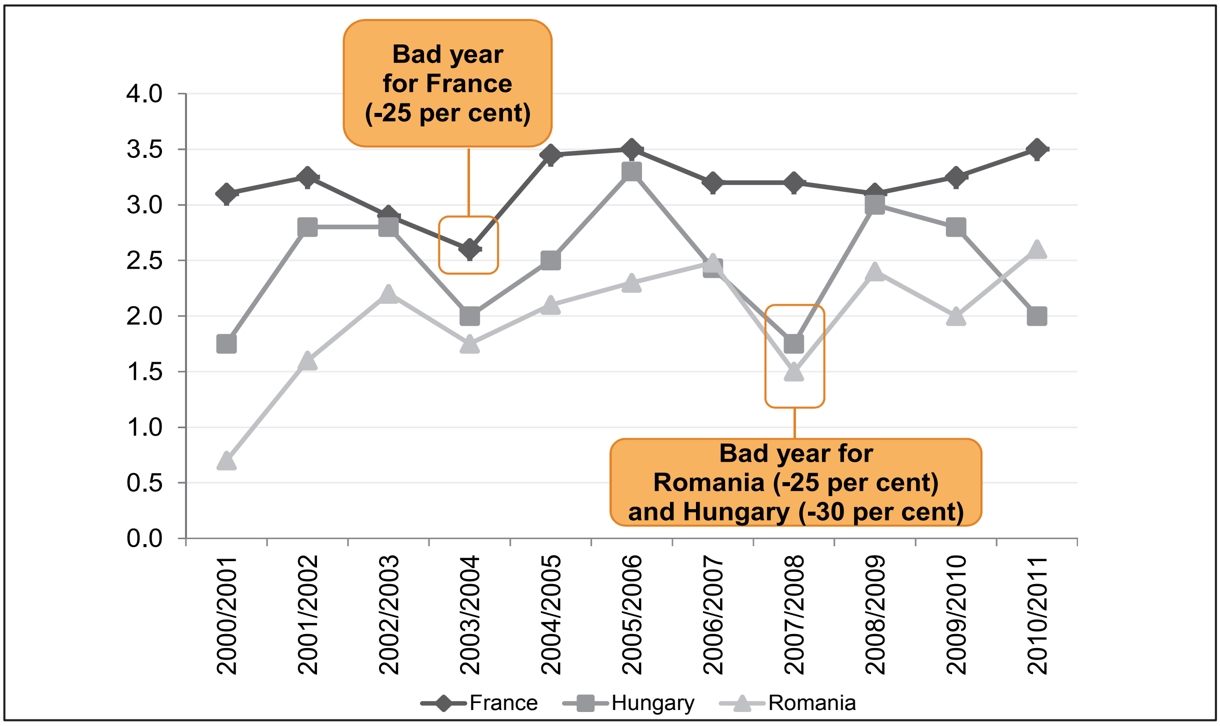
Figure 3.2: Economics of an average European Union seed company (in EUR/ha[1])



[1] per amount of seed necessary to plan one ha of commodity corn (EU average); [2] 'Active Ingredient' = NNi and processing; [3] based on 36 per cent NNi penetration and a 50 per cent margin on average 30 EUR/ha seed treatment price at the seed producer level; [4] land, labour, fuel, farm management, etc.; [5] R&D, sales force, etc.; [6] assuming 12 per cent yield impact, ignoring minor cost differences.

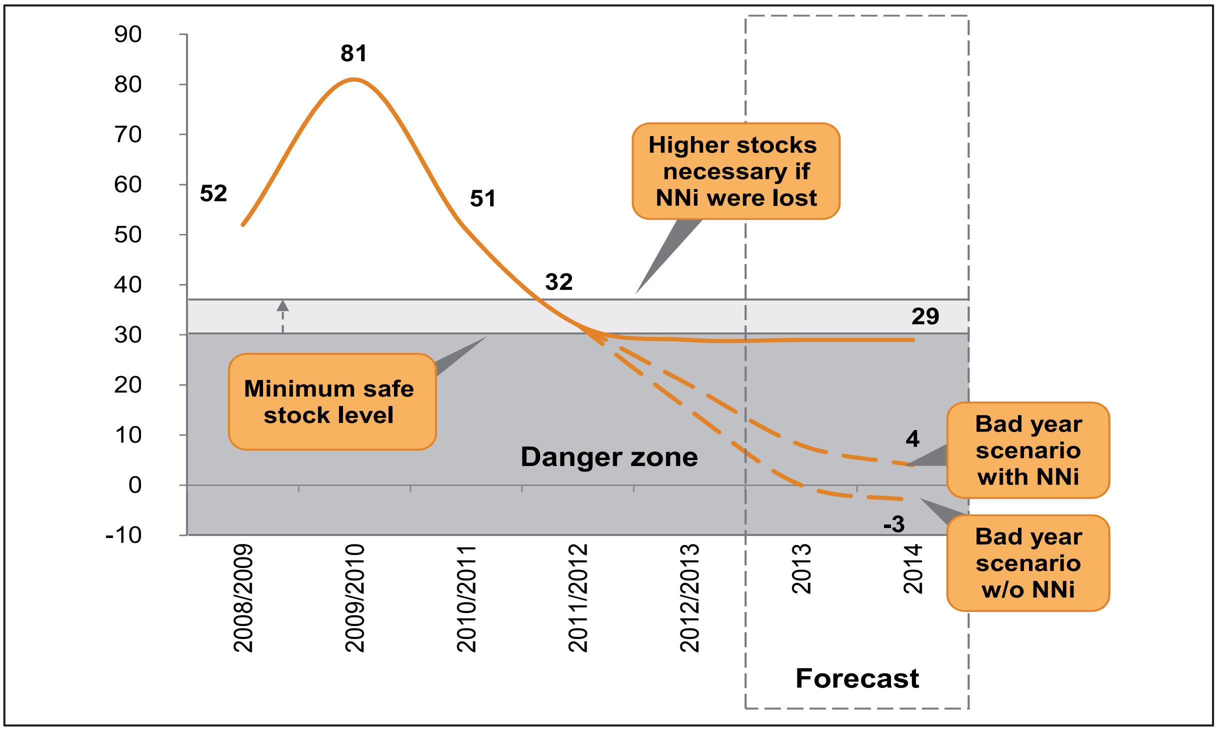
Source: Own analysis based on UFS (2012) and interviews with French and Hungarian seed producers.

Figure 3.3: Historic certified seed production yields (in tons/ha and year)



Source: Own analysis based on information provided by the Fédération Nationale de la Production des Semences de Maïs et de Sorgho (FNPSMS).

Figure 3.4: Corn seed stock level (in per cent of annual demand per year)



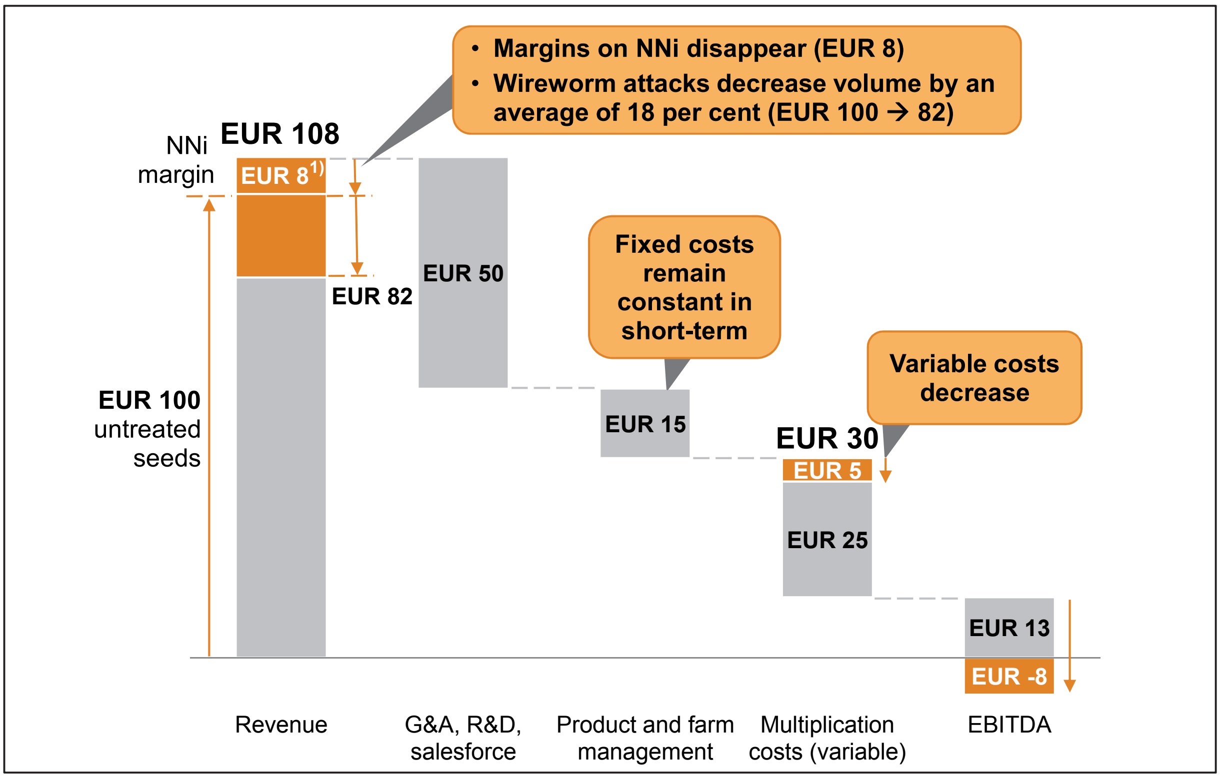
Source: Own analysis based on UFS (2012) and information provided by FNPSMS .

3.2 Hotspot HS2: A French corn seed producer

In order to illustrate the discussion above, we look at the specific case of Maïsadour, a French corn seeds producer. Maïsadour relies on NNi to maximize the productivity of its multiplication activities. In addition, as outlined in the generic case above, it generates a margin on the application and sale of NNi of about 8 EUR per 100 EUR of untreated seeds sold. A part of Maïsadour's operations is located in a very high pest pressure area, with an estimated 18 per cent average yield increase due to the use of NNi crop protection.

In the short-term, a loss of NNi technology would translate into a direct productivity loss (–18 per cent), as increasing surfaces is not possible given the complicated technical skills and conditions required, combined with the loss of margin on the NNi product itself, which is around 8 per cent. As a result, revenue would decrease by more than 20 per cent and the earnings before interest, tax, depreciation and amortization (EBITDA) would be negative (–10 per cent), as only variable costs (amounting to around 30 per cent of revenues) can decrease. In the longer term, the squeeze on profitability could drive the company to gradually transfer its R&D and operations outside of the EU, as reported in interviews with company executives. The economic picture is shown in Figure 3.5.

Figure 3.5: Economics of a French seed company (for 100 EUR of untreated seeds)



1) assuming 36 per cent penetration of NNi, 29 EUR of revenue per NNi dose, 50 per cent margin for the seeds producer, 70 EUR for the untreated seeds dose.

Source: Own analysis based on an interview with French seed producers.

3.3 Hotspot HS3: The Hungarian seed multiplication industry

In countries like Hungary, where the seed multiplication industry has a long tradition and contributes nearly 700 million EUR to national production, the impact of a NNi ban or suspension on societal welfare, jobs, exports, and overall economic growth could be even more acute.

Hungary is the second largest corn seed producer in Europe (see again Figure 3.1), and seed production provides income for approximately 60,000 seasonal farm workers and about 5,000 full time employees. In the country, an area of 34,000 ha is dedicated to corn seed multiplication. Pioneer, the largest player, has access to about 50 per cent of this area (16,000 hectares, 400 plots, 200 contractors) and runs the biggest corn seed production facility (Szarvas) in the world. According to the Hungarian Seed Association, 817 enterprises are involved in seed business. Around 60 per cent of the production is exported (mainly to other EU member states, Russia and the Ukraine), and 10 per cent is treated with NNi in the country.

In such a situation, the social impact of a decline of the Hungarian seed industry would clearly be severe. A ban or suspension of NNi would decrease the production of seeds in a context where there is high competition, in particular on the irrigated surface. Additionally, Hungary has introduced a new legislation on monoculture, which has the tendency to decrease the corn seed production. Finally, Hungary suffers from relatively high yield variability compared to France, the major EU corn seed player. For all these reasons, NNi technology is vital to maintaining a competitive productivity and to decreasing production variability.

The effect of the new legislation on monoculture and the potential switch of farmers to other crops for economic reasons is estimated by interviewed industry stakeholders to decrease corn seed production by 5 to 10 per cent each; the direct effect of yield reductions in case of a NNi ban or suspension is expected to lead to a production decline of 10 to 15 per cent. In such a scenario, the total output could decrease from 3 million units to 2.1 to 2.4 units, and in drought periods to well below these numbers.

In such conditions, the utilization factor of the production units would be close to 50 to 60 per cent. This could lead to (a) a gradual shift of production out of the EU, (b) an increase in corn seed price, (c) a negative impact on growers input cost and profitability, (d) an EU-wide shortage of corn seed supply considering the limited availability of seeds compliant with EU regulation from outside of Europe and (e) even lower stock levels than it is already the case (see again Figure 3.4).

3.4 Hotspot HS4: A Romanian corn farm

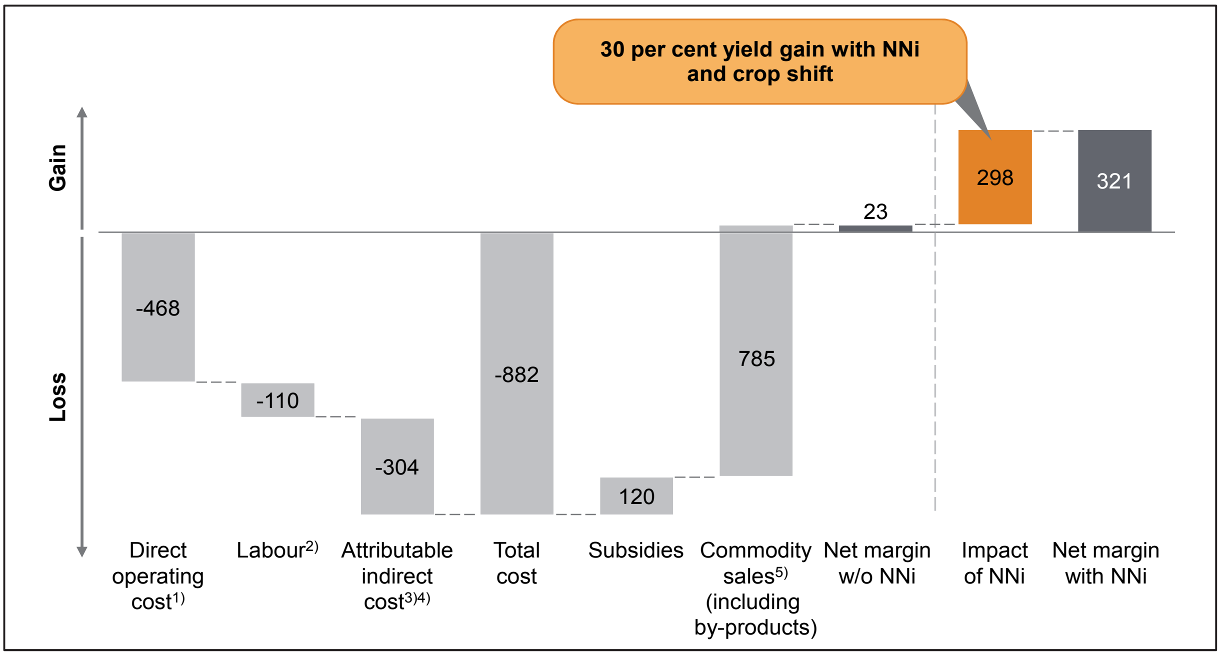
This hotspot shows a specific example of the impact of a potential ban or suspension of NNi on a mid- to large-size Romanian farm based on a series of interviews with farmers and industry stakeholders. Mid- and large-size farms are the driving force behind

Romanian agriculture as their yields are up to four times higher than what small farmers can achieve. They are also at the forefront of technology adoption, as profits are utilized to modernize business practices and to invest in increasing the farm size, allowing for economies of scale.

These Romanian farmers maximize corn production as it generates the highest returns. The specific farmer showcased in this hotspot is located on the border with Hungary and Serbia and cultivates on average 65 per cent of the farming area with corn, the rest being devoted to sunflower and wheat, the latter purely for rotation need. Due to high investments in equipment and technology, the farm currently achieves corn yields of more than double the Romanian average.

A loss of NNi would force a higher rotational switch of crops, which would translate into a shift of around 20 per cent of the growing area from corn to wheat and sunflower. Additionally, this farmer would suffer yield losses on corn of about 30 per cent due to the high Diabrotica pressure (in other regions this could also be due to Tanymecus). In summary, these factors would substantially decrease revenues and profits. This situation is summarized in Figure 3.6. Utilizing NNi technology, the exemplary farmer generates margins of about 35 per cent, based on current three-year commodity price averages. Without NNi, considering the same time-average, this farm would only be marginally profitable. In other words: almost the entire profitability of this typical mid- to large-sized farm can be attributed to NNi technology.

Figure 3.6: Economics of a Romanian corn grower (corn economics only, in EUR/ha)



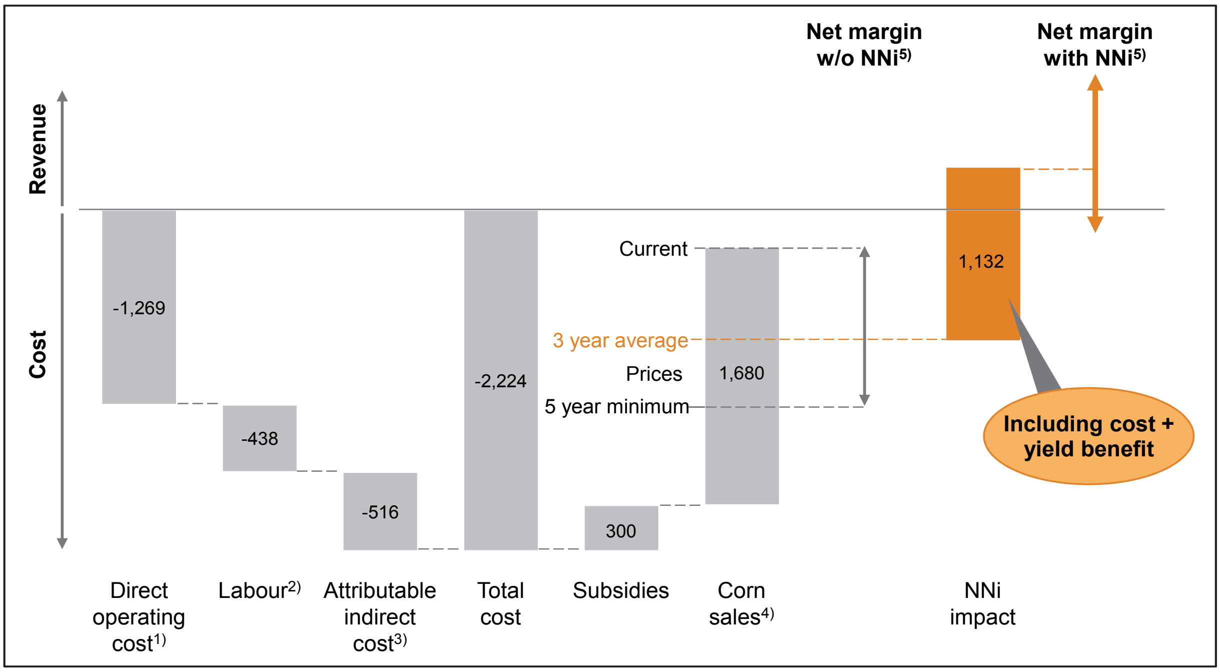
1) seeds, fertilizer, crop-protection, water, fuels, energy, maintenance, etc.; 2) contract work, wages, family labour; 3) depreciation, rent, interest, capital cost; 4) land rental: 150-200 EUR/ha; 5) three-year price average.

Source: Own analysis based on EC (2012) and interviews with farmer and industry stakeholders.

3.5 Hotspot HS5: A French corn grower

The Aquitaine region in the Southwest of France is the leading grain farming region in this country and hosts more than 10,000 farmers; the majority of these farms face high pest pressure. Located in Aquitaine this hotspot puts into focus the Terres Noires area, and with it about 1,000 farmers who cultivate crops under extremely high wireworm pressure (see Annex A.15). Local farmers and experts expect a yield impact through the use of NNi vs. a scenario where this technology would not be part of the deployed toolbox of up to 40 per cent in certain spots under maximum stress; and without NNi these farmers would suffer the associated productivity losses of the same size. As can be seen in Figure 3.7, under such conditions the loss of NNi would turn around the farmer's profitability from profit to significant losses, even when taking into account positive price developments over the last 5 years, which were quite significant. Without NNi, the farmer would remain unprofitable even with the maximum of historical prices paid. Opposed to that, with NNi the farmer would be profitable even at rather low market prices (except the historical price minimum). In other words: NNi also protects against severe market price volatility.

Figure 3.7: Economics of a French corn grower in the Terre Noires region under maximum stress (corn economics only, in EUR/ha)



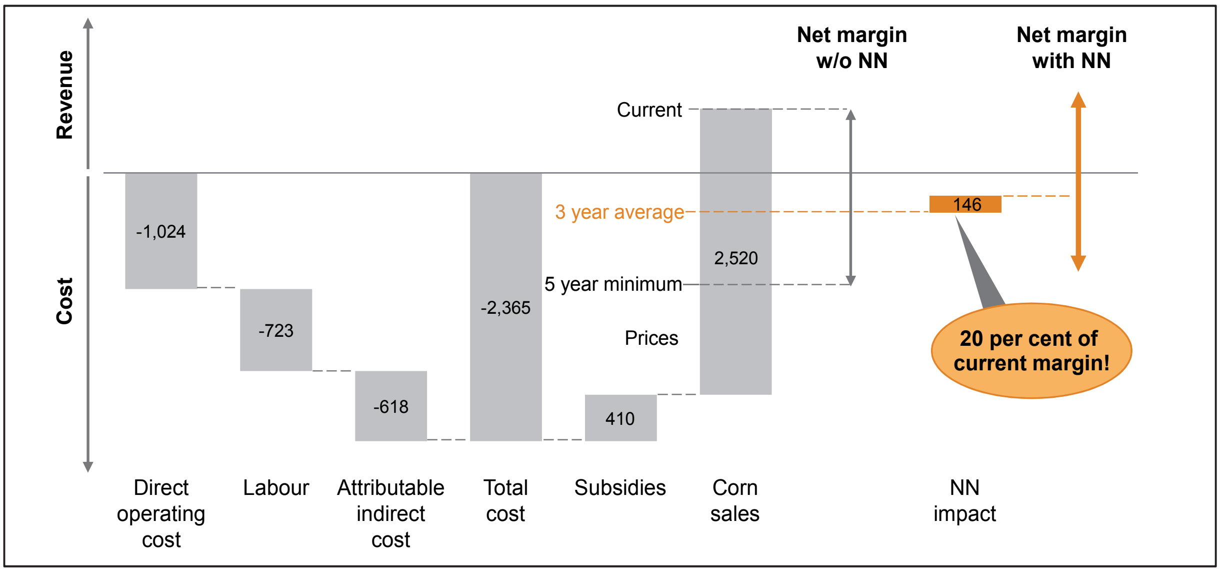
[1] seeds, fertilizers, crop protection, water, fuels, maintenance, energy, other direct cost; [2] contract work, wages, family labour; [3] depreciation, rent, interest, capital cost; [4] including by-products; [5] top of arrow represents margins with current prices, bottom of arrow margins with five-year minimum prices and the orange dotted line margins with 33-year average prices.

Source: Own analysis based on EC (2012) and information provided by Syngenta France.

3.6 Hotspot HS6: An Italian corn grower

In contrast to the previous case of a farmer in severe pest pressure conditions, this hotspot examines the case of an average farmer in Italy under average pest pressure conditions. While the hotspot, as seen in Figure 3.8, does not show a complete turnaround of the profitability due to NNi, it illustrates how NNi can provide additional protection against market volatility and marginally increase the farmer's earning with an impact of 20 per cent on margins. This impact is attributed to an average expected loss of productivity of almost 6 per cent due to the exclusion of NNi from the farmer's toolbox and increased application costs (for fuel and labour) due to the need of spray treatments to control Diabrotica in many cases as well as the product cost of these sprays and the necessity to additionally deploy micro-granules.

Figure 3.8: Economics of an Italian corn grower under average pest pressure (corn economics only, in EUR/ha)



Source: Own analysis based on EC (2012).

3.7 Hotspot HS7: A United Kingdom winter wheat grower

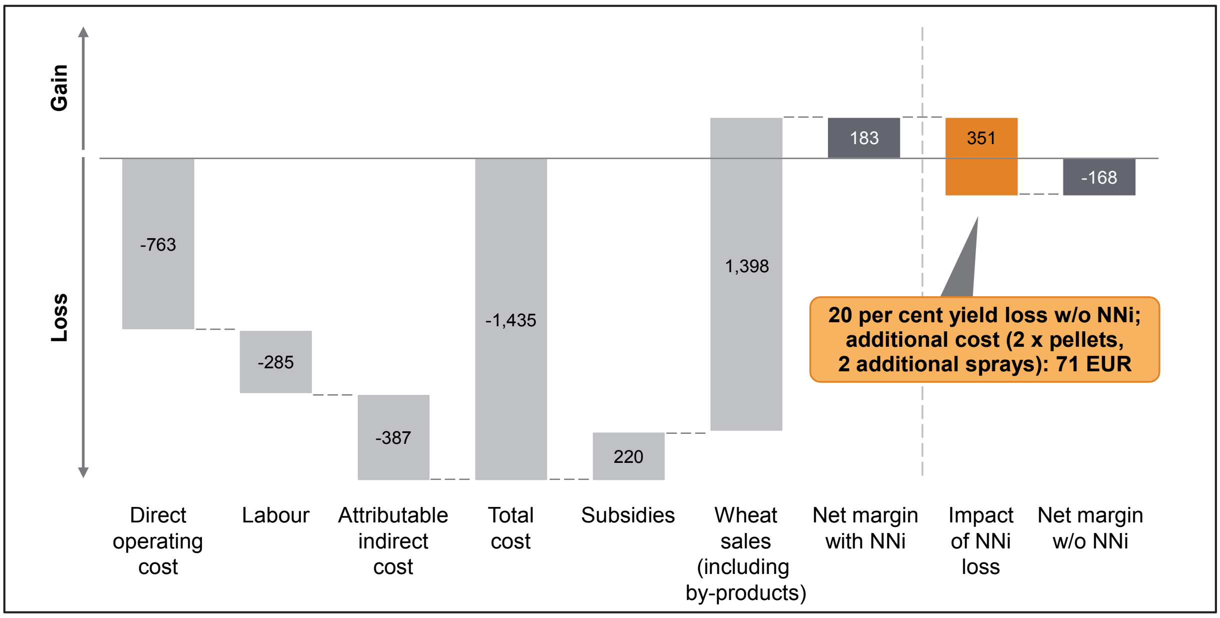
Winter wheat farmers in the United Kingdom (UK) rely on NNi to control severe fall pests while managing complex farming operations. Current farming practices for winter wheat therefore strongly depend on NNi technology: the loss of this technology could lead to a yield decline of up to 20 per cent. Without NNi, the production of winter wheat would no longer be profitable for many farmers.

This situation is exemplified by a hotspot based on a large farm (namely JSR) in the East Yorkshire region, which employs a base level of 13 full time employees for arable operations. JSR operates a six-year crop cycle and many winter wheat operations coincide with work on other crops, like OSR. During heavy summer and early fall farm activities, JSR ramps up workforce to 22 full time employees to manage the increased workload and the more complex workflow. The general workload is particularly high in September and October, when winter wheat drilling and fall pest management needs to be accomplished, and weather starts to deteriorate.

NNi effectively controls aphids (and thus prevent barley yellow dwarf virus (BYDV) infection) and repel slugs, while allowing the farmers to manage the high workload across all parts of the farming operation with current workforce, workflow, and equipment. Heavy slug pressure occurs twice a year, including the ploughing and drilling season. Therefore, NNi also supports crop establishment, particularly in the UK with very moist fall seasons. Annex A.16 depicts this situation alongside the winter wheat growing cycle. According to interviewed stakeholders and in unfavourable years, high yield losses of 20 per cent or more could occur without NNi protection, which would make winter wheat an intrinsically unprofitable crop.

Furthermore, the trend in the UK goes to early drilling, already in September. This practice increases yield and provides crop management benefits, but it also relies on solid aphid control, which is provided by NNi during the first growth stages of winter wheat. In summary, farmers indicate that accurate and effective pest management is hard to achieve without NNi while also conducting all other arable operations. All interviewed stakeholders indicate, that NNi on winter wheat are an enabling technology and a ban or suspension of NNi could lead to yield losses of 20 per cent or more in heavy aphid years. Figure 3.9 shows the economic situation as it relates to the typical production of UK winter wheat. Hence, UK farmers and related stakeholders strongly support the use of NNi on cereals.

Figure 3.9: Economics of a United Kingdom winter wheat grower (wheat economics only, in EUR/ha)



Source: Own analysis based on EC (2012).

3.8 Hotspot HS8: A German oilseed rape farmer in Mecklenburg-Vorpommern

OSR growers in Germany have no viable alternative to NNi to ensure competitive returns under potentially high pest pressure from Cabbage Root Fly (CRF) and the Rape Flea Beetle (RFB). Without such protection, yields could be reduced by up to 20 per cent in key areas such as Western Mecklenburg-Vorpommern under adverse conditions and erode farmer margins by more than 60 per cent. This would certainly make OSR cultivation less competitive, increase the EU dependency in vegetable proteins, and reduce the food supply provided by OSR for bees. By making rotational crops more profitable, NNi, thus, also contributes to the diversity of agricultural crops in some European regions.

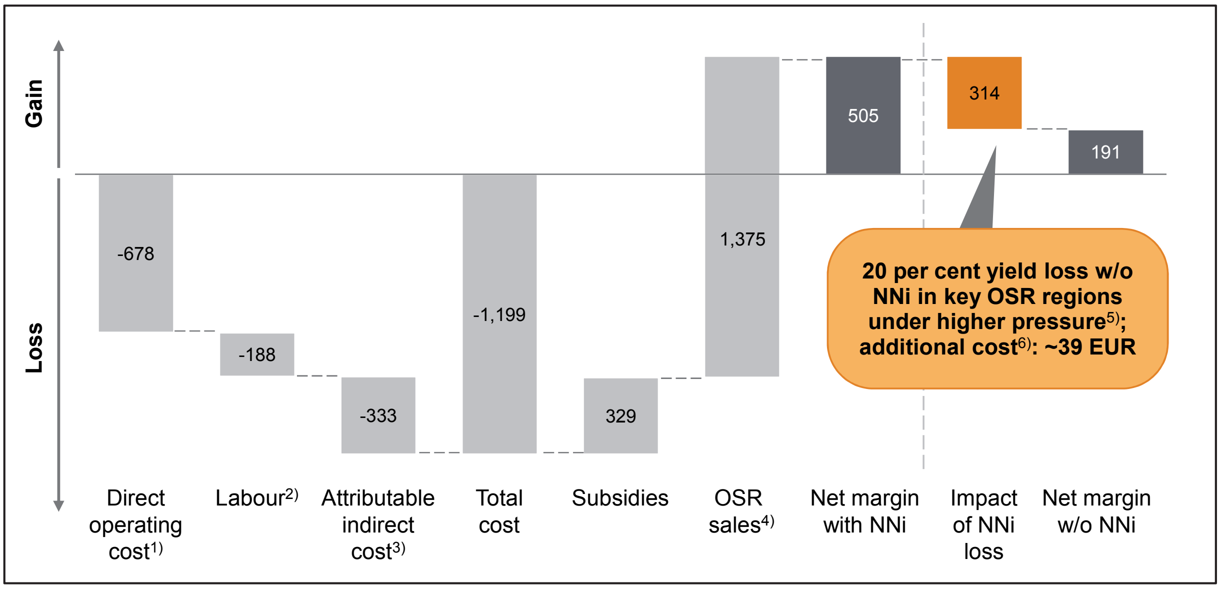
CRF and RFB are major OSR fall pests in Germany, and main growing regions in North-Eastern Germany suffer from serious infestations (see Annex A.17). In Western Mecklenburg-Vorpommern, up to 68 per cent (on average 22 per cent) of tested OSR fields have been infested during the 2011 sowing season by the CRF larvae and up to 62 per cent (on average 13 per cent) by RFB. Field observations show that OSR has a strong capacity to compensate when infested and almost no major yield effects are apparent when the plant is generally supplied well and NNi is used (as there is almost a 100 per cent NNi penetration); however, it is unclear what losses would be without the NNi technology.

Only NNi is registered to control CRF and it can be argued that the overall pest pressure could have been significantly reduced because of NNi use over the last years. NNi also protects against RFB until the four-leaf stage, while resistance is beginning to develop against the only other insecticide class registered to control this pest. OSR seeds in Germany are only processed (seed treatment being applied) in certified facilities and with trained personnel in order to ensure that abrasion and incidental release of the active ingredients are minimized and NNi is applied optimally. Against this overall background, interviewed experts expect average yield losses of approximately 15 per cent (due to CRF), about 10 per cent (due to RFB), and up to 2 per cent (due to aphids) in case of a ban or suspension of NNi. If problems coincide, losses of up to 20 per cent could easily occur. Under such conditions, grower margins would decline by 60 per cent or more. The economic situation for the grower relating to OSR is depicted in Figure 3.10.

3.9 Hotspot HS9: A German sugar beet grower

For sugar beet, NNi is now an integral part of modern European sugar production. Without NNi, the overall pest pressure could dramatically increase lowering yields by 10 to 20 per cent, significantly erode grower margins and undermine the efforts of the European sugar growers to be more competitive on the world market. Under these circumstances sugar beet production in Germany and other countries could become unsustainable.

Figure 3.10: Economics of a German oilseed rape grower based on a farm in Western Mecklenburg-Vorpommern (OSR economics only, in EUR/ha)



[1] seeds, fertilizer, crop-protection, water, fuels, energy, maintenance, etc.; [2] contract work, wages, family labour; [3] depreciation, rent, interest, capital cost; [4] current three-year price average; [5] 25 per cent are possible in worst-case scenarios; coincidence of CRF and RFB; [6] two additional spray treatments and seed treatment.

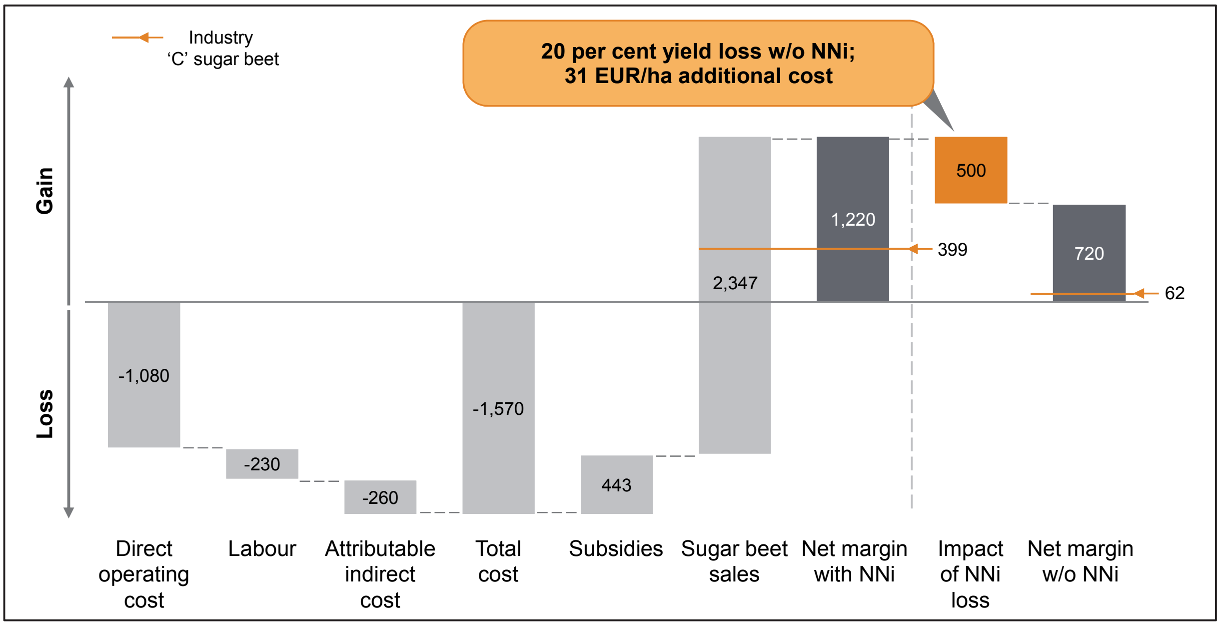
Source: Own analysis based on stakeholder interviews and information provided by Rapool-Ring and Norddeutsche Pflanzenzucht (NPZ) as well as Noleppa et al. (2012) and BMELV (2011).

The largest pest threat to sugar beet crops is a virus infection causing yellowing disease, which is transmitted through aphids and, according to experts, responsible for yield losses of up to 20 to 40 per cent. All the way up to the late 1980s, cyclic appearances of virus yellowing disease was the norm, and sugar beet production was revolutionized when NNi where introduced in the early 1990s (see Annex A.18; note that the data relating to the incidence of yellowing disease on the graph directly applies to the historic situation in France, but also correctly depicts the situation in Germany over the same period of time). A reverse development must be expected if NNi were lost.

If NNi protection is used, additional spray treatments are only necessary in 15 per cent of all cases. It is currently observed that aphids show increasing resistance against spray treatments. In case of a ban or suspension of NNi, experts expect yield losses of 10 o 20 per cent when pest pressure is heavy, which would reduce typical grower margins by up to 40 per cent. The grower economics relating to sugar beet under such a scenario is given in Figure 3.11.

In the long run, overall pest pressure could increase dramatically and the economic impact on the European sugar production would be even more severe. Although sugar is currently a very profitable crop, a selective loss of NNi on sugar beet would make the crop less attractive compared to other rotational crops such as OSR, which could make it harder to secure the area necessary to satisfy sugar production. Assuming a 20 per cent yield loss, current margins on so-called “industry” (C quota) sugar could be entirely wiped out (see Figure 3.11).

Figure 3.11: Economics of German sugar beet grower under high aphid pressure (sugar beet economics only, in EUR/ha)



Source: Own analysis based on stakeholder interviews and information provided by the German Institut für Zuckerrübenforschung.

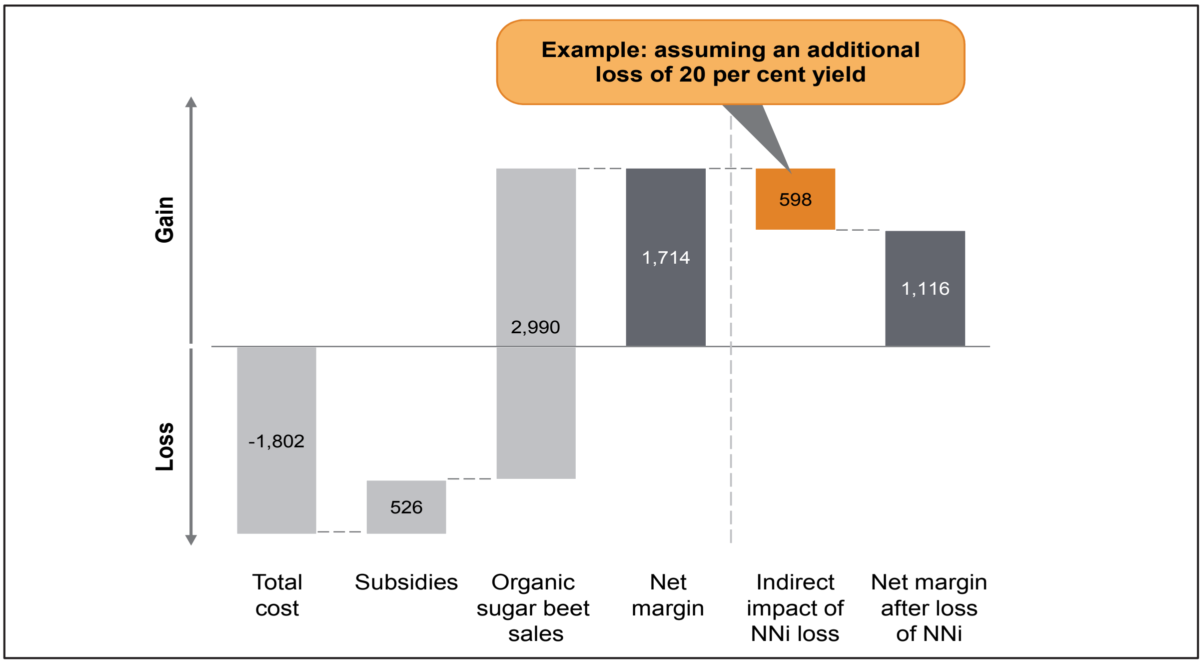
Beyond the direct impact on margins and while the industry is still regulated by quotas, NNi helps optimize profitability by reducing uncertainty in total production in a high pest pressure situation. This is conceptually shown in Annex A.19: If the quota is exceeded, the grower loses profit because alternative rotational crops would be more profitable (opportunity costs) than ‘industry’ sugar sales; in case of unfulfilled volumes high margin quota sugar sales are lost.

For all these reasons, all stakeholders interviewed strongly support the use of NNi on sugar beet. It remains to note, that this situation is not unique to Germany but similar arguments could be made for other sugar producing EU member states that have been investigated.

3.10 Hotspot HS10: A German organic sugar beet grower

The application of NNi has also benefited organic growers of sugar beet even though they do not use the technology directly. This is because the general use of NNi in key sugar beet production areas has reduced the overall pest pressure for all types of production. If NNi were lost, overall pest pressure would increase, also affecting organic sugar beet growers. Interviewed experts estimate that yield losses of up to 20 per cent would be likely, which would reduce margins of organic SB growers by up to 35 per cent. The economics of this scenario from the point of view of the organic grower is depicted in Figure 3.12.

Figure 3.12: Economics of German organic sugar beet grower under generally high aphid pressure (sugar beet economics only, in EUR/ha)



Source: Own analysis based on stakeholder interviews and information provided by the German Institut für Zuckerrübenforschung.

3.11 Hotspot HS11: Winter planting of sunflower in Andalucía, Spain

NNi has enabled many innovations in farming practices, including the planting of sunflower in Andalucía as early as January instead of April, what used to be the traditional practice. The seed treatment enables control of wireworms during the winter germination. Planting early also makes better use of soil moisture and water, and additional yields in sunflower of more than 20 per cent have been seen for a product that has been embraced by the public because of its health benefits. In time of a severe economic crisis (as it is currently the case in Spain) this technology provides an opportunity for this region (Andalucía) to generate more income (see below).

The hotspot additionally illustrates the flexibility that NNi provides in unlocking additional value vs. traditional farming approaches. Studies (see Annex A.20) have shown that early planting of sunflower (January vs. April) unlocks significantly higher yields of 22 per cent as compared to the traditional approach. These results are not only supported by academic research, but also by farmers who are already adopting this innovative new practice. Early planting is particularly useful in drought years to leverage the winter rains. The success of this approach became particularly evident in the dry year of 2012 and for this hotspot, which is based on the success achieved by an Andalucía farmer (Luis Prieto Carreño): the farmer achieved yields of 1.3 to 1.5 tons per hectare vs. no crop or a maximum of 1.0 ton per hectare, which were typical yields for neighbouring farmers during the same year, who have not planted in the winter.

It can be stated: the deployment of systemic seed treatment (such as NNi) is a necessary condition to unlock additional potential under realistic conditions, as it is required to control the increased exposure to wireworm caused by longer germination periods in sunflower production. According to interviewed experts, this technology could bring up to 50 million EUR per year to Andalucía.

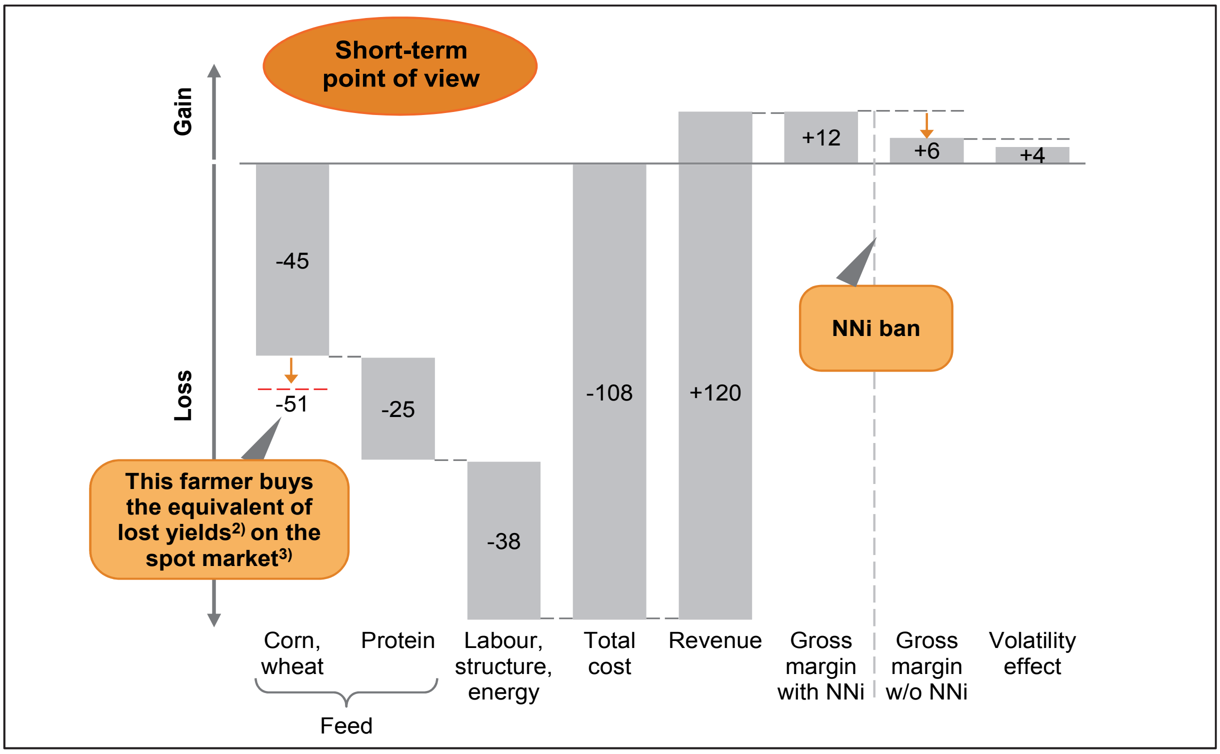
3.12 Hotspot HS12: A pork producer in France

This hotspot analyses the impact of a potential NNi ban or suspension on one of the biggest pork production enterprises in Western France (a cooperative with 2,700 pork producers – of which 20 per cent are 'self-sufficient' – fattening approximately six million pigs per year), relying on their own corn and wheat to feed the pigs. For 'self-sufficient' farmers, a ban or suspension of NNi would jeopardize the already thin margins and expose them to the market volatility for feed. For the cooperative itself, the ban would imply additional logistics challenges and stocking facilities for micro-granules as well as augmented teams of after-sales service personnel to manage the additional technical complexity of deploying them.

Feed in the hotspot example represents up to 70 per cent of the operational pork production costs and cereals (corn and wheat) represent 75 per cent of the pork diet. In this situation, the cooperative negotiates volume feed prices based on yearly forecasted quantities for their pork producers, and a ban or suspension of NNi would reduce the yield of corn and wheat for 'self-sufficient' farmers. In many instances this would drive them to buy the missed quantities of feed from the cooperative, and thereby increasing their costs. Furthermore, the cooperative will not be able to provide all these additional volumes from the pre-negotiated quantities (as they were not forecasted) but rather acquire them on the open market, further exposing the farmer to market volatility. Under such circumstances, the margins of these producers would be significantly reduced to a degree that overall profitability would be at stake, as shown in Figure 3.13.

Additionally, at the cooperative level, a ban or suspension of NNi would imply the use of micro-granules, which poses two main challenges: (a) a logistical challenge with the need to transport and stock additional 600 tons of material, and (b) an after-sales challenge as the micro-granules require additional technical skills that the cooperative sales team cannot fulfil with the current size (14 people) and skillset.

Figure 3.13: Economics of a French pork producer[1)] under high pest pressure (in 1,000 EUR)



1) illustrative example of a cooperative-farm with own feed production; 2) minus20 per cent for corn and minus7 per cent for wheat; 3) the case does not evaluate whether the choice of the farmer to be self-sufficient in terms of feed was a wise choice, but simply points out the additional feed costs spent on acquiring the feed that is normally produced on the farm.

Source: Own analysis based on stakeholder interviews and prices used for modeling purposes in chapter 2.

3.13 Hotspot HS13: A French oil crusher

This final hotspot case is based on the French oil crusher 'COC', a company that invested about 35 million EUR in an oil-crushing plant in the 1990s with a capacity of about 230,000 tons, producing oil for food and feed (about 30,00 tons), bio-diesel (about 60,000 tons) and oilcakes (around 140,000 tons). COC partially relies on cooperative OSR production as the input of its new oil crushing plant. Without NNi, additional foliar applications require an increased workforce and time that the cooperative growers do not have – in particular in years such as 2012, when OSR planting has been delayed from mid of August to late September – and the additional foliar application is coinciding with a high workload period (corn and sunflower harvest and wheat drilling), thus, resulting in lower yields or even complete crop losses. In addition, this has coincided with a strong pressure from flea beetles, which require careful observation and foliar spray application in the absence of NNi. As a result, the oil plant has to acquire the missing OSR quantities on the open market, with further exposure to market volatility and additional transportation costs for a total impact of up to 4.5 million EUR on the margin.

4 Concluding remarks and recommendations

This study shows that the socio-economic, technological, and environmental value contribution of NNi is extremely significant. It can be stated that a potential ban or suspension of NNi technology would have tremendous economic implications in the short-term as well as in the mid-term. To take few examples: over a five-year period, the EU could lose 17 billion EUR and more; 50,000 jobs could get lost economy-wide; and more than a million people engaged in arable production and their livelihoods would certainly suffer if NNi were lost.

In addition, if NNi were no longer available in the EU, there would be a significant reduction of food production considerably altering the agricultural trade balance. Moreover, any reduction in agricultural productivity in the EU would need to be compensated by making new arable land available outside of the EU. In the case of a ban or suspension of NNi, the EU's virtual land import of almost 30 million hectares would increase by at least additional ten per cent of arable land outside the EU territory. The environmental cost of converting this land for arable use would be substantial: around 600 million tons of additional CO_2 emissions would occur, which are equivalent to up to 15 billion EUR in emission certificate value.

A series of *hotspot* regions, stakeholders, and businesses has been identified, which exemplify the impact of a potential ban or suspension of NNi technology. Growers across the EU would loose a significant part or their economic margins, or entirely loose profitability on some major crops. Large agricultural industries, such as European sugar producers, or seed companies would be exposed to significant risks and become far less competitive and entire regions could suffer negative socio-economic consequences, or be deprived of important growths opportunities.

Altogether, this work highlights the transformative nature of NNi, and the catalysing role it plays in modern agriculture. In particular, it demonstrates the impact should the technology no longer be available. The study also underlines the importance of looking holistically at agriculture. An action taken in one area, not fully considered, can have major unintended consequences elsewhere. In addition, the study shows, perhaps surprisingly, that NNi has become an integral part of European agriculture and significantly contributes to European food production. If this technology were no longer available, food production would decline by an amount sufficient to feed many millions of people.

This would happen in a time when global demand for food and agricultural commodities is expected to more than double in the first half of the 21st century (Global Harvest Initiative, 2012). The rapidly growing demand could be met either by expanding the agricultural acreage or by increasing the productivity of the land being already farmed. As the land that is globally available for agricultural use is limited, the production growth necessary to meet the increasing needs of the world must mainly come through productivity growth. However, the actual situation is quite different: While global agricultural demand increases by at least 1.8 per cent per year, agricultural supply increases by not more than 1.3 per cent annually (Noleppa, 2012). Not only agricultural prices will rise therefore, but overall food availability might decline. This has surely the potential to lead to growing regional and global market instabilities, as increasing price volatility on agricultural markets does already proof. Any measure, be it a political intervention or a private investment, needs to be judged against this phenomenon.

Through additional productivity and agricultural supply, NNi helps in such an environment to minimise the price increase on world agricultural markets and tends to decrease price volatility, since tradable market volumes are higher with NNi and, thus, in a better position to compensate market shocks. Moreover, the use of NNi in the EU alone could currently increase global food availability in terms of energy, protein, and vegetable fat for millions of humans, thus, helping to combat malnourishment of currently around 1 billion people.

Neonicotinoid seed treatment is a key and currently often irreplaceable technology available to farmers today that helps secure the competitiveness of European agriculture – with all the discussed socio-economic and global environmental benefits – as well as achieve a level of productivity that supports the stability of agricultural markets, while also supporting the food security for a growing world population. The authors strongly recommend that these facts are considered in any regulatory decision making process that addresses this technology.

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Annexes

Annex A.1: Application of the constructed normal value approach

The approach used to calculate the costs and returns of agricultural production in this analysis is basically a full-cost-full-revenue calculation approach and consistent with the concept of the ‘constructed normal value’ (CNV). The basic methodology was developed by Eidman et al. (2000) and has become, meanwhile, a well-accepted methodology to measure cost and revenue impacts of changing production environments, especially in agriculture and for purposes of the World Trade Organization (WTO) (see, e.g. von Witzke et al., 2010; Noleppa et al., 2012). It particularly permits the crop specific calculation of total variable and fixed costs of production including the opportunity costs, which often are also referred to as indirect costs. This methodology is also used in the calculations of costs and returns of US agricultural production (e.g. McBride and Green, 2007; USDA, 2012), and it is consistent with standards set by the Agricultural and Applied Economics Association (AAEA), a not-for-profit association serving the professional interests of members working in agricultural and broadly related fields of applied economics (see, e.g., USDA, 2009).

The clustering of the cost components in accordance with the CNV approach is exhibited in the following Figure A.1.1 and gives guidance to the analysis applied here. To fit the approach to own purposes with reliable and robust data, a questionnaire was developed to get insights into crop-country specific production costs and revenues. The questionnaire was submitted to numerous agricultural stakeholders and ‘country champions’ and allows for a sound assessment of costs and revenues. Additionally, a stress test of the information obtained was carried out mainly using EC (2012) and KTBL (2011).

Figure A.1.1: Clustering of crop specific costs and returns for standardized calculations

Operating variable costs	Allocated overhead and fixed costs
Seed	Hired (and opportunity costs of family) labour
Certified and non-certified seed	Capital recovery machinery / equipment costs
Fertilisers	Land rental and opportunity costs of land
Lime, N, P, K fertilisers	Insurances
Chemicals	Other (general) farm overheads
Plant protection, other chemicals	Returns (gross value of production)
Other operational (variable) costs	Primary product
Fuel, electricity, services etc.	Secondary product

Source: Adopted from USDA (2012).

Annex A.2: Application of the world food equation approach

Applying a world food equation (WFE) simply means that agricultural supply q^s has to meet agricultural demand q^d. Agricultural supply and demand are usually determined by several factors. Each factor or major driving force can be discussed separately with the WFE. This is symbolised by the following simple function A.2.1.

(A.2.1) $t * q^s(p) = q^d(p, f, y)$

where:

t = technology factor,

q^s = supply quantity,

p =price,

q^d = demand quantity,

f = food (or feed) demand, and

y = income.

Deriving the rates of change and solving for dp/p yields equation A.2.2:

(A.2.2) $dp/p = 1/(\eta^s - \eta^d) * (-dt/t + df/f + \eta^y * dy/y)$

where:

η^s = supply elasticity,

η^d = demand elasticity, and

η^y = income elasticity.

According to this equation the price change on the world market will depend on a productivity change compared to a demand and/or income change. Applying the ceteris paribus condition for all but productivity changes allows calculating the partial price effect caused by a change in agricultural land productivity (in other words: in yields due to NNi) bringing the world market price up or down.

In order to calculate such price effects, meaningful elasticities have to be determined for the short-term. Elasticity values have been taken from von Witzke and Noleppa (2012), but the value has been adjusted to specific crops using elasticity ratios as determined in the partial equilibrium modelling approach (see below in Annex A.4).

Annex A.3: Overview on identified and defined agricultural multipliers for EU member states

A comprehensive meta-analysis was carried out in order to identify reasonable GDP respectively output multipliers as well as employment respectively job multipliers of agriculture in the various EU member states. The different challenges associated with the determination of reasonable multipliers discussed among scientists shall not be reloaded here. A rather comprehensive discussion on the meaning and calculation of different multipliers as well as on the pros and cons of partly diverging techniques for and results from multiplier analyses can be found, e.g., in D'Hernoncourt et al. (2011), EC (2007), Harris and Doeksen (2003), and Islam et al. (2010). Instead, an overview of the major findings with respect to this own meta-analysis on multipliers shall be given in the following.

Numerous sources published in the past decade – some of them were also used by OECD (2009) – have been studied to draw a picture. Among others, the following references (rich in information) shall be quoted (in alphabetic order): Andre-Fas (2001), Balamou and Psaltopoulos (2006), Bayramoglu (2008), Bonfiglio (2005), Bossard and Dauce (2004), Bossard et al. (2000), Cardenete et al. (2012), Leon and Surry (2009), Luptacik et al. (2005), Mahe et al. (2001), Mattas et al. (2008), Mayfield et al. (2005), Rocchi et al. (2005), Semerak et al. (2010), Sila and Juvancic (2005), Stehrer and Ward (2012), Ten-Raa and Rueda-Cantuche (2005), and van Leeuwen and Nijkamp (2008).

More than the quoted references have been included in the initial analysis, but had to be taken out for further consideration because of some doubts or potential misinterpretations: Many economists, argue, e.g., that multipliers above a certain level (> 3.0) should be seen as non-reliable or at least taken with greatest caution if used in further analyses. The specific robustness, reliability and plausibility checks of available data were made, mainly using Crawford (2011), D'Hernoncourt et al. (2011), Harris and Doeksen (2003), Islam et al. (2010), and Klein (2012).

Figure A.3.1 displays the results of this examination. It becomes apparent that a rather broad range of potential multipliers has been identified for almost all EU member states and the EU in total. To take an example: In the case of Germany, output/GDP multipliers (employment/job multipliers) may vary within a range of 1.01 to 1.61 (1.10 to 1.20); and for the EU in total, the identified intervals range from 1.49 to 1.91 respectively from 1.08 to 1.40. One question arises: What to do with the obviously existing uncertainty? Two sets of multipliers have been defined to better cope with this partial dilemma: A first set of multipliers implies 'average' multipliers being the average of the minimum and maximum value of identified country-specific multipliers; a second set uses the identified maximum values for multipliers, thus, demonstrating that economy-wide effects of a ban or suspension of NNi could be 'as high as' if based on the thoroughly analysed scientific knowledge (common wisdom).

Figure A.3.1: Identified and defined country-specific multipliers of EU agriculture

Output respectively GDP multipliers			
EU member state	Range of identified multipliers	Proposed multipliers for own analysis	
		average	"as high as"
United Kingdom	1.06 – 2.09	1.58	2.09
The Netherlands	1.41 – 1.63	1.52	1.63
Germany	1.01 – 1.61	1.31	1.61
Poland	1.18 – 2.94	2.06	2.94
Slovenia	1.59 – 1.64	1.62	1.64
Hungary	1.91 – 2.21	2.06	2.21
Romania	1.03 – 1.91	1.47	1.91
France	1.09 – 1.97	1.53	1.97
Spain	1.23 – 1.91	1.57	1.91
Italy	1.13 – 1.58	1.36	1.58
EU, total	*1.49 – 1.91*	*1.70*	*1.91*
Employment respectively job multipliers			
EU member state	Range of identified multipliers	Proposed multiplier for own analysis	
		average	"as high as"
United Kingdom	1.03 – 1.48	1.26	1.48
The Netherlands	1.09 – 1.28	1.19	1.28
Germany	1.10 – 1.20	1.15	1.20
Poland	1.06 – 1.40	1.23	1.40
Slovenia	1.35 – 1.40	1.38	1.40
Hungary	1.30 – 1.40	1.35	1.40
Romania	1.40 – 2.30	1.85	2.30
France	1.06 – 1.60	1.33	1.60
Spain	1.40 – 1.50	1.45	1.50
Italy	1.30 – 1.60	1.45	1.60
EU, total	*1.08 – 1.40*	*1.24*	*1.40*

Source: Own compilation based on studies quoted above.

How should the multipliers be used? One example: A job multiplier of 1.26 as in the case of the 'average' in the United Kingdom means that if one job in agriculture is created or lost, 1.26 jobs are created respectively lost in the entire economy. In other words: In addition to agricultural employment, 0.26 jobs are affected in other sectors.

Annex A.4: Description of the applied partial equilibrium model

The standard partial equilibrium modelling approach is specified here for a so-called multi-region multi-market model (MMM). MMMs are widely used in the analysis of agricultural change. MMMs are particularly suitable for the simulation of alternative production and policy scenarios analysing the impacts of changes in domestic agricultural and trade policies as well as of changes in production processes including changes caused by alternative input use. In addition, MMMs provide a useful tool to project future developments of world market prices, food gaps, and resource scarcities (Sadoulet and de Janvry, 1995; Saunders and Wreford, 2005). Such a model, as developed for this analysis, can quantify in a rather detailed way changes in agricultural production (supply) and their economic consequences, including land area used for the production of the various goods, demand and price changes, effects on trade flows between the regions as well as changing economic welfare indicators (Francois and Reinert, 1997).

Recent examples of the development and application of MMMs in the agricultural sector analysis include studies from Renwick et al. (2013), who analysed the impacts of a reform of the European agricultural policy on agricultural land abandonment in the EU, Gebrehiwet (2010), who examined the impacts of policy changes on agriculture input expenditures, Hosein and Khadan (2011), who investigated the potential benefits that can be derived from the proposed CARICOM-Canada free trade agreement for CARICOM countries, and Schwarz et al. (2011), who analysed the world-wide impacts of changing oil prices and bioenergy demand on world agricultural market prices and trade.

The specific MMM for this analysis is a purpose-built complex agricultural modelling framework developed to quantify the impacts of bans and/or suspensions of the use of plant protection products, namely NNi, on the production (supply) and consumption (demand) of agricultural commodities, the associated land use, market prices, trade and economic welfare indicators. The key advantage of such a modelling framework is the capability to simultaneously assess the impacts on a large number of commodity markets in a large number of different regions and countries, here EU member states, thus, capturing inter-market and inter-regional interdependencies.

To take an example: Certainly, the removal of plant protection products leads to lower crop yields and results in lower domestic production on the various crop markets. However, the impacts of the removal of plant protection products on crop yields, and consequently production quantities, vary between the markets and, thus, lead to different price effects, which in turn affect the allocation of resources between the different crop markets. The model should capture such cross-price effects and should additionally quantify the substitution effects between the different markets. Yield reductions due to the removal of plant protection products, e.g. for corn in France, lead to lower domestic corn production too. Global corn demand would, thus, need to be increasingly satisfied by corn production in South America or elsewhere. If yields are assumed to remain constant, the increase in corn production in South America can only be achieved through more land being used for corn production. The model should also be able to capture those inter-regional market interdependencies and should quantify the required increase in production, the change in prices and the resulting land allocation in other countries and regions.

The MMM developed here explicitly covers the following commodities: wheat, barley, corn, other cereals, oilseed rape, soybeans, sunflowers, other oilseeds, and sugar, the latter differentiated between sugar cane and sugar beet cultivation. For all these commodities, markets have been defined in the following 18 regions: Germany, France, The Netherlands, United Kingdom, Hungary, Italy, Poland, Romania, Slovenia, and Spain, rest of the EU, rest of Europe, North America, South America, Asia, Oceania, North Africa, and Sub-Sahara Africa. Note against this background, that the other cereals and other oilseeds markets represent residual commodities to close the model.

In addition, livestock markets (beef, pork, sheep meat, poultry, eggs, raw milk, butter, cheese and skim milk powder) have been included in the modelling framework to be able to capture market interdependencies and cross-price effects as detailed and realistic as possible: Increases in world market prices on crop markets due to a potential removal of plant protection products may result in higher costs for feed inputs and, thus, affect production and economic welfare indicators on livestock markets as well.

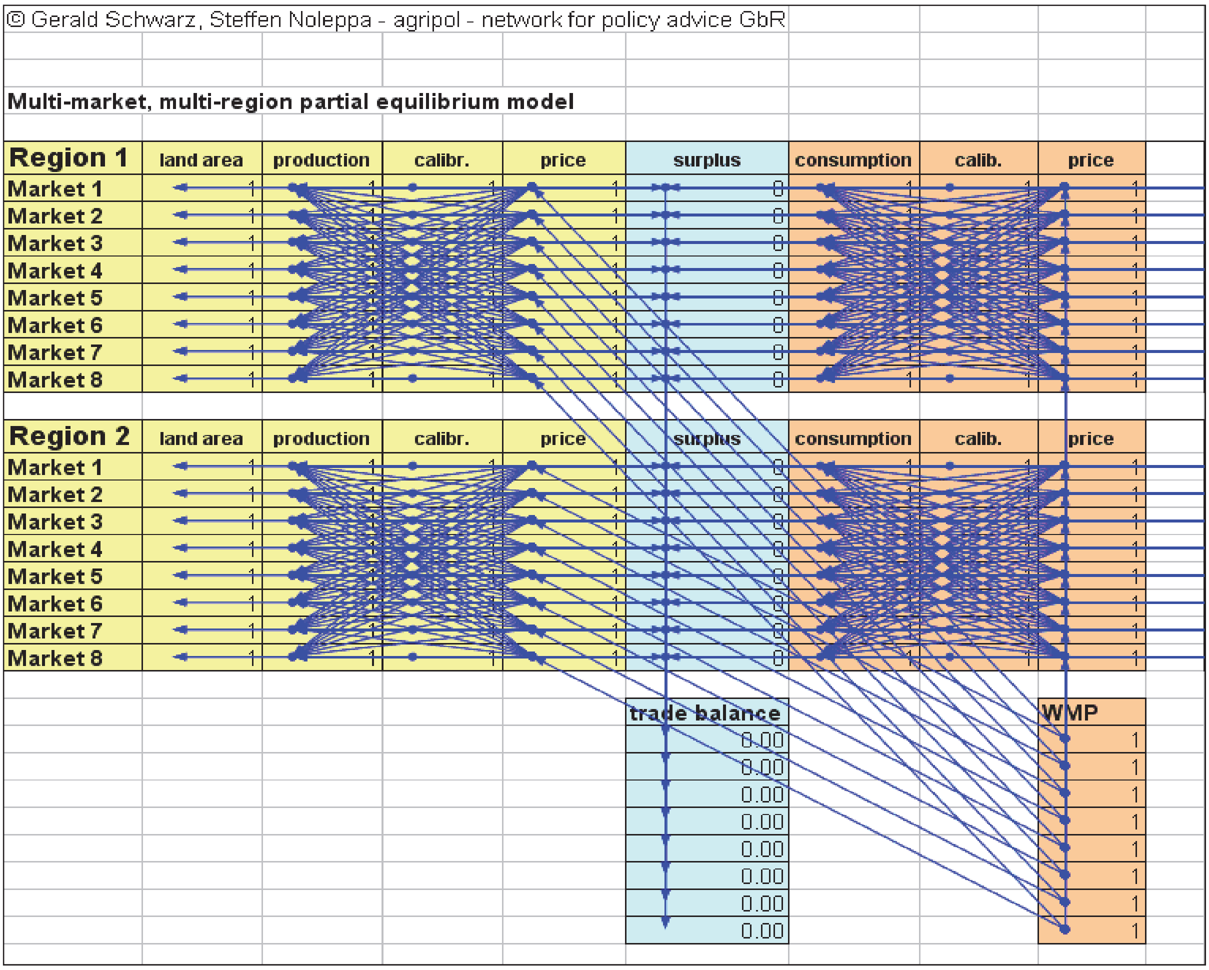
The model is based upon the principles of the so-called VORSIM modeling framework and its predecessor the Static World Policy Simulation Modelling Framework (see Roningen, 1986; 2004; Roningen et al., 1991) further developed by Jechlitschka et al. (2007).

The model employs so-called isoelastic Cobb-Douglas supply and demand functions (for more details, see Chiang, 1984; Wainwright and Chiang, 2005). Cobb-Douglas supply and demand functions are widely used in partial equilibrium models in agricultural production and policy analysis. An example is Ledebur (2001), who applies Cobb-Douglas functions for the analysis of agricultural trade liberalization between the EU and the MERCOSUR countries. Each market is linked with other markets through a set of cross-price elasticities. The elasticities ensure a consistent system of equations and consider the homogeneity and symmetry conditions needed (see again Wainwright and Chiang, 2005).

The model is static and assumes that domestic and foreign goods are perfect substitutes in consumption. International trade is the difference between domestic supply and demand in each region. The model is closed by the assumption of market equilibrium: Trade flows are such that world supply equals world demand and that total global exports equal total global imports, thus, all world markets are cleared.

The linkages between the different model regions and markets create a very complex set of a large number of equations, which have to be simultaneously solved to find a new equilibrium for each of the simulated scenarios. Figure A.4.1 provides an insight into the complexity of the linkages showing the 'trace precedents' of a rather simple two-region eight-market model example only. The complexity, of course, further increases with each of the 18 regions and 17 markets added to the model structure applied here.

Figure A.4.1: Complexity and 'trace precedents' of the modelling approach



Soure: Own figure.

In the following paragraphs the specification of the demand and supply sides of the model are illustrated in more detail followed by an explanation of the implementation of the supply shift factor, which represents the changes in plant protection product applications.

The demand side of the model represents the response of consumers to the market price effects resulting from negative production effects of the removal of plant protection products, namely the use of NNi in European agriculture. The quantity demanded of a commodity depends on its own price, prices of consumption substitutes, a calibration parameter and demand elasticities (which have to be specified for the own and cross-price). The description of the demand function (A.4.1) follows the approach of von Witzke et al. (2008) and can be written as follows:

(A.4.1) $$q^d_{l,g}(p^d_{l,g}) = a_{l,g} * p^d_{l,g} \wedge \eta^d_{l,g} * \prod_{m=1}^{w} p^d_{m,g} \wedge \eta^d_{lm,g}$$

where:

l = commodity l,

m = 1, …, w = competing goods (cross-commodities),

g = model region g,

$q^d_{l,g}$ = demand quantity of commodity l in region g,

$a_{l,g}$ = constant parameter (calibration factor) for demand of commodity l in region g,

$p^d_{l,g}$ = demand price for commodity l in region g,

$\eta^d_{l,g}$ = own-price elasticity of demand of commodity l in region g,

$p^d_{l,g}$ = cross-prices for commodities m = 1, …, w in region g, and

$\eta^d_{lm,g}$ = cross-price elasticities (m = 1, …, w) of demand of commodity l in region g.

The term $a_{l,g}$ is a calibration parameter which, in the initial state, is chosen (calculated) to match the quantity demanded in a reference scenario. Variations in this parameter, or the implementation of the shift factor (as explained for the supply side very soon below), could principally be used to account for changes in the determinants of demand other than market prices, for example population growth and changes in consumer preferences.

In this study, however, the supply side is of more interest and has been modelled more in detail to simulate the effects of removing plant protection products (i.e. of a ban or suspension of NNi) in the different crop production systems. Similarly to the demand side, the quantity supplied of a good initially depends in the model on its own price, prices of competing goods, own-price and cross-price elasticities, and a calibration factor as well as elasticities. Hence, the supply function (A.4.2) is as follows:

(A.4.2) $$q^s_{l,g}(p^s_{l,g}) = b_{l,g} * p^s_{l,g} \wedge \eta^s_{l,g} * \prod_{m=1}^{w} p^s_{m,g} \wedge \eta^s_{lm,g}$$

where:

$q^s_{l,g}$ = supply quantity of commodity l in region g,

$b_{l,g}$ = constant parameter (calibration factor) for supply of commodity l in region g,

$p^s_{l,g}$ = supply price for commodity l in region g,

$\eta^s_{l,g}$ = own-price elasticity of supply of commodity l in region g,

$p^s_{l,g}$ = cross-prices for commodities m = 1, …, w in region g, and

$\eta^s_{lm,g}$ = cross-price elasticity (m = 1, …, w) of supply of commodity l in region g.

The term $b_{l,g}$ is the calibration parameter of the supply functions and represents the initial state on each market. While exogenous shocks to crop production could, in principle, be directly entered through changes in the calibration parameter, it is methodologically sounder to distinguish between the calibration and shock parameters and to add a separate supply shift factor (Jechlitschka et al., 2007).

The impacts of the removal of plant protection products on yields (and cost) of the various crops per hectare are integrated in the model through multiplicative shift factors in the supply functions, an approach commonly used in partial equilibrium models (see, e.g., Kazlauskiene and Meyers, 2003; Cagatay et al., 2003; Schwarz et al., 2011). The implementation of a multiplicative shift factor allows for a percentage change of the supply (and generally also demand) quantities depending on the specific scenario analysed with the model. The implementation of the shift factor expands the supply function (A.4.2) as follows (see function (A.4.3)):

$$(A.4.3) \qquad q^s_{l,g}(p^s_{l,g}) \qquad = b_{l,g} * p^s_{l,g} \wedge \eta^s_{l,g} * \prod_{m=1}^{w} p^s_{m,g} \wedge \eta^s_{lm,g} * e_{l,g}$$

where:

$e_{l,g}$ = supply shift factor (initially equal 1.00).

Yield and cost changes resulting from changes in plant protection regimes can, thus, easily be transferred. To take an example: A yield decrease of 10 per cent would mean to set $e_{l,g}$ to 0.90. However, to ensure a realistic simulation of economic and other implications of the removal of plant protection products with the MMM, the actual market share of the plant protection products needs to be considered, and the supply shift factors need to be adjusted accordingly. Hence, the adjusted supply shift factor ($e^*_{l,g}$) is derived as described with function (A.4.4):

$$(A.4.4) \qquad e^*_{l,g} \qquad = s_{l,g} * e_{l,g} + z_{l,g} * 1$$

where:

$e^*_{l,g}$ = adjusted supply shift factor,

$s_{l,g}$ = market share of a particular plant protection product, and

$z_{l,g}$ = residual market share (= $1 - s_{l,g}$).

Of special concern in every model is the data selection and input for the modelling framework. The choice of consistent and reliable data for an appropriate base (reference) period is the most crucial part of any analysis. The quality and consistency of the data determines the quality and relevance of the model results. The complexity of the model with a large number of regions and markets requires a substantial amount of data input based on different data sources. To ensure the quality of the modelling results, a comparative analysis of data from different sources has been carried out to identify potential differences and inconsistencies. The consistency checks also ensure a theoretical, sound model closure (i.e., world supply equals world demand on each market).

Main sources for the data used to calibrate the above described MMM are official statistics and online databases. Averages for latest available three years (mainly the years 2009-2011) were calculated out of these sources to avoid that extreme events in one year (e.g. extreme weather conditions or price peaks) affect the results of the analysis. In detail, production figures for the different crops and livestock products were taken from FAO (2012). Consumption data were calculated for each country and region based on production and trade data also from FAO (2012), but additionally using OECD and FAO (2012) information. World market prices were calculated as weighted average prices based on price and export data from the ten most important exporting countries per product; such price and export data are also based on OECD and FAO (2012) as well as FAO (2012). By doing so, data consistency across all commodities and countries being part of the modelling exercise has been assured to the greatest extent possible.

Another important aspect for modelling with partial equilibrium approach is to use appropriate elasticities. The elasticities used in the specific MMM are based on Roningen et al (1991), but have been adjusted to take structural market developments during the past two decades into account in accordance with FAPRI (2012), who provide comprehensive sets of own and cross-price elasticities for most agricultural products differentiated by country and region.

For a numerical specification of the model, two approaches have been pursued in the literature. Most commonly, the calibration procedure is applied as the deterministic approach to specify the model, while econometric estimation is rarer and mainly used to supplement calibration (Hassan and Hallam, 1996; Britz and Heckelei, 2008). The calibration procedure is applied here to compute the system parameters for the equilibrium benchmark period.

The calibration of a model is a critical part of defining the equilibrium situation for the benchmark period as the starting point of the quantitative analysis. Thereby, the calibration factors used in the demand and supply functions (A.4.1) and (A.4.2) have to be defined reproducing the base (reference) time period. On the supply side, the respective function is solved for the supply calibration factor ($b_{l,g}$) by using the initial values of prices, supply quantity and elasticities of the averages of the base period and is expressed as follows in function (A.4.5):

(A.4.5) $$b_{l,g} = (p^s{}_{l,g} \wedge \eta_{l,g} * \prod_{m=1}^{w} p^s{}_{m,g} \wedge \eta_{lm,g}) / q^s{}_{l,g}$$

Accordingly, the demand function is solved for the calibration factor ($a_{l,g}$), which is defined as follows in function (A.4.6):

(A.4.6) $$a_{l,g} = (p^d{}_{l,g} \wedge \eta_{l,g} * \prod_{m=1}^{w} p^d{}_{m,g} \wedge \eta_{lm,g}) / q^d{}_{l,g}$$

Once all supply and demand equations are calibrated this way, the model represents the base period in a theoretically sound manner and can be used for the analysis of economic and other impacts of the different scenarios simulating an abolishment of plant protection products on the different crop markets.

The specific MMM system is written in spread-sheets of Microsoft Excel software. The spread-sheets are organised in groups of boxes reflecting the mechanical and logical aspects of the model structure. The system is solved by the Excel solver, which is able to solve a system of non-linear equations as an optimisation or programming model. Generally, all equations are run simultaneously and the model is consequently solved jointly for all endogenous variables. One equation cell in the solver is defined as target cell and other equations as constraints, which have to be fulfilled. When the objective function is solved for zero value, the model generates optimal values for all prices and quantities included in the model at the point where all markets are in equilibrium over all regions.

Annex A.5: Main features of the ILUC-tool applied to the analysis

The ILUC-tool applied here was introduced to scientific analysis by von Witzke and Noleppa (2010), where an in-depth discussion of the approach can be found. Further developments of the approach are additionally highlighted in von Witzke et al. (2011a, b). All this does not need to be entirely repeated here. Instead, only a few but main features of the ILUC- tool shall be highlighted:

- The ILUC-tool analyses changes in the virtual trade of land as a consequence of changes in domestic agricultural supply and/or demand and, hence, in international agricultural trade. The concept of virtual inputs was initially developed by Allan (1993; 1994) for water. His basic idea is as follows: Essentially, any good being produced requires water. The water used in the production of a good is considered virtual water. When a good is traded internationally the virtual water is traded simultaneously (see also, e.g., Hoekstra and Hung, 2003).

- Here, we modify this concept, so it can be applied to land in agricultural commodity production. By analogy, we define virtual land as the amount of land that is required to produce one unit of a given agricultural good. For instance: If it takes 'X' hectares of land to produce one metric ton of wheat, then 'X' is the number of hectares of virtual land contained in one metric ton of wheat, and exporting one metric ton of wheat from one country to another is equivalent to the export of 'X' hectares of virtual land. In essence, the import of agricultural goods adds land to the domestic resource base, while the export reduces it.

- The conversion of agricultural trade into land trade is a rather complex issue. In principle, there are different approaches of quantifying virtual land use (see, e. g., Würtenberger et al., 2006). In this paper we use what we refer to as an indicator approach. Starting point of the analysis are international agricultural trade flows. Available trade statistics are based on internationally agreed classifications of commodities. The Standard International Trade Classification (SITC) is the most widely used classification in trade analysis. The SITC is based on the degree of processing: Although goods produced from identical raw materials may end up in different classifications they can be attributed to their raw material again. In addition, SITC is time-proven in international trade analysis (Ximing and Fukao, 2010). Therefore, it is used here.

- For so-called SITC0, SITC1, SITC22, SITC263, SITC268, and SITC4 categories export and import data in terms of value and volume are generated from Eurostat (2012). Bilateral export and import flows of the EU-27 with trade partners (i.e. with North America, South America, Asia, North Africa and the Near East, Sub-Sahara Africa, Former Soviet Union (FSU), Oceania, rest of Europe, and rest of the world) are used for the last three years available. Weighted averages are calculated in order to avoid distortions in results caused by annual fluctuations.

- Finally, 270 categories of tradable products are included into our analysis. These represent almost twice as many trade categories as have been included in other recent studies. Steger (2005), e.g., analysed 149 tradable products for the EU-15 while van Sleen (2009) included 150 products for the EU-27.
- Trade volumes for all the 270 tradable products are converted into tradable agricultural raw products; and the resulting volumes are related to regional yields in order to compute land used for exports and imports.
- The respective analysis of land-use associated with agricultural trade is straightforward for unprocessed crops. In this case, only specific yields have to be known for proper conversion. Detailed information on yields can be found, e.g., in FAPRI (2012) and FAO (2012). The calculations are more complex for livestock-based commodities and for processed agricultural products, such as flour, macaroni or oilcakes. Meat and dairy products were converted into crops using feed ratios and feed mix percentages. Our calculations are mainly based on conversion rates provided by Sullivan et al. (1992), but they have been updated in order to account for increased feeding efficiency and improved feeding technologies. Processed products have been converted into agricultural raw products using a rather broad spectrum of processing parameters. Numerous weights, measures and conversion factors had to be combined. Main data bases used are FAO (2001) and USDA (2011; 1992), but the conversion factors have been updated using additional data sources such as Belitz et al. (2008), Seiler (2006), Steger (2005), and van Sleen (2009).
- A particular issue arises because agricultural raw materials may be processed into goods which end up in different SITC. One example are oilseeds, which usually are processed into oil cake and oil; and butter, cheese and dry milk have to be converted to liquid milk equivalents. Approaches on dealing with coupled products and information on crushing factors were used to avoid double counting of hectares (see, e.g., Sullivan et al., 1992; FAO, 2001; van Dam and Elbersen, 2004).
- Finally, more than 40 crops are covered within the ILUC-tool. Thus, it is possible to 'translate' traded goods into more than 40 crops such as wheat, corn, coarse grains (mainly consisting of barley, rye, oats, grain sorghum, and millet), rice, soybeans, palm fruits and nine other oilseeds, oleaginous fruits, sugar beet and sugar cane, coffee, cocoa, tea and tobacco, potatoes as well as additional 20 fruits and vegetables.

Based on the above-given definition of agricultural trade and the methodological framework described, the EU net trade in virtual agricultural land is presented in the following Figure A.5.1. It amounts to almost 29 million ha and is about equal to the entire territory of Italy.

Figure A.5.1. Current EU trade in virtual agricultural land by region and commodity (in million ha)

	Wheat	Corn	Other cereals	Rice	Soybeans	Palm	Oilseed rape	Other oilseeds	Coffee and cocoa	Tea and tobacco	Fruit	Vegetables and potatoes	Pulses	Sugar crops	Beef	Pork	Poultry	Sheep and goat meat	Eggs	Milk	Cotton	Total
North America	-0.93	-0.01	0.01	-0.02	-1.59	-0.01	-0.08	0.25	0.59	-0.02	0.09	0.00	-0.42	-0.01	-0.06	0.04	0.00	0.00	-0.01	0.08	-0.09	**-2.18**
South America	0.01	-0.80	0.10	-0.09	-12.87	-0.08	-0.01	-0.72	-2.03	-0.18	-0.82	-0.01	-0.05	-0.20	-1.78	0.00	-0.41	-0.07	0.00	0.09	-0.07	**-20.00**
Asia	0.45	0.04	0.17	-0.37	-0.20	-1.99	0.01	-0.64	-0.77	-0.15	-0.03	-0.02	0.00	-0.09	0.05	0.95	-0.05	0.01	0.01	0.32	-0.24	**-2.52**
North Africa and the Middle East	2.45	0.14	0.40	0.00	0.08	0.00	-0.09	-0.54	0.12	0.06	-0.05	0.00	0.05	0.06	0.13	0.01	0.15	0.01	0.01	0.52	0.09	**3.60**
Sub-Sahara-Africa	1.01	0.03	0.16	0.00	0.06	-0.13	0.00	-0.11	-4.81	-0.20	-0.22	0.02	0.00	-0.19	-0.02	0.10	0.20	0.01	0.01	0.23	-0.36	**-4.22**
Europe (excl. EU)	0.30	-0.08	0.14	0.02	-0.01	0.04	0.06	0.25	0.35	-0.20	-0.03	0.01	0.00	-0.01	0.28	0.09	0.06	0.00	0.02	0.03	0.08	**1.38**
CIS	-1.13	-0.21	-0.07	0.00	-0.16	0.08	-1.41	-1.89	0.41	0.04	0.17	0.04	-0.16	0.00	0.30	0.62	0.25	0.00	0.00	0.24	-0.10	**-2.98**
Oceania	-0.18	0.00	0.01	0.00	0.00	0.00	-0.40	0.04	0.02	0.00	-0.06	0.00	0.00	-0.02	-0.14	0.05	0.00	-1.04	0.01	-0.09	0.00	**-1.80**
Rest of the world	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**-0.05**
Sum	**1.97**	**-0.88**	**0.92**	**-0.44**	**-14.69**	**-2.09**	**-1.91**	**-3.36**	**-6.17**	**-0.65**	**-0.95**	**0.05**	**-0.58**	**-0.45**	**-1.24**	**1.84**	**0.19**	**-1.08**	**0.04**	**1.42**	**-0.70**	**-28.78**

Source: Own calculations based on von Witzke et al. (2011a, b).

Annex A.6: Identified yield and cost impacts for 'focus points' of the analysis

Figure A.6.1: Yield impacts measured at country level for scenario S1 and scenario S5

EU member state	Wheat		Barley		Corn		OSR		Sunflower		Sugar beet	
	S1	S5	S1	S5	S1	S5	S1	S5	S1	S5	S1	S5
United Kingdom	-6.8	-16.0	-3.2	-6.3			-5.2	-9.0			-9.1	-11.8
The Netherlands					-1.6	-2.3					-2.2	-5.8
Germany					-1.3	-2.7	-5.2	-13.0			-3.0	-8.0
Poland							-5.8	-10.9			-3.5	-12.3
Slovenia					-1.0	-3.7	-4.7	-10.4				
Hungary					-0.7	-1.4			-4.6	-9.6		
Romania					-5.7	-9.5			-5.5	-12.4		
France	-1.0	-2.4	-3.4	-23.5	-4.6	-5.9	-5.6	-10.2			-6.6	-11.2
Spain									-14.9	-20.2		
Italy					-3.9	-10.4						

Source: Own figure.

Figure A.6.2: Short-term[1] cost impacts measured at country level for scenario S1 and scenario S5

EU member state	Wheat		Barley		Corn		OSR		Sunflower		Sugar beet	
	S1	S5	S1	S5	S1	S5	S1	S5	S1	S5	S1	S5
United Kingdom	2.0	-0.9	1.1	-0.5			6.6	-1.9			6.3	-3.9
The Netherlands					-0.2	-0.4					3.6	-3.7
Germany					0.6	-0.9	4.2	-0.9			1.5	-4.4
Poland							6.2	-1.2			3.9	-3.6
Slovenia					4.0	-2.4	4.0	-3.3				
Hungary					0.8	-0.8			5.1	-1.6		
Romania					2.8	-2.1			4.8	-0.7		
France	0.3	-0.8	7.8	-4.8	-0.6	-1.9	6.6	-3.2			-1.7	-7.1
Spain									1.8	-0.6		
Italy					1.2	-2.7						

1) cost impacts for the mid-term slightly differ due to changing 'variable cost' considerations.
Source: Own figure.

Annex A.7: Short-term impacts of Neonicotinoids for scenario S1

Figure A.7.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	261	9	155	-12	0	-6	-8	-9	-7	60	53	**494**
Barley	11	2	65	-6	0	-2	-2	-2	-14	44	25	**122**
Corn	8	8	75	37	1	10	152	96	21	294	63	**766**
OSR	43	0	91	37	0	10	13	1	1	99	89	**385**
Sun-flower	0	0	2	0	0	21	37	8	58	52	37	**216**
Sugar beet	23	1	15	8	0	1	1	4	5	65	15	**138**
All six crops	**346**	**20**	**403**	**65**	**1**	**35**	**194**	**98**	**63**	**614**	**282**	**2,121**

Figure A.7.2: Agricultural cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-31	-1	-21	0	0	0	0	0	0	-12	-6	**-72**
Barley	-3	-2	-96	0	0	0	0	0	0	-31	-27	**-159**
Corn	-1	1	-18	-3	-2	-6	-34	-14	-3	22	-9	**-66**
OSR	-36	0	-53	-20	0	-5	-8	-1	0	-58	-64	**-245**
Sun-flower	0	0	-1	0	0	-18	-20	-4	-13	-33	-23	**-112**
Sugar beet	-8	-3	-6	-6	0	0	0	-1	-1	6	-4	**-23**
All six crops	**-80**	**-5**	**-196**	**-29**	**-2**	**-30**	**-62**	**-20**	**-17**	**-106**	**-132**	**-678**

Figure A.7.3: Agricultural value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	292	10	176	-12	0	-6	-8	-9	-7	72	59	**566**
Barley	14	4	162	-6	0	-2	-2	-2	-14	75	52	**281**
Corn	9	8	93	41	3	16	186	109	24	272	72	**833**
OSR	79	0	145	57	0	16	21	1	1	157	153	**630**
Sun-flower	0	0	3	0	0	39	57	12	71	86	60	**328**
Sugar beet	31	4	21	14	0	1	1	5	6	58	19	**160**
All six crops	**426**	**25**	**599**	**94**	**3**	**64**	**256**	**117**	**80**	**721**	**414**	**2,799**

Figure A.7.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	417	13	217	-21	0	-10	-10	-13	-10	92	90	**764**
Barley	20	6	206	-10	0	-3	-3	-2	-19	96	83	**374**
Corn	13	10	112	67	4	28	244	146	32	326	104	**1,087**
OSR	115	0	179	101	0	28	28	2	1	199	236	**890**
Sun-flower	0	0	3	0	0	71	76	17	97	108	90	**464**
Sugar beet	48	6	27	29	0	2	2	8	9	78	31	**240**
All six crops	**614**	**35**	**744**	**166**	**4**	**117**	**337**	**158**	**110**	**900**	**634**	**3,819**
for 'as high as' multipliers												
Wheat	529	14	257	-29	0	-11	-13	-16	-12	105	100	**923**
Barley	26	6	248	-13	0	-3	-3	-3	-22	110	93	**437**
Corn	16	10	131	89	4	30	298	177	37	359	114	**1,266**
OSR	147	1	211	139	0	30	35	2	1	226	260	**1,053**
Sun-flower	0	0	4	0	0	76	94	21	113	122	99	**530**
Sugar beet	64	7	33	41	0	2	2	10	11	90	35	**295**
All six crops	**782**	**37**	**884**	**226**	**4**	**124**	**414**	**192**	**127**	**1,013**	**700**	**4,505**

Figure A.7.5: Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	614	24	509	0	0	0	0	0	0	318	255	**1,721**
Barley	52	9	377	0	0	0	0	0	0	242	197	**877**
Corn	21	25	216	491	11	128	7,511	602	116	882	231	**10,234**
OSR	157	1	440	1,029	4	180	1,047	14	9	486	688	**4,053**
Sun-flower	0	0	10	3	0	324	2,216	105	1,097	278	289	**4,324**
Sugar beet	48	8	61	139	0	7	42	37	22	133	82	**579**
All six crops	**892**	**67**	**1,613**	**1,662**	**15**	**640**	**10,815**	**757**	**1,243**	**2,340**	**1,743**	**21,788**

Figure A.7.6: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	770	29	586	0	0	0	0	0	0	462	317	**2,163**
Barley	65	10	434	0	0	0	0	0	0	350	244	**1,104**
Corn	27	29	249	604	15	173	13,895	800	168	1,280	287	**17,526**
OSR	198	1	506	1,266	5	243	1,936	18	13	704	853	**5,742**
Sun-flower	0	0	12	4	0	438	4,100	140	1,591	403	359	**7,047**
Sugar beet	60	10	70	171	0	10	77	49	32	193	102	**774**
All six crops	**1,119**	**79**	**1,855**	**2,045**	**21**	**863**	**20,008**	**1,007**	**1,803**	**3,392**	**2,161**	**34,355**
for 'as high as' multipliers												
Wheat	908	31	611	0	0	0	0	0	0	509	357	**2,417**
Barley	77	11	452	0	0	0	0	0	0	387	276	**1,204**
Corn	31	32	259	688	15	179	17,274	962	174	1,412	324	**21,351**
OSR	233	1	528	1,440	5	252	2,407	22	13	777	963	**6,642**
Sunflo wer	0	0	12	4	0	454	5,097	168	1,646	445	405	**8,233**
Sugar beet	70	11	73	195	0	10	96	59	33	213	115	**875**
All six crops	**1,320**	**86**	**1,936**	**2,327**	**21**	**895**	**24,875**	**1,211**	**1,865**	**3,743**	**2,440**	**40,721**

Figure A.7.7: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**9.6**	**2.8**	**4.3**	**1.9**	**1.5**	**1.6**	**5.5**	**4.0**	**1.7**	**4.6**	**7.5**	**4.7**

Source: All figures are own calculations.

Annex A.8: Short-term impacts of Neonicotinoids for scenario S5

Figure A.8.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	621	20	368	-29	0	-14	-18	-22	-17	140	126	**1,175**
Barley	10	10	409	-34	-1	-11	-11	-10	-82	332	157	**769**
Corn	14	12	164	64	5	21	257	263	36	374	109	**1,319**
OSR	69	0	264	70	0	22	28	2	1	174	189	**818**
Sun-flower	0	0	3	0	0	47	91	15	77	96	69	**397**
Sugar beet	27	6	50	38	0	2	2	9	10	106	30	**279**
All six crops	**741**	**48**	**1,257**	**109**	**4**	**68**	**347**	**256**	**25**	**1,223**	**679**	**4,758**

Figure A.8.2: Agricultural cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	14	1	24	0	0	0	0	0	0	34	7	**80**
Barley	1	1	59	0	0	0	0	0	0	19	16	**97**
Corn	3	1	27	6	1	6	26	29	5	72	16	**192**
OSR	11	0	11	4	0	2	3	0	0	28	21	**79**
Sun-flower	0	0	0	0	0	6	3	1	4	8	5	**27**
Sugar beet	5	3	17	6	0	0	1	3	2	26	13	**77**
All six crops	**34**	**6**	**137**	**15**	**1**	**14**	**32**	**34**	**12**	**187**	**79**	**552**

Figure A.8.3: Agricultural value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	607	19	344	-29	0	-14	-18	-22	-17	106	119	**1,095**
Barley	9	8	351	-34	-1	-11	-11	-10	-82	313	141	**672**
Corn	11	11	137	59	4	15	231	233	31	302	93	**1,126**
OSR	58	0	253	66	0	20	25	1	1	146	168	**739**
Sun-flower	0	0	3	0	0	42	88	14	73	88	64	**371**
Sugar beet	22	3	33	32	0	1	1	6	8	80	16	**203**
All six crops	**707**	**42**	**1,120**	**94**	**3**	**53**	**315**	**222**	**13**	**1036**	**601**	**4,206**

Figure A.8.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	854	26	418	-51	-1	-24	-24	-31	-24	130	177	**1,449**
Barley	12	11	418	-59	-1	-18	-15	-14	-114	386	204	**810**
Corn	14	14	158	93	5	21	289	299	39	354	126	**1,414**
OSR	75	0	298	106	1	33	32	2	1	173	232	**952**
Sun-flower	0	0	3	0	0	64	110	17	95	105	87	**482**
Sugar beet	34	5	42	63	0	3	2	9	12	106	26	**301**
All six crops	**989**	**56**	**1,338**	**153**	**4**	**77**	**393**	**283**	**10**	**1,254**	**853**	**5,410**
for 'as high as' multipliers												
Wheat	1,074	27	489	-69	-1	-26	-30	-38	-28	144	195	**1,739**
Barley	15	11	484	-79	-1	-20	-18	-17	-133	433	223	**898**
Corn	17	15	179	121	5	22	343	354	45	387	136	**1,625**
OSR	91	0	342	139	1	34	38	2	2	190	251	**1,090**
Sun-flower	0	0	4	0	0	67	131	21	109	115	94	**540**
Sugar beet	45	5	51	89	0	3	2	11	14	123	29	**372**
All six crops	**1,242**	**59**	**1,549**	**202**	**4**	**80**	**466**	**333**	**8**	**1,392**	**928**	**6,264**

Figure A.8.5 Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	1,454	57	1,202	0	0	0	0	0	0	743	602	**4,058**
Barley	102	53	2,255	0	0	0	0	0	0	1,693	1,179	**5,281**
Corn	37	37	449	844	43	253	12,633	1,606	199	1,144	397	**17,641**
OSR	273	2	1,109	1,949	8	371	2,155	28	18	883	1,415	**8,210**
Sun-flower	0	0	18	6	0	673	4,988	191	1,489	505	526	**8,396**
Sugar beet	62	23	161	486	0	14	83	74	43	226	164	**1,335**
All six crops	**1,928**	**172**	**5,193**	**3,285**	**52**	**1,311**	**19,858**	**1,899**	**1,749**	**5,194**	**4,283**	**44,922**

Figure A.8.6: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	1824	68	1382	0	0	0	0	0	0	1077	747	**5,098**
Barley	129	63	2593	0	0	0	0	0	0	2454	1462	**6,700**
Corn	46	44	516	1038	59	341	23371	2136	288	1659	493	**29,991**
OSR	343	2	1275	2397	12	500	3986	37	26	1280	1755	**11,613**
Sun-flower	0	0	21	7	1	909	9227	254	2159	733	652	**13,962**
Sugar beet	78	27	185	598	0	19	153	98	63	328	203	**1,752**
All six crops	**2,419**	**203**	**5,972**	**4,040**	**71**	**1,769**	**36,737**	**2,525**	**2,535**	**7,532**	**5,311**	**69,115**
for 'as high as' multipliers												
Wheat	2,151	73	1,442	0	0	0	0	0	0	1,189	843	**5,698**
Barley	152	68	2,705	0	0	0	0	0	0	2,708	1,650	**7,283**
Corn	54	47	539	1,181	60	354	29,055	2,570	298	1,831	556	**36,546**
OSR	404	3	1,330	2,728	12	519	4,955	45	27	1,413	1,981	**13,418**
Sun-flower	0	0	22	8	1	942	11,472	305	2,233	809	736	**16,527**
Sugar beet	91	29	193	681	0	20	191	118	65	362	229	**1,978**
All six crops	**2,853**	**220**	**6,232**	**4,598**	**72**	**1,835**	**45,673**	**3,038**	**2,623**	**8,311**	**5,996**	**81,451**

Figure A.8.7: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**15.4**	**4.1**	**7.1**	**1.5**	**1.6**	**0.7**	**5.7**	**7.2**	**-2.0**	**5.9**	**10.1**	**6.3**

Source: All figures are own calculations.

Annex A.9: Mid-term impacts of Neonicotinoids for scenario S1

Figure A.9.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	293	8	162	-22	0	-11	-15	-22	-13	28	3	**411**
Barley	7	3	123	-17	0	-6	-5	-6	-46	94	-52	**94**
Corn	8	3	74	37	4	4	180	80	20	232	62	**703**
OSR	65	0	98	62	0	13	21	1	1	145	121	**527**
Sun-flower	0	0	2	0	0	35	51	8	53	53	39	**241**
Sugar beet	36	7	31	20	0	1	1	6	7	60	21	**191**
All six crops	**408**	**21**	**489**	**81**	**4**	**36**	**232**	**68**	**22**	**613**	**193**	**2,167**

Figure A.9.2: Agricultural variable cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	72	2	38	-6	-1	-3	-2	-5	-3	7	1	**100**
Barley	4	1	24	-2	-1	-1	-1	-1	-9	32	-8	**38**
Corn	3	5	7	2	1	1	16	17	5	49	23	**129**
OSR	14	1	27	10	1	4	3	1	1	37	24	**123**
Sun-flower	0	0	1	0	0	1	4	2	28	13	14	**63**
Sugar beet	1	2	6	4	0	1	1	1	1	9	7	**33**
All six crops	**94**	**11**	**103**	**8**	**0**	**3**	**21**	**15**	**23**	**147**	**61**	**486**

Figure A.9.3: Agricultural producer surplus increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	221	6	124	-16	1	-8	-13	-17	-10	21	2	**311**
Barley	3	2	99	-15	1	-5	-4	-5	-37	62	-44	**56**
Corn	5	-2	68	35	3	2	164	63	15	183	38	**574**
OSR	51	-1	71	52	-1	9	18	0	0	108	97	**404**
Sun-flower	0	0	1	0	0	34	47	6	25	40	25	**178**
Sugar beet	35	5	25	16	0	0	0	5	6	51	14	**158**
All six crops	**314**	**11**	**386**	**73**	**4**	**33**	**211**	**53**	**-1**	**466**	**132**	**1,680**

Figure A.9.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	313	9	160	-30	1	-14	-18	-29	-19	28	4	**405**
Barley	3	3	127	-28	1	-8	-6	-9	-70	79	-73	**19**
Corn	6	-4	84	62	4	4	212	96	25	225	53	**767**
OSR	68	-1	86	92	-1	13	23	0	-1	134	148	**561**
Sun-flower	0	0	1	0	0	57	60	10	37	49	34	**247**
Sugar beet	56	10	35	37	0	1	1	11	14	73	27	**264**
All six crops	**446**	**17**	**493**	**134**	**5**	**52**	**271**	**79**	**-14**	**587**	**193**	**2,263**
for 'as high as' multipliers												
Wheat	387	10	186	-40	1	-15	-22	-35	-23	31	4	**485**
Barley	4	3	147	-38	1	-9	-7	-10	-83	87	-80	**15**
Corn	6	-4	97	82	4	4	253	114	29	246	57	**887**
OSR	82	-1	97	121	-1	14	28	0	-1	146	160	**645**
Sun-flower	0	0	1	0	0	60	71	11	40	53	36	**273**
Sugar beet	74	10	43	53	0	1	1	14	17	84	30	**326**
All six crops	**553**	**18**	**571**	**178**	**5**	**55**	**323**	**93**	**-20**	**647**	**207**	**2,630**

Figure A.9.5: Environmental implications of the use of NNi

	Land use change	CO_2 emissions	Monetary value of avoided (+) / caused (-) CO_2 emissions	
	avoided (+) / caused (-)		at 10 EUR/t CO_2	at 25 EUR/t CO_2
	(in million ha)	(in million t)	(in million EUR)	
North America	0.29	42	420	1,051
South America	0.44	66	660	1,650
Asia	0.22	65	652	1,631
Africa	0.88	173	1,725	4,314
(Rest of) Europe	0.32	54	544	1,359
CIS	1.01	196	1,960	4,900
Oceania	0.16	18	182	454
Total	**3.32**	**614**	**6,143**	**15,358**

Figure A.9.6: Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	710	25	587	-30	-2	-16	-130	-87	-12	322	332	**1,700**
Barley	52	17	739	-103	-2	-25	-81	38	-217	527	191	**1,137**
Corn	24	18	284	548	38	157	9,315	574	126	788	257	**12,129**
OSR	227	1	512	1,593	5	224	1,579	19	11	685	921	**5,778**
Sun-flower	0	0	11	4	0	513	3,045	119	1,051	305	321	**5,368**
Sugar beet	66	17	79	230	0	8	48	43	26	110	97	**725**
All six crops	**1,079**	**79**	**2,212**	**2,243**	**40**	**862**	**13,777**	**705**	**985**	**2,737**	**2,119**	**26,837**

Figure A.9.7: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	895	30	675	-37	-2	-21	-240	-116	-17	466	412	**2,044**
Barley	66	21	850	-126	-3	-33	-149	50	-314	765	236	**1,361**
Corn	30	21	327	674	52	212	17,233	763	183	1,143	319	**20,957**
OSR	286	2	588	1,960	7	303	2,921	25	17	993	1,143	**8,244**
Sun-flower	0	0	13	5	0	692	5,633	158	1,523	443	397	**8,864**
Sugar beet	83	20	91	283	0	11	90	58	37	160	120	**954**
All six crops	**1,359**	**94**	**2,544**	**2,759**	**55**	**1,164**	**25,488**	**937**	**1,429**	**3,969**	**2,627**	**42,424**
for 'as high as' multipliers												
Wheat	1,051	33	704	-42	-2	-22	-298	-140	-18	514	465	**2,245**
Barley	77	22	887	-144	-3	-34	-186	60	-325	844	267	**1,465**
Corn	35	23	341	767	53	220	21,425	918	190	1,261	360	**25,592**
OSR	335	2	614	2,231	8	314	3,632	30	17	1,096	1,290	**9,568**
Sun-flower	0	0	13	5	0	718	7,003	190	1,576	488	449	**10,443**
Sugar beet	98	22	95	323	0	12	112	69	38	176	136	**1,080**
All six crops	**1,596**	**101**	**2,654**	**3,140**	**56**	**1,207**	**31,687**	**1,128**	**1,478**	**4,379**	**2,966**	**50,393**

Figure A.9.8: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**6.2**	**0.7**	**2.2**	**1.2**	**1.8**	**0.3**	**3.7**	**1.5**	**-1.5**	**2.5**	**0.8**	**2.0**

Source: All figures are own calculations.

Annex A.10: Mid-term impacts of Neonicotinoids for scenario S2

Figure A.10.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-2	0	-2	-1	0	1	-1	-1	0	-4	-3	**-14**
Barley	-1	0	-3	-1	0	0	0	0	-2	-1	-4	**-12**
Corn	9	6	85	42	5	13	191	92	22	254	68	**787**
OSR	-1	0	-2	0	0	0	0	0	0	-2	-2	**-8**
Sun-flower	0	0	0	0	0	-1	-1	0	0	-1	0	**-3**
Sugar beet	0	0	0	0	0	0	0	0	0	-1	0	**-2**
All six crops	**5**	**5**	**78**	**39**	**5**	**13**	**189**	**91**	**20**	**245**	**58**	**747**

Figure A.10.2: Agricultural variable cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**-11**
Barley	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**-11**
Corn	4	5	7	2	1	4	17	20	5	53	27	**144**
OSR	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**-11**
Sun-flower	0	0	-1	0	0	-1	-1	-1	-2	-1	-1	**-8**
Sugar beet	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	**-10**
All six crops	**0**	**1**	**2**	**-2**	**-2**	**-1**	**12**	**15**	**-1**	**48**	**22**	**93**

Figure A.10.3: Agricultural producer surplus increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-1	1	-1	0	1	2	0	0	1	-3	-2	**-3**
Barley	0	1	-2	0	1	1	1	1	-1	0	-3	**-1**
Corn	5	1	79	40	4	9	174	72	17	201	41	**643**
OSR	0	1	-1	1	1	1	1	1	1	-1	-1	**3**
Sun-flower	0	0	1	0	0	0	0	1	2	0	1	**5**
Sugar beet	1	1	1	1	0	1	1	1	1	0	1	**8**
All six crops	**5**	**4**	**76**	**41**	**7**	**14**	**177**	**76**	**21**	**197**	**36**	**654**

Figure A.10.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	-2	8	-1	0	2	5	0	0	1	-4	-4	**5**
Barley	1	10	-2	1	2	2	1	1	-1	0	-5	**9**
Corn	9	3	98	67	5	14	219	92	23	238	52	**819**
OSR	0	9	-1	1	2	2	1	2	2	-1	-1	**14**
Sun-flower	0	0	1	0	0	1	1	1	3	1	1	**9**
Sugar beet	2	12	1	2	0	2	1	1	2	1	1	**25**
All six crops	**10**	**42**	**95**	**71**	**10**	**25**	**224**	**98**	**29**	**234**	**45**	**881**
for 'as high as' multipliers												
Wheat	-3	9	-2	0	2	5	0	0	1	-4	-4	**5**
Barley	2	10	-2	1	2	2	2	2	-1	0	-5	**11**
Corn	10	3	112	88	5	14	261	108	26	259	55	**942**
OSR	0	10	-2	2	2	2	2	2	2	-1	-1	**17**
Sun-flower	0	0	2	0	0	1	1	2	3	1	1	**11**
Sugar beet	3	13	1	3	0	2	2	2	2	1	2	**29**
All six crops	**13**	**45**	**109**	**94**	**10**	**26**	**268**	**115**	**33**	**255**	**47**	**1,014**

Figure A.10.5: Environmental implications of the use of NNi

	Land use change	**CO_2 emissions**	**Monetary value of avoided (+) / caused (-) CO_2 emissions**	
	avoided (+) / caused (-)		at 10 EUR/t CO_2	at 25 EUR/t CO_2
	(in million ha)	(in million t)	(in million EUR)	
North America	0.01	1	10	24
South America	0.24	37	367	917
Asia	0.02	6	56	141
Africa	0.06	13	126	315
(Rest of) Europe	0.07	12	122	305
CIS	0.07	13	133	334
Oceania	0.00	0	0	0
Total	**0.47**	**81**	**814**	**2,035**

Figure A.10.6: Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-1	0	2	0	0	24	0	0	2	0	4	**31**
Barley	0	0	-2	-6	0	0	4	0	-6	1	-3	**-11**
Corn	23	19	246	553	39	161	9,368	588	126	776	251	**12,149**
OSR	-1	0	-3	0	0	-1	-2	0	0	-3	-3	**-12**
Sun-flower	0	0	0	0	0	-4	-4	0	-2	1	1	**-9**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**0**
All six crops	**21**	**19**	**243**	**547**	**39**	**179**	**9,367**	**587**	**119**	**776**	**251**	**12,149**

Figure A.10.7: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	-1	0	2	0	0	32	0	0	3	0	5	**41**
Barley	-1	0	-3	-7	0	1	8	0	-9	2	-4	**-12**
Corn	29	23	283	680	53	217	17,332	782	182	1,126	311	**21,017**
OSR	-1	0	-3	0	0	-2	-4	0	0	-4	-3	**-16**
Sun-flower	0	0	0	0	0	-6	-7	0	-3	2	1	**-14**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**1**
All six crops	**27**	**22**	**280**	**673**	**53**	**242**	**17,329**	**781**	**173**	**1,126**	**311**	**21,017**
for 'as high as' multipliers												
Wheat	-1	0	2	0	0	33	0	0	3	0	6	**43**
Barley	-1	0	-3	-8	0	1	10	0	-9	2	-4	**-12**
Corn	34	24	295	774	54	225	21,547	940	189	1,242	352	**25,676**
OSR	-1	0	-3	0	0	-2	-4	0	0	-4	-4	**-18**
Sun-flower	0	0	0	0	0	-6	-9	0	-3	2	1	**-16**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**1**
All six crops	**31**	**24**	**292**	**766**	**54**	**251**	**21,544**	**940**	**179**	**1,242**	**351**	**25,674**

Figure A.10.8: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**0.1**	**0.4**	**0.5**	**0.9**	**3.8**	**0.3**	**3.5**	**2.5**	**0.7**	**1.2**	**0.3**	**0.9**

Source: All figures are own calculations.

Annex A.11: Mid-term impacts of Neonicotinoids for scenario S3

Figure A.11.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-1	-1	-1	-2	0	-1	-2	-3	0	-4	-2	**-17**
Barley	-1	0	-4	-1	0	0	0	0	-3	-3	-9	**-24**
Corn	-1	-2	-15	-2	0	-6	-5	-6	-2	-14	-5	**-56**
OSR	67	0	104	63	0	14	22	1	1	152	125	**550**
Sun-flower	0	0	2	0	0	37	53	9	54	56	40	**250**
Sugar beet	0	0	0	0	0	0	0	0	0	-1	0	**-2**
All six crops	**65**	**-2**	**85**	**57**	**0**	**44**	**67**	**1**	**50**	**187**	**149**	**702**

Figure A.11.2: Agricultural variable cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**-11**
Barley	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**-11**
Corn	0	0	-2	-2	-1	-1	-1	1	-1	-2	-2	**-12**
OSR	14	1	29	11	1	4	3	1	1	40	25	**130**
Sun-flower	0	0	1	1	0	1	5	2	28	14	14	**66**
Sugar beet	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	**-10**
All six crops	**11**	**-2**	**25**	**7**	**-2**	**1**	**4**	**1**	**25**	**49**	**34**	**153**

Figure A.11.3: Agricultural producer surplus increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	0	0	0	-1	1	0	-1	-2	1	-3	-1	**-6**
Barley	0	1	-3	0	1	1	1	1	-2	-2	-8	**-13**
Corn	0	-1	-13	0	1	-5	-4	-7	-1	-12	-3	**-45**
OSR	53	-1	75	52	-1	10	19	0	0	112	100	**420**
Sun-flower	0	0	1	-1	0	36	48	7	26	42	26	**184**
Sugar beet	1	1	1	1	0	1	1	1	1	0	1	**8**
All six crops	**54**	**0**	**60**	**50**	**2**	**43**	**63**	**0**	**25**	**137**	**115**	**550**

Figure A.11.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	0	-1	0	-2	2	1	-1	-23	1	-4	-1	**-28**
Barley	1	-3	-5	0	2	1	1	8	-4	-2	-13	**-14**
Corn	0	3	-16	0	2	-7	-6	-89	-1	-15	-4	**-132**
OSR	77	2	97	86	-2	14	24	2	-1	138	148	**585**
Sun-flower	0	0	1	-2	0	58	61	82	31	50	34	**316**
Sugar beet	2	-4	1	2	0	2	2	19	2	1	2	**26**
All six crops	**79**	**-4**	**77**	**84**	**5**	**70**	**82**	**-1**	**30**	**168**	**166**	**754**
for 'as high as' multipliers												
Wheat	0	-2	-1	-2	3	1	-1	-29	2	-5	-1	**-35**
Barley	1	-3	-6	0	3	1	1	10	-4	-3	-14	**-14**
Corn	0	3	-19	1	2	-8	-7	-114	-1	-16	-4	**-162**
OSR	94	2	110	112	-2	15	29	2	-1	151	160	**671**
Sun-flower	0	0	1	-3	0	61	73	104	33	55	37	**361**
Sugar beet	2	-4	1	3	0	2	2	24	2	1	2	**34**
All six crops	**96**	**-4**	**87**	**110**	**5**	**73**	**98**	**-2**	**31**	**183**	**179**	**855**

Figure A.11.5: Environmental implications of the use of NNi

	Land use change	CO_2 emissions	Monetary value of avoided (+) / caused (-) CO_2 emissions	
	avoided (+) / caused (-)		at 10 EUR/t CO_2	at 25 EUR/t CO_2
	(in million ha)	(in million t)	(in million EUR)	
North America	0.05	7	72	180
South America	0.09	14	140	349
Asia	0.02	6	60	150
Africa	0.09	18	181	452
(Rest of) Europe	0.10	17	171	426
CIS	0.99	194	1,937	4,843
Oceania	0.20	22	222	555
Total	**1.55**	**278**	**2,782**	**6,955**

Figure A.11.6: Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	6	0	15	12	0	6	0	-6	16	19	33	**102**
Barley	0	0	0	0	0	0	2	-1	-3	0	-3	**-5**
Corn	0	-1	-7	-3	-1	-18	-40	-11	-2	-10	-4	**-96**
OSR	226	1	515	1,574	5	229	1,589	19	12	690	919	**5,778**
Sun-flower	0	0	11	4	0	521	3,061	120	1,056	307	320	**5,399**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**0**
All six crops	**232**	**0**	**535**	**1,586**	**5**	**737**	**4,612**	**121**	**1,078**	**1,006**	**1265**	**11,179**

Figure A.11.7: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	8	0	18	15	0	9	0	-8	23	27	41	**132**
Barley	0	0	0	0	0	0	4	-1	-4	0	-4	**-5**
Corn	0	-1	-8	-4	-1	-24	-74	-14	-3	-14	-5	**-148**
OSR	285	2	592	1,936	7	309	2,939	25	17	1,000	1139	**8,251**
Sun-flower	0	0	13	5	0	703	5,663	159	1,531	446	397	**8,916**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**0**
All six crops	**292**	**0**	**615**	**1,951**	**7**	**996**	**8,532**	**161**	**1,563**	**1,459**	**1,569**	**17,146**
for 'as high as' multipliers												
Wheat	9	0	19	17	0	9	0	-9	24	30	47	**144**
Barley	0	0	0	0	0	0	5	-1	-5	0	-4	**-5**
Corn	-1	-1	-8	-4	-1	-25	-92	-17	-3	-15	-5	**-173**
OSR	335	2	618	2,203	8	320	3,654	30	17	1,104	1,286	**9,577**
Sun-flower	0	0	13	5	0	729	7,040	191	1,583	492	448	**10,503**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**0**
All six crops	**343**	**0**	**642**	**2,221**	**7**	**1,032**	**10,608**	**194**	**1,617**	**1,610**	**1,771**	**20,046**

Figure A.11.8: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**0.9**	**0.1**	**0.2**	**0.8**	**1.1**	**0.8**	**1.0**	**-0.1**	**-0.5**	**0.6**	**0.8**	**0.6**

Source: All figures are own calculations.

Annex A.12: Mid-term impacts of Neonicotinoids for scenario S4

Figure A.12.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-3	-1	-4	-3	0	1	-3	-4	-1	-9	-5	**-33**
Barley	-1	0	-7	-2	0	-1	-1	-1	-6	-4	-14	**-36**
Corn	8	4	71	40	4	7	186	86	21	240	64	**731**
OSR	66	0	102	63	0	13	22	1	1	150	123	**542**
Sun-flower	0	0	2	0	0	37	52	9	54	55	39	**248**
Sugar beet	0	0	-1	0	0	0	0	0	0	-1	0	**-4**
All six crops	**70**	**3**	**162**	**97**	**5**	**57**	**257**	**92**	**69**	**431**	**207**	**1,449**

Figure A.12.2: Agricultural variable cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	-1	**-12**
Barley	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	**-12**
Corn	4	5	7	2	1	2	17	18	5	51	25	**137**
OSR	14	1	28	11	1	4	3	1	1	38	25	**127**
Sun-flower	0	0	1	0	0	1	5	2	28	14	14	**65**
Sugar beet	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	**-10**
All six crops	**15**	**3**	**33**	**10**	**0**	**4**	**22**	**18**	**31**	**99**	**60**	**295**

Figure A.12.3: Agricultural producer surplus increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	-2	0	-3	-2	1	2	-2	-3	0	-7	-4	**-21**
Barley	0	1	-6	-1	1	0	0	0	-5	-3	-12	**-24**
Corn	5	-1	64	38	3	4	169	68	16	189	38	**594**
OSR	52	-1	74	52	-1	9	19	0	0	112	98	**415**
Sun-flower	0	0	1	0	0	36	47	7	26	41	25	**183**
Sugar beet	1	1	0	1	0	1	1	1	1	0	1	**6**
All six crops	**55**	**1**	**130**	**86**	**5**	**52**	**235**	**74**	**38**	**332**	**147**	**1,153**

Figure A.12.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	-4	-1	-4	-4	2	3	-2	-4	0	-10	-7	**-30**
Barley	0	-4	-8	-2	2	1	1	1	-7	-4	-18	**-39**
Corn	6	1	85	63	5	6	214	95	22	229	50	**776**
OSR	77	2	97	85	-1	14	24	0	-1	136	142	**575**
Sun-flower	0	0	1	0	0	57	59	9	30	49	33	**239**
Sugar beet	1	-5	0	1	0	2	1	2	2	0	1	**5**
All six crops	**80**	**-6**	**169**	**144**	**7**	**84**	**297**	**102**	**46**	**400**	**202**	**1,526**
for 'as high as' multipliers												
Wheat	-4	-1	-5	-5	2	3	-2	-5	0	-11	-7	**-36**
Barley	0	-4	-10	-2	2	1	1	1	-8	-4	-20	**-44**
Corn	7	1	97	83	5	6	255	112	25	250	53	**894**
OSR	93	3	110	111	-1	15	28	0	-1	149	154	**659**
Sun-flower	0	0	1	0	0	60	70	11	32	53	35	**263**
Sugar beet	2	-6	0	2	0	2	2	2	2	0	1	**7**
All six crops	**97**	**-7**	**193**	**189**	**7**	**88**	**354**	**120**	**50**	**436**	**217**	**1,744**

Figure A.12.5: Environmental implications of the use of NNi

	Land use change	**CO_2 emissions**	**Monetary value of avoided (+) / caused (-) CO_2 emissions**	
	avoided (+) / caused (-)		at 10 EUR/t CO_2	at 25 EUR/t CO_2
	(in million ha)	(in million t)	(in million EUR)	
North America	0.04	7	66	164
South America	0.32	48	483	1,208
Asia	0.04	11	114	284
Africa	0.14	28	279	699
(Rest of) Europe	0.15	25	250	624
CIS	0.75	147	1,472	3,680
Oceania	0.12	14	141	352
Total	**1.57**	**280**	**2,804**	**7,010**

Figure A.12.6: Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	7	0	17	12	0	30	0	-9	18	19	37	**132**
Barley	-1	0	-2	-3	0	0	9	-1	-9	1	-6	**-11**
Corn	23	18	239	549	38	141	9,315	578	124	769	247	**12,042**
OSR	225	1	512	1,574	5	227	1,585	19	11	687	916	**5,764**
Sun-flower	0	0	11	4	0	517	3,057	119	1053	306	319	**5,387**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**0**
All six crops	**255**	**19**	**778**	**2,136**	**44**	**916**	**13,966**	**707**	**1,197**	**1,783**	**1,514**	**23,314**

Figure A.12.7: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	9	-1	20	15	0	41	0	-12	26	27	46	**172**
Barley	-1	0	-3	-3	0	1	17	-1	-13	2	-8	**-10**
Corn	29	21	275	676	53	190	17,233	769	179	1,115	307	**20,847**
OSR	284	2	589	1936	7	307	2,932	25	17	997	1,136	**8,231**
Sun-flower	0	0	13	5	0	698	5,655	159	1,527	444	396	**8,897**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**1**
All six crops	**321**	**22**	**895**	**2627**	**60**	**1,236**	**25,837**	**940**	**1,736**	**2,585**	**1,877**	**38,138**
for 'as high as' multipliers												
Wheat	11	-1	21	17	0	42	0	-14	27	30	52	**185**
Barley	-1	0	-3	-4	0	1	21	-1	-14	2	-9	**-8**
Corn	34	23	287	769	53	197	21,425	926	186	1,230	346	**25,476**
OSR	334	2	615	2,203	8	318	3,645	30	17	1,100	1,283	**9,554**
Sun-flower	0	0	13	5	0	724	7,031	191	1,580	490	447	**10,481**
Sugar beet	0	0	0	0	0	0	0	0	0	0	0	**1**
All six crops	**377**	**24**	**934**	**2,990**	**61**	**1,282**	**32,122**	**1131**	**1,796**	**2,852**	**2,120**	**45,689**

Figure A.12.8: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**0.9**	**-0.1**	**0.7**	**1.6**	**2.5**	**1.0**	**4.3**	**2.3**	**-0.1**	**1.8**	**1.0**	**1.4**

Source: All figures are own calculations.

Annex A.13: Mid-term impacts of Neonicotinoids for scenario S5

Figure A.13.1: Agricultural revenue increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	585	15	304	-36	-1	-21	-27	-40	-24	17	-16	**756**
Barley	3	8	332	-38	-1	-13	-13	-14	-107	269	-113	**312**
Corn	9	4	86	42	1	-14	204	196	23	250	72	**873**
OSR	39	0	216	65	0	14	23	1	1	84	132	**576**
Sun-flower	0	0	2	0	0	36	78	12	67	73	53	**322**
Sugar beet	25	5	39	36	0	2	2	9	10	114	28	**269**
All six crops	**661**	**32**	**979**	**68**	**0**	**4**	**267**	**163**	**-30**	**807**	**157**	**3,108**

Figure A.13.2: Agricultural variable cost increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	145	4	71	-10	-1	-6	-4	-9	-6	4	-3	**185**
Barley	2	2	64	-5	-1	-2	-2	-3	-21	92	59	**185**
Corn	4	6	7	2	1	-4	19	40	5	51	29	**160**
OSR	8	1	59	11	1	4	3	1	1	21	27	**137**
Sun-flower	0	0	1	0	0	1	7	2	34	18	19	**82**
Sugar beet	5	1	7	7	0	1	1	2	2	17	10	**53**
All six crops	**164**	**14**	**209**	**5**	**0**	**-6**	**24**	**33**	**15**	**203**	**141**	**802**

Figure A.13.3: Agricultural producer surplus increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	440	11	233	-26	0	-15	-23	-31	-18	13	-13	**571**
Barley	1	6	268	-33	0	-11	-11	-11	-86	177	-172	**127**
Corn	5	-1	79	39	0	-10	185	155	18	199	44	**713**
OSR	31	-1	157	54	-1	10	20	0	0	63	105	**439**
Sun-flower	0	0	1	0	0	35	71	10	33	55	34	**240**
Sugar beet	20	4	32	29	0	1	1	7	8	97	18	**216**
All six crops	**497**	**19**	**771**	**63**	**0**	**10**	**243**	**129**	**-45**	**603**	**16**	**2,306**

Figure A.13.4: Economy-wide value added increase (+) respectively decrease (-) due to NNi (in million EUR)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	620	19	294	-51	0	-29	-32	-48	-18	17	-22	**750**
Barley	1	10	337	-66	0	-22	-14	-17	-86	223	-312	**53**
Corn	6	-3	97	73	0	-17	241	223	17	244	62	**943**
OSR	42	-1	188	98	-1	18	26	0	0	77	165	**612**
Sun-flower	0	0	1	0	0	63	92	14	26	66	49	**312**
Sugar beet	33	7	45	68	0	2	1	12	8	138	36	**349**
All six crops	**701**	**31**	**963**	**123**	**0**	**14**	**314**	**182**	**-53**	**765**	**-21**	**3,019**
for 'as high as' multipliers												
Wheat	766	20	342	-68	0	-31	-39	-59	-20	19	-24	**906**
Barley	1	10	391	-89	0	-23	-18	-21	-98	246	-346	**53**
Corn	7	-3	112	96	0	-18	287	263	19	266	66	**1,096**
OSR	50	-1	212	130	-1	18	31	0	-1	84	179	**702**
Sun-flower	0	0	2	1	0	67	110	16	25	72	52	**344**
Sugar beet	43	8	54	96	0	2	2	15	10	159	41	**429**
All six crops	**867**	**32**	**1,113**	**165**	**0**	**15**	**373**	**214**	**-65**	**846**	**-32**	**3,530**

Figure A.13.5: Environmental implications of the use of NNi

	Land use change	CO_2 emissions	Monetary value of avoided (+) / caused (-) CO_2 emissions	
	avoided (+) / caused (-)		at 10 EUR/t CO_2	at 25 EUR/t CO_2
	(in million ha)	(in million t)	(in million EUR)	
North America	0.57	83	831	2,078
South America	0.69	104	1,035	2,589
Asia	0.45	134	1,344	3,360
Africa	1.68	328	3,281	8,201
(Rest of) Europe	0.57	96	961	2,403
CIS	1.48	288	2,880	7,200
Oceania	0.23	26	259	647
Total	**5.67**	**1,059**	**10,591**	**26,478**

Figure A.13.6: Agricultural job increase (+) respectively decrease (-) due to NNi (in AWU)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
Wheat	1396	47	1,082	12	-3	-43	-238	-157	-22	468	490	**3,034**
Barley	69	44	1,872	-261	-4	-61	-213	-92	-523	1,400	440	**2,672**
Corn	29	28	376	666	22	90	10,908	1,302	156	898	322	**14,796**
OSR	185	1	907	1,743	6	250	1,784	21	13	537	1,045	**6,493**
Sun-flower	0	0	15	5	0	575	4,573	162	1,333	418	441	**7,523**
Sugar beet	49	13	102	396	0	11	65	58	34	204	130	**1,062**
All six crops	**1,729**	**134**	**4,355**	**2,562**	**21**	**822**	**16,879**	**1,294**	**991**	**3,925**	**2,868**	**35,579**

Figure A.13.7: Economy-wide job increase (+) respectively decrease (-) due to NNi (in AWU)

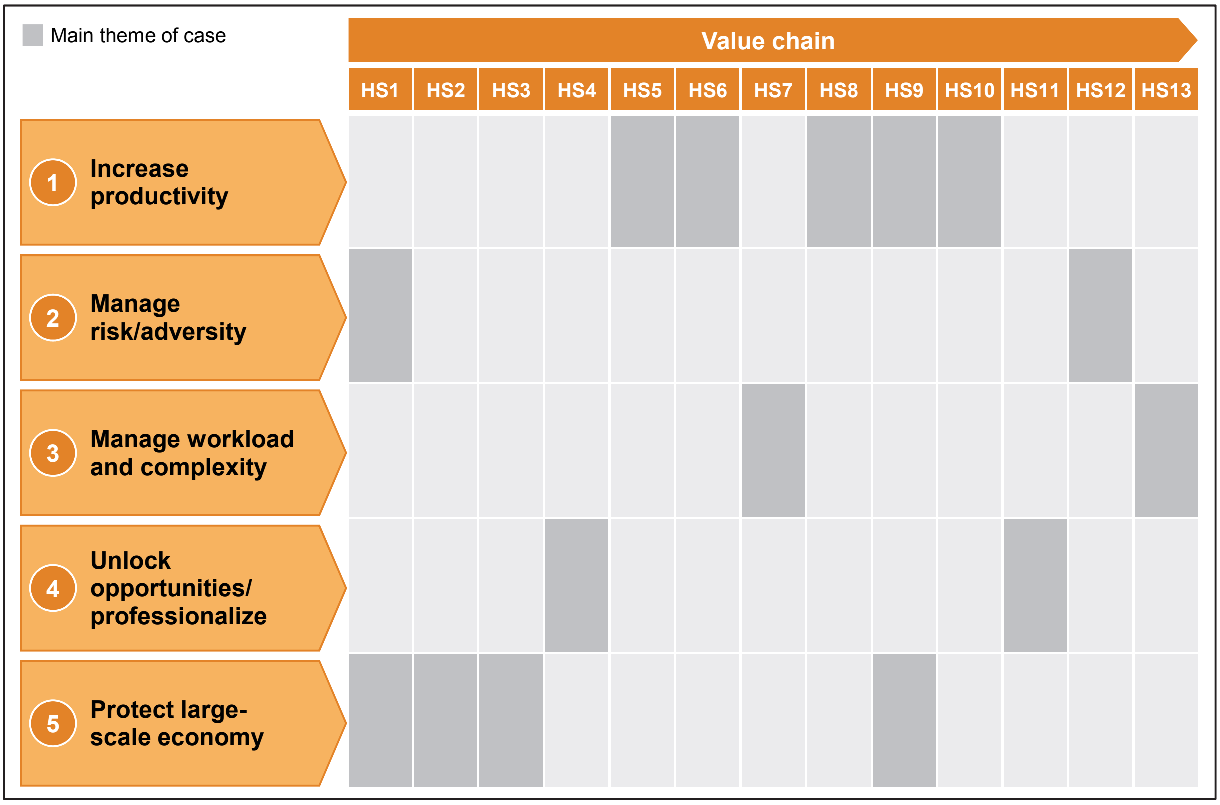
	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
for 'average' multipliers												
Wheat	1,759	56	1,245	15	-5	-58	-440	-209	-32	679	608	**3,619**
Barley	87	52	2,153	-321	-6	-83	-394	-122	-759	2,030	546	**3,185**
Corn	37	33	432	819	30	122	20,179	1,731	226	1,302	399	**25,310**
OSR	233	2	1,043	2,144	9	337	3,301	28	19	779	1,296	**9,190**
Sun-flower	0	0	17	7	1	776	8,461	216	1933	606	547	**12,562**
Sugar beet	62	15	117	487	0	15	120	77	50	296	161	**1,400**
All six crops	**2,178**	**159**	**5,008**	**3,151**	**29**	**1,109**	**31,227**	**1,721**	**1,436**	**5,692**	**3,556**	**55,266**
for 'as high as' multipliers												
Wheat	2,067	61	1,299	17	-5	-60	-547	-252	-33	749	686	**3,983**
Barley	103	56	2,247	-365	-6	-86	-490	-146	-785	2,241	617	**3,384**
Corn	43	36	451	932	30	126	25,088	2,082	234	1,437	451	**30,910**
OSR	273	2	1,089	2,441	9	349	4,104	34	19	860	1,463	**10,642**
Sun-flower	0	0	18	7	1	805	10,519	259	1999	669	617	**14,894**
Sugar beet	73	16	122	554	0	16	149	93	51	326	182	**1,583**
All six crops	**2,559**	**171**	**5,226**	**3,586**	**29**	**1,150**	**38,822**	**2,070**	**1,486**	**6,281**	**4,015**	**65,395**

Figure A.13.8: Income increase (+) respectively decrease (-) for arable growers due to NNi (in per cent)

	UK	NL	GE	PL	SL	HU	RO	IT	SP	FR	Rest EU	EU, all
All six crops	**9.9**	**1.4**	**4.5**	**0.9**	**-0.3**	**-0.4**	**4.0**	**4.0**	**-3.4**	**3.0**	**-0.5**	**2.6**

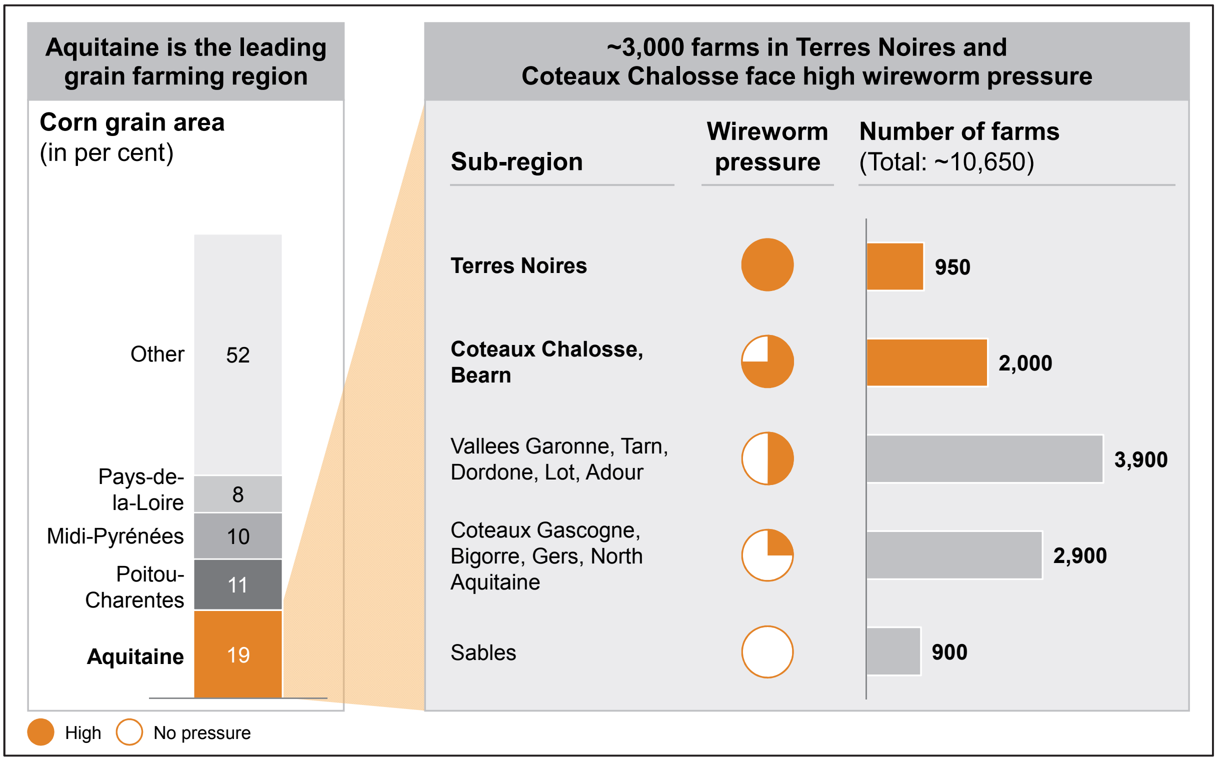
Source: All figures are own calculations.

Annex A.14: Classification of hotspots by impact lever



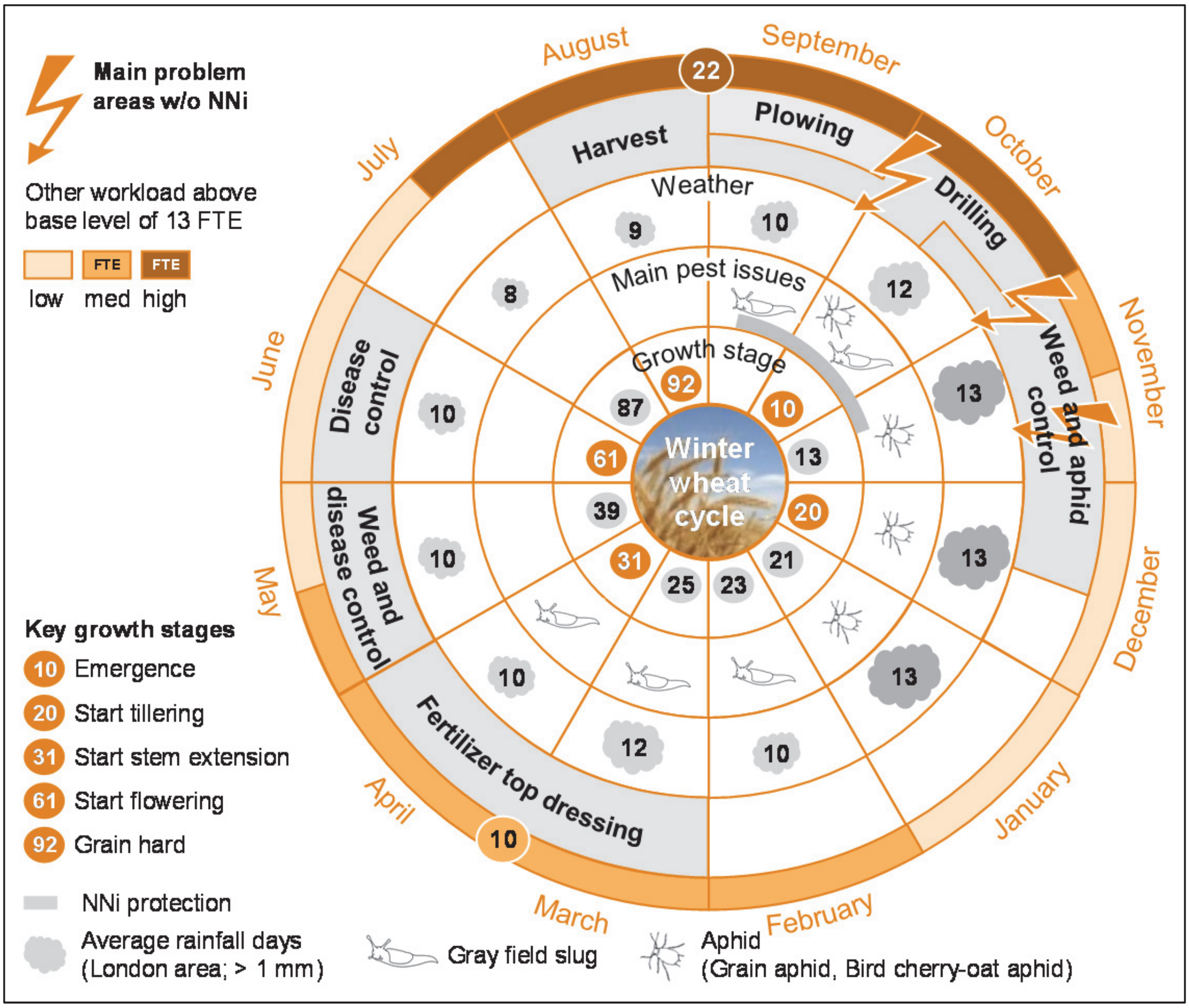
Source: Own categorization.

Annex A.15: Wireworm pressure in the Terres Noires region in France



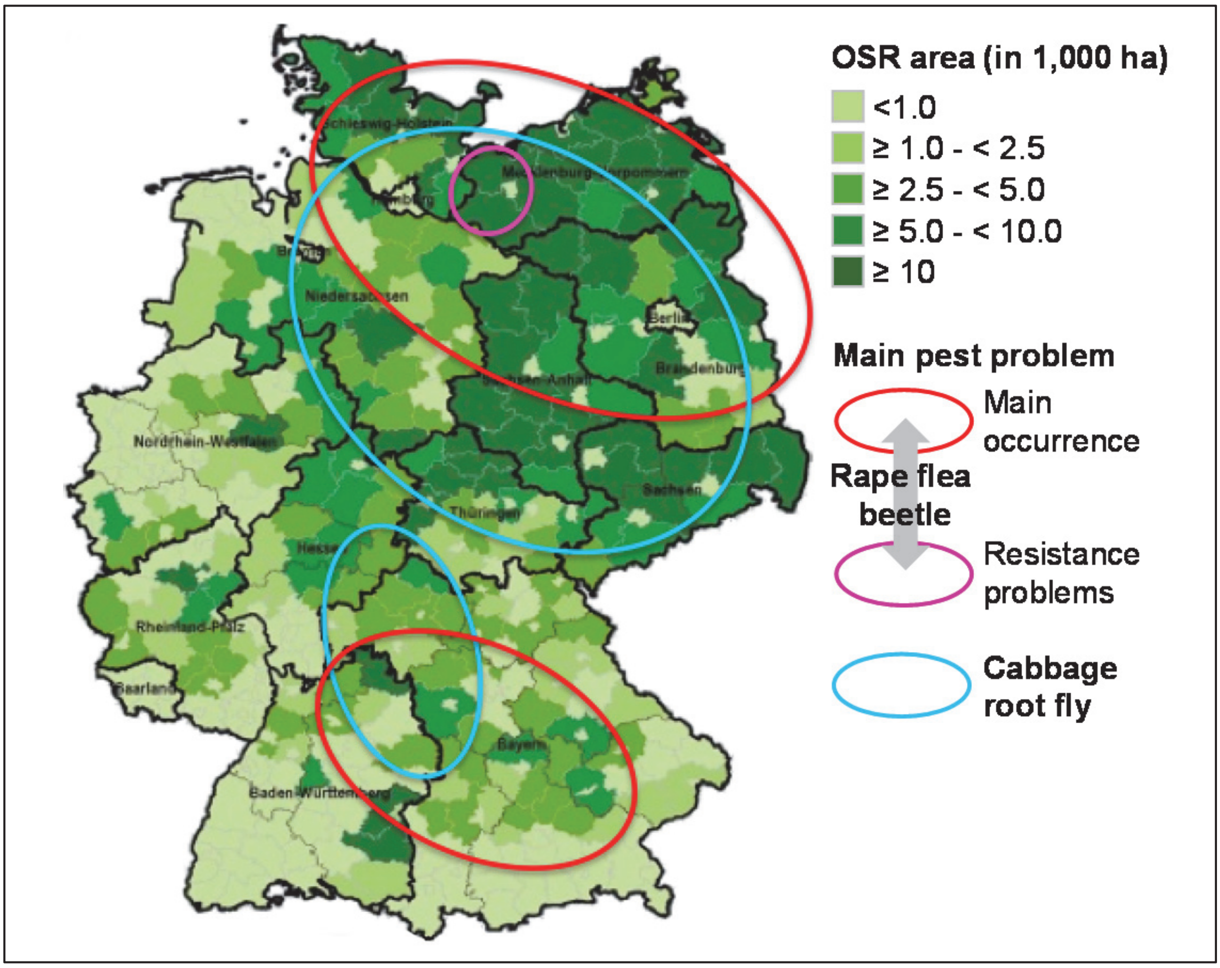
Source: Own figure based on information provided by Arvalis, Agreste and Syngenta.

Annex A.16: Typical winter wheat growing cycle in the United Kingdom



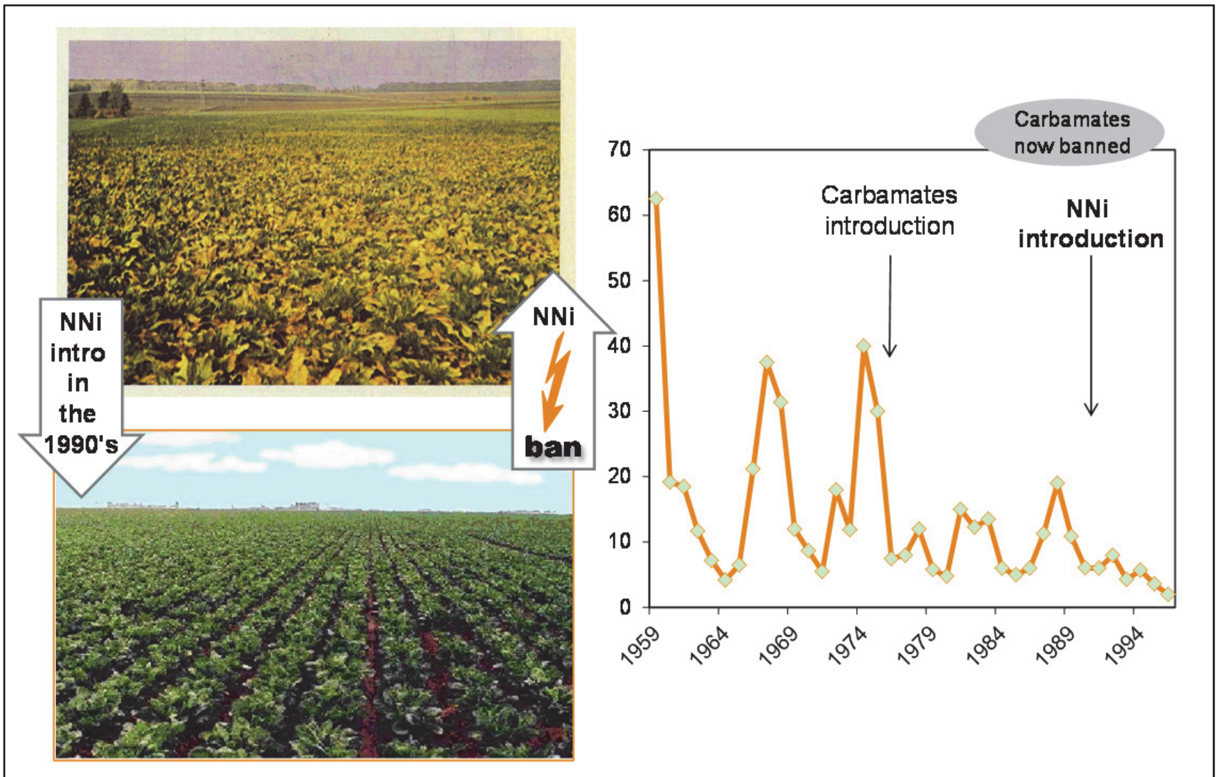
Source: Own analysis based on interviews with experts from the UK based farming company JSR.

Annex A.17: Incidence of main oilseed rape pests in Germany



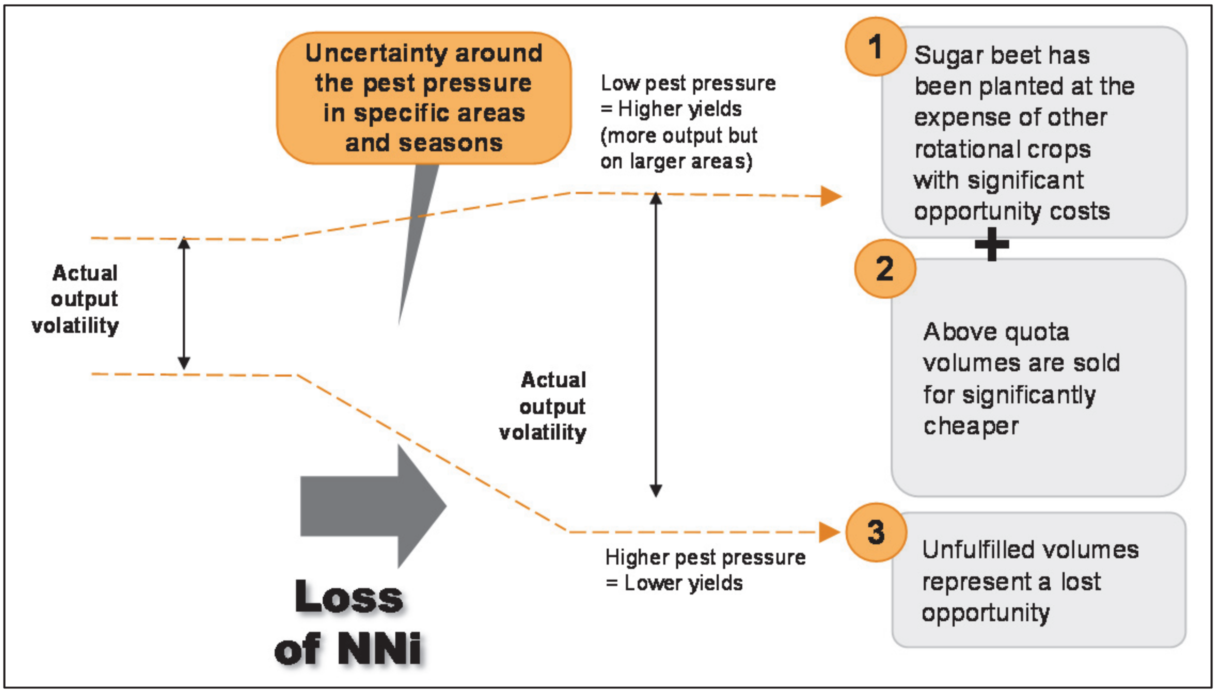
Source: Own analysis based on stakeholder interviews and information provided by Rapool-Ring and NPZ.

Annex A.18: Historic incidence of yellowing disease (in per cent of areas affected)



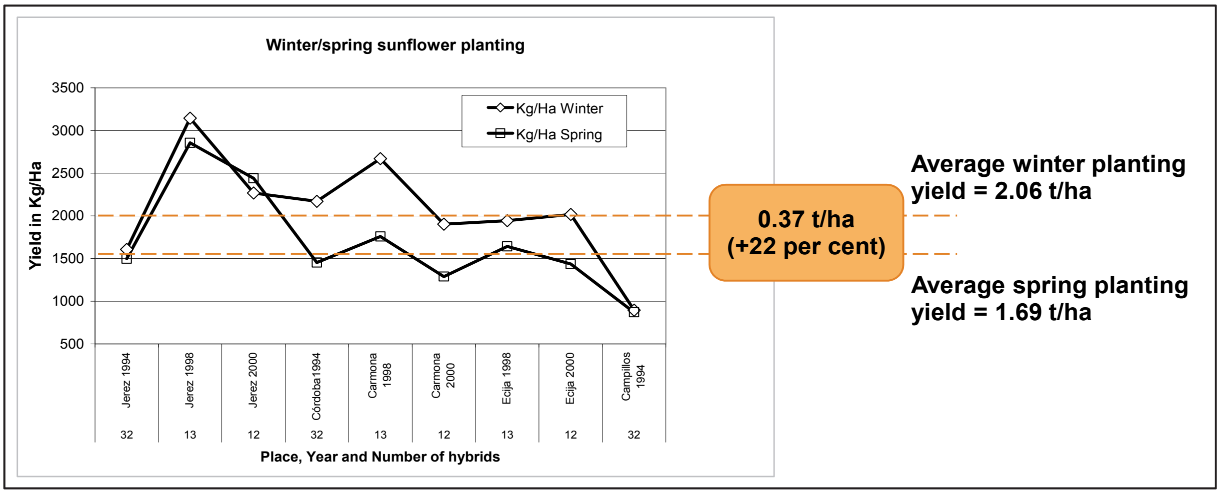
Source: Own compilation based on information provided by the Institut für Zuckerrübenforschung and ITB France.

Annex A.19: Impact of an increased output volatility in the case of a loss of Neonicotinoids



Source: Own analysis based on stakeholder interviews.

Annex A.20: Sunflower yield for winter vs. spring planting in Andalucía, Spain



Source: Own analysis based on Gimeno et al. (1986) and an interview with Luis Carlos Alonso.

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A socio-economic, technological and environmental review

– Research Report –

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