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Banning neonicotinoids in the European Union

An ex-post assessment of economic and environmental costs

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Content

List of figures iii
List of abbreviations v
Executive summary vii
1 Introductory remarks 1
2 Meta-analysis and expert judgements 3
3 Extrapolated economic and environmental effects of banning neonicotinoids to the European Union level 38
4 Concluding remarks 61
Reference list 66

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List of figures

Figure 2.1: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2015/16 (Alves et al., 2016) 7
Figure 2.2: Economic impacts of the ban on neonicotinoids – winter oilseed rape – European Union – marketing year 2014/15 (ESA, 2015) 10
Figure 2.3: Economic impacts of the ban on neonicotinoids – winter oilseed rape – European Union – marketing year 2015/16 (ESA, 2016) 13
Figure 2.4: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Scotland – marketing year 2014/15 (Hughes et al., 2016) 14
Figure 2.5: Economic impacts of the ban on neonicotinoids – oilseed rape – aggregated for Germany, France and the United Kingdom – on average for marketing years 2014/15 and 2015/16 (Kim et al., 2016) 17
Figure 2.6: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Germany – marketing year 2014/15 (Market Probe, 2015a; b) 20
Figure 2.7: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Hungary – marketing year 2014/15 (Market Probe, 2015c; d) 22
Figure 2.8: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2014/15 (Market Probe, 2015e; f) 24
Figure 2.9: Economic impacts of the ban on neonicotinoids – oilseed rape – Poland – marketing year 2014/15 (Meszka et al., 2016) 25
Figure 2.10: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2014/15 (Nicholls, 2016; 2015) 26
Figure 2.11: Economic impacts of the ban on neonicotinoids – winter oilseed rape – England – marketing year 2014/15 (Scott and Bilsborrow, 2015) 28
Figure 2.12: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Romania – marketing year 2014/15 (Vasilescu et al., 2015) 29

Figure 2.13: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2014/15 (White, 2016) 31
Figure 2.14: Overview of main outcomes of the meta-analysis 32
Figure 3.1: Missing annual production of oilseed rape in the European Union due to the ban on neonicotinoids: a cross-country comparison 40
Figure 3.2: Market revenue losses for oilseed rape in the European Union due to the ban on neonicotinoids 42
Figure 3.3: Economic impacts of the ban on neonicotinoids – oilseed rape – European Union – marketing years 2014/15 and 2015/16 (average) 44
Figure 3.4: Annual gross domestic product impact of banning neonicotinoids in oilseed rape production in the European Union 45
Figure 3.5: Regional distribution of arable land additionally needed at global scale to compensate for oilseed rape production losses in the European Union after the ban on neonicotinoids (in 1,000 hectares) 52
Figure 3.6: Additional regional CO_2 emissions due to the ban on neonicotinoids in oilseed rape production in the European Union (in million tons) 53
Figure 3.7: Globally lost biodiversity due to the ban on neonicotinoids in oilseed rape production of the European Union 55
Figure 3.8: Balance of domestic and foreign water use changes due to the ban on neonicotinoids in oilseed rape production of the European Union 57

List of abbreviations

AHDB – Agriculture and Horticulture Development Board

AWU – Annual Working Unit

BCPC – British Crop Production Council

BUND – Friends of the Earth Germany (German: Bund für Umwelt und Naturschutz Deutschland)

CBD – Convention on Biological Diversity

CIS – Commonwealth of Independent States

CSFB – Cabbage Stem Flea Beetle

DEFRA – Department for Environment, Food and Rural Affairs

EEA – European Environment Agency

EASAC – European Academies Science Advisory Council

EC – European Commission

ECB – European Central Bank

EFSA – European Food Safety Authority

ESA – European Seed Association

EU – European Union

FAO – Food and Agriculture Organization

GDP – Gross Domestic Product

GEF-BIO – Global Environment Facility Benefits Index of Biodiversity

GHG – Greenhouse Gas

HGCA – Home Grown Cereals Authority

KTBL – Association for Technology and Structures in Agriculture (German: Kuratorium für Technik und Bauwesen in der Landwirtschaft)

LEL – State Institute for the Development of Agriculture and Rural Areas (German: Landesanstalt für Entwicklung der Landwirtschaft und der ländlichen Räume)

NBI – National Biodiversity Index

OBT – Observaçao da Terra

OSR – Oilseed Rape

UBA – German Environmental Agency (German: Umweltbundesamt)

UK – United Kingdom

UNEP – United Nations Environment Programme

ZMP – Central Market and Price Information System (German: Zentrale Markt- und Preisinformationen GmbH)

Executive summary

In January 2013 the European Commission proposed to restrict the use of neonicotinoids in the European Union. Since 1 December 2013 farmers have been unable to buy or sow seeds that are treated with these active ingredients on crops that are known to be attractive to bees. When implementing the restrictions, the European Commission confirmed that within two years after imposing the ban on neonicotinoids it would initiate a review of new scientific and other relevant information on the risks posed to bees. Thus, the European Food Safety Authority is currently reviewing the available material to formulate conclusions based on updated risk assessments.

A holistic risk and impact assessment of neonicotinoids should also evaluate the verifiable risks and costs which can be allocated to the agricultural sector facing the ban. This study has been conducted to provide that view. More particularly, this research aims at providing a condensed, science-driven and expert-triggered judgement on various economic and environmental effects of the ban on neonicotinoids in European agriculture using the case of oilseed rape.

Altogether, 13 relevant clusters of scientific studies dealing with mainly agronomic impacts of the ban on neonicotinoids in oilseed rape production in member states of the European Union have been identified. Analysing them leads to several conclusions, i.e. consequences of the ban on neonicotinoids. Major findings of this meta-analysis are displayed in the following overview.

Overview on major findings of the meta-analysis conducted within this study

Study	Region	Yield impact (in percent)	Additional foliar applications (in number per hectare)	Total economic impact (in million EUR per region)
Alves et al. (2016)	UK	–1.0	2.00	–33.0
ESA (2015)	EU	–5.1	0.75	–547.5
ESA (2016)	EU	–3.1	0.50	–331.4
Hughes et al. (2016)	SC	–0.5	0.23	–0.469
Kim et al. (2016)	FR	–5.0	n. a.	–146.0
	DE	–5.0		–99.2
	UK	–9.0		–79.6
Market Probe (2015)	DE	–5.4	1.20	–157.3
Market Probe (2015)	HU	–2.1	0.60	–11.7
Market Probe (2015)	UK	–3.2	1.00	–45.1
Meszka et al. (2016)	PL	–10.0	0.33	–182.6
Nicholls (2016; 2015)	UK	–3.5	n. a.	–33.2
Scott/Bilsborrow (2015)	EN	–1.1	1.90	–34.4
Vasilescu et al. (2015)	RO	–22.0	1.35	–103.3
White (2016)	UK	–2.7	1.81	–49.9
European Union (total)	***EU***	***–4.0***	***0.73***	***–512.5***

Source: Own figure.

All studies highlight that the ban on neonicotinoids has caused a yield decrease in oilseed rape production of the European Union. The measurable negative yield impacts differ between less than one and more than 20 percent depending on insect pressure and pest coverage of an individual study. On average, a yield depression of 4.0 percent for oilseed rape production in the European Union as a whole can be extrapolated from the studies.

Quality impacts of the ban are also covered in some of these studies. Smaller seeds and a lower oil content are major quality changes. On average, these developments in quality occurred in 6.3 percent of the harvest volume and account for a price difference of 36.50 EUR per ton affected.

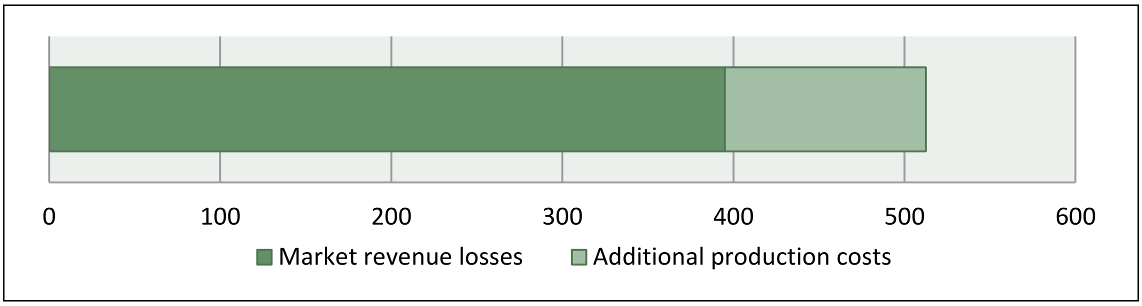
Without the ban on neonicotinoids, 912,000 tons of OSR would have been produced more annually in the European Union. This loss in production is as large as the oilseed rape production volume in Romania and worth almost 350 million EUR. Quality depressions add an additional market revenue loss of more than 50 million EUR. Thus, total annual market revenue losses following the ban on neonicotinoids for the European Union as a whole and oilseed rape production amount to around 400 million EUR.

All the analysed studies confirm that in the absence of neonicotinoid seed treatment, insecticide foliar applications are used more often than before the restrictions came into effect. The application of pyrethroids appears to be the next best solution for combating insects. Additional sprays range from 0.2 to 2.7 applications per hectare depending again on insect pressure and pest coverage analysed by an individual study. The weighted average of additional insecticide (mainly pyrethroid) applications per hectare according to our extrapolation from the studies is 0.73 for oilseed rape production in the entire European Union. This additional application of pyrethroids and other insecticides has not only increased resistance problems but also oilseed rape production costs for the European Union as a whole by close to 120 million EUR annually.

However, this should be considered a rather low estimate of the real production cost increase as a consequence of the ban on neonicotinoids since costs attributable to other necessary management efforts could not be included in the extrapolations. This refers, first of all, to costs of additional monitoring activities, more re-drilling and higher seed rates which by far outweigh comparably small cost savings that can be attributed to a non-treatment of seed with neonicotinoids post the ban.

The additional production costs together with the losses in market revenue are equal to the total economic loss oilseed rape farmers in the European Union have experienced. These economic losses on-farm and per annum can be aggregated; they accumulate to more than 510 million EUR as the following graph depicts and can be considered the sectoral income foregone in oilseed rape producing member states of the European Union as a consequence of the restrictions.

Economic losses in oilseed rape production of the European Union (in million EUR)



Source: Own figure.

Because of reduced transport, crushing, processing, packaging, trading activities, etc. along the value chain, additional income losses in other sectors of the economy can be related to the ban on neonicotinoids. These losses are worth approximately 360 million EUR. The total gross domestic product impact, therefore, is equivalent to an annual loss of almost 880 million EUR. Over a time period of two marketing years since the ban came into effect, this amounts to a national income loss for the European Union as a whole of more than 1.75 billion EUR.

Already before banning neonicotinoids in flowering crops, negative economic impacts had been suggested by scientific research. The results of this analysis show that the ban has caused massive economic disruptions, which are much larger than expected prior to the implementation of the ban. Moreover, it turns out that currently available analyses, studies and papers as well as plenty of expert knowledge do not support criticisers who had considered scientific ex-ante assessments of implications due to restrictions on the use of neonicotinoids as being not realistic enough, overrating the negative effects of pests and showing a tendency of arguing in favour of industry lobbyists.

Banning neonicotinoids has increased global land conversion towards agricultural uses by 533,000 hectares since the 912,000 tons of oilseed rape missing in the European Union had to be produced somewhere else on this land to compensate for the losses at world market level. The vast majority of the land additionally needed is located in Oceania (mainly Australia) and the former Soviet Union (mainly the Ukraine) who are the European Union's major trading partners with respect to oilseed rape.

All this now agriculturally used land had sequestered carbon both above and below ground before it was converted into farmland as a consequence of the ban on neonicotinoids in the European Union. Consequently, a large part of this carbon has been released into the atmosphere in the form of CO_2. If it had been possible to circumvent such a ban, an emission of more than 80 million tons of CO_2-equivalents would have been avoided. This is equal to what Austria currently emits per year as greenhouse gases.

Converting more than 500,000 hectares of grassland and natural habitats constituting eco-zones rather rich in species compared to more or less intensely used arable land in the European Union also requires to take a look at the associated biodiversity losses. It turns out that global biodiversity equivalent to a loss of species when converting more than 250,000 hectares of Brazilian or 330,000 hectares of Indonesian natural or nature-like habitats, e.g. rain forests, has been lost due the ban on neonicotinoids in oilseed rape production of the European Union.

Finally, it can be concluded that the ban on neonicotinoids on balance has caused an additional water use of more than 1.3 billion m^3 at a global scale. Less oilseed rape has been produced in the European Union after the ban, and this decreased production needs less agricultural water remaining available for other purposes. Almost 1.5 billion m^3 of water have been domestically "saved" this way. However, since water productivity in many other parts of the world is not as high as here in the European Union, much more water has to be used in other regions to cultivate a compensatory amount of oilseed rape after banning the use of neonicotinoids here. In total it amounts to more than 2.8 billion m^3. This higher agricultural water use abroad outweighs the lower water use embedded in domestic oilseed rape farming post the ban.

All these findings are the result of conducting a comprehensive meta-analysis and applying scientific modelling and calculation approaches. Moreover, the results are supported by numerous experts. This broad-based consensus allows to state that a policy-decision such as the ban on neonicotinoids has its economic and environmental impacts, and such impacts are repeatedly substantial and too often negative.

Indeed, it turns out that not applying a technology – such as neonicotinoid treatment in oilseed rape production – may have some positive implications (on very specific environmental aspects) but definitely causes much more negative disturbances. These disturbances must be taken into account when making decisions. Pros and cons of applying or not applying a technology need to be assessed in a more balanced and holistic way; and if such a comprehensive assessment results in societal benefits of applying a technology outweighing the costs, then the technology should be applied. In the case of not banning neonicotinoids in oilseed rape production of the European Union such benefits to society are obvious as shown above.

Losing neonicotinoid seed treatment as a management option thus means: These benefits are lost!

This loss can only partly be lowered, e.g. through the use of pyrethroid and other insecticides. However, in the long term, this move towards second-best solutions may create other challenges, such as a stronger resistance problem. It is therefore necessary to have a rather broad tool box of management options available enabling farmers across the European Union to combat not only insects being enemies of our arable crops but all pests in a resource-efficient way. Neonicotinoid seed treatment is one of these tools, and it is a very valuable tool.

1 Introductory remarks

Following a risk assessment examining the effects of three neonicotinoids, namely clothianidin, imidacloprid and thiamethoxam, on bees (EFSA, 2013a; b; c), the European Commission (EC) proposed in January 2013 to restrict the use of these three compounds in the European Union (EU). Succeeding this proposal and a stalemate vote in March 2013, the EC announced a two-year restriction of the use of the three above mentioned active ingredients (McGrath, 2014). Subsequently, the EC imposed a ban on neonicotinoids (EC, 2013a): Starting on 1 December 2013 farmers in the EU have not been able to buy or sow seeds of crops attractive to bees which are treated with neonicotinoids (see e.g. McGrath, 2014).

When implementing the corresponding restrictions, the EC confirmed that within two years after imposing the ban it would initiate a review of new scientific and other relevant information on the risks posed to bees by neonicotinoids. Most likely, this review will mirror the long-lasting and controversial debate among scientists and policy makers regarding this issue (see e.g. Budge et al., 2015; DEFRA, 2015a; Deutscher Bundestag, 2015; EASAC, 2015; Godfray et al., 2014; Hickman, 2013; Hoppe et al., 2015; Jensen 2015; Lapin, 2015; McGrath, 2014; Pilling et al., 2013; Raine and Gill, 2015; Rundlöf et al., 2015). As part of this decision-preparing process, the European Food Safety Authority (EFSA) has asked all interested stakeholders to submit new relevant information (EFSA, 2015). Until January 2017, the EFSA is reviewing this material to formulate conclusions based on updated risk assessments (EFSA, 2016).

A holistic impact assessment of neonicotinoids should not only evaluate the perceived risks or the potential costs attributed to bees (or more generally speaking: pollinators) if the active ingredients were applied, but also the verifiable risks and costs which can be allocated to the agricultural sector facing the ban. Such a comprehensive analysis has not been done so far and is the key motivation for conducting this study. Our major research objective is the following: The research aims at providing a condensed, science-driven and expert-triggered judgement on various economic and environmental effects of the ban on neonicotinoids in EU agriculture. More particularly, the case study of oilseed rape (OSR) production is used to focus on the identification of market revenue and production cost impacts as well as other than pollinator-related environmental consequences of the ban.

A dual approach will be used to achieve this challenging objective. Point of departure is a meta-analysis of already available information concerning specific economic and other meaningful aspects discussed post the ban on neonicotinoids in EU OSR production. This meta-analysis shall necessarily comprise a review of scientific studies and academic papers as well as the gathering of additional expert knowledge. Based on these various pieces of information, a synthesis, i.e. a quantification of the EU-wide economic and environmental effects, which have resulted since the ban, will be carried out. The report is structured accordingly:

- Following these short introductory remarks (chapter 1), scientific studies, academic papers and additional expert knowledge will be discussed and assessed (chapter 2). It will start with an in-depth discussion of the major findings presented in altogether 13 studies or study clusters which all focus on some direct on-field impacts and economic implications of the ban (sub-chapter 2.1). These findings will then be summarised and stress-tested using expert knowledge and additional academic input as well as supplementary statistical information (sub-chapter 2.2).
- Discussing and synthesising the findings of the individual studies and combining them with additional expert inputs allow for an extrapolation of EU wide impacts of the ban on neonicotinoids (in chapter 3). Therefore, some definitions have to be determined (sub-chapter 3.1). Based on these definitions and for the EU as a whole, various economic impacts will then be calculated (sub-chapter 3.2) before selected but important environmental effects will be highlighted (sub-chapter 3.3).
- Finally, some important conclusions for further decision-making will be drawn (chapter 4).

2 Meta-analysis and expert judgements

2.1 Major findings from individual scientific studies and academic papers

In the following, major findings from various scientific studies and academic papers focussing on mainly "production process"-oriented implications of the ban on neonicotinoids in OSR production in the EU as a whole and/or some of its member states will be displayed, discussed and compared. A meaningful comparison of the economic and environmental effects, however, is difficult from a twofold perspective:

- Each analysis follows its own methodological approach that has its own data background and systemic frontiers. Therefore, each of the following papers also has its own conceptual pros and cons; some of the most important strengths and weaknesses will be highlighted below when discussing an individual study. Generally speaking, some of the thus available information can be considered a selective expert-based insight while some other information is more representative since data has been gathered on farm via proper questionnaire techniques. The impact of the ban analysed and described in the various papers is often somewhat limited since only the OSR damage associated with one or a few species of insects and/or a particular time period (mainly autumn) of an entire marketing year is extensively discussed. It is the missing of a standardised methodology in terms of data necessities and a (more or less full) coverage of impacts that hampers the comparative analysis.

- In addition, it has to be noted that most of the identified analyses follow a concept of natural sciences (in particular agronomy) and not an approach of agricultural economics to clarify "impacts". Consequently, the impacts of the ban on neonicotinoids analysed in the various studies and papers concentrate on issues such as changes in crop yields and qualities, additional application numbers of substitutive insecticides and other (alternative) management efforts. Transferring such primary or direct effects on fields into meaningful economic impacts and subsequent environmental consequences is for the most part missing in the various analyses. While most of these missing links can be closed by linking detected yield and quality information as well as changes in management with monetary indicators such as prices and specific costs, the impact of a particularly important management option – the reallocation of land from OSR towards other crops (not or less affected by the ban) – cannot easily be covered since all the following studies look at areas cropped with OSR only.

This is also the reason, why findings with respect to two studies, namely Johnsson (2015) and Ketola et al. (2015), dealing with consequences of the ban on spring OSR are not included in the discussion below. If spring OSR production is affected by a damage due to pests which could have been avoided without the ban, there will be no time to meaningfully react with substitutive management efforts and the crop is (partly or totally) lost. If the likelihood of being affected is high, the only management option is not to cultivate spring OSR but something else. Analysing the prophylactic cultivation of other crops than OSR from an in-depth economic perspective is beyond the scope of our own analysis.

Thus, factoring out findings from Johnsson (2015) and Ketola et al. (2015), 17 other scientific studies and academic papers dealing with mainly agronomic impacts of the ban on neonicotinoids in EU OSR production have been identified as meaningful for our own analysis. They can be grouped into 13 studies or study clusters. In alphabetic order these are:

1. Alves et al. (2016),
2. ESA (2015),
3. ESA (2016),
4. Hughes et al. (2016),
5. Kim et al. (2016),
6. Market Probe (2015a; b),
7. Market Probe (2015c; d),
8. Market Probe (2015e; f),
9. Meszka et al. (2016),
10. Nicholls (2016; 2015),
11. Scott and Bilsborrow (2015),
12. Vasilescu et al. (2015), and
13. White (2016).

The major findings of each of these analyses will be described in the upcoming paragraphs before a summary on them will be given. Thereby, the individually covered direct impacts on yields and/or the quality of crops as well as on the process management will be described before they will be translated – if not already done within a very few of the identified studies – into economic impacts. This transformation of mainly agronomic effects into monetary consequences such as changes of market revenues and production costs – and thus: profits – will be done by using reliable statistical information on market and input prices, exchange rates, etc. The precise information base for doing so will be made transparent on a case by case study. In this sense, the following discussion first of all concentrates on economic impacts; a discussion of subsequent environmental impacts is transferred to chapter 3 of this report.

Alves et al. (2016)

Alves et al. (2016) collected data using an expert assessment which involved 56 leading national agronomists. All of them had to answer a standardised questionnaire. Finally, information covering 62,000 hectares cultivated with winter OSR in altogether 42 counties of the United Kingdom (UK) was gathered. This equates approximately eleven percent of total UK winter OSR area. In particular, qualitative and quantitative data on damages due to the cabbage stem flea beetle (CSFB) – which the authors consider a direct impact of banning neonicotinoids – were gathered in autumn 2015 leading to an authors' assessment of potential effects for the harvest in 2016. The authors themselves consider this assessment as representative for all winter OSR planted in the UK in 2015 which was not treated with neonicotinoids.

Following the expert assessment, 65 percent of the entire non-treated winter OSR area in the UK was damaged by CSFB at the two-leaf stage; this ratio rose to approximately 70 percent at the four-leaf stage. Damage at the latter stage is assessed by the authors to transform into a production loss which is equivalent to the OSR production on 6,000 hectares. Given a winter OSR yield of 3.65 tons per hectare for the 2016 harvest in the UK (Coceral, 2016), a total loss of 21,900 tons just due to CSFB can thus be calculated. This is equivalent to a national yield decrease of slightly more than 1.0 percent since overall OSR production is assessed to be in the range of 2.146 million tons (Coceral, 2016). Using a recent market price of approximately 309 GBP per ton of winter OSR (Farming Online Ltd., 2016), this would equal to a loss in production revenues of approximately 6.8 million GBP or – using a current exchange rate of 1.00 EUR equal to 0.84 GBP (ECB, 2016b) – close to 8.1 million EUR for the entire winter OSR area not treated with neonicotinoids in the UK.

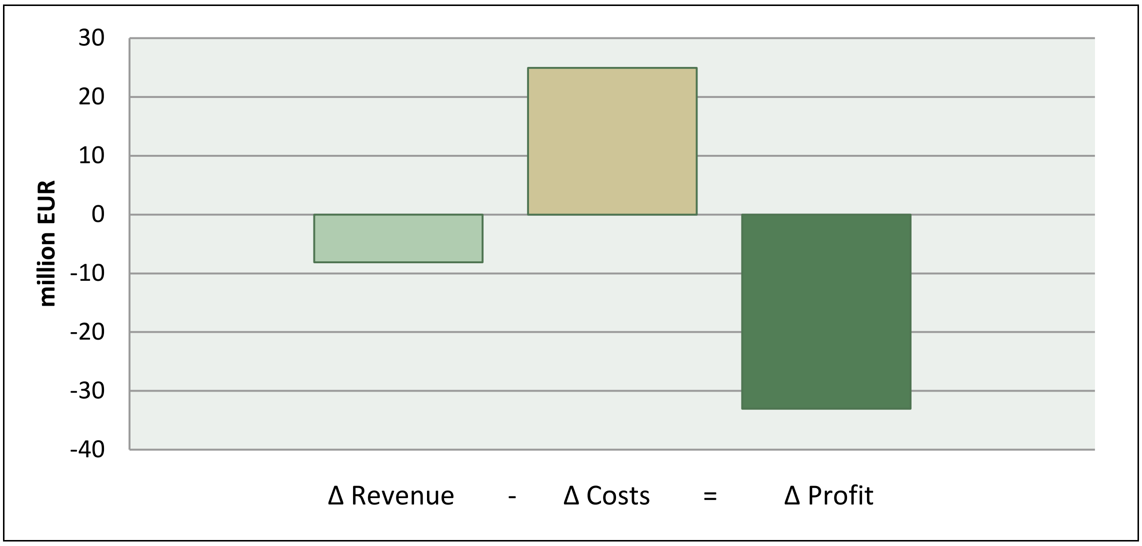
This should be considered a very conservative assessment of the true market revenue losses due to the ban. According to Alves et al. (2016), another 3.1 percent of the crop will be potentially lost for harvest in 2016 due to other reasons. Unfortunately, this has not further been split and thus we cannot derive from the authors' results what part of this additional loss should be considered an additional direct impact of banning neonicotinoids, e.g. related to re-seeding, a change of the drilling date or a partial movement towards lighter and finer soils which are less susceptible to CSFB.

Consequently, Alves et al. (2016) define potential production losses as those which will emerge with the harvest in 2016 due to the very high CSFB pressure in autumn 2015 that appeared because non-neonicotinoid protection options failed to reduce this particular pest. However, combating the insects has been possible with other remedies on many sites where winter OSR is cultivated in the UK. The main alternative control option identified by Alves et al. (2016) is the application of foliar pyrethroid insecticides as a substitute for neonicotinoids. According to the authors, winter OSR crops received on average two substitutive applications of pyrethroids. Using information provided by Redman (2016), it costs at least 16.20 GBP per hectare (on average 5.20 GBP for the active ingredient and 11.00 GBP for spraying it) to apply a pyrethroid in OSR in the UK. Using an average exchange rate of 1.00 EUR to 0.77 GB before the "leave" vote – which will be used throughout this paper if the GBP reference value cannot be associated to a particular point of time – this equals 21.04 EUR per hectare. Applied to an acreage of altogether 588,000 hectares (Coceral, 2016), this means that additional production costs of at least 24.7 million EUR need to be taken into consideration.

Additional production cost increases can be calculated using data from Alves et al. (2016), because costs associated with partially higher seeding rates have so far not been taken into account. The proportion of winter OSR that was under high and severe CSFB pressure in the UK is assessed by Alves et al. (2016) to be around eight percent. In such a case, experts suggest to increase seed rates by ten percent (see e.g. Agra-Europe, 2016b). This would imply that approximately 47,000 hectares in the UK have been planted with higher seed densities. With respect to winter OSR in the UK, average costs of home saved seed and seed royalty accumulate to 30.93 GBP per hectare (Redman, 2016). Increasing this by ten percent and applying this higher seeding rate on eight percent of the total OSR acreage alone results in additional costs of close to 0.2 million EUR. Hence, the additional production costs of banning neonicotinoids in the UK are most likely higher than 24.9 million EUR, because Alves et al. (2016) only assess combating CSFB with insecticides and no other.

Following the authors' arguments and own monetary calculations, the economic effect stemming from decreased market revenues and increased production costs of the CSFB impact after banning neonicotinoids in UK winter OSR production amounts to at least 33.0 million EUR. This conservative assessment of the economic effects resulting from Alves et al (2016) is displayed in figure 2.1.

Figure 2.1: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2015/16 (Alves et al., 2016)



Source: Own calculations and figure based on Alves et al. (2016).

ESA (2015)

The analysis provided by ESA (2015) is one of three studies (in addition: ESA, 2016; Kim et al., 2016) in which the authors assess the effects of banning neonicotinoid seed treatment in OSR production for not only one specific country but as many EU member states as possible. The ESA (2015) analysis refers to the marketing year 2014/15 and is based on a survey, i.e. a standardised questionnaire sent to national member associations of the ESA. These associations provided feedback by using a country-specific, i.e. a non-uniform expert judgement approach. This makes it fairly difficult to compare developments in individual EU member states. The following discussion shall therefore concentrate on the ESA (2015) findings for the EU as a whole only.

Altogether, information from 15 EU member states including all major OSR producing countries was used for this analysis. Subsequently, the study covers 4.634 million hectares cultivated with OSR in the EU. This equals 72 percent of the total EU area harvested in 2015 which amounted to 6.451 million hectares (Coceral, 2016).

The analysis essentially concludes that in the marketing year 2014/15 CSFB and other pests which could have been avoided if neonicotinoids were used, caused substantial crop yield losses in OSR that are depicted in the following table.

Overview of EU-wide OSR crop losses to CSFB and other pests related to the ban on neonicotinoids in marketing year 2014/15

	Percentage interval of crop losses due to CSFB and other pests			
	1 – 25	*25 – 50*	*50 – 75*	*75 – 100*
Affected winter OSR area drilled without neonicotinoid seed treatment (in hectare)	*2,315,000*	*105,000*	*39,000*	*27,000*
Percentage of total winter OSR area covered in ESA (2015)	*50.0*	*2.3*	*0.8*	*0.6*

Source: Own overview based on ESA (2015.)

Therefore, it becomes clear that half the area covered by the ESA (2015) analysis suffered from a yield loss between one and 25 percent. Based on this primary finding, ESA (2015) also provides an expert-based assessment of the associated revenue losses due to pests which could have been avoided during the marketing year 2014/15 in EU OSR production without banning neonicotinoids. Accordingly, the revenue loss is as large as 440 million EUR. However, this number is based on the expert assumption that in the EU 6.695 million hectares were cultivated with OSR. Latest data only count 6.451 million hectares (see above as well as Coceral, 2016). Calculating with this updated information, the ESA (2015) analysis implies a production loss of "only" 424.0 million EUR. Taking, first, the total harvest of 21.7 million tons (Coceral, 2016) and, second, a price of 385 EUR per ton which was paid around harvest in 2015 (ZMP, 2016), we thus may calculate an EU-wide yield loss of nearly 5.1 percent based on the ESA (2015) study.

The above indicated four intervals for assessing the ESA (2015) yield losses are rather wide-ranging; and unfortunately a more precise assessment could not be given by ESA (2015) using this data. To cross-check, we employ an additional but rather conservative estimation and add it to the ESA (2015) analysis. The underlying assumptions are as follows:

- Let us initially assume that the average percentage of crop losses per interval is not found in the middle of each respective interval depicted in the table above but much closer to the lower bound of the given range.
- Given that, let us furthermore assume that the average yield impact for the intervals "1 – 25", "25 – 50" and "50 – 75" is a percentage score equal to the lower-bound percent value of the given interval for crop losses plus 2.5 percent (i.e. a tenth of the dimension of the three intervals).

- Furthermore, let us accept that a 75 – 100 percent loss is a complete OSR crop failure with no direct management option to compensate for.
- Subsequently, the average yield loss in EU winter OSR production for the marketing year 2014/15 is calculated to be around 3.4 percent, at least.
- Extrapolated to an EU harvest level of 21.738 million tons (Coceral, 2016) for the marketing year 2014/15, this is equal to approximately 739,000 tons of actually foregone OSR. Again valued at a price of 385 EUR per ton, this equals 284.5 million EUR.

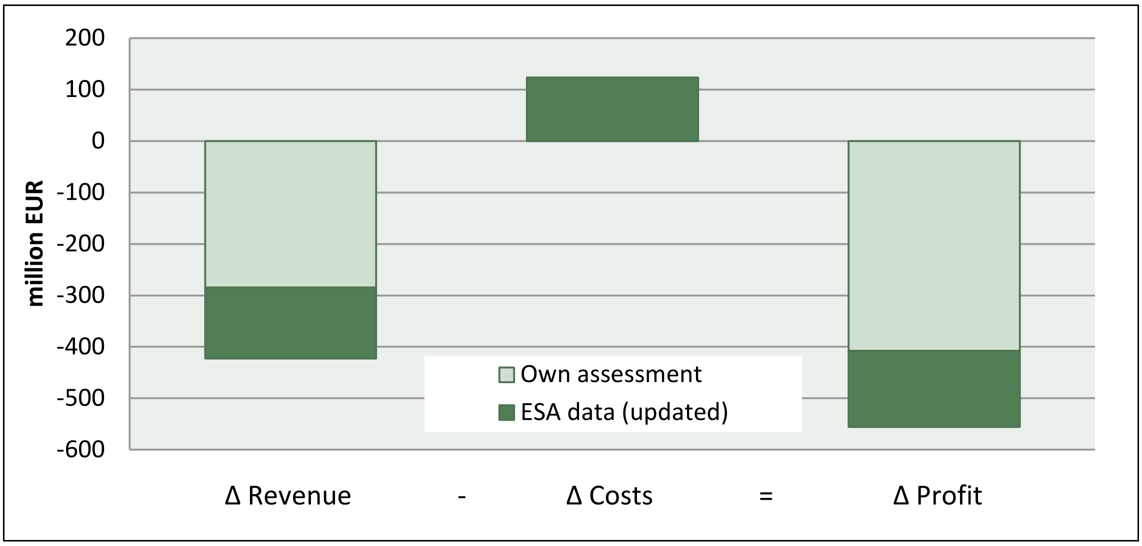
In the following this estimation should be considered as our own but still ESA (2015)-based estimation providing a minimum of likely market revenue losses for OSR production in the EU due to the ban on neonicotinoids. As such it accentuates the ESA (2015) information.

Apart from revenue losses, a production cost impact can be derived from ESA (2015) too:

- According to the study, a substitute insecticide spray (often including pyrethroids) was applied on at least 75 percent of the winter OSR area. The associated costs per hectare are assumed to be 25 EUR. Extrapolated to all hectares cultivated with OSR in the EU, this implies an additional production cost due to the ban of altogether 121.0 million EUR. ESA (2015) derives 126.1 million EUR, but assumed an area slightly above the actual OSR acreage (see above) which we used for our updated calculations.
- However, the ESA (2015) cost estimate does not include the necessity to re-drill at least the 0.6 percent of all the OSR area confronted with a complete crop failure. Since we do not know if this acreage has been re-drilled with OSR or another crop, we assume "average" drilling costs of 65 EUR per hectare which are in the range of contractors' charges and farmers' average drilling costs listed in Redman (2016). Applied to 0.6 percent of all the area cultivated with OSR in the EU in the marketing year 2014/15, this accumulates to an additional 2.5 million EUR.

Together with the derived revenue losses of at least 284.5 million EUR and the additional foliar application costs, this translates to an overall economic loss of about 408.0 million EUR. However, this loss would amount to 547.5 million EUR if the original data from ESA (2015) was updated with the actual OSR area in the EU. Figure 2.2 depicts this and our own calculation.

Figure 2.2: Economic impacts of the ban on neonicotinoids – winter oilseed rape – European Union – marketing year 2014/15 (ESA, 2015)



Source: Own calculations and figure based on ESA (2015).

ESA (2016)

The approach of ESA (2015) has also been applied in ESA (2016). However, this particular analysis refers to the marketing year 2015/16. Again experts assessed pest developments and management efforts combating them without neonicotinoid seed treatment in OSR production. As in ESA (2015) national expert knowledge was gathered by using questionnaires, and this country-specific expertise was accumulated to the EU level.

The following overview provides the "updated picture" that can be drawn from the ESA (2016) data, which takes into account 4.803 million hectares of cultivated OSR in the past marketing year. This is equal to approximately 75 percent of the EU area which was harvested in 2016. According to Coceral (2016), these are around 6.431 million hectares.

Overview of EU-wide OSR crop losses to CSFB and other pests related to the ban on neonicotinoids in marketing year 2015/16

	Percentage interval of crop losses due to CSFB and other pests			
	1 – 25	*25 – 50*	*50 – 75*	*75 – 100*
Affected winter OSR area drilled without neonicotinoid seed treatment (in hectare)	*1,293,000*	*138,000*	*24,000*	*5,300*
Percentage of total winter OSR area covered in ESA (2016)	*26.9*	*2.9*	*0.5*	*0.1*

Source: Own overview based on ESA (2016).

Comparing this overview with the respective synopsis for ESA (2015), it becomes apparent that the damage due to insect pests is assessed to be lower in the marketing year 2015/16 than the previous marketing year. Three effects which mainly explain this change have to be mentioned:

- The first refers to the – on average – more favourable weather conditions across the EU which helped to keep insect activity rather low. The autumn of 2015 in many major OSR production regions was characterised by less and shorter periods of mild, fine weather, which lowered the activity of pest insects such as CSFB (AHDB, 2016a).
- Second, farmers across the EU learned from the experiences they gained one year before. Many of them drilled a bit earlier, thus giving OSR plants the possibility to emerge before pest appearance. Consequently, plants were more tolerant to severe CSFB attacks (AHDB, 2016a).
- Finally, it should be noted that compared to the marketing year 2013/14, which was the last marketing year prior to the ban, the EU OSR area in 2014/15 already went down by 1.6 percent (Eurostat, 2016). This downward trend has continued until today. In 2016 the harvested area is forecasted to additionally decrease by at least 0.4 percent (Coceral, 2016). However, Copa-Cogeca (2016) estimates a decrease of 2.6 percent. It can be expected that most unsuitable areas – i.e. those with a rather high potential pest pressure – were cropped with other arable crops or left fallow first. Due to this specific OSR area loss over time, the rather high negative yield impacts on such unsuitable pieces of land cannot be taken into account anymore.

Consequently, the economic impacts of banning neonicotinoids are also less pronounced. Using the same calculation approach as in the discussion of ESA (2015), the following aspects can be highlighted:

- Our own "best guess" minimal yield impact for OSR production in the EU is 2.1 percent. Multiplied with the harvest of 22.024 million tons (Coceral, 2016) this equals approximately 463,000 tons. Following the harvest in 2016, the trade and market price for a ton of OSR is around 370 EUR (ZMP, 2016). Consequently, an EU-wide market revenue loss of at least 171.1 million EUR should be expected.

- ESA (2016) – based on expert assumptions made in March 2016 – calculates with a market revenue loss that can be as large as 251 million EUR. Updated with the most recent information on the OSR harvest area and volume this number should be around 250.3 million EUR. This implies an EU-wide yield decrease of 3.1 percent.

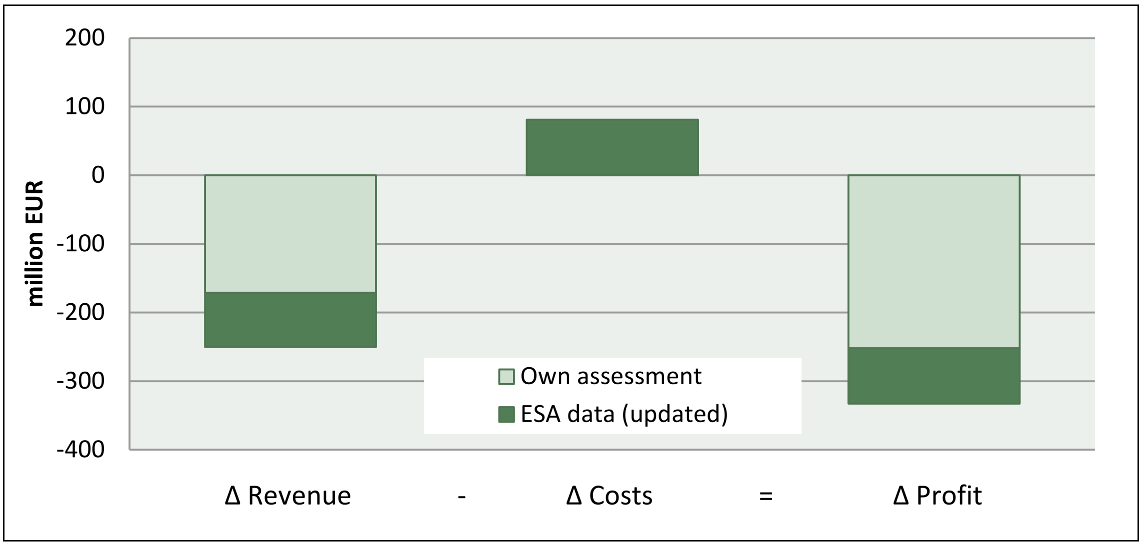
- Again on top of that, production costs are larger than they would have been without the ban on neonicotinoids. ESA (2016) continues to assume that an extra insecticide spray has been applied; however, this time only on 50 percent of the entire OSR area in the EU. Hence, not less than 3,216,000 additional applications of alternative insecticides should be taken into consideration. Using again an average of 25 EUR per hectare as a reasonable estimate of application costs, this alone accumulates to additional production costs due to the ban of 80.4 million EUR.

- The corresponding ESA (2016) estimation is 81.0 million EUR, using once more a slightly different acreage which has been updated at this point.

- Finally, re-drilling of 0.1 percent of the entire OSR acreage in the EU can be valued at 0.4 million EUR.

With the data and information provided by ESA (2016) and with respect to the OSR production in the EU, an overall economic loss ranging between 251.8 and 331.1 million EUR should be considered as the potential outcome of banning neonicotinoids in the current marketing year (see figure 2.3).

Figure 2.3: Economic impacts of the ban on neonicotinoids – winter oilseed rape – European Union – marketing year 2015/16 (ESA, 2016)



Source: Own calculations and figure based on ESA (2016).

Hughes et al. (2016)

Hughes et al. (2016) focus on winter OSR cultivation in Scotland for the marketing year 2014/15. They base their analytic findings on a survey that includes 115 farmers who also grew winter OSR the previous season and who were asked to provide information. Whether this has been done via interviews or a standardised questionnaire technique remains unclear. Nevertheless, the survey represents 16 percent of the Scottish winter OSR acreage recorded in 2015, which was according to the authors about 35,200 hectares.

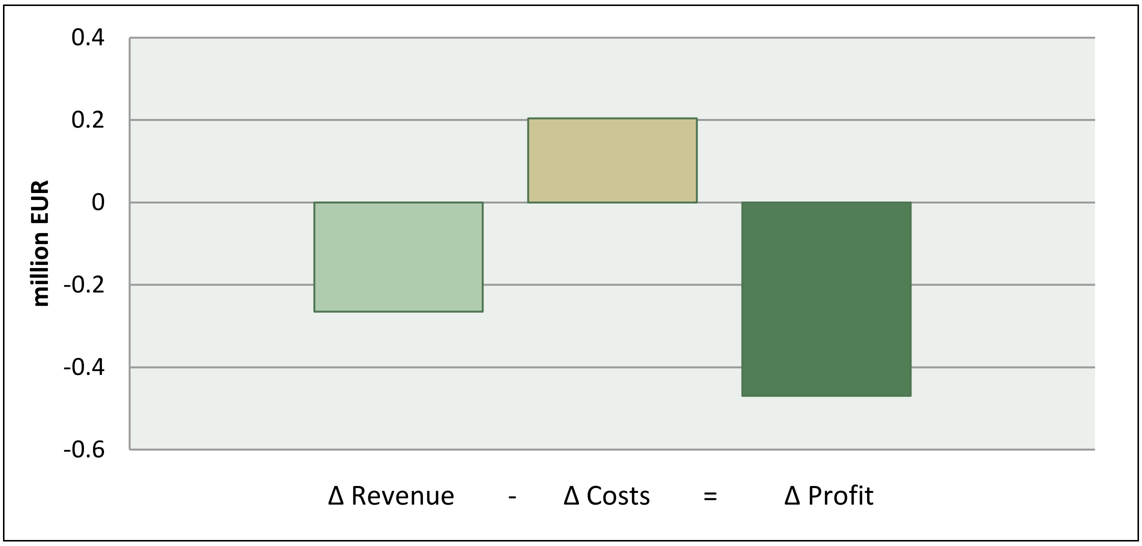
First the authors examine management adjustments in winter OSR production following the ban. More than 60 percent of the growers used at least one application of a foliar insecticide – mainly pyrethroids – to combat pests in the absence of neonicotinoids. According to the authors the ban's net-effect triggered only 0.23 additional foliar applications per hectare of winter OSR. This is mainly attributed to an overall low pest pressure in that particular region during the investigated marketing year. Unfortunately, Hughes et al. (2016) do not provide a cost estimate for the associated economic effects. Using again 16.20 GBP (21.04 EUR) per hectare and insecticide spray application (see again Redman, 2016) as a reasonable cost level, we calculated additional plant protection costs due to the ban of 170,300 EUR.

According to Hughes et al. (2016), re-drilling OSR due to CSFB damage was additionally necessary on 1.1 percent of the area. This costs around 86.40 EUR per hectare in the UK (Redman, 2016; Scott and Bilsborrow, 2015), i.e. 33,500 EUR for the total acreage which had to be re-drilled with OSR in Scotland. Hence, total additional production costs assumed by Hughes et al. (2016) accumulate to about 204,000 EUR.

Calculating a market revenue impact is challenging when using the limited data provided by Hughes et al. (2016). Solely based on information by yield loss-reporting farmers, approximately seven percent of these observed yield losses can be attributed to damages due to CSFB and other relevant insects triggered by the ban. This equals approximately 0.5 percent of the entire harvest. Using an average yield of 4.15 tons per hectare (Scottish Government, 2015) and the acreage mentioned above, the total production loss accumulates to 730 tons of winter OSR. With an OSR price around harvest of 265 GBP in 2015 (AHDB, 2016c) or – using an exchange rate at that time of 0.73 GBP per EUR (ECB, 2016b) – 363 EUR per ton, a revenue loss of 265,000 EUR can be calculated.

The overall economic loss of 469,000 EUR concerning winter OSR production in Scotland is depicted in figure 2.4 and should be considered the outcome of banning neonicotinoid seed treatment for the marketing year 2014/15 based on Hughes et al. (2016).

Figure 2.4: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Scotland – marketing year 2014/15 (Hughes et al., 2016)



Source: Own calculations and figure based on Hughes et al. (2016).

Kim et al. (2016)

Kim et al. (2016) provide a rather comprehensive and complex cumulative impact assessment dealing with the potential loss of several plant protection products. Within the approach, the authors also evaluate the implications of banning neonicotinoids in OSR production for some of the most important OSR producing EU member states. They base their impact estimations on expert judgements as well as field tests corrected for the share of cultivated land to which the various active ingredients have been applied. Various technical institutes as well as representatives of farmers' organisations have contributed their knowledge. The list of contributors in an OSR context includes – among others – the UK-based Anderson Centre, the Arvalis Institute from France, the Austrian Chamber of Agriculture, and the renowned Irish Teagasc.

For the case of banning neonicotinoids, these experts estimate the pest-affected area (percent of total OSR area) as well as the immediate changes in yields and production costs. The following overview summarises the findings of Kim et al. (2016) that can be directly related to insect damage in OSR without neonicotinoid seed treatment in the three EU member states for which respective data and information is completely given: These are France, Germany, and the UK. In the case of Germany and the UK, the following figures can thus be considered a "best guess" expert judgement of the effects of the ban on neonicotinoids as discussed above. However, in the case of France a corresponding suspension was announced years before the EU-wide ban. Indeed, the country withdrew the authorisation of neonicotinoid seed treatment in OSR already in June 2012 (EC, 2013b); the below listed effects thus should be discussed as impacts which became manifest well before the ban, but still remain evident.

Overview of the affected area, yield losses and changes in production costs related to insect damage in OSR without neonicotinoid seed treatment in three EU member states

	Affected area (in percent)	*Immediate yield loss (in percent)*	*Change in production costs (in EUR per hectare)*
France	*95*	*5*	*38*
Germany	*60*	*5*	*up to 55*
United Kingdom	*67*	*9* [*)]	*up to 67*

Source: Own overview based on Kim et al. (2016).
[*)] In addition to neonicotinoids, pyrethroids are also assumed to be banned in the UK. According to the authors, banning both active ingredients results in a yield drop of 17 percent. We conservatively assumed here that only neonicotinoids account for at least half of that impact since Kim et al. (2016) include three neonicotinoids into the UK case study approach, but only one pyrethroid.

In addition, some numbers were given for Poland and other EU member states in Kim et al. (2016). However, in these cases it was not possible to distinguish potential impacts of banning neonicotinoids from those of suspending other plant protection products, e.g. fungicides. Therefore, these additional findings of Kim et al. (2016) are excluded from our following analysis. Furthermore, it shall be noted that the figures displayed in the overview are not referring to a particular marketing year. They should rather be considered as a reference value for a year facing a five-year-average pest pressure, according to the authors. Referring to the marketing year 2014/15 and the marketing year 2015/16, i.e. the years post the ban on neonicotinoids, the estimates provided by Kim et al (2016) result in the following own calculation of annual losses of market revenue as well as production cost increases and, hence, total economic losses per country:

- France experiences a tremendous loss in market revenue. Since almost the entire crop area is affected (95 percent) by the already long-lasting suspension and yield losses are assumed to amount to five percent. Thus, 249,000 tons of French OSR would be lost taking into consideration overall OSR production figures provided by Coceral (2016). Valued at French market prices paid during harvest in 2015 and reported for the harvest in 2016, i.e. on average 371 EUR per ton (see ZMP, 2016), this equals a market revenue loss of 92.3 million EUR. In addition, production costs have increased due to the ban. Taking the numbers of the above overview and area figures again from Coceral (2016) this amounts to 53.7 million EUR. Hence, a total negative economic impact of 146.0 million EUR should be taken into consideration for OSR producers in France. Kim et al. (2016) used a slightly different calculation approach and concluded that the average “gross margin effect” (how they call it) over a time period of five years is around 157 million EUR per year in France. It has to be stressed that France was the only country for which the outcomes calculated by Kim et al. (2016) and by us could directly be compared with such detail. In the other country cases Kim et al. (2016) fail to provide meaningful economic calculations for OSR.

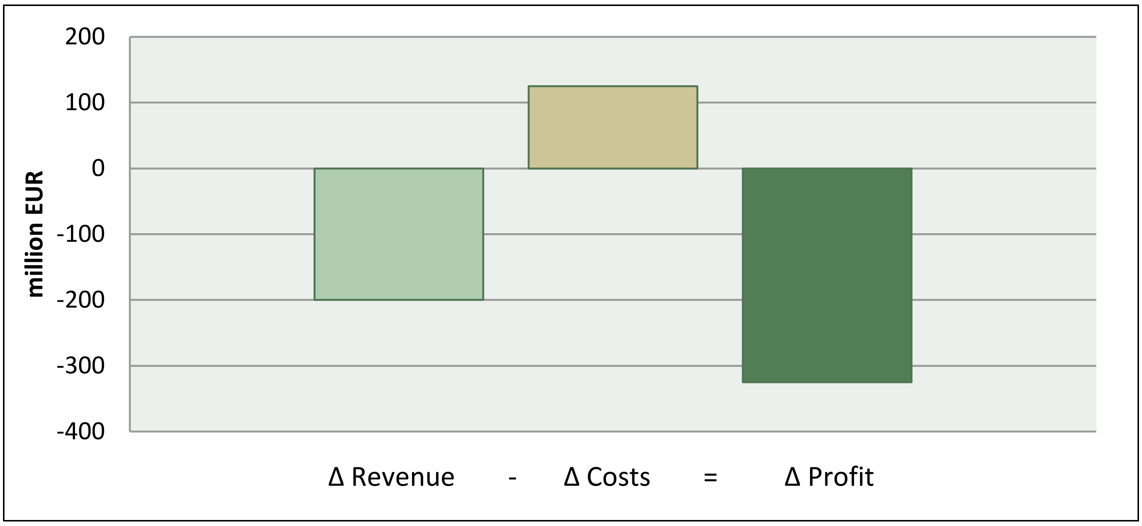
- Also for Germany, the impacts are remarkable. The production losses accumulate to 155,500 tons. Given a price paid in Germany around harvest in 2015 of approximately 355 EUR per ton (LEL, 2015) and for the harvest in 2016 of around 360 EUR per ton (Agra-Europe, 2016a), the corresponding market revenue loss is 56.0 million EUR. In addition, production costs increased up to 43.2 million EUR due to the ban. Consequently, the entire economic loss in German OSR production is equal to 99.2 million EUR.

- The UK is also suffering economically from banning neonicotinoids. According to Kim et al. (2016) and given OSR production data described in Coceral

(2016) and national prices paid around harvest in 2015, i.e. 363 EUR per ton (see, again, AHDB, 2016c), and forecasted for the harvest in 2016, i.e. 368 EUR per ton (see, again, Farming Online Ltd., 2016; ECB, 2016b), revenue losses are as high as 51.7 million EUR. Including increased production costs of as much as 27.9 million EUR, the entire economic damage in UK OSR production accumulates to 79.6 million EUR.

Summed up, the average economic loss which can be attributed to the ban on neonicotinoids in the two marketing years and for these three EU member states accumulates to 324.8 million EUR. This is the result of an aggregated drop in market revenue of about 200.0 million EUR and a total increase in production costs of approximately 124.8 million EUR. These results are visualized in figure 2.5.

Figure 2.5: Economic impacts of the ban on neonicotinoids – oilseed rape – aggregated for Germany, France and the United Kingdom – on average for marketing years 2014/15 and 2015/16 (Kim et al., 2016)



Source: Own calculations and figure based on Kim et al. (2016).

Market Probe (2015a; b)

Market Probe (2015a; b; c; d; e; f) has written six studies which constitute three investigations with two so-called waves each. These studies aim at better understanding the impacts of banning neonicotinoids in winter OSR production in three EU member states. One of these countries is Germany. The results for Germany (and the other two countries, namely Hungary and the United Kingdom; see below) provided by Market Probe (2015a; b) are very detailed as they focus not only on yields and some management efforts but also on very specific insects and corresponding damages, etc.; and they are based on 110 standardised interviews of which 100 interviewees were farmers in Germany's main OSR production regions and ten German winter OSR experts. To assess the implications of the ban for the marketing year 2014/15, these interviewees were surveyed twice, first in autumn 2014 (wave 1; Market Probe, 2015a) and second in autumn 2015 (wave 2; Market Probe, 2015b).

After finishing the first wave, Market Probe (2015a) concluded that approximately 62 percent of the German winter OSR area cultivated in autumn 2014 were affected by CSFB; 39 percent were additionally affected by the cabbage root fly. IN autumn 2014, 72 percent of all farmers assessed that year's pest pressure being worse than prior to the ban. In spring 2015, still 68 percent of them came to the same conclusion. According to Market Probe (2015a), these pest infestations had implications on both the production costs and yield levels.

Production costs increased due to various management efforts trying to combat the negative consequences of banning neonicotinoids. Indeed, 82 percent of all farmers changed their previous winter OSR management. Apart from devoting more area to other crops than winter OSR (an issue that will be discussed below in more detail and taking into account a broader range of studies), the following aspects describe major impacts on management practices:

- 74 percent of all interviewed winter OSR farmers in Germany increased insecticide spray applications; on average 3.6 instead of 2.4 foliar insecticide applications per hectare and season were used. That means, after the ban 1.2 additional applications per hectare – often with pyrethroids – were needed.
- Twelve percent of all farmers also increased monitoring efforts and consequently labour input.
- Higher seed rates, changing seed timing and others were additional management options applied by German OSR producers.

According to Market Probe (2015b) and referring to the entire winter OSR acreage covered within the study, all this amounts to additional production costs of 24 EUR per hectare. For Germany, this would be equal to 30.9 million EUR using again production figures published in Coceral (2016). However, this seems to be a rather basic and rough (and also not very transparently described) economic assessment by Market Probe (2015b). In this regard two aspects need to be mentioned:

- According to ESA (2015, 2016) and supported by KTBL (2014), an additional application of insecticides (mostly pyrethroids) costs 25 EUR per hectare. Against this background, 1.2 additional applications alone equal 30 EUR per hectare. Given the German OSR acreage (Coceral, 2016), this translates to a country-specific production cost effect of 39.3 million EUR.

- In addition, ten percent of all farmers used higher seed rates. Using again the suggestions of Agra-Europe (2016b) to increase seed rates by ten percent if OSR area is under higher pest pressure and following KTBL (2014) for seed costs, an additional 1.2 million EUR need to be added to farmers' production costs.

It becomes obvious: At least 40.5 million EUR and not only 30.9 million EUR extra production costs should be considered if data provided by Market Probe (2015a; b) were meaningfully taken into account.

According to Market Probe (2015a; b) the revenue side has also been affected by the ban:

- During the first wave of the study only 14 percent of all German winter OSR farmers declared that their crop can be harvested without any damage.
- This "expectation" was reduced to ten percent when asking the farmers for a second time in autumn 2015 about their "experience" after the first harvest following the ban.

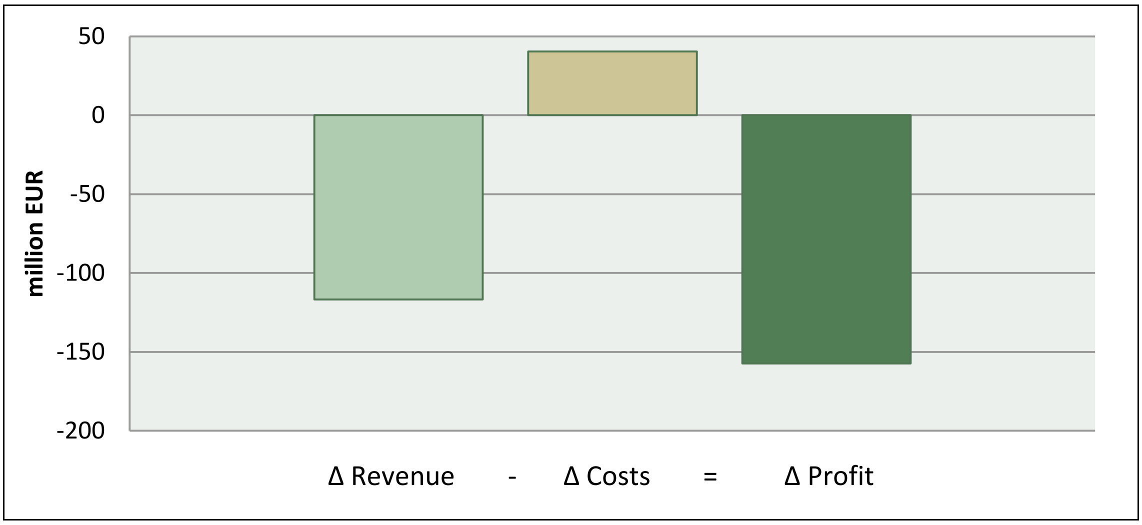
This means that about 90 percent of the entire winter OSR acreage was affected by some damage. According to Market Probe (2015b), 42 percent of this damage is directly linked to the ban of neonicotinoids and the resulting yield decrease is around 0.21 tons per hectare in the farms and regions covered by the study approach.

Taken this as a quasi-representative number, a yield loss of 5.4 percent referring to the German harvest in 2015 can be calculated. Based on Coceral (2016) again, this yield depression allocated to the ban on neonicotinoids accumulates to 287,000 tons which were not produced in 2015. Given a price paid around harvest of 355 EUR per ton (LEL, 2015), this translates to a revenue loss in German winter OSR production of approximately 101.9 million EUR.

Furthermore, a quality impact has to be added to that loss. According to Market Probe (2015b) data, 13 percent of the harvest in 2015 did not meet certain quality standards and 57 percent of this quantity can directly be linked to banning neonicotinoids. This means that 7.4 percent of the produced winter OSR harvest in Germany did not meet the quality standards as prior to the ban, mainly due to a lower oil content or smaller seeds. The average costs of losing quality have been valued at around 40 EUR per ton. Considering a harvest of altogether 5.023 million tons (Coceral, 2016), this reduced quality applies to 372,000 tons and is worth an additional 14.9 million EUR. Hence, the entire revenue loss in German winter OSR production for the marketing year 2014/15 caused by the ban should be around 116.8 million EUR.

These market revenue losses and the more than 40 million EUR of additional production costs accumulate to exactly 157.3 million EUR of overall economic losses in winter OSR production in Germany. These numbers are for marketing year 2014/15 and are a consequence of banning neonicotinoids. Figure 2.6 displays the results.

Figure 2.6: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Germany – marketing year 2014/15 (Market Probe, 2015a; b)



Source: Own calculations and figure based on Market Probe (2015a; b).

Market Probe (2015c; d)

An almost similar analysis of economic effects resulting from the ban on neonicotinoids can be drawn for Hungary using the arguments provided by Market Probe (2015c; d). Again the following analysis refers to winter OSR production in the marketing year 2014/15. It is based on interviews of more than100 farmers across Hungary and additionally ten country experts. Once more the available information allows for estimating the economic impacts in terms of production costs and revenue changes.

According to Market Probe (2015c; d) Hungarian winter OSR growers faced considerable flea beetle– in particular CSFB – attacks in autumn 2014: 51 percent of the entire winter OSR area were affected. Other insects such as the pollen beetle and turnip sawfly also contributed to this rather strong pest pressure. Hungarian farmers were able to mitigate this pressure by changing their management compared to the situation before banning neonicotinoids:

- 67 percent of all growers used additional insecticide spray applications in autumn 2014 and 44 percent again in spring 2015. Foliar spraying of insecticides increased from 3.2 to 3.8 applications on average. These are 0.6 additional treatments per hectare.
- Almost half of all Hungarian farmers additionally intensified monitoring and overall labour efforts.
- Four percent of all winter OSR farmers in the country had to replant part of the winter OSR acreage; however, a concrete percentage of re-drilling winter OSR could not be defined. Still, three percent of all farmers had to use higher seed rates.

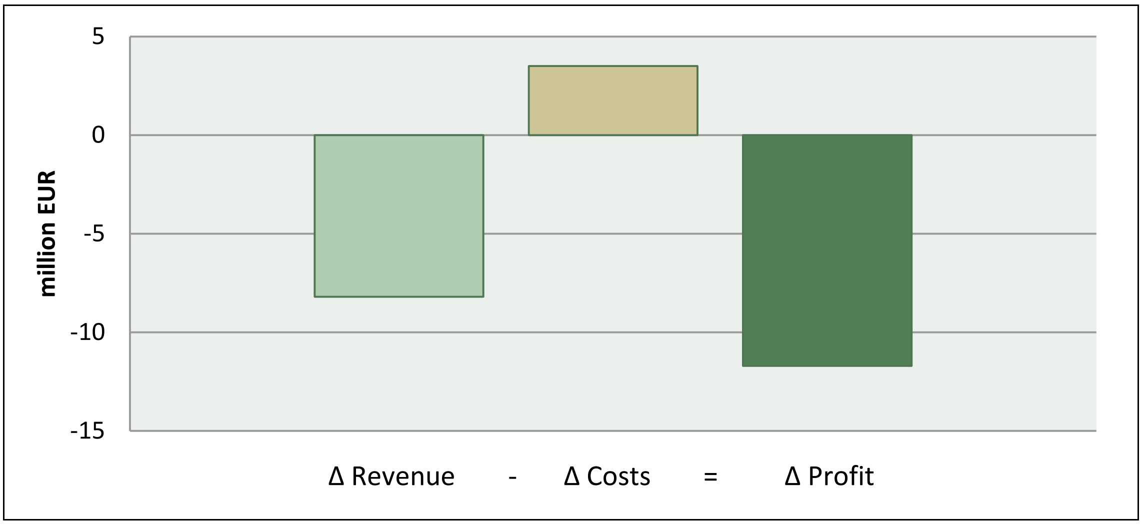
According to Market Probe (2015d), the overall production costs related to better controlling and the combating of insects in Hungarian winter OSR production rose by 17 EUR per hectare during the marketing year 2014/15. In opposite to Market Probe (2015a; b), we assess that this is a more realistic level of production cost increases since the major cost driver – 0.6 additional foliar applications multiplied by 25 EUR – accounts for 15 EUR per hectare. Applying the cost estimate of Market Probe (2015d) to the overall 207,000 hectares of OSR planted in Hungary during the marketing year 2014/15 (Coceral, 2016), it accumulates to an additional 3.5 million EUR.

In terms of yields, it is worth being noted that according to Market Probe (2015c; d) 70 percent of Hungarian winter OSR growers experienced at least some damage on their crops. This obviously caused an overall lower land productivity of 15 percent. 14 percent of this decrease was directly attributed to the ban on neonicotinoids. This implies a 2.1 percent drop of the Hungarian winter OSR harvest. Relating this to the overall yield of 517,000 tons in 2015 (see again Coceral, 2016), the loss equals 10,900 tons of winter OSR. Valued at a market price paid around harvest in 2015 of 385 EUR per ton (ZMP, 2016), this translates to a loss in production revenues of 4.2 million EUR.

As in the case of Germany, quality-related losses are documented as well. According to Market Probe (2015d), these are mainly caused by lower oil content and concern nine percent of the yield, i.e. more than 46,500 tons. On average, Market Probe (2015d) calculates that the associated damage is about 87 EUR per affected ton. Extrapolated to the country level, an additional revenue loss of more than 4.0 million EUR can thus be attributed to such quality damages that occur as a direct effect of banning neonicotinoids. Consequently, the entire revenue loss of the ban for the marketing year 2014/15 equals 8.2 million EUR in Hungary.

Hence, the overall economic loss in Hungarian winter OSR production, the sum of the above discussed market revenue losses and increased production costs, can be valued at 11.7 million EUR as figure 2.7 visualises.

Figure 2.7: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Hungary – marketing year 2014/15 (Market Probe, 2015c; d)



Source: Own calculations and figure based on Market Probe (2015c; d).

Market Probe (2015e; f)

We can also discuss for the UK what we analysed for Germany and Hungary. For the UK we use data and information gathered by Market Probe (2015e; f) for winter OSR cultivation and the marketing year 2014/15. As in the two other case studies, 100 farmers – mainly in England – and ten additional experts were asked to provide their comprehensive assessment on impacts of the ban on neonicotinoids. Again, we will distinguish in the following the obvious effects on production costs and farmers' revenues.

Our discussion of the results starts with the impacts on production costs in UK winter OSR cultivation. CSFB infestation is considered the most relevant problem after banning neonicotinoids. Market Probe (2015e; f) assesses that around 57 percent of the entire winter OSR area was affected during the marketing year 2014/15 and 73 percent of all farmers faced these difficulties. In addition, aphids (and other insects) affected approximately half of the winter OSR acreage in the UK. Consequently, 79 percent of all farmers adjusted their management to better cope with the associated pest impacts following the ban:

- More than two thirds of all winter OSR farmers increased insecticide spray applications. The average spraying intensity rose from 2.0 to 3.0 applications, i.e. one additional foliar application of mainly pyrethroids was used.
- Additional monitoring efforts were applied by 44 percent of all farmers. Other management options (e.g. re-drilling, higher seed rates, other drilling times, etc.) were used, too, but played a minor role.

According to Market Probe (2015f), these management adjustments led to an average increase of production costs of 8 GBP per hectare. This should again be considered a very basic and rough assessment since it costs at least 16.20 GBP per hectare (on average 5.20 GBP for the active ingredient itself and 11.00 GBP for spraying it) to apply the additional pyrethroid application in OSR (see again Redman, 2016). This alone equals 21.04 EUR per hectare and will be used by us as a more realistic estimate for additional costs in the UK context discussed within Market Probe (2015e; f). Based on this assumption and production figures from Coceral (2016), production costs increased by 13.7 million EUR in UK winter OSR production.

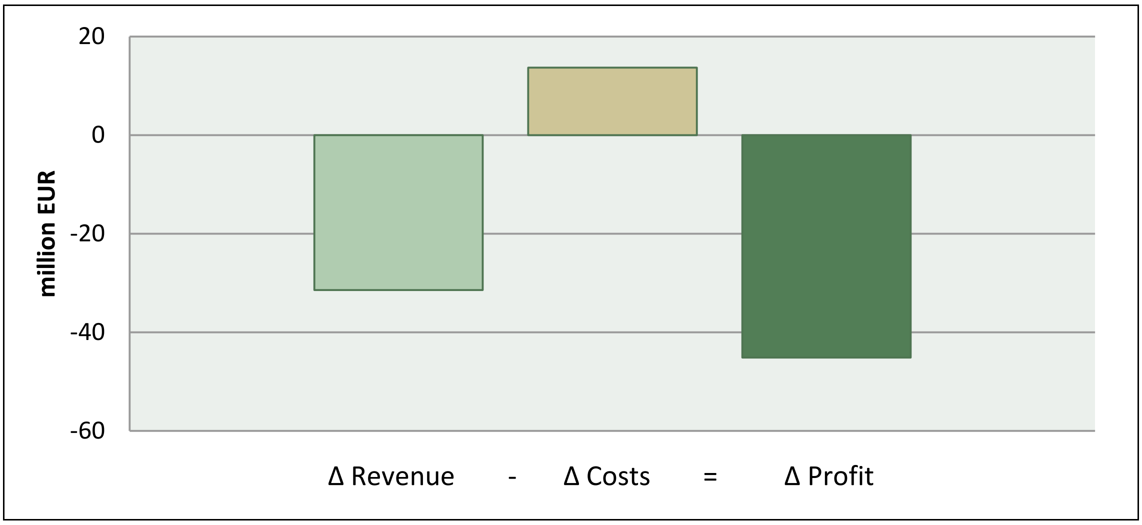
Looking at revenues, we are able to calculate the quality-related loss due to banning neonicotinoids from the data provided by Market Probe (2015e; f). Lower oil content and smaller seeds led to a decrease in quality affecting approximately 3.7 percent of the harvest. These cost a farmer 15 GBP (i.e. 19.48 EUR) per ton affected. Given a total harvest of 2.547 million tons in 2015 (Coceral, 2016), this translates to a revenue loss of more than 1.8 million EUR for the area under investigation.

However, it is more difficult to calculate the yield impact with the data provided by Market Probe (2015e; f) since yields went up in the UK compared to the marketing year before the ban, and a calculation of the most probably foregone yield increase (if neonicotinoids were allowed to more efficiently combat insects) is challenging. The particular topic will be discussed in greater detail within an excursus below.

Yet, we can calculate yield impacts for the UK using data of the country's Eastern region. There, a real yield depression of five percent was observed, and 63 percent of this decrease were attributed to banning neonicotinoids. Consequently, a ban-related yield depression of 3.2 percent will be assumed. Extrapolated to the UK harvest, a production loss of 81,500 tons occurs. Again, using an OSR price paid around harvest time in 2015 of 265 GBP (i.e. 363 EUR) per ton (AHDB, 2016c), a revenue loss of 29.6 million EUR can be calculated. Thus, revenue losses of 31.4 million EUR in total can be considered a direct effect of banning neonicotinoids in UK winter OSR production.

The calculated market revenue losses and additional production costs after the ban accumulate to an overall economic loss of approximately 45.1 million EUR depicted in figure 2.8.

Figure 2.8: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2014/15 (Market Probe, 2015e; f)



Source: Own calculations and figure based on Market Probe (2015e; f).

Meszka et al. (2016)

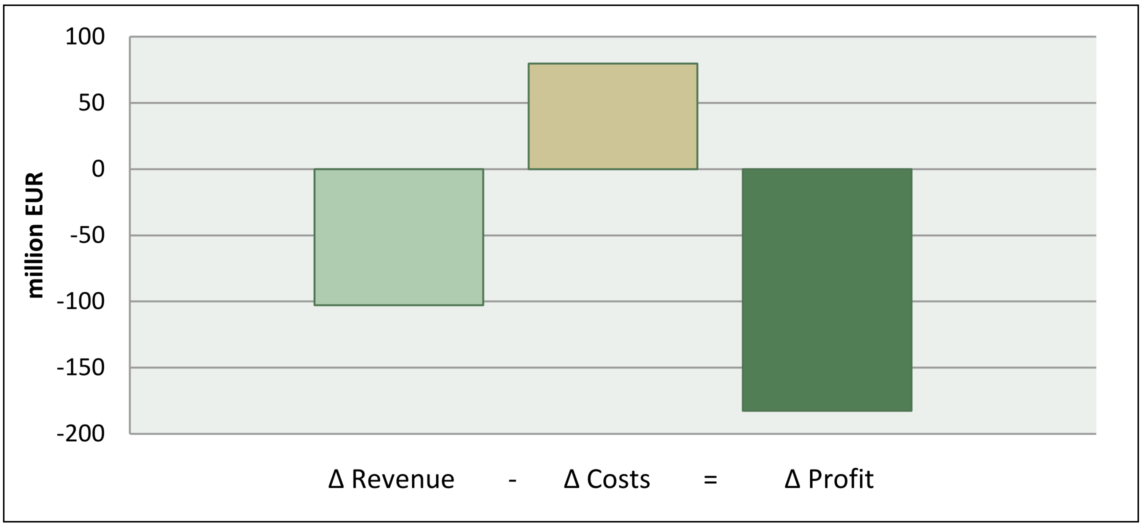
Effects of banning neonicotinoids in Polish OSR production are – among other impacts of a potential withdrawal of plant protection products – a focal point of the study conducted by Meszka et al. (2016). The authors based their analysis on surveys with scientists and practitioners using a standard but not well-described Delphi approach. While doing so, they solely looked at effects for the first year after the ban on neonicotinoids, i.e. the marketing year 2014/15.

First of all, the authors discussed the number of substitutive insecticide sprayings to combat pests after the ban. According to their non-transparent data background, additional 305,000 foliar insecticide treatments in OSR were given in Poland. This results overall into the use of additional 75 tons of insecticides and equals 0.33 additional applications per hectare cultivated with OSR in Poland. The authors did not further specify the substitutive active ingredients behind these applications. However, they explained that these applications alone were worth approximately 1.1 million EUR given a reasonable exchange rate of 4.2 PLN per EUR (ECB, 2016a). Apart from this, the authors furthermore assessed the overall increase of production costs as a consequence of banning neonicotinoids in Polish OSR production (again without any further explanation) to be around 79.8 million EUR. Given a harvest area in Poland of 930,000 hectares in 2015 (Coceral, 2016) this translates into about 85 EUR per hectare and is thus rather high compared to the other studies' results. However, assuming that most of the acreage has been under comparatively high pest pressure, such additional cost might be possible (see chapter 2.2).

In addition to that and despite the application of alternative insecticide options, the production loss of the harvest in 2015 due to the ban is judged by Meszka et al. (2016) to have accumulated to (at least) ten percent for Poland. Using a total harvest quantity of 2.669 million tons (Coceral, 2016) and a harvest price of around 385 EUR per ton (ZMP, 2016), this transforms to a production loss of 102.8 million EUR in Polish OSR production. Meszka et al. (2016) also note crop quality losses, but do not provide meaningful data to calculate the associated economic impact.

Based on Meszka et al. (2016), the estimated loss in revenues and additional production costs for Polish OSR production in the marketing year 2014/15 accumulate to at least 182.6 million EUR as visualised with figure 2.9.

Figure 2.9: Economic impacts of the ban on neonicotinoids – oilseed rape – Poland – marketing year 2014/15 (Meszka et al., 2016)



Source: Own calculations and figure based on Meszka et al. (2016).

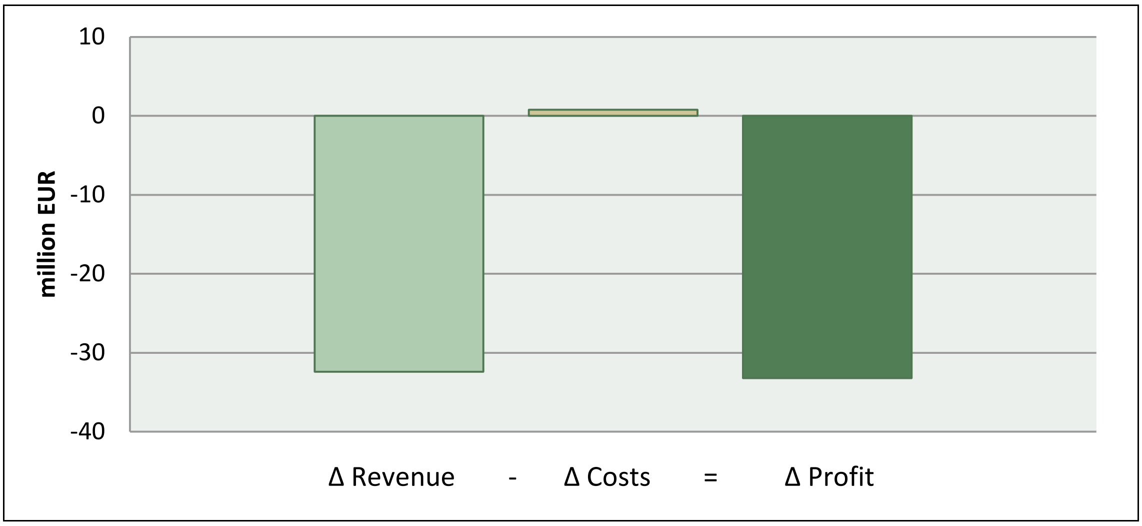
Nicholls (2016; 2015)

Nicholls (2016) provides an updated review on other previously conducted studies dealing with particular aspects of CSFB damage in UK winter OSR production (including the Alves et al. (2016) study already analysed above). The results – including those from Nicholls (2015) – have partly been gathered by using a standardised questionnaire and are very particular, i.e. specifically targeting issues like the incidence and severity of CSFB and associated damage on a county scale; nevertheless, the findings allow accentuate the discussion of other studies in an UK context for the marketing year 2014/15.

The Nicholls (2016; 2015) findings and own monetary calculations based on such finding can be summarised as follows: In the marketing year 2014/15 yields in UK OSR production decreased by 3.5 percent. Using Coceral (2016) data on OSR production in the EU and its member states this implies a physical loss of more than 89,000 tons of OSR in the UK. Valued again at an OSR price paid around harvest time in 2015 of 265 GBP (i.e. 363 EUR) per ton (AHDB, 2016c), a revenue loss of approximately 32.4 million EUR should be envisaged. In addition, 9,000 hectares of OSR had to be re-drilled in the UK. Since this costs approximately 86.40 EUR per hectare (see Redman, 2016; Scott and Bilsborrow, 2015), another 0.8 million EUR need to be added.

Other consequences of banning neonicotinoids in UK OSR production cannot be drawn using data and information provided by this study. Hence, total economic losses covered by Nicholls (2016; 2015) – only taking into account CSFB damages and re-drilling costs – accumulate to 33.2 million EUR as figure 2.10 visualises.

Figure 2.10: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2014/15 (Nicholls, 2016; 2015)



Source: Own calculations and figure based on Nicholls (2016; 2015).

Scott and Bilsborrow (2015)

The authors have measured the effect of banning neonicotinoids by comparing winter OSR production and management efforts in England for the harvest in the marketing year 2014/2015. Findings are based on a representative survey conducted in 205 so-called Farm Business Survey farms growing winter OSR. While asking farmers, the authors concentrated on the impacts of controlling CSFB only. Respective limitations have to be kept in mind in the following.

From the data provided by Scott and Bilsborrow (2015), it can be concluded that for entire England in 2015 an equivalent of 6,600 hectares drilled with winter OSR were completely lost due to heavy CSFB occurrence. This corresponds to a real production loss of at least 1.1 percent of the harvest. However, this percentage should be considered the minimum of real production losses because two other production losses were only observed by Scott and Bilsborrow (2015) but unfortunately not measured within the study. These are losses due to a re-drilling of winter OSR on additional 9,200 hectares and those caused by higher numbers of larvae in plants. Such larval infestation leads to growth depression as well as increased susceptibility to diseases at later stages of the vegetation period. Given the fact that in total 2.363 million tons of winter OSR were harvested in England in 2015 (DEFRA, 2015c) and that winter OSR prices at harvest in 2015 were around 363 EUR per ton (see again AHDB, 2016c), the total loss of winter OSR (at least 1.1 percent) which would have been producible without a ban on neonicotinoids accumulates to a revenue loss of 9.5 million EUR if only the total damage attributable to CSFB covered by Scott and Bilsborrow (2015) is taken into account.

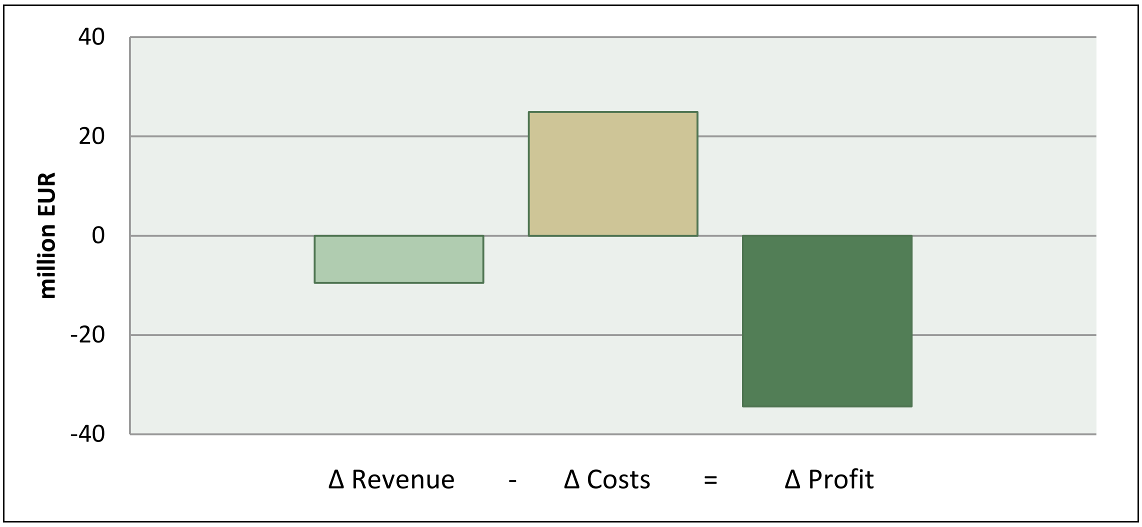
Scott and Bilsborrow (2015) also looked at effects of the ban on neonicotinoids with respect to production costs:

- Pyrethroids were mainly used to combat damages of CSFB. Altogether, 1.145 million additional applications were counted; these are 1.9 additional foliar sprays per hectare cultivated with OSR in England. According to the authors the costs per application were equal to around 13.33 EUR. Consequently, the additional costs of applying insecticides against CSFB accumulate to 15.3 million EUR. However, as discussed above an additional pyrethroid application realistically costs 21.04 EUR (see again Redman, 2016). This leads to additional production costs of 24.1 million EUR.
- Furthermore, re-drilling 9,200 hectares with winter OSR was necessary and cost according to Scott and Bilsborrow (2015) almost one million EUR. More accurately, 0.8 million EUR can be calculated, using again Redman (2016) data and a proper exchange rate.

Hence, total additional production costs of mitigating CSFB damage in winter OSR production for England and the harvest in 2015 can be judged to be as high as 24.9 million EUR.

Thus, the total economic effect in winter OSR production calculable from the study conducted by Scott and Bilsborrow (2015) is around 34.4 million EUR; its composition is visualised in figure 2.11.

Figure 2.11: Economic impacts of the ban on neonicotinoids – winter oilseed rape – England – marketing year 2014/15 (Scott and Bilsborrow, 2015)



Source: Own calculations and figure based on Scott and Bilsborrow (2015).

Vasilescu et al. (2015)

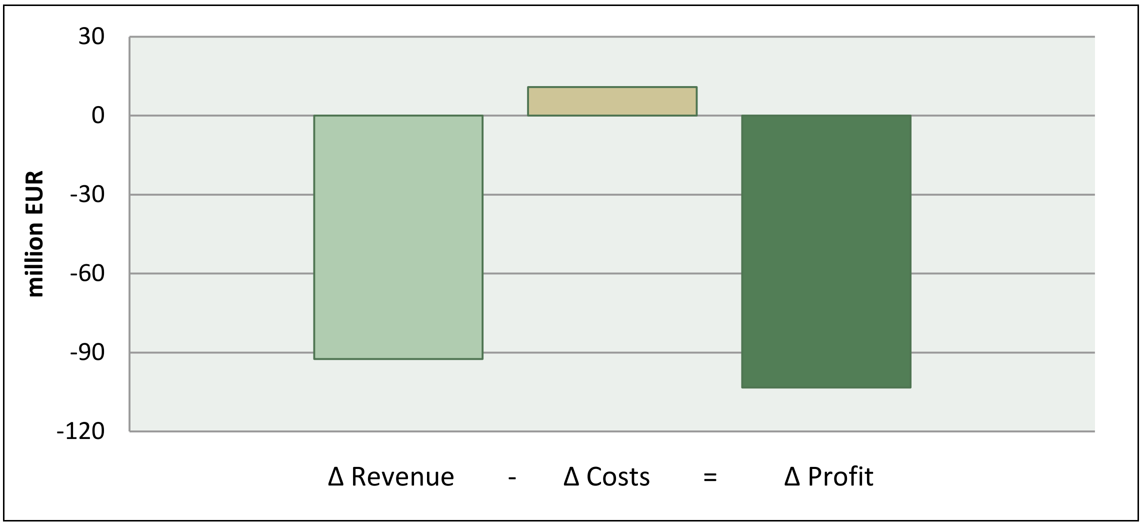
The authors conducted a not very transparently described expert-led probability analysis to estimate the total damages and potential losses due to flea beetle considering larval infestation levels in the autumn of 2014 on 400,000 hectares cultivated with winter OSR in Romania for the harvest in 2015. According to the authors, the insects were present in the entire winter OSR acreage. The attack level was considered as being weak on 25 percent of the covered area, it was assessed medium on another 25 percent of the acreage, and it was evaluated strong on the remaining winter OSR area under investigation.

Depending on the attack level, yield losses were assessed to be between ten and 30 percent. According to the authors and using best guesses of experts available at the time of publication (before the harvest in 2015), these losses were estimated to amount to 240,000 tons, i.e. 22 percent of the actual harvest in 2015 (see Coceral, 2016). Using an obviously forecasted market price of 346 EUR per ton of winter OSR at the time of conducting the study, Vasilescu et al. (2015) conclude a revenue loss of 83.0 million EUR. However, using again an average OSR price around harvest time for winter OSR of 385 EUR per ton (ZMP, 2016), the total revenue loss should be higher and at around 92.4 million EUR.

According to the authors, increased production costs occurred on top of that during the marketing year 2014/15. Approximately 100,000 hectares of winter OSR in Romania required an extra application of foliar treatment, and 200,000 hectares required on average 2.22 additional foliar treatments. This sums up to 544,000 additional foliar treatments and equals 1.35 additional applications per hectare finally harvested in 2015 if Coceral (2016) data (404,000 hectare) is used. The additional costs per foliar application were considered by the authors to be in a range of 20 EUR and more. Based on this, the additional costs were assessed by the authors to average 10.9 million EUR. This seems plausible since it accounts for 20.03 EUR per application what is in line with other specific cost levels (see e.g. Redman, 2016).

Figure 2.12 visualises the particular outcome for winter OSR in Romania and the marketing year 2014/15. Revenue losses and increased production costs accumulate to an overall economic loss of 103.3 million EUR.

Figure 2.12: Economic impacts of the ban on neonicotinoids – winter oilseed rape – Romania – marketing year 2014/15 (Vasilescu et al., 2015)



Source: Own calculations and figure based on Vasilescu et al. (2015).

White (2016)

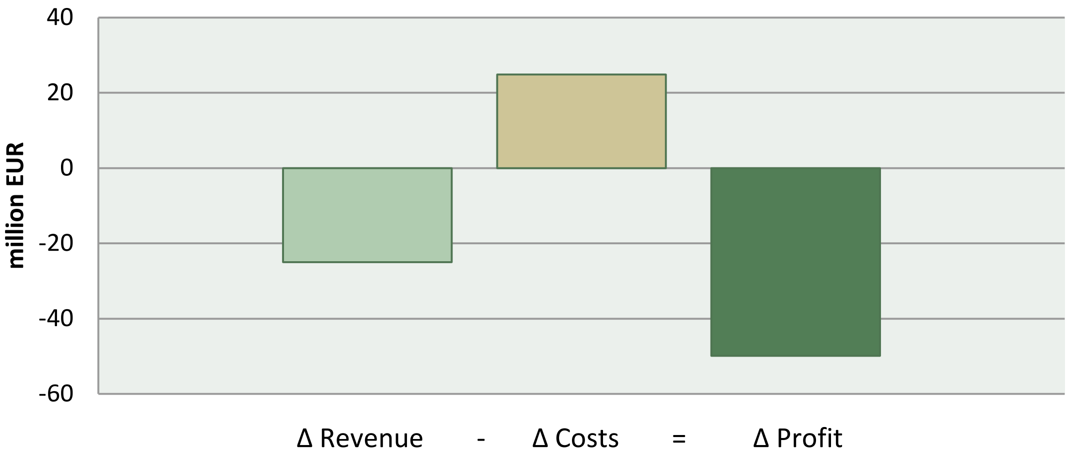
The author monitored CSFB larval populations in altogether six UK counties using an expert-based sampling approach. More particularly, local and regional agronomists were asked to provide information, and field visits were carried out to gather additional data. Based on this approach, White (2016) found a general trend for decreasing yields in winter OSR after the ban came into effect with increasing larval numbers, as alternative insecticide treatments only provided inadequate pest control.

No precise calculation of the corresponding yield impact was done by the author. However, White (2016) provided a forecast of the potential national drop in winter OSR production for 2015 of 2.7 percent, and this drop has mainly been attributed to CSFB. Given an UK harvest of 2.547 million tons in 2015 (Coceral, 2016), the loss equals 68,800 tons of winter OSR. Applying a price of 363 EUR per ton of winter OSR paid around harvest 2015 in the country (see again AHDB, 2016c), we calculate a loss in production revenues for UK OSR farmers of almost 25.0 million EUR.

Looking at production costs, an average of 2.7 additionally necessary pyrethroid applications per hectare under low and high pest risk was measured by White (2016). Since CSFB is estimated to have affected around 67 percent of the total winter OSR area in the UK, i.e. 437,500 at that time, the total number of additional foliar application is close to 1.2 million or 1.81 per hectare if the entire winter OSR acreage is taken as a reference value. Using again the above mentioned cost estimates for foliar applications (21.04 EUR per application per hectare), total additional costs for foliar insecticide applications to minimise the negative effects of the ban on neonicotinoids with respect to CSFB can be valued at around 24.9 million EUR.

Thus, we assess the accumulated economic loss of banning neonicotinoids in UK winter OSR production in the particular marketing year at around 49.9 million EUR what is also shown with figure 2.13.

Figure 2.13: Economic impacts of the ban on neonicotinoids – winter oilseed rape – United Kingdom – marketing year 2014/15 (White, 2016)



Source: Own calculations and figure based on White (2016).

2.2 Summarising and stress-testing identified scientific findings

The findings of the 13 (clusters of) academic papers and scientific studies presented above are summarised in figure 2.14. It displays once again the yield impact that can be associated with a regional study and one hectare cropped with OSR as well as the number and average costs of additional pyrethroid applications per hectare. It furthermore includes the subsequently calculated changes in market revenue, production costs and total economic performance in OSR production of the entire region under investigation. The monetary indicators are depicted in million EUR and refer to the specific region under consideration.

On the one hand, the picture that can be drawn from this meta-analysis is divers, i.e. very region-specific:

- The measurable negative yield impacts differ between less than one and more than 20 percent.
- The number of additional insecticide foliar applications vary as well: It is within the range of 0.2 and 2.7 per hectare.
- Also the studies' coverage of regional yields, specific insect damages as well as production cost items is divers. Hence, market revenue impacts are greater than cost impacts in some case studies; in other case studies, production cost effects are larger than revenue effects.

Figure 2.14: Overview of main outcomes of the meta-analysis

Study	Region	Yield impact (percent)	Management impact		Change of market revenue (m EUR per region)	Change of production costs (m EUR per region)	Total economic impact (m EUR per region)
			Additional foliar applications (#/ha)	Costs per application (EUR/ha)			
Alves et al. (2016)	UK	–1.0	2.00	21.04	–8.1	24.9	–33.0
ESA (2015)	EU	–5.1 *–3.4*)*	0.75	25.00	–424.0 *–284.5*)*	123.5	–547.5 *–408.0*)*
ESA (2016)	EU	–3.1 *–2.1*)*	0.50	25.00	–250.3 *–171.1*)*	80.8	–331.4 *–251.9*)*
Hughes et al. (2016)	SC	–0.5	0.23	21.04	– 0.265	0.204	–0.469
Kim et al. (2016)	FR DE UK	–5.0 –5.0 –9.0	n. a.	n. a.	–92.3 –56.0 –51.7	53.7 43.2 27.9	–146.0 –99.2 –79.6
Market Probe (2015a; b)	DE	–5.4	1.20	25.00	–116.8	40.5	–157.3
Market Probe (2015c; d)	HU	–2.1	0.60	25.00	–8.2	3.5	–11.7
Market Probe (2015e; f)	UK	–3.2	1.00	21.04	–31.4	13.7	–45.1
Meszka et al. (2016)	PL	–10.0	0.33	n. a.	–102.8	79.8	–182.6
Nicholls (2016; 2015)	UK	–3.5	n. a.	n. a.	– 32.4	0.8	–33.2
Scott and Bilsborrow (2015)	EN	–1.1	1.90	21.04	– 9.5	24.9	–34.4
Vasilescu et al. (2015)	RO	–22.0	1.35	20.03	–92.4	10.9	–103.3
White (2016)	UK	–2.7	1.81	21.04	–25.0	24.9	–49.9

Source: Own compilation based on the cited studies;
*) Figures in *Italic* refer to own calculations of economic impacts provided while discussing the ESA data and estimations.

On the other hand, the overall findings of the meta-analysis are very straightforward and can be generalised as follows:

- In every study, the market revenue is negatively affected by the ban on neonicotinoids because yields decreased in general and the quality of primary production partially suffered.
- According to all studies, costs of producing OSR have increased after banning neonicotinoids. This is mainly attributed to the costs of substitutive foliar applications but also to a partial re-drilling of crops and other management efforts such as additional monitoring.

- Consequently, a remarkable economic loss in all covered regions can be associated with the suspension of the active ingredients under consideration: Profits went down considerably.

This leads us to the following major conclusion: The economic performance of OSR producers in the EU suffers from the ban on neonicotinoids. This is regardless of the region where the overall economic development was observed and the methodology of how the impact was assessed and measured in the various individual studies.

Although this main outcome is rather clear, it shall be stress-tested in the following by adding substantial expert knowledge, further academic insights and some statistical findings. Therefore, a thorough additional literature analysis has been conducted beside the more specific meta-analysis. Furthermore, various experts have been identified and asked for proper feedback and some new impulses. The list of experts directly contacted and consulted includes (in alphabetic order):

- J. Arnold (Area Manager at United Oil Seed, United Kingdom),
- H. Doonan (Head of Crop Protection and Agronomy Sector at Agricultural Industries Confederation Ltd., United Kingdom),
- H. Eggeling (Researcher at Steward Redqueen, The Netherlands),
- L. M. Field (Head of Department Biological Chemistry & Crop Protection at Rothamsted Research, United Kingdom),
- G. Gagen (Chief Arable Adviser at National Farmers Union, United Kingdom),
- T. Heathcoste (Partner at Fisher German, United Kingdom),
- U. Heimbach (Researcher at Julius-Kühn-Institute, Germany),
- B. Johnsson (Researcher at the Swedish Board of Agriculture, Sweden),
- C. Nicholls (Crop Protection Scientist at AHDB, United Kingdom); together with S. Bolton (Head of Knowledge Exchange at AHDB, United Kingdom) and J. Knight (Head of Crop Health and Protection at AHDB, United Kingdom),
- P. Stephenson (Chairman at Association of Independent Crop Consultants, United Kingdom).

Based on this additional literature analysis and extensive expert involvement, the following conclusions can be drawn. We grouped these in three clusters dealing with changes related to a situation without the ban on neonicotinoids and (1) the harvestable crop, (2) management processes of producing OSR and (3) monetary implications. Note: If one of the following arguments refers to one of the experts listed above rather than a publication, the initials are added in bold italic letters (i.e. ***JA*** for J. Arnold, ***HD*** for H. Doonan, etc.):

1. OSR crops have been damaged in terms of quantity and quality.

   It has long been known that seed treatment with neonicotinoids (compared to other insecticides) increases yields in winter OSR (see e.g. Kazda et al., 2005). Against this background, the negative yield impacts identified here as well could have been expected (see Pilgermann, 2013). Many other observations beyond what is published in the studies discussed above prove that the ban has caused yield depressions. Among these are the following:

   - ***CN*** reports that AHDB research estimated crop losses in the UK have been in the range of one to five percent. She also states that as a consequence some yield impacts might have been underestimated, because these crop losses are not reflected in the official yield data and it is not known how e.g. re-drilled OSR has developed.
   - ***HD*** estimates the crop loss associated with the ban around 3.0 percent in an UK context. So does Case (2015).
   - Copa-Cogeca (2015) stated one year ago that banning neonicotinoids should be made responsible for a drop in EU OSR production of not less than 3.5 percent in 2015 with a further decrease to be expected in 2016 (Copa-Cogeca, 2016). These findings have most recently been supported by a study conducted by Wynn and Alves (2016) on behalf of Copa-Cogeca.
   - Even under ideal growing conditions, the yield loss is seen in a range of two percent (see BCPC, 2016).
   - A considerable drop in OSR yield following the ban on neonicotinoids is also observed by ***TH*** and ***BJ***.
   - Yield losses being as large as 9.7 percent are named by Mitchell (2015).
   - ***PS*** highlights that while in the UK an average production loss of five to nine percent should be envisaged some areas have been hit even more severely with a negative yield impact of ten to 15 percent and more.

It becomes obvious: The argument of Kleinschmit and Lilliston (2015), who see a lack of measurable yield benefits arising from the use of neonicotinoids, does not hold true, at least with respect to OSR production in the EU. Our finding is even confirmed by a strong criticizer of neonicotinoids: Goulson (2015) reports a loss of 3.5 percent in the UK and five percent in Sweden.

But not only the quantity of the harvest has suffered from the ban. The quality of the harvested seeds has been partially lower as well. This argument is not only supported by Pilgermann (2013), but also confirmed by several experts:

- ***TH*** argues that a drop in the crop performance (i.e. the quality) can be observed, e.g. the oil content of the harvested seeds dropped by two to three percent during the two last seasons.
- Considering no correlated evidence, an occasionally lower quality of harvested OSR crops is also observed by ***PS***.
- Likewise, ***JA*** forecasts a reduction not only of quantity but also of quality of harvested OSR due to the ban.

2. Managing OSR production in the EU has become more challenging.

If neonicotinoid seed treatment of OSR is not a feasible management option for combating insects, the foliar application of pyrethroids (and to a lower degree of other insecticides) is often chosen by farmers as the second best solution. This is highlighted by several authors and experts:

- Forecasts for a higher application rate of pyrethroids as a reaction to the ban on neonicotinoids can be found in e.g. Case (2015), Deutscher Bundestag (2015), Pilgermann (2013) as well as Wynn and Alves (2016).
- Common active ingredients in pyrethroid-based products used then are cypermethrin, deltamethrin, lambda-cyhalothrin, and pymetrozine (Case, 2015; Matyjaszcyk et al., 2015).
- More particularly, Pilgermann (2015) notes that the frequency of applying pyrethroids is a logical reaction of most farmers to the ban since no other feasible management measures do exist and thus those applications need to be increased.
- This argument is also supported by Matyjaszcyk et al. (2015) – from a Polish perspective – who found that foliar applications of mainly pyrethroids have doubled in OSR production post the ban.

- ***CN*** also reports that in an UK context pyrethroids were estimated to have been applied twice on average while many farmers anecdotally told that there had been many more sprayings going on.
- Likewise, ***TH*** estimates that most probably two additional applications (of mainly pyrethroids) have been conducted by farmers in the UK.
- In addition, ***HD*** points out that the use of other insecticides, mainly pyrethroids, increased in autumn 2014 and also in autumn 2015.
- Mitchell (2015) reveals that the number of applications with pyrethroids (and organophosphates) even triples without the option of applying neonicotinoid seed treatment.
- ***PS*** as well as ***LF*** suggest that following the removal of neonicotinoids from the spectrum of available insecticides 4 to 5 sprays instead of the one used prior to the ban have been applied.
- Under very specific circumstances even eight to nine applications have been done with still limited success on pest damage reduction according to some experts.
- In the view of ***GG*** supported by independent data (Scott and Bilsborrow, 2015), on average two and a half times as many applications of foliar insecticides compared to what normally (without the ban) would have been done.

Despite this variation in the number of additional applications it becomes apparent that the use of pyrethroids has been the main solution of farmers to pest management changes following the ban on neonicotinoids in EU OSR production. This solution helped to mitigate some of the insect-related problems. However, using pyrethroids also has some considerable disadvantages compared to neonicotinoids what has been highlighted by e.g. ***UH*** and ***HD*** and will be discussed below in more detail (see excursus at the end of sub-chapter 3.3).

Apart from increased field applications of other insecticides, various other management options have been applied to combat pest pressure in the absence of neonicotinoid seed treatment:

- ***HD*** points at improved seed bed preparation and an increase of the seeding rate to secure against potential crop losses.
- The use of additional seeds, drilling and re-planting efforts as well as the introduction of crop rotations without OSR have been observed by ***PS*** as important aspects in farmers' reaction strategies.

- In addition to that, ***HD*** agrees that most likely more working time (labor costs) has been devoted e.g. to monitor crops.
- Finally, ***CN*** points out that a good seed bed preparation is central, but also highlights earlier drilling dates for OSR (to enable the crop to better emerge before the pest may migrate) as a management strategy. However, she also points out that earlier drilling could potentially provide better conditions for CSFB to breed giving rise to larger numbers of larvae later in the season.

3. Production costs increased and market revenue was lost after the ban.

Each of the named management options adds costs to the production process. This has already become obvious from the meta-analysis above. Also in BCPC (2016) it is reported that production costs increased (in this case by approximately 62 GBP per hectare, i.e. more than 80 EUR), what was mainly attributed to additional foliar applications of insecticides.

The assumption that yield depression causes considerable revenue losses at market level is also supported by the following sources:

- Bohl (2015) argues that up to 150 EUR per hectare are lost in absence of neonicotinoid seed treatment in German OSR production.
- Sauermann (2015) estimates that such losses can be worth up to 370 EUR per hectare; Behn (2015) even observed losses of up to 400 EUR per hectare.
- Remarkable revenue and losses are also reported in BCPC (2016): These losses have been estimated as high as 300 GBP (almost 390 EUR) per hectare in the UK.

Therefore, it is not surprising that DEFRA (2013) forecasted substantial overall economic losses following the ban: An annualised loss of up to 116 million GBP in the UK covering not only OSR but also maize was expected in this study. Mitchell (2015) also reports tremendous total economic losses even though in a North American context. Finally, a considerable worsening of competitiveness in OSR production in the EU is not only predicted by ***HE*** but also by Pilgermann (2013) as well as Wynn and Alves (2016). In summary, our results fit these arguments.

3 Extrapolated economic and environmental effects of banning neonicotinoids to the European Union level

We will now use the major findings of our meta-analysis as well as the additional expert knowledge and scientific information gathered for an analysis of likely EU-wide economic and environmental effects following the restrictions applied to the use of neonicotinoids in OSR production. First, this analysis requires to determine the average impacts of banning neonicotinoids on the EU as a whole with respect to yields, additional foliar applications, etc. (sub-chapter 3.1). This allows us to calculate sound economic implications (sub-chapter 3.2) and based on these also some important environmental effects (sub-chapter 3.3) for the entire EU.

3.1 Determination of average yield changes and other impacts of banning neonicotinoids in the European Union

The economic performance of European OSR producers facing the ban on neonicotinoids is – first of all – based on three major drivers of change: (1) yield depressions, (2) quality losses with associated price differentials and (3) additional insecticide foliar applications. We determine an EU average of these economic triggers by using the findings of the studies which were included in meta-analysis and weighting these with the regional acreage (in case of (1) and (3)) or country-specific production (in case of (2)) of OSR. Such an algorithm leads to the following conclusions:

(1) The weighted average yield impact of banning neonicotinoid seed treatment in OSR production in the EU is –4.0 percent. This is much closer to the lower bound of the interval of individual yield impacts identified above which are in the range of –0.5 and –22.0 percent and almost perfectly fits with the conclusion by ESA (2016; 2015): These two analyses implied a yield impact of –5.1 percent for the marketing year 2014/15 (ESA, 2015) and –3.1 percent for the current marketing year (ESA, 2016), hence an average yield impact of –4.1 percent.

The herewith calculated yield depression of 4.0 percent is interestingly also as large as the yield decrease most recently analysed by Wynn and Alves (2016). On behalf of Copa-Cogeca the authors have looked at the impact of the neonicotinoid withdrawal on the EU OSR (and maize) sector and concluded that production losses (being the sum of early losses on area lost to the establishment of pests and of later (during season) reductions in yield) in seven major OSR production member states is four percent too.

(2) Quality impacts are subject of some but not all studies. Nevertheless, a sound estimation can be given by weighting the available data. On average, losses

in quality occur in 6.3 percent of the harvest and cost a price differential of 36.50 EUR per ton affected.

(3) The weighted average of additional insecticides (mainly pyrethroids) applications per hectare is 0.73. Again, this is much closer to the lower bound of the interval derived in our meta-analysis (being in the range of 0.23 to 2.70). Interestingly, it almost perfectly fits again with what has already been concluded by ESA (2015).

Other drivers occasionally mentioned in the one or other study cannot meaningfully be aggregated to an average EU level since the very limited information on such determinants found during our meta-analysis hinder a sound science-based discussion. First of all, it concerns additional production costs with respect to a re-drilling of fields affected by relevant (high) pest pressures as well as additional monitoring efforts undertaken by the concerned farmers. This limits the following calculations insofar as the resulting outcome should be considered a rather conservative assessment of the true costs of the ban on neonicotinoids, i.e. an analysis underestimating the negative economic impact. The issue will be highlighted within an excursus later again.

3.2 Analysis of economic impacts

The ban on neonicotinoids in EU OSR production has several economic implications: In the following it will be shown that the ban has shortened agricultural supply, has left European farmers with a considerable loss of market revenue and income and has created a loss in societal welfare which obviously is larger than assumed.

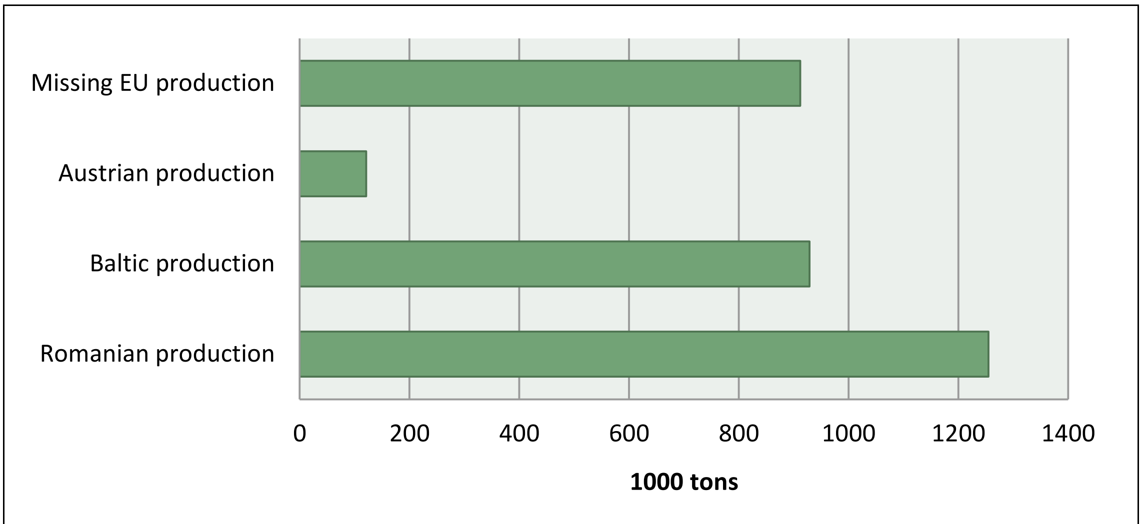
Banning neonicotinoids has shortened agricultural supply by almost 1 million tons of OSR

The analysis of the economic impacts is done for the average of the two marketing years following the ban. It starts with a calculation of the missing harvest volume. Coceral (2016) states that 21.738 million tons of OSR were harvested in 2015 and that 22.024 million tons are projected to be harvested in 2016. Having in mind the just defined EU-wide yield impact of –4.0 percent, these volume numbers can thus be considered the result of only 96.0 percent of the achievable yield.

Corrected for this underlying yield gap of 4.0 percent to the achievable yield (with neonicotinoid seed treatment), not only approximately 21.9 million tons but 22.8 million tons of OSR would have been produced in the EU without the ban. Speaking more precisely: 912,000 tons are missing. This particular result can be compared as follows – using again Coceral (2016) data for single EU member states and the two years post the ban – and is also visualised in figure 3.1:

- It is almost equivalent to eight times the Austrian OSR harvest;
- it is also almost equivalent to the entire OSR production in the three Baltic countries together or
- just slightly below what has been produced in Romania.

Figure 3.1: Missing annual production of oilseed rape in the European Union due to the ban on neonicotinoids: a cross-country comparison



Source: Own calculations and figure.

It might also be worth noting that compared to Germany and the UK, this OSR production loss accounts for almost 20 percent respectively almost 40 percent of the national crop harvest. The following comparison is very illustrative too: Assuming all these missing production volumes of OSR being loaded on trucks carrying 25 tons each, these trucks would cause a traffic congestion which totally blocks three lines of the highways connecting Brussels and Paris.

Excursus:
Distinguishing positive annual yield changes and negative yield impacts due to the ban on neonicotinoids in the UK

In opposite to the just mentioned EU-wide yield loss of four percent and on behalf of Greenpeace UK, Carter (2016) pointed out referring to DEFRA (2015b) *that yields of OSR in the UK increased by seven percent in 2015 compared to the harvest in 2014 and despite restrictions on treating the crop with neonicotinoids.*

At first glance, one might think that the ban has not negatively affected the yield. That would partially contradict the findings of our study. Indeed, according to DEFRA (2016) the oilseed rape yield in the UK has increased by 6.9 percent, from 3.6 tons per hectare in 2014 to 3.9 in 2015. Four questions need to be answered to better understand and interpret this multifactorial outcome.

1. *Did we see yield increases in all areas?*

   Where pest pressure was high in the UK, yield depressions instead of yield increases in OSR production were observed. This was for instance the case in Eastern regions of the country (see also White, 2015). Apart from that it shall be noted that in autumn 2014 approximately 5.0 percent of the original planted area was reported to have been lost to adult CSFB. However, only 1.5 percent of that area was reported to have been successfully replanted. This rest has never been harvested (nor included in the yield calculation).

2. *What factors contributed to overall yield improvements?*

   Since overall pest pressure was low, the level of crop damage due to CSFB in autumn 2014 was modest and not worse than in the years before (Wynn et al, 2014). However, the major positive yield impact most probably came from the weather conditions. Good establishment conditions in autumn of 2014 were attested by AHDB (2015), and according to data from Met Office (2015), the average sunshine levels in key growing months such as April and June were higher in 2015 than on average. This and also rather good precipitation conditions contributed to very favourable growing conditions in spring and early summer when seeds matured and must have had resulted in high yields.

3. *Did farmers respond to neonicotinoid seed treatment not being available?*

   It is important to note here that the area grown with OSR was lower in 2015 compared to 2014, and it continues to decrease in the UK. Farmers being entrepreneurs have re-allocated land to minimise the impact of banning neonicotinoids in such a way that areas potentially heavily affected by insects and therefore suffering from potential yield depressions more than other units of land went out of production first. Likewise, in the first year of the ban (with all its uncertainties) farmers mainly used – wherever possible – such pieces of land that were still available for cultivating OSR and that were characterised by a comparably low risk of being targeted by insects. Such management efforts have certainly had a positive yield impact if only the remaining OSR area is observed.

4. *Were there other changes to OSR cultivation?*

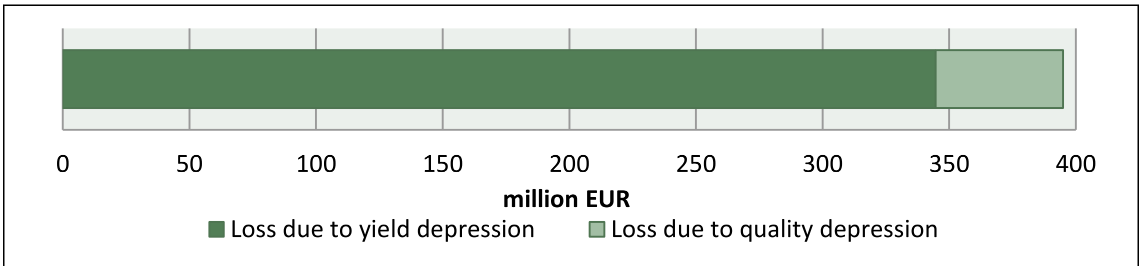
   The ratio of winter OSR vs. spring OSR shifted in favour of winter OSR between 2014 and 2015, i.e. the decrease of land devoted to OSR was much more accentuated for spring crops than for winter crops. Knowing that winter OSR is able to yield substantially more than spring OSR per hectare, a structural effect pushing average yields has additionally to be taken into consideration.

EU OSR farmers would have generated 400 million EUR more market revenue without the ban on neonicotinoids

Valuing the market revenue losses for the EU as a whole is challenging since no average EU reference price for the entire period is given and farmers supply OSR not only while harvesting but over a larger time horizon of several months. In the following, a price of 378 EUR per ton of OSR is used. The country-specific analyses above used prices ranging from 355 EUR to 385 EUR per ton. The "average" price used in this study has been generated by weighting weekly prices paid for exchanging OSR volumes at Matif in Paris with the volumes traded at Matif as given by ZMP (2016). This price has fluctuated between 345 EUR and 399 EUR per ton.

Consequently, the missing annual market revenue in the EU in OSR production following the ban on neonicotinoids should be considered to amount to 344.7 million EUR. Still this does not take into account price differences with respect to charges which had to be offered at the market level with lower qualities (mainly due to smaller seeds and less oil content). As mentioned above, this concerns 6.3 percent of the harvest and should be valued at a price loss of 36.50 EUR per affected ton compared to the respective market price. Subsequently, an additional market revenue loss of 50.3 million EUR has to be envisaged. Thus, total annual market revenue losses following the ban on neonicotinoids for the EU as a whole and OSR only are close to 400 million EUR as figure 3.2 depicts.

Figure 3.2: Market revenue losses for oilseed rape in the European Union due to the ban on neonicotinoids



Source: Own calculations and figure.

Referring to OSR production only an arable farmer in the EU has lost an annual income equivalent to more than one week of work

Concerning additional production costs after banning neonicotinoids, only the efforts with respect to extra foliar insecticide applications can be reasonably calculated for the EU as a whole (for explanation see above). On average, 0.73 additional applications per hectare cultivated with OSR in the EU were done. Using 25.00 EUR as an approximate value for the associated costs (covering the costs of the active ingredients as well as those for applying them) and referring to published data on the area cultivated with OSR (Coceral, 2016) – 6,451 million hectares in 2014/15 and 6,431 million hectares in 2015/16 – production costs increase at least by 117.5 million EUR annually.

Excursus:
Dealing with other changes in production costs: additional monitoring, more re-drilling and higher seed rates

It has been mentioned above that some studies also looked at costs associated with additional monitoring and/or a partial re-drilling of acreage. However, the available data to extrapolate these additional costs for the EU level is (very) limited. The same applies for the data to extract the additional production costs associated with banning neonicotinoid seed treatment (Nicholls, 2013).

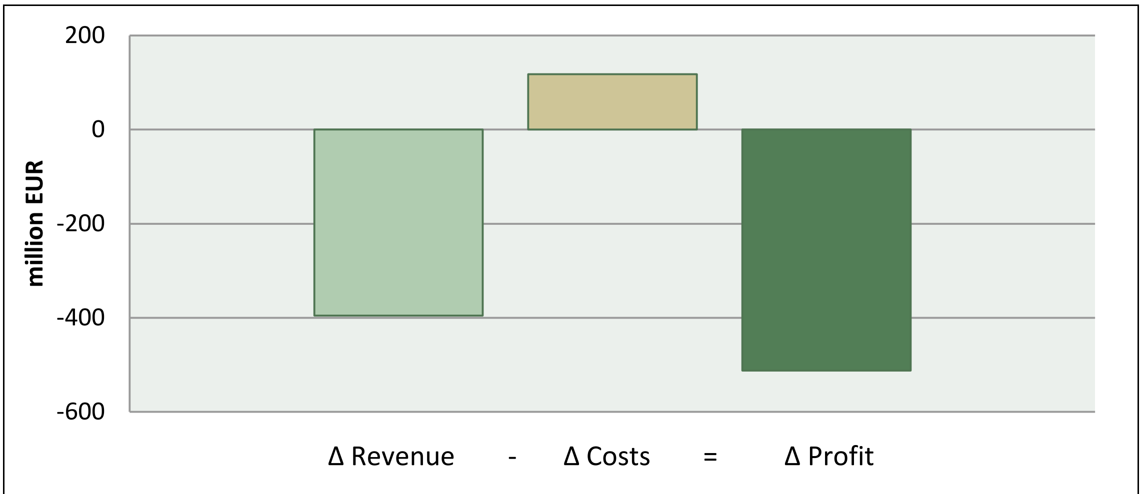
Still we can assume that those additional production costs are most likely well above the cost savings for not applying the neonicotinoid seed treatment:

- *Only one of the studies included in our meta-analysis offers a cost saving estimation of banning neonicotinoid seed treatment. According to Vasilescu et al. (2015), costs of three to four EUR per hectare are avoided in Romania. Using additional information provided by Nicholls (2013), neonicotinoid seed treatment with respect to OSR in the UK has cost between 4.78 and 6.45 GBP (6.21 and 8.38 EUR) per hectare depending on the seed that has been used and just referring to neonicotinoids and not to other active ingredients used in mixtures to treat seeds. Weighting these numbers equally leads to an average cost position of around 5.40 EUR per hectare.*
- *The additional monitoring efforts alone offset these cost savings of the ban. According to KTBL (2014), just one additional monitoring in OSR accounts for 2.37 EUR per hectare for diesel and machinery costs. The corresponding working time can be valued at not less than 3.00 EUR per hectare (see Noleppa and Lüttringhaus, 2016). These factors lead to costs of at least 5.37 EUR per hectare, a level that is supported by Mitchell (2015) and almost as large as the cost saving discussed above.*

It can be assumed that especially under heavy pest pressure risk, fields will be monitored much more frequently than only once per season by farmers to minimise insect risks following the ban (see also HGCA, 2014). In light of these considerations and adding to the argument the still not included re-drilling costs (being around 86.40 EUR per hectare, see Redman, 2016) and other costs associated with the ban such as applying higher seed rates to some percent of the entire winter OSR acreage, the overall increase of production costs mentioned above can fairly be accepted as the minimum level. The calculated economic impact is thus underestimating the real effect.

These additional production costs of at least 117.5 million EUR together with the losses in market revenue calculated above are equal to the total economic loss OSR farmers in the EU have experienced so far due to the ban on neonicotinoids. These aggregated economic losses on-farm and per annum accumulate to 512.5 million EUR as described in figure 3.3.

Figure 3.3: Economic impacts of the ban on neonicotinoids – oilseed rape – European Union – marketing years 2014/15 and 2015/16 (average)



Source: Own calculations and figure.

The economic loss displayed in figure 3.3. can be considered the EU-wide farm income gone. Therefore, the economic loss first of all hits the individual arable farmer in the EU. Assuming that at present approximately 1.1 million so-called annual working units (AWU) – a statistical measure to characterize a fully employed farmer or paid farm worker – are engaged in EU arable farming (see Noleppa, 2016), this total loss can be translated into an income loss of 466 EUR per AWU.

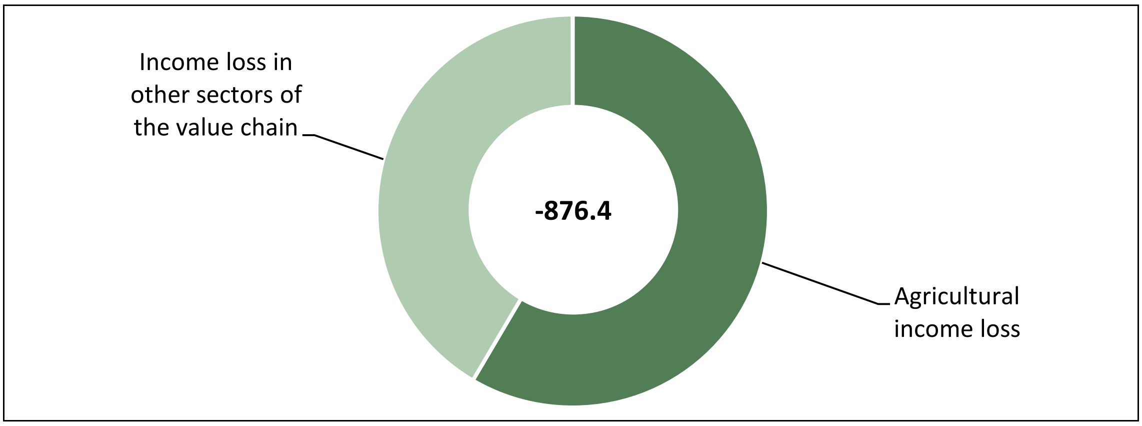
Latest data from EC (2016) suggest that specialised arable farmers in the EU have earned an income of 21,400 EUR per year or 412 EUR per week. In other words: Banning neonicotinoids – only in OSR production – has forced EU farmers to work one week and a day per year unpaid.

Referring to an average hectare, this loss is equal to 9.3 percent of the gross margin a farmer may receive (see, e.g. KTBL, 2014). Wynn and Alves (2016) have most recently concluded in a study conducted on behalf of Copa-Cogeca that gross margin loss in seven major OSR producing member states in the EU is around 182 million EUR. This is equivalent to a nine percent reduction in gross margins according to the authors. The particular result again can be considered a positive stress-testing of own research findings.

So far the EU society facing the ban in OSR production has lost more than 1.7 billion EUR

A multiplier analysis also allows to calculate the Gross Domestic Product (GDP) impact of banning neonicotinoids in OSR production. From a very comprehensive meta-analysis provided by Noleppa and Hahn (2013), it is known that 1.00 EUR of economic performance generated in the agricultural sector of the EU is able to generate an additional 0.71 EUR upstream and downstream the agricultural value chain. Consequently, the missing agricultural income (i.e. the foregone value added in the sector) of 512.5 million EUR implies an additional income gone in other sectors of the economy – because of less/fewer transport, crushing, processing, packaging, trading activities, etc. – worth approximately 363.9 million EUR. The total GDP impact, therefore, is equivalent to an annual loss of 876.4 million EUR. Figure 3.4 visualises this negative macroeconomic consequence of the ban which has accumulated over a time period of two marketing years to more than 1.75 billion EUR.

Figure 3.4: Annual gross domestic product impact of banning neonicotinoids in oilseed rape production in the European Union



Source: Own calculations and figure.

Excursus:
Considering other than direct OSR-related economic and agri-ecological impacts

The above analysis has focussed on direct economic impacts of banning neonicotinoids in OSR production of the EU, i.e. on yield and quality impacts as well as cost implications of the production process itself. However, another aspect has yet not been included in this examination due to data limitations: the implications of the management decision of farmers to stop OSR production (totally or partially) in reaction to the ban.

Indeed, a reduced crop area resulting from decisions not to grow OSR in a regional context is frequently reported for the EU (see e.g. Market Probe, 2015a; b; c; d; e; f as well as Wynn and Alves, 2016). According to Coceral (2015; 2016), almost 6.7 million hectares of OSR were still harvested in 2014, i.e. when cropping decisions were not affected by the ban. One year later, 6.4 million hectares were cultivated; and in 2016 only 6.3 million hectares of OSR were harvested. Within just two marketing years, the EU OSR area exactly went down by 252,000 hectares or approximately 4 percent. This development was particularly severe in the UK. Here, almost 13 percent of the area was lost according to Coceral (2015; 2016). Also Germany lost more than the average EU member state, i.e. 5 percent.

From information gathered within the studies conducted by Market Probe (2015a; b; c; d; e; f), we know that:

- *21 percent of farmers in Germany decided to grow less winter OSR, but more wheat, maize, barley and other winter cereals as well as intermediaries instead;*
- *71 percent of farmers in Hungary reduced the winter OSR area by partly replacing it with cereals, maize, sunflower, soybeans, radish, peas, and beans; and*
- *up to 19 percent of farmers in the UK also opted for other crops on part of the area cultivated with winter OSR prior to the ban; cereals (barley, wheat, oat, maize) and pulses (beans, peas, linseed) have apparently been most often used for switching cultivation.*

The case of spring OSR is interesting as well. Although the crop is only cultivated on a very limited acreage in the EU, it has at least a certain importance for making cropping decisions in Scandinavian and Baltic countries. The very particularity here is twofold. This has been made clear by Johnsson (2015) and has furthermore been confirmed by ***BJ*** *when asking the expert:*

- *If the spring OSR crop is affected by an insect which could have been targeted with neonicotinoids but not (or only to a substantially lower degree)* *with pyrethroids, as a result not only a few percent of the yield are lost, but a rather high percentage or even the entire harvest. This is attributed to the time until harvest being rather short for compensating plant damages due to pests at early stages of plant development. In such a case, not only some but (almost) the entire market revenue is lost and production costs are more or less completely "sunk".*

- *Alternatively, a spring OSR farmer may cultivate beans or flax instead as other optional spring crops or even winter OSR. However, in such a case gross margins are much lower; and in the case of winter OSR again substantial yield losses are likely since the crop may only be used as "organic fertilizer" under normal (rather cold) winter weather conditions in Northern European regions.*

It is beyond the scope of this research paper to calculate the economic impact of such a complex change in land allocation. For such an undertaking at least the differences in gross margins would have to be calculated and appropriately balanced on a regional base. However, the mid-term economic impact on an individual farm is very likely a negative one. Otherwise, farmers – being entrepreneurs – would have done this switch in cultivating crops already before the ban came into effect.

Evaluating the changing cropping situation from an agri-ecological point of view, this partial replacement with other crops than OSR certainly had a negative impact on the diversity of crops on the field. Crop rotations certainly became more "narrow" due to limitations in opting for OSR, thus leaving less room for agricultural biodiversity.

Apart from that, a lot of missing pollen to feed additional bee populations should be considered another agri-ecological direct impact of switching from OSR to other (non-flowering) crops after the ban on neonicotinoids. In fact, most of the alternative crops grown are non-flowering crops offering no or less potential feed for nectar-dependent insects. This may allow us to particularly conclude that a balanced view on the various effects of avoiding the use of one technology while replacing it through another technology seems to add value to respective discussions and debates.

Comparison of findings of an ex-ante evaluation and this ex-post assessment

Figure 3.4 is the outcome of a straightforward and science-based ex-post assessment of the ban on neonicotinoids. Its results can be compared with an ex-ante evaluation of the ban which was conducted three years ago. Then Noleppa and Hahn (2013) concluded that such a ban would cause an EU-wide farm income loss of 415 million EUR when having alternative plant protection measures available to combat insects in OSR production. Yet, it obviously turns out that the ban has led to an OSR-specific sectoral income decrease of 513 million EUR, i.e. an additional 100 million EUR to what had been expected prior to the ban.

The expectations expressed by Noleppa and Hahn (2013) should from today's point of view indeed be considered rather low in terms of the negative economic impact of banning neonicotinoids in the EU for flowering crops such as OSR. This becomes even more apparent when adding the following arguments:

- Using the data provided by Market Probe (2015a; b; c; d; e; f) and subsequent own calculations, an economic loss of 210.1 million EUR can be attributed to OSR production in Germany, Hungary and the EU together. Noleppa and Hahn (2013) projected 137 million EUR.
- Referring to Kim et al. (2016), the accumulated economic loss in France, Germany and the UK is about 324.8 million EUR. Noleppa and Hahn (2013) argued that it should be around 238 million EUR.
- There are altogether five (clusters of) studies, namely Alves et al. (2015), Kim et al. (2016), Market Probe (2015e, f), Nicholls (2016, 2015) and White (2016), that assessed the impacts of the ban on neonicotinoids in the UK. However, these studies are often very narrow in terms of the pests covered, e.g. by looking at CSFB effects only. On average a negative impact of more than 48 million EUR is the consequence; Noleppa and Hahn (2013) forecasted 52 million EUR taking into consideration all pests that can be associated with the use of neonicotinoids.

Against this background it shall be noted that the assessment of Noleppa and Hahn (2013) was criticized when published, among others, by Neumeister (2013) and BUND (2015):

- Neumeister (2013) – on behalf of Greenpeace –particularly stated that the applied scenarios were not realistic enough and the contribution of pest control was overrated.
- The BUND (2015), while acknowledging the scientific approach of Noleppa and Hahn (2013), also argued that the results of the study showed a tendency of overrating in favour of industry lobbyists.

Given the results of this ex-post assessment vs. the ex-ante assessment in Noleppa and Hahn (2013), the following can be concluded: Currently available analyses, studies and papers as well as plenty of expert knowledge do not support these criticisers. The opposite holds true. Thus, we conclude that the ban on neonicotinoids has caused massive economic disruptions which are much larger than predicted by Noleppa and Hahn (2013).

3.3 Analysis of environmental impacts

The calculation of EU-wide effects of banning neonicotinoids in OSR production has so far concentrated on an evaluation of the pure economic impacts. In addition, various environmental impacts, which are often neglected when solely concentrating on pollinator issues, are worth being considered. In the following a few selected topics shall be highlighted and accentuated with quantitative information where possible. It will become apparent that various environment-related societal benefits result from the application of neonicotinoid seed treatment.

Excursus:
Methodological considerations for analysing environmental impacts of modern, productivity-enhancing technologies applied in agriculture

This study does not only define economic indicators as target variables but also environmental indicators. Changes in global resource (land and water) use, GHG emissions and biodiversity have been selected as relevant environmental parameters. Below they are detected in a stepwise approach using indicator-driven satellite models and calculation tools. These models and tools as well as related reference data had formerly been explained in detail and are, thus, just briefly discussed in the following referring to sources of full explanation.

1. *Detecting changes in the use of global land resources*

   The basis for calculating effects of the ban on neonicotinoids for a variety of environmental indicators is an analysis of the potential range of natural or nature-like habitats to be converted into agricultural land in the absence of neonicotinoid seed treatment in the EU. This particular analysis is based on a self-developed and meanwhile twice peer-reviewed virtual agricultural land trade approach (see Kern et al., 2012; Lotze-Campen et al., 2015). The latest version of this concept also used as a reference system in other research studies (see e.g., Meier et al., 2014; UNEP, 2015) and the underlying data are extensively documented in Noleppa and Cartsburg (2015a; 2014) and do not need to be displayed here again.

   The concept allows to calculate how much land the EU uses outside its own territory for agricultural purposes and how much land this would equal in case of a change in domestic agricultural production and/or consumption in the EU. Such a change also occurs as a consequence of the ban on neonicotinoids and can be translated into international trade changes. While applying the concept (which is based on the assumption of constant trade preferences), regional differences in yields are already taken into account. That means, if one ton of OSR is (not) exported from the EU to other world regions less land is virtually (not) traded from here to *elsewhere than in the case of (not) importing a ton of canola, e.g., from countries with lower yields than in the EU into its member states.*

2. *Detecting changes in global GHG emissions*

   All other things being equal and given the fact that worldwide – except in the EU (see Searchinger et al., 2008) – more and more land is being used for agricultural purposes, the extra land the EU needs without neonicotinoid seed treatment would have to come from additional land use changes elsewhere, in particular from converting natural habitats into acreage. Natural habitats which are not used for farming, however, still serve as a carbon sink. They sequester carbon and do not release CO_2. Now knowing where and how much land to be converted, allows for calculating GHG effects. Regional yields and carbon release factors per converted hectare are used for calculating these effects and are obtained from FAO (2015) and Tyner et al. (2010). For more details on the entire calculation approach see Noleppa et al. (2013).

3. *Detecting global biodiversity losses*

   The conversion of natural habitats into agricultural land also leads to a loss of biodiversity (see e.g. Firbank et al., 2008; Hood, 2010; Tscharntke et al., 2012). Although measuring biodiversity and its changes is a challenging task (Croezen et al., 2011; Saling et al., 2014), a variety of methods have already been developed and a considerable number of biodiversity indicators has been published. All of them appear to have pros and cons and are still in their academic infancy while the scientific debate continues (Wright, 2011). Hence, a generally accepted science-based indicator of mapping biodiversity and the loss thereof is not in sight. Therefore, this study applies a pragmatic approach. Two rather dissimilar, but already frequently used indicators are applied to cope with the inherent uncertainty in measuring biodiversity:

   First, the Global Environment Facility Benefits Index of Biodiversity (GEF-BIO) is used (see e.g. UNEP, 2009; Wright, 2011). It is scientifically sound and reasonable and can be combined with the economic and spatial approaches used here. The GEF-BIO captures the status quo of biodiversity as well as its changes per country. Thus, it allows not only for a pure accounting of species but for mapping a regional distribution of species. The indicator is also consistent with the targets of the Convention on Biological Diversity (CBD) and widely used by research and international organisations (e.g. World Bank, 2013). The GEF-BIO originally developed by Dev Pandey et al. (2006) is more particularly a tested composite index of relative biodiversity. It is based on the species represented in a country, their threat status, and the diversity of habitats. Moreover, the index is *easy to handle. It is standardised on the interval {0; 100}: Brazil is defined as the country with maximum biodiversity. Its natural habitats are rated 100. On the other end of the scale is Nauru, a small island nation in the Pacific Ocean, where only a few sea birds and insects live while the flora is characterised by coconut palm trees. Other countries are rated between these extremes. Germany, France and the UK for instance are all rated well below 10 index points, i.e. have a biodiversity level that comparable with less than one tenth of species richness in Brazil.*

Second, the National Biodiversity Index (NBI) is applied. This index was developed by the CBD itself (CBD, 2001). It continues to be used in the Global Biodiversity Outlook Report (CBD, 2014). The NBI is based on estimates of a country's richness and endemism in four terrestrial vertebrate classes and vascular plants which have the same weight in the index. Multiplied with 100, original NBI values range from 100 (the maximum value is assigned to Indonesia) to 0 (the minimum value is allocated to Greenland). In this context Germany is marked with 37, France with 42 and the UK with 32 index points.

Deforestation and grassland conversion caused by productivity changes in EU agriculture due to banning neonicotinoids lead to changes in biodiversity. These changes can be analysed by multiplying the additional land use of the EU in other world regions with the GEF-BIO or NBI index value of that specific region (per hectare).

4. *Detecting changes in the use of global water resources*

Calculating impacts of the ban on neonicotinoids on agricultural water use requires to link production and associated trade change data (already used for detecting changes in the use of global land resources, see above) with information on regional water footprint data for EU and global agriculture. Such water footprint data is given by unit of production and reported in Mekonnen and Hoekstra (2011) for every crop, i.e. also for OSR, and each trading partner of the EU. Thus, the simple combination (multiplying) of changing regional trade (import vs. export) volumes with water footprint data – extensively described in Noleppa and Cartsburg (2015b) – leads to a statement on how much agricultural water is/will be used domestically and abroad in alternative scenarios (here: with or without the use of neonicotinoid seed treatment in the EU).

Continued use of neonicotinoids would have saved global land resources

The discussion starts with an assessment of the additional land requirements necessary to meet the global demand for OSR and products thereof in the absence of commodity volumes that could not be produced in the EU due to the ban. Assuming that this global demand holds constant – even though it is more likely to continue growing (Valin et al., 2014), especially with respect to oilseed demand pushed by increasingly requested protein meals and vegetable oils (HGCA, 2014) – the missing OSR volume in the EU following the ban on neonicotinoids needs to be produced somewhere else. Since global land productivity will not rise as a direct consequence of the ban, this production increase has to come from additional land resources. However, facing an already increasing pressure on scarce land resources this additional area does not "fall like manna from heaven". It mainly has to be borne by cultivating natural or nature-like land for agricultural purposes.

As the excursus above has described, we can calculate how many hectares of land are needed and where this land is located. The latest version of the respective concept and the underlying data are extensively documented in Noleppa and Cartsburg (2015a). Accordingly, it can be stated that the EU has used in addition to its own arable land roughly 17.6 million additional hectares outside its territory to satisfy domestic demand for all major arable crops before banning neonicotinoids. More than 2.6 million of these hectares refer to OSR respectively canola.

Banning neonicotinoids has increased this land import by 533,000 hectares, i.e. it has increased the EU's virtual import of OSR/canola land by more than 20 percent. Now, the 912,000 tons of OSR missing in the EU are produced on this land to compensate for the losses at world market level. Figure 3.5 reveals where this land outside the EU is located already taking into consideration that yields in the EU are (much) higher than in many other parts of the world.

Figure 3.5: Regional distribution of arable land additionally needed at global scale to compensate for oilseed rape production losses in the European Union after the ban on neonicotinoids (in 1,000 hectares)

North America	Asia	Sub-Sahara Africa	CIS
10.9	22.8	0.6	206.0
South America	**MENA region**	**Oceania**	**Rest of Europe**
7.0	22.4	232.3	31.1

Source: Own calculations and figure.

It turns out that the vast majority of these additional land resources (almost 440,000 hectares) is located in Oceania and the Commonwealth of Independent States (CIS). Indeed, both world regions – more particularly: Australia and the Ukraine – continue to be EU's major trading partners due to the particular requirement for non-genetically-modified products (AHDB, 2016b). A comparison shows:

- The area additionally needed in Oceania (mainly Australia) alone is as large as the entire territory of Luxembourg;
- and the entire global land resources needed to balance global OSR/canola production after banning neonicotinoids in the EU can be considered as large as the territory of Cyprus or ten times the area of Berlin.

Banning neonicotinoids has caused tremendous greenhouse gas (GHG) emissions

The arable land additionally needed at a global scale when banning neonicotinoids in the EU OSR production is not available per se. In a situation where estimates suggest the global acreage to be expanded by 45 million hectares per years during this decade (Laborde, 2011; Marelli et al., 2011), this land needs to be converted foremost from grassland or natural habitats.

All this now agriculturally used land has sequestered carbon both above and below ground before having been converted into farmland as a consequence of the EU ban on neonicotinoids. Consequently, a tremendous part of this carbon has been released into the atmosphere in the form of CO_2. The corresponding amount of GHG emitted outside the EU can be calculated by using the approach described in the excursus above. The results are shown in figure 3.6.

Figure 3.6: Additional regional CO_2 emissions due to the ban on neonicotinoids in oilseed rape production in the European Union (in million tons)

North America	Asia	Sub-Sahara Africa	CIS
1.636	6.752	0.112	34.817
South America	**MENA region**	**Oceania**	**Rest of Europe**
1.054	4.364	26.247	5.261

Source: Own calculations and figure.

If it had been possible to circumvent a ban on neonicotinoids in EU OSR production, an emission of more than 80.2 million tons of CO_2-equivalents would have been avoided. This is equal to what Austria currently emits per year (EEA, 2016).

However, the above calculated impact is a one-time-only effect and it is challenging putting these savings into perspective. Such non-recurring emissions are usually annualised by dividing total emissions by 20 (see e.g. Laborde, 2011). Consequently, the additional "annualised" emission of banning neonicotinoids in OSR production in the EU amount to approximately 4.0 million tons of CO_2 equivalents. This annualised level of GHG emissions can be compared again: It is as high as 150 percent of the direct annual CO_2 emissions caused by the entire German agricultural sector (UBA, 2016).

Beyond that, further annual GHG emissions occurring not outside but inside the EU need to be considered. It has been shown above that additional insecticide foliar applications are done in the absence of neonicotinoid seed treatment. However, unlike seed treatment these applications need additional agricultural machinery and diesel on-farm. The associated GHG emissions can be assessed as follows:

- According to Heimpel et al. (2013), spraying one hectare of oilseeds with insecticides causes 6.96 kg of CO_2 equivalents. This finding is supported by Kern et al. (2013): Accordingly, a total emission of 5.59 to 5.88 kg of CO_2 equivalents per hectare need to be taken into consideration for foliar application in OSR production.

- Using 6.0 kg of CO_2 equivalents as best approximation available allows to state that all the additional foliar applications of mainly pyrethroids have caused additional GHG emissions of more than 28 million kg of CO_2 equivalents in the EU.

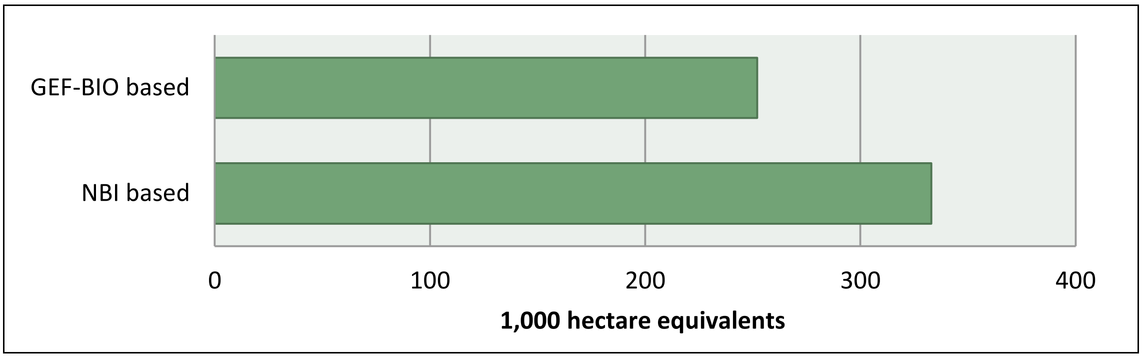
This means that less than 0.03 million tons of direct GHG emissions – occurring when applying foliar insecticides instead of treating seeds with neonicotinoids – need to be added to the annualised 4.0 million tons of indirect GHG emissions already related to global land use changes as describe above. Hence, the total amount of emissions due to the ban under consideration here does not change too much when EU emissions are added to the global GHG emissions occurring in parallel due to (indirect) land use changes.

Without the ban global biodiversity would have been preserved

The conversion of natural habitats into agricultural land caused by the ban on neonicotinoids also leads to a loss of biodiversity that can be calculated with the methodology outlined in the excursus above. Basically, the number of hectares displayed in figure 3.5 and additionally cultivated due to the ban need to be multiplied with the regional GEF-BIO and NBI values. This linear mathematical transformation leads to a hectare equivalent that symbolises a loss of biodiversity similar to when cutting rainforests and ploughing grasslands in Brazil (GEF-BIO) or doing the same with tropical rain forest or biomass-rich grassland in Indonesia (NBI).

Remembering that banning neonicotinoids in EU OSR production worldwide triggered a conversion of more than 500,000 hectares of grassland and natural habitats constituting eco-zones which are rather rich in species compared to more or less intensely used arable land in the EU (Croezen et al., 2014; von Zeijts et al., 2011), it is indeed worth highlighting the associated biodiversity loss. The results of the two separate analyses based on the GEF-BIO and the NBI are depicted in figure 3.7.

Figure 3.7: Globally lost biodiversity due to the ban on neonicotinoids in oilseed rape production of the European Union



Source: Own calculations and figure.

Based on the GEF-BIO, global biodiversity that is equivalent to a loss of more than 252,000 hectares of Brazilian natural or nature-like habitats has been lost due the ban on neonicotinoids in EU OSR production. Assuming a current cutting rate in the Brazilian Amazon Forest of 0.54 million hectares per year (OBT, 2013) implies that the investigated ban alone has caused a similar biodiversity loss as half a year of deforestation in the Amazon region at current pace. However, based on the NBI an even larger loss in global biodiversity is suggested. As a consequence of not applying neonicotinoid seed treatment in EU OSR production, global biodiversity has declined as much as it would have been by slashing and burning 333,000 hectares of Indonesian rainforest.

Banning neonicotinoids in the EU causes additional water use at a global scale

As in the case of GHG emissions, direct water use impacts can be distinguished from indirect water use effects. The direct impact relates to the water use of additional foliar applications on affected land in the EU while the indirect effect is linked to the obvious shift of production from the EU to other world regions after banning neonicotinoids.

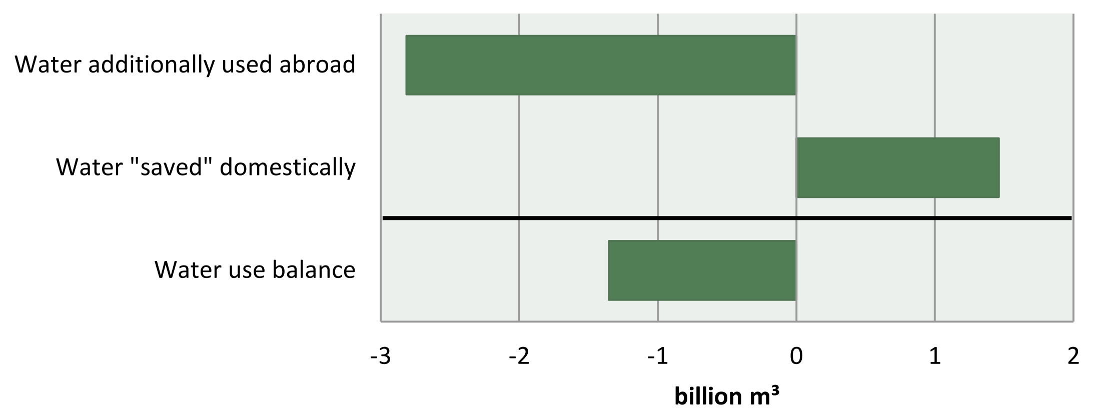
Calculating the direct water impact can be done by multiplying the number of additional foliar applications of insecticides (mainly pyrethroids) with a relevant factor, here the amount of water needed to spray one hectare of OSR in the EU. Using data from KTBL (2014), it can be argued that approximately 300 litres of water per hectare are used to spray the products as well as fill and clean the tank before respectively after the application process on the field. Using the information discussed above on additional foliar applications per hectare and the entire OSR acreage in the EU, a total of 1.411 billion litres or 1.411 million m^3 of water are needed annually to substitute neonicotinoid seed treatment with pyrethroids and/or other plant protection products. This is equivalent to the daily water use of almost ten million persons living in England or Hungary or the annual water use of a town in the EU with 25,000 to 30,000 inhabitants (see Biswas and Kirchherr, 2012).

On top of that, water use impacts of banning neonicotinoids with respect to regional trade and production shifts have to be added. It has been explained in the above excursus that calculating such impacts requires linking available data on the change in production (and trade) with information on regional water footprint data for EU and global agriculture. Two effects have to be separated:

- In the EU less OSR is produced after the ban, and this decreased production of biomass needed less agricultural (so-called blue and green) water which remained available for other purposes. Knowing that across the EU, the average water productivity in OSR production is around 0.62 kg OSR per m^3 of water (see Noleppa and Cartsburg, 2015b; Mekonnen and Hoekstra, 2011), 1.462 billion m^3 of water were “saved” this way for other purposes.
- In many other parts of the world, however, water productivity is not as high as here in the EU. On average it is approximately 0.47 kg OSR (or canola) per m^3 of water; and it is even lower in Australia and the Ukraine, our major trading partners (see again Noleppa and Cartsburg, 2015b; Mekonnen and Hoekstra, 2011). In these regions more water has to be used to cultivate a compensatory amount of OSR after banning the use of neonicotinoids in the EU. In total it amounts to 2.815 billion m^3.

This higher agricultural water use abroad outweighs the lower water use embedded in domestic OSR farming following the ban on neonicotinoids. On balance, 1.353 billion m^3 of water are additionally used at a global scale as figure 3.8 displays.

Figure 3.8: Balance of domestic and foreign water use changes due to the ban on neonicotinoids in oilseed rape production of the European Union



Source: Own calculations and figure.

Again, when applying substitutive plant protection measures the change in direct water use is marginal compared to the change in water use that can indirectly be linked to the ban on neonicotinoids because of shifting production. The following comparison makes effects of the ban on neonicotinoids more descriptive: The amount of totally needed additional agricultural water is as high as the water volume carried by the river Rhine into the North Sea near Rotterdam within almost one week.

Excursus:
Additional effects of pyrethroid application vs. neonicotinoid seed treatment

It has been highlighted above several times that foliar application of pyrethroids is the most appropriate means when it comes to substitute neonicotinoid seed treatment in OSR. Just to take another example: Also Heimbach (2015) – using the German example – confirms that such insecticide applications have tremendously increased as a reaction to the ban.

However, the use of pyrethroid can only be considered the second-best solution for farmers in combating crop damage from insects since applying such insecticides foliar instead of using seeds treated with neonicotinoids not only increases production expenses but also costs yield. The fact that yields in OSR production across the EU are often somewhat lower when pyrethroids are applied instead of neonicotinoid seed treatment has several reasons worth being highlighted.

Pyrethroids are used against numerous agricultural pests such as aphids and weevils, cockroaches and wasps, ants and spiders, fleas and ticks, but also human pests such as lice and mosquitos (Henault-Ethier, 2016). As such they have been proven to be a powerful tool in different contexts, but in comparison to neonicotinoids, they are indeed less specific; in particular pyrethroids do not effectively surrogate neonicotinoids when it comes to combating some target insects. This concerns first of all the cabbage root fly (Heimbach, 2015). Against this insect no insecticide alternative – apart from neonicotinoids – is available (Heimbach and Brandes, 2014).

Alongside with that, a much more important issue which OSR farmers are facing has to be raised: the challenge of resistances. While apparently no known resistance problem is existing with respect to neonicotinoids (Wynn and Alves, 2016), pyrethroid resistances are widespread. In Germany first resistance problems with respect to pyrethroids and CSFB, e.g., were observed in 2008 (Heimbach and Müller, 2013). In England such observations had even been made earlier. By now, this resistance is considered by many experts to be extremely worrying since in light of the ban on neonicotinoids pyrethroids are the only remaining recommended insecticide to control CSFB in many regions of the European Union (Zimmer et al., 2014). Even more challenging is that cross-resistance in at least 20 other pest insects, e.g. the pollen beetle, has additionally been observed (Rinkevich et al., 2013). In Germany, e.g., resistances against pyrethroids have been found in all parts of the country and apart from CSFB at least with to the following insects in OSR: rape winter stem weevil, green peach aphid, pollen beetle, and cabbage seedpod weevil (see also Brandes and Heimbach, 2016). Knock-down resistances aggravate the problem and may lead to a complete loss of efficacy of pyrethroids in the upcoming seasons (Heimbach, 2015).

It can indeed be argued that the emerging resistance problem concerning pyrethroids is directly linked to the ban of neonicotinoids. Several of the experts who gave feedback to our study results as well as various academic papers support this conclusion:

- ***LF** as well as **GG** note that resistance is becoming an ever growing problem for field management following the ban on neonicotinoids.*
- *Also Foster and Williamson (2015) state that growers who do not have access to neonicotinoid treated seed are likely to encounter increasing problems of controlling CSFB in areas where there is a high frequency of pyrethroid resistance as there aren't any viable spray alternatives.*
- *Additionally, **UH** confirms that the option to use neonicotinoids as a second mode of action has clearly led to a lower application of pyrethroids*

during the last years before the ban. Consequently, he and also Zimmer et al. (2014) argue that we have to expect a parallel increase of resistances due to the sudden increase of pyrethroid applications in reaction to the neonicotinoid withdrawal.

- *This statement is mainly based on the fact that after the ban most farmers have been confronted with certain pests (e.g. turnip-sawfly) which did not appear during the last 20 years of neonicotinoid applications. As a kind of "panic" reaction farmers conducted an over-use of mainly pyrethroids. However, every selection cycle leads to an even higher selection pressure for the insects. According to **UH** this can have an exponential effect for the spreading of resistances within the affected pest population.*

- *Additionally, Foster and Williamson (2016) have most recently confirm that post the ban a so far unknown metabolic-based resistance mechanism which confers strong pyrethroid resistance was detected in the UK. This is fully in line with the findings of Zimmer et al. (2014) who state that due to the lack of alternatives, the continuous and increasing use of pyrethroids creates a favourable environment for the emergence of already known as well as new insecticide resistances.*

- *Against this background, **UH** stresses to take into account that resistances are becoming more complex. To avoid a selection process concerning such second resistance mechanism, **UH** furthermore underlines that it is essential to keep the application of pyrethroids as low as possible and to include other integrated pest management options into the cultivation process. Otherwise, so **UH**, the spread of resistances due to the reduction of available modes of action should be considered a factor that can lead to much higher production costs for OSR in the future.*

- *More particularly, **UH** points out that in the past the application of neonicotinoids had contributed to a small pest population, thereby keeping the reproduction process rather low. Since this population-reducing effect of neonicotinoids does no longer apply, it might push an even faster increase of the population in a rather short period of time. This might result in even higher control needs or alternatively yield losses during the upcoming years.*

*In conclusion, **UH** and also **LF** stress the need for a broad resistance strategy based on several control options including various modes of action to avoid the spreading of resistances (see also Heimbach and Müller, 2013). The relevance of different modes of action as an important strategy to reduce the risk of resistance is also stressed with the EU Directive 2009/128/EC. Here it is stated that "... where the risk of resistance against a plant protection measure is* *known and where the level of harmful organisms requires repeated application of pesticides to the crops, available anti-resistance strategies should be applied to maintain the effectiveness of the products. This may include the use of multiple pesticides with different modes of action."*

It becomes apparent that a carefully balanced and complementary use of pyrethroids and neonicotinoids would help meeting the obvious and increasing challenge of resistances in OSR production in the EU (and most likely also beyond that).

Apart from these considerations mainly focusing on resistance-specific and economic impacts of banning neonicotinoids, additional environmental shortcomings related to the increased use of pyrethroids following the ban have to be named. One specific case is their effect on non-target insects. Although it is difficult to compare effects of different modes of action on different species, ***UH*** *additionally states that in the case of pyrethroids it is known that they have negative effects e.g. on the spider species abundance and richness on-field. However, spiders are important predators for many different insects. Consequently, their reduction or loss as a natural predator can in return have severe impacts on the pest population. For example, aphids can become an even bigger problem in the absence of spiders.*

Against this background, ***UH*** *also notes that the increased application of pyrethroids did also lead to an increase of the cabbage root fly population in some parts of Northern Germany – simply because it's important antagonists, namely carabids and staphylinids as well as spiders, had been reduced. It becomes clear that ecological trade-offs between the ban on neonicotinoids and the resulting use of second best modes of action have to be taken into closer consideration.*

4 Concluding remarks

In January 2013 the EC proposed to restrict the use of three neonicotinoids, namely clothianidin, imidacloprid and thiamethoxam, in the EU. Since 1 December 2013 farmers in the EU have been unable to buy or sow seeds that are treated with these active ingredients on crops that are known to be attractive to bees. When implementing the restrictions, the EC confirmed that within two years after imposing the ban on neonicotinoids it would initiate a review of new scientific and other relevant information on the risks posed to bees. Thus, the EFSA is currently reviewing the available material to formulate conclusions based on updated risk assessments.

A holistic risk and impact assessment of neonicotinoids should also evaluate the verifiable risks and costs which can be allocated to the agricultural sector facing the ban. This study has been conducted to provide that view. More particularly, our research has aimed at providing a condensed, science-driven and expert-triggered judgement on various economic and environmental effects of the ban on neonicotinoids in EU agriculture using the case study of OSR.

Altogether, 17 relevant scientific studies and academic papers dealing with mainly agronomic impacts of the ban on neonicotinoids in EU OSR production have been identified. They can be grouped into 13 clusters, and analysing them leads to the following ten conclusions, i.e. consequences of the ban on neonicotinoids:

1. A negative yield impact is measurable.

   All studies highlight that the ban on neonicotinoids has caused a yield decrease in OSR production of the EU and/or its member states. The measurable negative yield impacts differ between less than one and more than 20 percent depending on insect pressure and pest coverage of an individual study. On average, a yield depression of 4.0 percent for OSR production in the EU as a whole can be extrapolated from the studies.

2. The quality of the OSR harvest suffers as well.

   Quality impacts of the ban are also covered in some of the studies. Smaller seeds and a lower oil content are major quality changes. On average, these developments in quality occurred in 6.3 percent of the harvest volume and account for a price difference of 36.50 EUR per ton affected.

3. Lower yields and qualities minimise market revenues of OSR farmers.

   Without the ban on neonicotinoids, 912,000 tons of OSR would have been produced more annually in the EU. This loss in production is as large as the

OSR production volume in Romania and worth almost 350 million EUR. Quality depressions add an additional market revenue loss of more than 50 million EUR. Thus, total annual market revenue losses following the ban on neonicotinoids for the EU as a whole and OSR amount to around 400 million EUR.

4. Additional foliar application of insecticides, mainly pyrethroids, are used instead of neonicotinoid seed treatment.

   All the analysed studies confirm that in the absence of neonicotinoid seed treatment, insecticide foliar applications are used more often than before the restrictions came into effect. The application of pyrethroids appears to be the next best solution for combating insects. Additional sprays range from 0.2 to 2.7 applications per hectare depending again on insect pressure and pest coverage analysed by an individual study. The weighted average of additional insecticide (mainly pyrethroid) applications per hectare according to our extrapolation from the studies is 0.73 for OSR production in the entire EU.

5. The foliar application of insecticides considerably increases production costs.

   The additional application of pyrethroids and other insecticides has not only increased resistance problems but also OSR production costs for the EU as a whole by close to 120 million EUR annually.

   However, this should be considered a rather low estimate of the real production cost increase as a consequence of the ban on neonicotinoids since costs attributable to other necessary management efforts could not be included in the own EU-wide extrapolations. This refers, first of all, to costs of additional monitoring activities, more re-drilling and higher seed rates which by far outweigh comparably small cost savings that can be attributed to a non-treatment of seed with neonicotinoids post the ban.

6. Lower market revenues and increased production costs reduce the farm income as well as the sectoral and national income.

   These additional production costs together with the losses in market revenue are equal to the total economic loss OSR farmers in the EU have experienced. These economic losses on-farm and per annum can be aggregated; they accumulate to more than 510 million EUR and can be considered the sectoral income foregone in OSR producing member states of the EU as a consequence of the restrictions applied in OSR.

   Because of reduced transport, crushing, processing, packaging, trading activities, etc. along the value chain, additional income losses in other sectors of the economy can be related to the ban on neonicotinoids. These losses are worth approximately 360 million EUR. The total GDP impact, therefore, is equivalent to an annual loss of almost 880 million EUR. Over a time period of two marketing years since the ban came into effect. This amounts to a national income loss for the EU as a whole of more than 1.75 billion EUR.

7. The negative economic impact of banning neonicotinoids is worse than expected prior to the ban.

   Already before banning neonicotinoids in flowering crops, negative economic impacts had been suggested by scientific research. The results of this study show that the ban has caused massive economic disruptions, which are much larger than expected prior to the implementation of the ban.

   Moreover, it turns out that currently available analyses, studies and papers as well as plenty of expert knowledge do not support criticisers who had considered scientific ex-ante assessments of implications due to restrictions on the use of neonicotinoids as being not realistic enough, overrating the negative effects of pests and showing a tendency of arguing in favour of industry lobbyists.

8. The ban on neonicotinoids causes an additional use of already scarce global land resources.

   Banning neonicotinoids has increased global land conversion towards agricultural uses by 533,000 hectares since the 912,000 tons of OSR missing in the EU had to be produced somewhere else on this land to compensate for the losses at world market level. The vast majority of this land additionally needed is located in Oceania (mainly Australia) and the CIS (mainly the Ukraine) who are the EU's major trading partners with respect to OSR.

9. Since non-agricultural land sequesters carbon and is home of many species, banning neonicotinoids also causes GHG emissions and biodiversity losses.

   All this now agriculturally used land had sequestered carbon both above and below ground before it was converted into farmland as a consequence of the EU ban on neonicotinoids. Consequently, a tremendous part of this carbon has been released into the atmosphere in the form of CO_2. If it had been possible to circumvent such a ban in EU OSR production, an emission of more than 80 million tons of CO_2-equivalents would have been avoided. This is equal to what Austria currently emits per year.

   Converting more than 500,000 hectares of grassland and natural habitats constituting eco-zones rather rich in species compared to more or less intensely used arable land in the EU also requires to take a look at the associated biodiversity losses. Using two common but different scientific calculation approaches, it turns out that global biodiversity equivalent to a loss of species when converting more than 250,000 (330,000) hectares of Brazilian (Indonesian) natural or nature-like habitats, e.g. rain forests, has been lost due the ban on neonicotinoids in EU OSR production.

10. Banning neonicotinoids in the EU also causes additional water use at a global scale.

    Finally, it can be concluded that the ban on neonicotinoids on balance has caused an additional water use of more than 1.3 billion m^3 at a global scale. Less OSR has been produced in the EU after the ban, and this decreased production needs less agricultural water remaining available for other purposes. Almost 1.5 billion m^3 of water have been domestically "saved" this way.

    However, since water productivity in many other parts of the world is not as high as here in the EU, much more water has to be used in other regions to cultivate a compensatory amount of OSR after banning the use of neonicotinoids here. In total it amounts to more than 2.8 billion m^3. This higher agricultural water use abroad outweighs the lower water use embedded in domestic OSR farming post the ban.

Our findings are the result of conducting a comprehensive meta-analysis and applying scientific modelling and calculation approaches. Moreover, the results are supported by numerous distinguished experts. This broad-based consensus allows us to state that a policy-decision such as the ban on neonicotinoids has its economic and environmental impacts, and such impacts are repeatedly substantial and too often negative.

Indeed, it turns out that not applying a technology – such as neonicotinoid treatment in OSR production – may have some positive implications (on very specific environmental aspects) but definitely causes much more negative disturbances. These disturbances must be taken into account when making policy (and private) decisions. Pros and cons of applying or not applying a certain technology need to be assessed in a balanced and more holistic way than it is done today; and if such a comprehensive assessment results in societal (economic, environmental and also social) benefits of applying a technology outweighing the costs, then the technology shall of course be applied.

In the case of not banning neonicotinoids in OSR production of the EU such benefits to society are obvious: Market revenues would be higher, production costs would be lower, farmers' income and national economic performance would increase, less scarce natural resources such as land and water would be used thereby making it easier to meet our global challenges with respect to climate change and biodiversity developments. Losing neonicotinoid seed treatment as a management option thus means: These benefits are lost!

This loss can only partly be lowered, e.g. through the use of pyrethroid and other insecticides. However, in the long term, this move towards second-best solutions may create other challenges, such as a stronger resistance problem. It is therefore absolutely necessary to have a rather broad tool box available in terms of management options enabling farmers across the EU to combat not only insects being enemies of our arable crops but all pests in a (monetary and natural) resource-efficient manner. Neonicotinoid seed treatment is one of these tools, and it is a valuable instrument when looking at it from a wider societal perspective.

Apart from that, a very particular conclusion shall be drawn. Meanwhile, a lot of studies do exist assessing the economic impacts – and based on these effects also environmental and other implications – of banning neonicotinoids or more generally speaking of managing agriculture with or without modern technologies. In the case of analysing the ban on neonicotinoids all of these studies concluded among others that economic impacts are negative and severe although each study applied its own approach and consequently has got its own pros and cons. The vast methodological experience gained in assessing and evaluating may now be brought together by condensing it and – based on this condensation – by developing a sophisticated and standardised science-driven methodology on how to analyse the various benefits (and costs) of agricultural technologies. This would enable respective stakeholders to properly accentuate and also guide pending and certainly upcoming very complex decision-making processes as regards the use of agricultural technologies on a “stand-by” base.

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An ex-post assessment of economic and environmental costs

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