UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Master Degree Project in Economics

Farmers not Farming?

An empirical study of the elimination of the mandatory set-aside policy in the EU

Amanda Karlsson

2017-06-01

Supervisor: Jessica Coria
Graduate School

1 June, 2017

Abstract

This thesis evaluates European farmers which were subject to mandatory set-aside entitlements for many years. Mandatory set-aside of land, required farmers to leave arable land out of production to be eligible for subsidies. The policy effect of a reform in 2008, where the mandatory set-aside policy was abolished due to inefficiencies, is studied by applying a quasi-experimental method to estimate the casual relationship between mandatory set-aside abolishment and farm environmental performance. This evaluation is relevant as the mandatory set-aside was re-introduced in 2013 and this study contributes with insights into policy implications of mandatory set-aside, as it has never been evaluated before. The difference-in-difference results show signs of improved environmental performance of farmers due to the policy change, in opposite towards the hypothesis. Thus, it does not support the expectation that more land would be used for fertiliser and pesticide due to the mandatory set-aside elimination. The results can give an indication for not re-introduce mandatory set-aside policy in the EU.

2017-06-01

Amanda Karlsson

Supervisor: Jessica Coria

Keywords: Agriculture; Common Agricultural Policy; set-aside policy; the Health Check of the CAP, FADN data, difference-in-difference.

Acknowledgements

I am grateful for the support I have received during the work with the thesis. I would like to extend special thanks to my supervisor Jessica Coria for motivation, inspiration and involvement in the agricultural topic, and to Mónica M. Jaime for guidance, collaboration and interest shown in my progress. Additionally, I would like to thank Jorge Alexander Bonilla Londoño for organizing the data and involvement in the topic. I hope my thesis will be of value to all of you when you continue to develop this topic.

I would also like to give special thanks to Nicholas Saunders and Carl Nilsson, whose engaged involvement has been invaluable in absence of a co-author. Finally, thanks to my family and friends for the support throughout the process.

Amanda Karlsson, Mörrum June 2017

Table of Contents

Acronym list

AE – Agri-environmental
CAP – Common Agricultural Policy
DD – Difference-in-difference
EC – European Commission
EU – European Union
FADN – Farm Accountancy Data Network
GAEC – Good Agricultural and Environmental Condition
HCC- Health Check of the CAP
LFA – Less Favoured Areas
OLS – Ordinary Least Squares
RD – Rural Development
RDP – Rural Development Plan
SAPS - Single Area Payment Scheme
SFP – Single Farm Payment
UAA – Utilized Agricultural Area.

Useful Agricultural Glossary

Agri-environmental – voluntary agricultural land use policy, subsidies under pillar two.
Coupled subsidies – imply that amount of production determines the amount of received subsidies.
Decoupled subsidies- imply that number of hectares determine the amount of received subsidies.
Direct payments – income support under Pillar One, called single farm payments after 2003 reform.
Mandatory policy – farmer is obliged to fulfil some entitlement in order to receive a subsidy.
Modulation – Funding is transferred from Pillar One to Pillar Two.
Pillar One – Funding of direct payments.
Pillar Two – Funding of Rural Development Plans.
Set-aside - field margin, leave land out of production.
Single farm payment – decoupled direct payment under Pillar One, after 2003 reform.
Voluntary policy – Farmer decide themselves to adapt measures to receive a subsidy.

1. Introduction

Several recent reforms of the Common Agriculture Policy (CAP) have increasingly integrated environmental concerns into its funding instruments, with the goal to increase the environmental benefits produced by the agricultural sector. The CAP provide both incentives and rules, hence the CAP is the underlying incentive for agriculture in EU. One direct intervention on land use is the set-aside requirement (Gay et al., 2005), which is the component of relevance for this thesis. Set-aside of land implies that a share of the arable land is left out of production and in return the farmer receives subsidies for losses in income. In other words, farmers can receive subsidies for adopting an environmentally friendly farming method. The farm management component of relevance for this thesis is the mandatory set-aside that regulates agricultural land use, specifically the focus is its abolishment in the 2008 reform. This evaluation is relevant as the mandatory set-aside policy were re-introduced in 2013. The importance of this farming method does not only imply a less intensive agriculture sector as less land is productive, it also creates environmental benefits such as increased biodiversity through providing habitats. Biodiversity losses and other environmental damages, are a globally driven problem as there is a conversion of natural areas to agricultural land (Zeijts et al. 2011).

For many years, the set-aside was mandatory, but due to the Health Check of the CAP (HCC) reform in 2008 the measure was abolished. The main implication of the reform was that the subsidy funding, which constitutes of two pillars, abolished mandatory set-aside under Pillar One. There are two sources of financial support under the CAP, market support under Pillar One which is called direct payments and Rural Development (RD) support under Pillar Two. In contrast, under Pillar Two, set-aside continued to be voluntary. Pillar two is funded by EU and co-financed by national funding. On average, each EU citizen contributes with 100 EUR as the CAP expenditure was 50 billion euros in 2009 (Zeijts et al. 2011). Therefore, policy evaluations of the CAP should be of the interest to society, as funding should not be misallocated and it should provide its intended public goods (Cooper et al. 2009). During recent years, there have been an ongoing discussion of its effects and costs on compatibility, as the mandatory set-aside later became re-introduced (Koster, 2011).

The focus of this thesis is to study the effects of the mandatory set-aside elimination. Already in 2011, Koster published an article about the concern of the "greening" of the CAP under Pillar One. In terms of incentives, the 2013 reform would imply re-introducing the mandatory sticks on farmers instead of only using the voluntary carrots, whilst carrots have been proven to be important in the UKs set-aside scheme (Ansell et al. 2016), there are no clear conclusions in the literature whether regarding the mandatory set-aside is efficient or inefficient; more research is required about its costs and benefits. Thus, the aim of this thesis is to estimate and evaluate the policy effect of abolishing mandatory set-aside on farmers' environmental behaviour because such evaluation does not exist.

Environmental concerns have been integrated into the agricultural sector mainly through three reforms. Firstly, the 2003 reform, which made Pillar One subsidies decoupled from production, introduced environmental compliance and transferring more funding was from Pillar One to Pillar Two. Secondly, the HCC reform in 2008 that abolished the mandatory set-aside under Pillar One. Finally, the 2013 reform which introduced "greening" of the CAP. This reform did not only introduce greater environmental objectives within agriculture in EU, it also re-implemented the mandatory set-aside that was previously abolished. Having these three reforms linked together, an empirical evaluation of the mandatory set-aside elimination is demanded empirically (Areté srl, 2008). The previous literature has mainly focused on the monetary aspects of the set-aside or it has studied the voluntary set-aside. Jaraite and Kazukauskas (2012) studied the effect of mandatory measures due to the 2003 reform on farmer's environmental performance. In contrast, this thesis will contribute to the gap of evaluations on farmers' environmental performance in the context of the HCC reform and additionally contribute with a policy study in terms of environmental performance.

The research question of this thesis is; *what is the policy effect of abolishing the mandatory set-aside on farmer's environmental performance?* To answer this question, I consider two proxies for environmental performance; expenditures on fertilisers and crop protection (pesticide). For the purpose of this thesis, farm-level micro data from the Farm Accountancy Data Network (FADN) will be used. The data is a pooled cross-section, over the period 2004-2008. It includes variables on farm structure, outputs, costs and subsidies. The observed and unobserved heterogeneity will be accounted for by controlling for farm productivity and other farm and time-variant and-invariant specific characteristics.

The theoretical framework presents the land allocation problem in the context of leaving land out of production, combined with a behavioural model of farmers input decisions for which the hypothesis is outlined. The expectation is that land that was out of production before will once again become productive land, where more fertilisers and pesticide can be used. The hypothesis to test is if abolishment of the mandatory set-aside policy worsens farmers' environmental performance. Hence, some European countries are treated with an earlier abolishment of mandatory set-aside which will capture the policy effect. The hypothesis will be tested by using a difference-in-difference (DD) model and for identification, utilise the difference in timing of the abolishment between three European countries.

The results from the DD baseline model show that pesticide and fertiliser usages decreased in countries which abolished mandatory set-aside, compared to a country which kept using the mandatory set-aside. Those results were also confirmed when estimating the baseline model with subsamples. When investigating the policy effect among the different farming sector, the policy effect is large within arable production, which also signify that productive land is the type of land that is decreasing its fertiliser and pesticide use. Additionally, among the farmers who are having productive land and those that are dependent on Pillar One subsidies are also improving their environmental performance. This policy evaluation can give an indication for not re-introducing mandatory set-aside policy on European farmers, which recently was made. The mandatory set-aside policy need future research to investigate if mandatory sticks on farmers provide the best incentive to improve the environmental performance within the agriculture sector.

The paper proceeds as follows: in section 2 a background of the CAP policy and the previous literature on set-aside is provided, to finally describe the contribution of this thesis. In section 3 the theoretical framework is presented which focus on the land allocation problem, input use decision and finally stating the hypothesis. In 4^{th} and 5^{th} sections the methodology and data is outlined, showing the DD approach and describing the data which is used, respectively. In section 6 and 7 the results are presented, followed by robustness checks of the results, and a discussion of policy implications and limitations of this thesis. Finally, section 8 outline the conclusions and future research of the set-aside policy.

2. Background

This thesis is focused on the CAP and therefore this section firstly provides a background of the European land-use policy and the abolishment of mandatory set-aside. Secondly, this section outline previous literature and the contribution of this thesis.

2.1 Land-use policy in EU

The CAP was introduced in 1962 and EU Member States have adopted several instruments during the evolution of the CAP to improve the agricultural sector. Agricultural land use policy has a short history with set-aside first implemented voluntarily in 1988. From the beginning, the aim of this scheme was to regulate the agricultural production, because production surpluses were a burden for the EU budget. The 1992 reform (MacSharry) included the main introduction of agricultural land use policy. It aimed to improve competitiveness, a part by introducing mandatory set-aside. The implication of a mandatory set-aside was that farmers must take arable land out of production, by so doing receive subsidies for reduction in price support (Ansell et al., 2016). More recently, as the set-aside has been evaluated over the years, it is shown that set-aside has also resulted in unexpected environmental benefits.

In EU, 50 percent of the land is covered by agriculture and thus agriculture is one of the most important land usages. Many of the European rural communities are involved since they depend largely on agriculture. There are two sources of financial support under the CAP, market support under Pillar One which is called direct payments and Rural Development (RD) support under Pillar Two. In 1992, the direct payment introduced mandatory set-aside which implied that farmers had to leave 15 percent of the productive land out of production. At that time, farmers received direct payments which was coupled to production, and which compensated for losses of income. Sustainability within the CAP was introduced in the 2003 reform (EC, 2003). Farmers have since then been required to keep land in good agricultural and environmental condition (GAEC). In 2003, direct payments as compensatory payments (Pillar One) became decoupled from production and thus called single farm payments (SFP). Decoupling of direct payments implied that payments to farmers were given to farmers depending on number of hectares, and not per amount of production as before. Pillar Two was also introduced in the 2003 reform to add incentives for farmers to protect and provide environmental goods and services on their land (Ansell et al., 2016).

Today, almost all farmers can apply for Pillar One subsidies and the aim is to provide a steady income and improve the competitiveness among farmers. Pillar two subsidies consists of several subsidies which aim is to support RD and broader environmental goals, but these subsides are also co-financed with national funding. The participation of Pillar Two subsidies are voluntary whereas Pillar One subsidies puts mandatory obligations on the farmers (Jaime et al. 2016). These two instruments are developing when new reforms are implemented and money spent under these instruments accounted for 50 billion euros in 2009. For example, around 80 percent of the CAP budget was spent on direct payments and 20 percent was spent on RD programs (Zeijts et al. 2011). Thus, the hectares of farmland that benefits from Pillar One are a much large share than the hectares receiving subsidies for sustainable agriculture.

In 2008, the 2003 reform was said to need a "Health Check" and as a result, the mandatory set-aside, in the single farm payment (SFP) scheme, was decided to be completely abolished in 2009. It was argued that the market of the arable crops had developed and that farmers received enough subsidies from Pillar One (EC, 2009a; 2009b).

2.2 Mandatory set-aside

The reform of main consideration in this thesis is the abolishment of the mandatory set-aside under Pillar One in 2008. Some Member States: Sweden and Finland, decided to fully abolish set-aside in 2008, even though the reform was first put into legislation in 2009 (see Article 33(3) of Regulation (EC) No 73/2009, which was applicable from 1 January 2009 and Article 149 of the same regulation (EC, 2009b)). The set-aside policy implies that land is left out of production and this farming method is i.e. important for conserving habitats. Over the years, since 1988, the set-aside has contributed with many efficiencies as lowering pesticides but it has also been associated with inefficiencies such as reversed effects on the environment in terms of certain landscape features and in general, the uptake of voluntary set-aside has been high in the Higher-Level Stewardship scheme in the U.K (EC, 2009b; Ansell et al., 2016). As mentioned before, mandatory scheme started in 1992 and this was mandatory for Member States to implement under Pillar One and it continued until 2009. Some positive effects of the mandatory set-aside were the lowering of chemical inputs, crop rotation and improving impacts on biodiversity, water and soil (Areté srl, 2008).

However, the CAP always gets reformed within some yearly interval and thus to improve the agricultural sector. In 2013, it was time for a new reform and now the EC decided to re-introduce the mandatory set-aside under Pillar One (EC, 2013a; 2013b), with the aim to make direct payments more environmentally-friendly. This obliged farmers to set-aside 7 percent, with the intention to increase that share in the coming years.

2.3 Previous literature

This section summaries literature which have examined the set-aside with a monetary perspective and the voluntary set-aside (Agri-environmental) perspective. The voluntary set-aside research is informative and important for making policy evaluation on set-aside policy. But in contrast, this thesis will contribute with a mandatory set-aside policy evaluation.

The environmental impacts associated with set-aside depend on many factors. For example, if the set-aside is rotational over time or not, the state of the land i.e. bare or vegetation, location and size of the set-aside land and overall land management (IEEP, 2008). In the field of agricultural economics, these above-mentioned factors have been studied in several papers in terms of voluntary adoption of set-aside. The mandatory set-aside policy has received less attention, even though most funding is placed on Pillar One (Zeijts et al. 2011).

In the context of the abolishment of mandatory set-aside during the HCC reform, a substantial body of research focused on important considerations due to the design of land use policy. The oldest studies on mandatory set-aside have mostly focused on the monetary aspects. As a starting point, through the introduction of direct payments in 1992, the possibility to compensate farmers for foregone production income on set-aside land became analysed. The research by Fraser (1993) evaluated the set-aside premium in relation to the 1992 reform and in 1997, he evaluated the land heterogeneity issue and suggested two characteristics of the importance of land quality in the context of the payment. The two land qualities were the expected yield and variability of the cereal yield, and he concluded that farmers with low and unreliable yield are those who benefitted from the 1992 reform. That is, when mandatory set-aside under direct payments was introduced. The reversed was found for those with high and reliable yield. These are some monetary studies of the mandatory set-aside, which focuses on income foregone payment. Froud et al. (1996) evaluated the participation in voluntary set-aside, which is rotational and more specifically what determines the opting-in price. The price was found to be insensitive towards uncertainty and risk attitude of the farmer. Nevertheless, a farms cost structure, yield and other key policy variables seems to affect the price.

The monetary studies have focused on the incentive compatibility issue. Incentive compatibility implies whether individuals follow their true preferences or not, and the monetary perspective that have been studied refers to issuing the payment which is based in production income foregone. In the context of heterogeneous land quality, Rygnestad and Fraser (1996) evaluated the CAP´s set-aside policy. Their results showed that it is in farmer's best interest that the lowest quality of land will be set-aside. It should be noticed that the mainly aim of set-aside at that time was to control the amount of output. Thus, if the lowest quality of land is set-aside, then there will be a policy slippage issue because the set-aside policy lead to a more intensive agricultural sector. If the lowest quality of land is set-aside, the marginal cost of diverting land is increasing as more land gets diverted, which is shown graphically by Fraser (2009). When the subsidy is paid then the amount of hectares that is chosen to be diverted requires that the marginal cost is less than the incentive payment. In that case, the costs are not higher than the benefits. Additionally, the marginal cost curve would be flatter if the land is more homogenous, but then the diverted area is concluded to be more sensitive to the level of payment. The socially optimal diverted area is defined by the social willingness-to-pay for environmental goods and services. Then, the ideal outcome is shown as the actual choice of area to convert by the farmer equals the social optimal area to convert (Fraser, 2009). In the years after the study by Rygnestad and Fraser (1996), land heterogeneity has been studied in the context of voluntary set-aside policy design by Campbell (2007) and Hanley et al. (2007).

Land heterogeneity among farms is one of the main design issues to consider and the heterogeneity of agricultural and environmental values have been studied by Fraser (2009) in context of land conversion. He shows that public funding could be misallocated, as the subsidy for conversion must be higher than the cost of conversion. He says "…scheme participation encourages farmers to participate based on income forgone, rather than on the benefits participation is supposed to deliver to the wider public" (s.191, Fraser, 2009). Thus, income foregone payment to farmers' raises the question within the policy design perspective, whether the subsidies correct for the market failure in the context of environmental goods and services, and whether the socially optimum level thereby is reached. The requirement for the farmer to participate in such scheme is that the benefits should exceed the costs of participation. Overall, the characteristics of European farms are heterogeneous and not fully observed, resulting in systematic differences between voluntary program participants and non-participants (Pufahl and Weiss, 2009). Implications of voluntary set-aside policy designs (i.e. AE programs) have also been analysed by Wu and Babock (1996), and Fraser (2002). Other policy evaluations of the voluntary AE programs have been applied by for example investigating issues such as asymmetric information (Fraser and Fraser, 2005).

Concluding, Rob Fraser has performed a significant contribution to the field of AE program evaluations on behavioural aspects as; moral hazard (Fraser, 2004; 2012; 2013), adverse selection (Quillerou and Fraser, 2010) and farmers' compensation and its consequences for environmental benefit provision (Quillerou et al. 2011). Since the AE programs are voluntary, this aspect has for example been applied by Pufahl and Walesh (2009) in Germany by using a propensity score matching DD model to evaluate the voluntary AE programs. In Austria, Salhofer and Streicher (2005) studied the effect of self-selection processes in the Austrian AE program and its effect on grain yield. Another study by Mann (2005) investigated the relationship between farm growth and participation in AE schemes in Switzerland. In the study of Fraser in 2009, which investigated the UK's environmental Stewardship Scheme (AE program), he linked incentive compatibility with land heterogeneity as a design problem of AE schemes. His graphical analysis confirms that given land is heterogeneous, environmental goods and services are expected to be under-or over provided because the existing divergence between actual and socially optimal level of environmental goods and services provision. Conversion adoption analysis are also comprehensive, where Pannell et al. (2006) and Knowler and Bradshaw (2007) provide analyses of the understanding and promoting adoption of conservation practices by rural landholders. In contrast to all these studies, the environmental performance is one of the fields that have not been as empirically applied and additionally not in context of the HCC reform.

2.4 Contribution

Policy evaluations of the CAP are broad and empirical findings are available in different fields of the CAP. In general, the studies are increasingly empirically applied to evaluate different reforms and much attention have been given to the 2003 reform. The cross-compliance and decoupling measures introduced in Pillar One through the 2003 reform, are those of interest for the contribution of this evaluation as this thesis evaluates a reform which has received less attention. Interesting dimensions that have been studied most recently in relation to decoupling are for example; decoupling effects on the distributional and wealth effects, farm investment and output, risk attitudes of Finnish farmers, disinvestment and farm exit, land market participation and environmental aspects of decoupling have also been studied, i.e. the uptake of organic farming and more specifically the interactions between the two pillars (Jaime et. al 2016). Additionally, environmental consequences have been studied by Schmid and Sinabell (2007) by investigating the choice of farm management practices. Schmid et al. (2007) analysed environmental subsidies by simulating the effects of the 2003 reform and concluded that decoupling delivered better outcomes than previous Agenda 2000 promised.

Studies that have investigating environmental performance are scarcer but have been applied by Jaraite and Kazukauskas (2012). Their paper is the first and most closely linked literature which evaluates environmental performance due to a reform of Pillar One. Their study evaluates the mandatory cross-compliance effects in the context of the 2003 reform on farmers' environmental performance. By using a DD strategy, they want to identify the casual relationship between environmental performance and cross- compliance. The environmental performance is not measured directly and two proxies for environmental performance are used; fertiliser and pesticide expenditures. Their results indicate that cross-compliance reduced those expenditures, but farmers with large shares of public payments are not found to have higher motivation to improve their environmental performance. In line with their paper, this thesis will make use of their methodology to find a casual policy effect, but instead for the mandatory set-aside abolishment in 2008.

Previous studies on the adoption and participation in environmentally friendly practices are scarce (Jaraite and Kazukauskas, 2012) and to the best of my knowledge an evaluation have not been performed in the context of the mandatory set-aside, as it became abolished in 2008. The set-aside is expected to be an environmentally friendly farming method in terms of lowering the rate of biodiversity losses and pesticides usage (Zeijts et.al. 2011). To the best of my knowledge this thesis will contribute to a scarce literature field which attempts to evaluate empirically the impact of European agricultural policy on farmer's environmental performance, and additionally by using a DD strategy. The results can offer a partial explanation for why the re-introduction of the set-aside in 2013 could worsened environmental performance, as abolishing mandatory set-aside will here be shown to improve environmental performance.

3. Theoretical framework

A method for analysing the behaviour of a farmer is to first outline the land allocation problem and then the behavioural model of a farmer. The evaluation of this thesis focuses on two time periods. The period before the policy change (2004-2007) which consists of two systems of set-aside; voluntary under Pillar Two and mandatory under Pillar One. Due to the policy change, mandatory set-aside was abolished under Pillar One. The casual effect of the policy change on the behaviour of farmers input choices is of special interest in the following two scenarios when set-aside is i) mandatory and voluntary and ii) only voluntary.

The decisions of what to use arable land for and which shows the choice of the farmer compromises into two decisions; the farmer can use the land for farming activities and/or leave it out of production. A land allocation model which shows the farmer's choice of how much land to put into production during these two periods can be followed by the model of Serra et al. (2009). Total cropped land can be denoted A_{total}, consisting of land allocated to A_1, A_2 and A_3 ($A_{total} = A_1 + A_2 + A_{3;v,m}$). The A_1 and A_2 denote land used for crops under program and non-program participation, respectively. Program refer to the programs available under the CAP. A_3 is land set-aside, and by extending the model by Serra et al. (2009), this amount of land can be divided into two different systems of set-aside, voluntary (*v*) and mandatory (*m*). Due to the policy change, the *m* component is abolished and thus the share of land in production should increase. To express land out of production in proportions, the land allocation problem can be given by L= (L_1, L_2, L_3) and where $L_i = A_i/A$. For the treatment group, the share of land in production *before* the policy change is

$$[1 - (L_{3,m} + L_{3,v})] \qquad [1]$$

and Eq. [1] applies all the time for the control group as they are unaffected by the mandatory set-aside policy abolishment. Therefore, the share of land in production *after* the policy change for the treatment groups is given by

$$[1 - (L_{3,v})] \qquad [2]$$

Thus, if total land L is assumed to be fixed over the period, more share of total agricultural land should be productive due to the policy change, thus

$$[1 - (L_{3,m} + L_{3,v})]_{before\_2008} \leq [1 - (L_{3,v})]_{after\_2008} \qquad [3]$$

In Eq. [3], the expected utility of the farmer could be assumed to be higher when no mandatory set-aside is put on the farmers. Thus, it is assumed that a farmer maximise utility.

Proposition 1: *More land will be in production after the policy change because farmers have no longer mandatory set-aside policy restricting their productive land allocation* L_{total}.

Furthermore, to incorporate the input decision regarding fertiliser and pesticide use, a behavioural model of a farmer can be applied. Taken into consideration the previous land allocation problem, the input decision is assumed to be a function of the land allocation.

$$Y = f(L_{total}) \quad [4]$$

However, the farmer firstly decides what to grow during mandatory (control group) or no mandatory set-aside (treatment group) under Pillar One. Secondly, the farmer additionally decides upon to adopting voluntary set-aside available under Pillar Two (Chabé-Ferret and Subervie, 2013), independently whether in the treatment or control group. Within the household of a farmer, only one type of agricultural good is produced Q. Thus, the production function includes the price p^Q of the produced good Q and an inconstant input Y whose price is p^Y which thereby requires household labor (H) and other factors of production. The production function can be formulated as:

$$\mathrm{Q} = \mathrm{F}(\mathrm{Y}, \mathrm{H}, \mathrm{I}, \epsilon) \quad [5]$$

where vector I consists of fixed factors possessed by the household, vector ϵ are unobserved factors. Fixed factors are for example, physical and human capital and land. The unobserved factors are those that are observed by the farmer but not by the evaluator, such as ability, land quality and climate. Additionally, vector ϵ can also be distinguished between those factors varying over time (climate; **e**) and in-varying (ability, land quality; μ). Thus, $\epsilon = (\mu, e)$. The expected utility function to maximise within the agricultural household is;

$$\max \mathrm{E}[\mathrm{U}(\mathrm{C}, \mathrm{L}, \mathrm{H}, \mathrm{H}^{\mathrm{off}}, \mathrm{Y})] \quad [6]$$

where the farmer gets utility from consumption C, leisure L, on-farm work and the farmer can get distaste for some inputs, due to ecological preferences. The problem that the household must solve is maximising the utility function (see Eq. [6]).

Given *proposition 1*, the input Y gets more restricted if having mandatory set-aside ($Y^{v,m}$.) or not (Y^{v}). Thus, we can assume inputs used with no mandatory set-aside is larger than if not, $Y^{v} > Y^{v,m}$. This, because less land is productive when also having mandatory set-aside and thereby inputs will be used less in that case. Given that the farmers are obliged to mandatory set-aside policy or not; Y^{v} or $Y^{v,m}$ will be chosen. The procedure to incorporate the mandatory set-aside is to assume a smaller Y in Eq. [5], as less inputs can be used in a smaller proportion of land, shown by previous assumption, $Y^{v} > Y^{v,m}$.

Proposition 2*: More inputs will be used if mandatory set-aside is taken away, implying that the environmental performance of farmers is worsened.*

Thus, both $Y^{v}$and $Y^{v,m}$ are potential outcomes and the farm-level casual effect of the set-aside abolishment. $\triangle Y$ is the differences between the two scenarios: the input level chosen by a farm that only need to decide on voluntary set-aside land and the input level chosen by a farm that also are obliged to set-aside land: $\triangle Y = Y^{v,m} - Y^{v}$. The observed choice Y depends on whether the farmer abolished mandatory set-aside or not. The individual casual effect of the mandatory set-aside abolishment is thus not observable, since only one of the two potential input choices is observed. This is an illustration of the fundamental problem of casual inference. In line with the two propositions, I will attempt to investigate the environmental performance in terms of input usage of farmers during the two scenarios.

Hypothesis: *After the mandatory set-aside abolishment, environmental performance is worsened, because changes in set-aside obligations affect input use.*

The pesticide and fertiliser use is expected to increase if abolishing mandatory set-aside because then inputs gets less restricted, as input choices are a function of the land allocation (see Eq. [4].

4. Methodology

To answer the research question, *what the effect is of abolishing mandatory set-aside on farmer's environmental performance,* the hypothesis previously mentioned will be tested; after abolishing mandatory set-aside under Pillar One, environmental performance worsened. A common method to estimate the casual policy effect is to use a DD procedure, which will be employed and used as the baseline model. Further, this hypothesis can be sharpened by using a triple DD. Firstly, investigating the policy effect for farmers in the baseline model. Secondly, if the dependency on Pillar One subsidies are improving environmental performance in the triple DD. Finally, this thesis will evaluate the policy effect in the baseline DD model which considers the different farming sectors.

In table 1, the control and treatment group is presented. A natural experiment need a control group, which is not affected by the exogenous policy change, and a treatment group which is affected. The difference between the treatment and control groups in post-2008 period, when considering the difference among the group's pre-2008 period and the common trend, is the mandatory set-aside policy abolishment effect.

Table. 1

Abolishment of mandatory set-aside in the Member States.

Group	*Mandatory Set-aside*	*Countries*
The Treatment group	Abolishment in 2008	Finland and Sweden
The Control group	Abolishment in 2009	The Netherlands

4.1 Empirical Identification strategy

The empirical strategy that is used to establish casual policy relationships between mandatory set-aside abolishment and environmental performance, is to make use of differences in the timing of the reform policy implementation between European countries, in a quasi-natural experiment approach. To address the changes in the environmental performance of the elimination of the mandatory set-aside, the variation in the countries different timing of the policy within is exploited by using a DD identification strategy in a forward-looking DD procedure. That is, the pre-policy period is used as the base reference point for the policy effect. In this case, the mandatory set-aside period is the base reference point for the policy effect of mandatory set-aside. Finland and Sweden set the mandatory set-aside rate to 0 percent in 2008, whereas the Netherlands abolished it in 2009. These differences in timing of the policy make it possible to identify the casual effect of the exogenous mandatory set-aside abolishment in 2008.

Furthermore, the environmental performance of farmer is difficult to model by using farm-level data because that performance is not observed directly. To solve this problem, this thesis utilises two proxies for environmental performance in the same way as Jaraite and Kazukauskas (2012), explicitly expenditures on pesticides and fertilisers.

4.2 Baseline DD model

This DD constitutes of quasi-experimental experiment, where the DD estimator can be used to estimate the effect of a policy change on an economic outcome, environmental in this case. Before introducing the model, there are some considerations that can be worth mentioning. The policy change in 2008 was exogenous for individual farmers, but the possible self-selection into implementing zero set-aside rate might lead to biased estimates if the decisions in the countries was based on farm pesticide or fertiliser use. The underlying argument followed by Jaraite and Kazukauskas (2012), is that the abolishment was broad and thus expenditures on pesticide and fertiliser as indicators for policy effectiveness is not likely to be correlated with the set-aside abolishment.

Another consideration by Jaraite and Kazukauskas (2012) is potential country-specific bias and to reduce this, country-specific time trends can be used. This implies that the treatment and control group can follow different trends, but as the time period in this thesis is limited by one year of the policy effect, year dummies will be used instead. But the motivation for time trends relies on countries having different national agricultural policies, socioeconomic conditions and climate which potentially can affect the trends in the variables of interest. The same motivation occurs for farm sector time trends, which imply that abolishing mandatory set-aside affect farm sectors in different ways. These considerations could be taken into account if having more years available in future research. However, the policy effect on environmental performance outcome can be estimated through the following baseline model of Jaraite and Kazukauskas (2012),

$$\text{environ\_indicator}_{it} = \gamma_{0c} + \varrho_{0s} + \lambda_t + \theta_1 T_i + \theta_2 Y_t + \theta_3 (Y_t * T_i) + \mathbf{z_i}\beta + \mathbf{x_{it}}\gamma + \alpha \quad [7]$$

where the environmental indicator is the outcome variable (fertiliser or pesticide) for group *i* at time *t*, γ_{0c} are country specific intercepts; ϱ_{0s} are farm sector-specific intercepts; and λ_t are time dummies by years; and T_t is a binary treatment indicator equal to 1 if a farm is in the treatment group and 0 otherwise; Y_i is a time dummy for the year of mandatory set-aside abolishment and α is a constant. By controlling for $\boldsymbol{z_i}$ which are farm-specific time invariant variables and $\boldsymbol{x_{it}}$ which are farm-specific time variant variables, the only observable difference between the treatment and control group will be the difference in mandatory set-aside policy.

The main variable of interest is the θ_3 variable, which is an interaction term and it is the DD estimator. The effect of abolishing mandatory set-aside on environmental performance is captured by the θ_3 parameter. $\widehat{\theta_3}$ is the DD estimator, also called the average treatment effect. If adding other factors, the form of $\widehat{\theta_3}$ won't be the same, but with similar interpretation. This DD estimator (see Eq. [8]) estimates the difference by subtracting the difference between treatment (T) and control (C) after the policy change (denoted with 2), with the difference between treatment and control before the policy change (denoted with 1), see Eq. [8]. If this variable is found positive and statistically significant it would indicate that eliminating mandatory set-aside policy had a negative impact on environmental performance. If negative, the policy change effect had a positive impact.

$$\widehat{\theta_3} = \left(\overline{y_{2,T}} - \overline{y_{2,C}}\right) - \left(\overline{y_{1,T}} - \overline{y_{1,C}}\right) \qquad [8]$$

The advantage of the DD approach is that it allows for level differences between the treatment and control group. For the DD to be valid, the assumption of parallell trends is crucial. That is, in the counterfactual scenario (if no treatment), both the control and treatment group should show identical trends in the outcome variable. Therefore, any differences over time can be attributed to received treatment. Although this assumption cannot be tested, the trends prior the treatment can be analysed. In the period before the treatment, both the groups should show similar trends, there should be no significant differnces in means. Following, there should be no spillover effects and that implies that treatment group only recives the treatment, zero mandatory set-aside rate. In section 5, the two outcome variables will be described.

In this thesis, an OLS estimator is used to estimate the parameters. In addition to the parallel trend assumption, the Gauss-Markov assumptions have to be fulfilled for OLS to be the preferred estimator. Due to the field of policy evaluation and agriculture, the assumptions on strict exogeniety and homogenous conditional variance of the error term is of importance. Strict exogeniety can be violated due to omitted variable bias, but variables that could correlate with the treatment and affect pesticde or fertiliser use are controlled for. Secondly, heterogeniety in error term among observations is always a problem with cross-section and farm-individual unobserved heterogeniety. This will be controlled for by using year, country and farm sector dummies.

The standard errors are robust to correct for heteroskedasticity and throughout the models it is clustered at a regional level, following the procedure Jaraite and Kazukauskas (2012). They cluster at the region level even if the treatment level is at a country level. For the purpose of this analysis, clustering at a regional level is useful, because it is likely that it should be a correlation among farmers in the same region in terms of type of farming sector, environmental condition, agricultural area and thus, productvity.

4.3 Triple DD

To sharpen the baseline model, inclusion of an additionally interaction can further investigate the policy effect. The way for how additional interactions can be incorporated into the baseline model is showed in Eq. [9]. The triple DD will be;

$$\text{environ\_indicator}_{it} = \gamma_{0c} + \varrho_{0s} + \lambda_t + \theta_1 T_i + \theta_2 Y_t + \theta_3 (Y_t * T_i) + \tau_0 dpr_{it} + \tau_1 (Y_T * dpr_{it}) + \tau_2 (T_i * dpr_{it}) + \tau_3 (Y_T * T_i * dpr_{it}) + \mathbf{z_i}\beta + \mathbf{x_{it}}\gamma + \alpha \quad [9]$$

That is, following the procedure of Jaraite and Kazukauskas (2012), some farmers might be less responsive to policy changes if the income is not significantly dependent on Pillar One subsidies. In this evaluation, it could be relevant as it was under Pillar One where mandatory set-aside was abolished. Therefore, Pillar One payment dependency can be captured by the inclusion of a decoupled payment dependency rate. This new variable (see Eq. 10) is denominated by total farm output and it accounts farmers' dependency on pillar one subsidies and it is included in the baseline DD by adding three additional interactions τ_1, τ_2 and τ_3.

$$dpr_{it} = [\frac{\text{Total decoupled payments}_{it})}{\text{total farm output}_{it}}] \quad [10]$$

I investigate within the two groups, if it can be expected that some countries have greater reliance on direct payment subsidies than others and thereby I investigate the dependency on Pillar One subsidies.

5. Data description

5.1 Variables

For the purpose of this analysis, a data set from the Farm Accountancy Data Network (FADN) is utilised on a micro-level for Finish, Swedish and the Dutch farmers for the 2004-2008 period. FADN is an instrument created by EU to evaluate the impact of the Common Agriculture Policy (CAP) and for evaluating income of agricultural holdings, in the European Union. The data contain annual surveys and it includes two elements: physical/structural and economic/financial data and there are three dimensions within the data; region, economic size and type of farming (FADN, 2010). The unbalanced panel consists of 16 791 farmers in total and will be used in a pooled/repeated cross-section dimension, because farmers is only partially followed over time.

To describe the main variables of interest, I have made own elaborations with the data to give a broad description, as the agricultural sector is complex and heterogeneous in many aspects. Firstly, the farms used in this study is greatly specialized in the milk, field crops and horticulture. Table 2 provide the distribution of the farmers in terms of farming sector by type of agricultural area in the three countries over the study period. Among these specializations there are many farms that are obtained in the Less Favoured Area (LFA). The LFA variable can give an indication of productivity as this represent if the farm has any disadvantages in production. Thus, more than half of the farmers are productive and if only the LFA mountain area is considered as unproductive, 80 percent of the farms have productive land. This variable can be utilized as an indicator for low productivity in the empirical analysis. Concluding, an even better indicator of productivity would be a soil quality index but such index is not observable and the study by Jaraite and Kazukauskas (2012) created a polynomial for productivity which is out of the scope of this analysis.

Table 2.

Percentage of farmers by farming specialization status and type of agricultural area.

Farming specialization	*All*	*No significant area*	*Normal Areas*	*LFA non-mountain*	*LFA mountain*
Field crops	18.34	14.67	26.99	21.26	11.66
Horticulture (Gardening)	16.84	32.32	16.03	5.28	5.11
Other permanent crops	1.42	2.94	1.03	0.24	0.67
Milk	32.46	22.46	20.42	37.76	56.58
Other grazing livestock	10.66	4.41	7.16	18.49	15.54
Granivores (Pigs and poultry)	14.26	18.22	18.85	10.44	7.13
Mixed	6.0	4.98	9.51	6.53	3.30
Observations	16 791	5 780	3 575	4 168	3 268

*Own elaboration with FADN data. Figures correspond to the unbalanced panel and are expressed in percentages.

Another variable of interest is the proportion of hectares that is set-aside, showing how much area that is taken out of production. In table 3, it can be obtained that how big proportion of the farmers' total utilized agricultural area that is set-aside, on average and separated by type of agricultural area. That is, how big proportion of the farmers who set-aside land is obtained in productive and unproductive areas. When looking at those with zero share of set-aside, 67 percent of the farmers set aside nothing of their land, whereas 33 percent is adopting the environmental friendly farming practice. According to the two LFA area columns, most farmers are obtained in LFA who set-aside land, 56 % and 45 % compared to 6 % and 37 % in the non-LFA area. This implies that those farms which are having more handicaps seems to be more likely to adopt environmental friendly farming methods. In line with the study of Rygnestad and Fraser (1996), it seems like those with less productive land are those who set-aside land.

Table 3.

Percentage of farmers by set-aside status and type of agricultural area.

Set-aside proportion	*All*	*No sign. area*	*Normal Areas*	*LFA non-mountain*	*LFA mountain*
Zero % set-aside	66.93	93.51	63.10	43.85	55.05
Positive % set-aside	33.07	6.49	36.90	56.15	44.95
Total %	100	100	100	100	100
Observations	16 504	5 574	3 507	4 157	3 266

*Own elaboration with FADN data. Figures correspond to the unbalanced panel and are expressed in percentages.

5.2 Descriptive statistics of included variables

In the following section, descriptive statistics of main variables included in the empirical analysis and additional descriptive variables are summarised in table 4. It is separated by treatment and control group and the table presents both mean and standard deviation values. The number of observation is similar among the two groups, but there are many other differences. The table shows that treatment and control group are different in terms of agricultural land and additionally hectares that are left out of production. It should be noticed that the average hectares of agricultural land are much smaller in the control group, implying that land is much scarcer in the control group compared to the treatment group. Thus, the opportunity to leave land out of production must have a higher cost for the control group. It can also be noted that the opportunity to leave out of production is to produce and yield of wheat is a variable that can capture this opportunity.

The two dependent variables of interest are expenditures on fertiliser and pesticide. Both the variables are adjusted for its price index to isolate the policy effect more than just using the consumer price index (CPI) which is used for the other monetary variables. The input-specific deflators are obtained from Eurostat[1]. The reason for not only deflate the two dependent variables with CPI is because the dramatic change of fertiliser price in 2008[2] in all the countries and the pesticide price increased by a large amount in Sweden in 2008. To the descriptive statistics, it can be obtained that the control group is using almost 5 times as much pesticide and almost equally much fertilisers compared to the treatment group. In the group where there are large expenditures on pesticides and fertilisers, it is likely that these farms are more labour and capital intensive than those using less pesticide or fertiliser, as they will have more land under production which also requires labour. One possible reason for using different amount of these inputs could also be due to national regulation differences.

Table 4

Descriptive statistics of variables for full sample separated by treatment and control group, period ***2004-2008.***

		Control group *Obs: 7 254*		***Treatment group*** *Obs: 9 537*	
	Variables	*Mean*	*Sd*	*Mean*	*Sd*
Structure variables					
	Total agricultural land, ha	34.51	43.73	82.93	90.17
	Land out of production, ha	0.52	2.75	5.48	9.50
	Economic size units, ESU	584.85	676.48	133.96	165.40
	Total labour, AWU	4.13	6.13	1.86	1.64
	Yield wheat, quintals	12.23	29.49	17.44	25.96
	Land owner occupation (%)	0.70	0.33	0.62	0.31
	Land rented (%)	0.30	0.33	0.38	0.31
	Family farm income, EUR	53 207.45	160 948.4	25 387.92	52 821.36
Dependent variables	*Pesticide, EUR*	12 174.54	22 885.95	2 480.13	5 436.06
	Fertiliser, EUR	6 617.76	11 978.44	6 071.80	9 047.19
Farming sectors	*Specialist field crops*	0.15	0.35	0.21	0.41
	Specialist milk	0.23	0.42	0.40	0.49
	Specialist grazing	0.04	0.21	0.15	0.36
	Specialist granivores	0.18	0.38	0.11	0.32
	Specialist horticulture	0.32	0.47	0.05	0.22
Other variables	*Pillar One, EUR*	5 682.68	12 637.35	13 142.65	18 647.39
	Pillar Two, EUR	1 287.15	11 010.10	17 131.68	20 369.62
	Organic, =1if organic	0.04	0.18	0.16	0.36
	LFA =1 if land in LFA mountain area	0	0	0.34	0.47
	ENV =1 if participate in Pillar Two	0.16	0.37	0.92	0.27
	Dpr, dependency on Pillar One	0.024	0.06	0.15	0.04
	Rddep, dependency on Pillar Two	0.0068	0.04	0.36	3.70

Notes: Variables in EUR are deflated by country-specific deflators from Eurostat (CPI 2004=100), variables in ha are determined by 1 hectare is equivalent to 10 000 square meters, variables in ESU are

[1] In Appendix A, the development of the two outcome variables are presented in line graphs.
[2] In Appendix A, the indexes of CPI, fertiliser real price index and pesticide real price index is obtained.

measured through economic size units, most important farming specialist variables are obtained from figures in appendix A and other variables are specific dummy indicators.

On average the treatment group is smaller in terms of economic size and labour, thus farms are on average much smaller than those in the control group where almost all farms are very large. From these descriptive statistics, it is likely that farms which have smaller economic size, are more likely to adapt and take advantage of subsidies for survival within the agricultural sector, which also can be obtained in the treatment group. Both farm direct payments (Pillar 1) and rural development subsidies (Pillar 2) are much larger in the treatment group. Most farms in both groups are occupied by the owner and only 30 percent is rented. The income among the groups are very different and the mean and standard deviation value is much bigger in the control group. This indicate that farms in the control group are much bigger and as noted in the previous section, many farms in the treatment group is obtained in less favoured mountain areas.

More farms in the treatment group have more handicaps making the survival within the agricultural sector very sensitive. As land is not scarce in the treatment group, the opportunity to use the land for other purposes is more possible in such countries. Another consideration is the differences in farming specialisation. The control group are most specialised in horticulture, whereas milk and field crop farmers are more commonly in the treatment group[3]. In line with all these differences, it is important to control for farm heterogeneity in the empirical analysis.

The funding is also very different among the farms in the two groups. The treatment group is much more dependent on these funding and this suggest that mandatory set-aside under farm direct payments should be much higher in the treatment group. Farm dependency on direct payments subsidies is measured by the constructed direct payment ratio variable (dpr), the same is done for rural development subsidies (Rddep). Participation in AE schemes is measured by a dummy variable (ENV) and accounts for farms that devote some of their land to AE programs. Therefore, farmer’s environmental performance may also be affected by its participation in voluntary Pillar Two schemes. Thus, a dummy variable indicating Pillar Two participation will be used, because in Germany, Pufahl and Weiss (2009) find that purchased pesticide and fertiliser is reduced when farmers participate in these types of schemes.

[3] In Appendix A, the farming specialisations are graphically showed, separated by countries.

6. Results

From the data description in the previous section, it is not evident whether on average farmers in the treated group have reduced their fertiliser and pesticide use due to mandatory set-aside abolishment. Therefore, the empirical strategy will be applied to estimate the casual policy effect by using a DD estimator and, additionally subsamples are used for testing robustness of the baseline DD model. Other robustness checks include a triple DD estimator and an analysis of the parallel trend, made by a test and graphs. In each result table, the four model specifications include; i) no controls, year effects, sector indicators and country indicators, ii) structure controls and year, farming sector and country indicators and iii) structure and other controls, and year, farming sector and country indicators and iv) adding dependency on Pillar One into the iii) procedure.

6.1 Baseline Policy Effect

In the baseline model (see table 5) it is evident that farmers who were subject to elimination of the mandatory set-aside policy in 2008, reduced their fertiliser and pesticide use on average. The control group consists of the country that introduced the abolishment later than 2008, which is the Netherlands. The treatment group consist of two countries that abolished the mandatory set-aside in 2008, Sweden and Finland. The interaction coefficient between the treatment dummy and the time dummy is the main variable of interest, as it shows the casual policy effect. In Model 1 and 5, the DD is made without control variables and the interaction term is negative and significant. When adding structure controls, fertiliser and pesticide decreases with EUR 667 and EUR 2 914, both at a 1 percent significance level, respectively (Model 2 and 6). If adding more control variables in model 3 and 7, fertilisers decreased with EUR 739 relative to the control group, in the same period. Pesticide expenditure did also decrease with EUR 3 009, which is almost three time as much compared to fertiliser. Both variables are still significant at a 1 percent level. Finally, in Model 4 and 8, the dependency on Pillar One is also included, this only affect the interaction term slightly and it is still negative and significant. The negative sign of this interaction coefficient shows that, in opposite of the hypothesis, the policy change affected farmers by improving their environmental performance. The mechanisms behind improved environmental performance could be that farmers set aside land that is less productive. Thus, the farmers decrease their use of fertiliser and pesticide as these inputs does not have to be used on land that is very productive.

Table 5

Baseline DD estimates on *fertiliser and pesticide*.

	Fertiliser				Pesticide			
Variables	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)
T	2,348*	1,497**	1,864**	1,867**	-5,335***	-5,024***	-4,629***	-4,624***
	(993.2)	(434.7)	(579.6)	(580.3)	(739.9)	(1,025)	(573.8)	(575.3)
Y*T	-600.9***	-666.7***	-739.3***	-729.5***	-3,133***	-2,914***	-3,009***	-2,991***
	(168.4)	(131.7)	(136.7)	(138.0)	(95.22)	(144.6)	(195.9)	(189.8)
Structure controls	-	Yes	Yes	Yes	-	Yes	Yes	Yes
Other controls	-	-	Yes	Yes	-	-	Yes	Yes
Pillar 1 dependency	-	-	-	Yes	-	-	-	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	8,962***	738.8	996.1	1,002	16,635***	8,346***	8,607***	8,619***
	(680.2)	(703.0)	(757.1)	(756.5)	(3,454)	(1,944)	(2,257)	(2,260)
Observations	16,791	16,504	16,504	16,504	16,791	16,504	16,504	16,504
R-squared	0.095	0.461	0.477	0.477	0.207	0.408	0.412	0.412

Robust standard errors in parentheses, clustered at a region level.
*** p<0.01, ** p<0.05, * p<0.1

Furthermore, the coefficient of the treatment variable estimate the mean difference in the dependent variable between the treatment and control groups prior to the intervention. Thus, before the intervention in 2008 there was a difference in fertiliser and pesticide usage between the control and treatment group (see all models). The difference was bigger among pesticide than fertiliser, these differences can also be obtained in the figures in Appendix C. Overall, after abolishing mandatory set-aside, and environmental performance is improved due to the reform, which is shown by the negative sign of interaction term. The number of observations decreases to 16 504 in the models where controls are included and the reason is that not all farmers have land owner occupation reported.

Result estimates of the baseline model with all controls can be obtained in Appendix B, Table B1. In table B2, results from not using clustered standard errors are obtained and the only difference towards the results in table B1, is that more control variables are significant. Among the 8 different model specifications, the results of interaction term are consistent throughout the models and this suggest that the findings are robust.

6.2 Farming sector Policy Effect

As a final part of this baseline DD analysis, the result of the baseline model could be more informative by estimating the DD by farming sector and find the policy effect among the different type of farms. The expectation is that the largest effect is obtained within the field crop sector, as this sector constitutes of arable land because arable land is that type of land that have mandatory set-aside entitlements. For the fertiliser and pesticide, the sign is negative and significant for the field crop sector (see Table 6). This is somewhat reasonable and as expected as arable land is used for set-aside purposes. For the permanent crop sector, it is only negative and significant for pesticide. These results could indicate that the mandatory set-aside abolishment probably decreased pesticides and fertiliser, but different sectors was affected differently. The mechanism behind is that arable land is of main importance in an analysis of set-aside policy.

Table 6

Policy effect in two arable farming sectors, separated by the outcome variables fertiliser and pesticide.

	Fertiliser		Pesticide	
Variables	Field crops	Permanent crops	Field crops	Permanent crops
T	2,699**	1,926*	-2,275	14,124***
	(845.4)	(450.3)	(1,505)	(1,422)
T*Y	-3,331***	561.3	-6,238***	-4,384*
	(304.5)	(320.2)	(322.0)	(1,285)
Structure Controls	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes
Constant	1,325	-778.3*	-1,655	-3,823**
	(3,170)	(237.7)	(2,646)	(418.8)
Observations	3,080	239	3,080	239
R-squared	0.640	0.553	0.783	0.809

Robust standard errors in parentheses, clustered at a region level
*** p<0.01, ** p<0.05, * p<0.1[4]

[4] Policy effects for all the 7 different farming sectors have been estimated, and all are available upon request.

6.3 Triple DD

One triple DD have been made, following the procedure of Jaraite and Kazukauskas (2012). Following, the triple DD result are obtained in Appendix D. When investigating subsidy dependency on Pillar One, the triple DD shows that Pillar One dependency make the farmer improve environmental performance, in terms of fertiliser (see table D), but not for pesticide. The results of the triple DD highlights that there could be some significant differences between treated and control farms across different levels of subsidy dependency. Additionally, the coefficient for the interaction term for the policy effect (Y*T) remains negative and significant across all models. The results from this sharpened DD, could give an indication that farmers who have large shares of subsidies in total output and where mandatory obligations are taken away, is more likely to be affected compared to those that are not dependent on Pillar One subsidies. Thus, a negative sign could indicate that the policy change also in this case improved environmental performance.

6.4 Robustness Checks

To check the robustness of the results, I have firstly checked the parallel trend assumption to justify that the DD estimator provide a consistent estimate of the treatment effect (Angrist and Pischke, 2009). That is, the trend in outcome variables should be the same among the treatment and control group in absence of the treatment. This check have been made by performing a test and by graphically showing the parallel trend. Secondly, subsamples of the treatment group have been made to confirm the baseline model, and optimal would also have been to test for using another control group for robustness, but this will be discussed in the discussion.

To test whether there is any difference in trends between the treatment and control group prior the policy change, a pre-treatment test can be performed. The regression test includes an interaction term where the treatment variable interact with year dummies for the period before the reform. Each interaction term between treatment and year dummies signifies the expenditure on fertilizer and pesticide, respectively, for the specific pre-treatment year. If the interactions are significant, there is a difference in trends prior the reform and that situation invalidates the parallel trend assumption, since any differences over time might be attribute to pre-treatment causes. The results from the regressions are shown in Appendix C, table C1 (using clusters at region level) and table C2 (using no clusters) and it shows that the parallel trend assumption might be violated for some years. This specific test has not been adopted in policy evaluations in previous agricultural studies to my knowledge and the parallel trend assumption has not been discussed when using the proxies that is used in this thesis (i.e. Jaraite and Kazukauskas, 2012). The reason for omitting that discussion could be that the input variables (fertiliser and pesticide) vary too much and is subject to different national legislation. Another reason for this could also be that the policy change is exogenous, that farmers are informed about the policy change in advance and therefore this test does not support the parallel trend.

For the DD estimation to be valid, the parallel trend is crucial and this assumption is also analysed graphically. By including the price variation for fertiliser and pesticide over time, where each real price index is included for the two outcome variables to compare their mean values between the treatment and control group. For the period before the policy change, there can be obtained a parallel trend for both pesticide and fertiliser between the groups, see figure 6 and 7 in Appendix C. The graphical analysis of the trends in fertiliser and pesticide use among the farmers show a parallel trend among the two outcome variables. The fact that these two outcome variables shows

To further check the robustness of the results, the treatment has been split into two subsamples to see if the coefficient of the interaction term confirms the baseline results. The two subsample consists of Sweden or Finland as treatment group and with the Netherlands as control group in the both subsamples. Results for using only Sweden as treatment group shows negative and significant results, and similar results are found for Finland. These subsample results can be found in appendix B, table B3 and B4, and they confirm the main results in table 5. Additionally, to the use of sub-samples of the baseline model, the baseline model was also tested for an introduction of a fallow scheme in Finland, which could bias the baseline DD models. Thus, I created an interaction term between Finland and the 2008-year dummy, and if that interaction turns out to be insignificant, introduction of the fallow scheme is not biasing the results. The inclusion of this variable turns out to be insignificant, therefore Finland could still be used as a treated group in the baseline model.

7. Discussion

7.1 Policy implications

The fact that this thesis finds positive effects on environmental performance in Sweden and Finland after abolishment of mandatory set-aside, has indications for the re-introduction of the mandatory set-aside in 2013. The findings of this policy analysis seem to justify a possible drawback of using the current mandatory policy, in terms of environmental performance. In addition, the less effectiveness of mandatory incentives applied for agricultural subsidies. Thus, the results show that environmental performance is improved as mandatory set-aside is abolished, as opposed to the hypothesis where environmental performance was expected to be worsened. One explanation for using less fertiliser and pesticide, could be that less land is taken into production due to the abolishment of the policy, instead of more land as suggested by the theoretical framework. Another explanation could be that more land is taken into production, but this land is more productive so that explain the use of less fertiliser and pesticide.

As previous literature, mainly have focused on the monetary aspects and the voluntary adoption of set-aside, little attention has been given to analyse the main funding component, which is Pillar One. Pillar One abolished an environmental friendly farming method and the expectation, as explained in the theoretical framework, was that environmental performance should be worsened due to the policy change. In opposite to the suggested positive effects of mandatory set-aside as outlined by Areté srl (2008), this analysis find that chemical inputs is decreased as mandatory set-aside was abolished. Concluding, the results show that the impacts of a mandatory set-aside need further investigation as the effect of the newly re-introduction of mandatory set-aside under Pillar One is not clear.

Because environmental performance is affected by abolishing mandatory set-aside, this gives important implications for the 2013 reform of the CAP. If farmers are obliged to set-aside land (7 %), their environmental performance can be worsened as the stick can be difficult to justify compared to only using carrots. Thus, the re-implementation of a mandatory set-aside should be made by caution, as the results from this thesis indicate positive effects on environmental performance due to the abolishment of mandatory set-aside. The effect of the policy change on the different farming sectors varies, in line with expectations and studies should evaluate the policy effects within sectors to be sure that the intended outcome is achieved in each sector.

7.2 Delimitations and potential problems

To start with, the main contribution of this thesis is the policy evaluation of the mandatory set-aside, as policy evaluations on mandatory set-aside are scarce. The evaluation of the CAP is complex but it is also demanded as Member states place a huge amount of public funding on both the pillars under the CAP. The second contribution is the empirical strategy, which is a usual strategy in policy evaluations but this thesis has attempted to apply it to a reform which has not been studied in the field of agricultural economics before. It is important to note that the set-aside is complex, and the environmental performance approach is only one dimension to study the environmental benefits. For example, biodiversity effects have been studied in the field of biology (see i.e. Kleijn and Sutherland (2003), Kleijn et. al (2004) and Kleijn and Baldi (2005)), but such data is not available in FADN and is therefore out of the scope of this thesis.

The two outcome variables used in this analysis are adjusted for their price index but another interesting consideration would be a log transformation. But as this thesis apply the same procedure as Jaraite and Kazukauskas (2012), that type of transformation was not considered. However, it should also be mentioned that the price trend for pesticide show a much higher price in Sweden compared to the other two countries, whereas the fertiliser price trend is much more similar among the three countries. This difference in price trend could affect the magnitude of the pesticide coefficient of the policy effect. Another comparison that this thesis did not apply to the results due to time limitation was to divide the analysis into balanced and unbalanced sample as Jaraite and Kazukauskas (2012) did.

One of the drawbacks with the FADN data is that the set-aside variable does not distinguish between voluntary or mandatory set-aside. This makes it difficult to apply an approach that investigate the mandatory set-aside determinants. In that case the dependent variable could be explained in a proportion and where a fractional response approach could be applied. Investigating its determinants is preferable in a more advanced research, to evaluate its associated costs and benefits, before and after a policy change.

According to the time period, it must be noted that the treatment period (2008) is only one year and that the national rural development plans under Pillar Two could have been introduced to substitute the abolishment of mandatory set-aside. In Finland, the mandatory set-aside was replaced with an agricultural fallow scheme, in order to not lose the environmental benefits received from the mandatory set-aside. This agricultural fallow scheme in Finland was checked for and thus included in the baseline model by creating an interaction term between Finland and the 2008-year dummy. This interaction turned out to be insignificant and thus, the replacement of a fallow scheme did not affect the estimated policy effect.

Since there is no country of the EU-15 which could introduce the abolishment of mandatory set-aside later than 2009, this thesis only makes use of the earlier implementation of the abolishment. Some of the main changes of the reform in 2009 resulted in funding under Pillar One being transferred to Pillar Two, called modulation. Thus, the farmers received less direct decoupled payments but also more national funding was required as Pillar Two funding increased. Evaluating the effect of all the changes of the reform, which were in place in 2009, is out of the scope for this thesis because of data availability and time limitation.

To improve robustness, future research could utilise more countries and years, if it is possible. According to this analysis division of control and treatment group there are other countries which could be used within the control groups. The Member States which joined the EU in 2004 and in 2007, implemented the single area payment scheme (SAPS) and not the SFP as the EU-15 countries. SAPS is a simplified decoupled payment and is operated based on the declaration of eligible land. These countries had no payment entitlements. As regards the area eligible to the SAPS, referring to Article 124 of Regulation (EC) No 73/2009; the set-aside obligation was not applicable in the SAPS Member States. However, EU-15 countries are only available in the data for this thesis and not countries adopting SAPS. One procedure would be to evaluate the pure HCC reform in 2009 and take advantage of data of these countries, which could be used as control group in future research, to elaborate and to improve this evaluation. The control group here, was chosen as the Netherlands was one of the countries that did not introduce an earlier abolishment of mandatory set-aside.

8. Conclusions

In this thesis, I study European farmers' environmental performance before and after the abolishment of the mandatory set-aside in 2008. I find negative and significant casual policy effect of the mandatory set-aside abolishment, implying that farmers reduced their environmental impact due to the policy change, in terms of pesticide and fertiliser use. The policy effect is identified by using a DD strategy, where a differential in environmental response of farms that were not subject to mandatory set-aside implementation is compared to the performance of farmers that continued to use mandatory set-aside. When using subsamples of the baseline model, the baseline results was confirmed. To sharpen the identification of mandatory set-aside abolishment effect, farms dependency on Pillar One subsidies was accounted for in a triple DD and showed a significant negative effect for fertiliser use.

I find evidence that farmers subject to no mandatory set-aside reduce their use of fertiliser and pesticide. For the treated farms this effects is approximately 12 % of their average annual fertiliser expenditure and 21 % of the average pesticide expenditure. This results can contribute with insights for policy development for the re-introduction of a mandatory set-aside in 2013 CAP reform and that this evaluation is a contribution as a similar study has not been made on the 2008 reform. The robustness of the results was showed graphically, to evaluate the parallel trend assumption. When using subsamples, the baseline results were confirmed. The triple DD indicates that abolishment of mandatory set-aside under Pillar One, make farmers using less fertiliser due to the policy change.

The results from this evaluation could serve as an input for future evaluations on mandatory set-aside in the context of the 2013 reform, and to highlight the need of future investigation of the policy relevant 2013 reform of the CAP. Suggestion for future research on this topic could be to investigate the greening of the CAP more deeply as data becomes available in FADN. This thesis evaluates the policy in a somewhat backward looking approach whereas a forward-looking approach would be good as the policy has developed through the 2013 reform. Due to the potential problems and limitations, a more advanced fractional response model could be employed to investigate the proportion of set-aside and find the associated costs and benefits that are associated with the intensity of set-aside. Since this thesis is a preliminary study in the sense of the greening of the CAP, available data is the only limitation for further investigating the implications for using mandatory or voluntary policy instruments on European farmers.

References

Angrist, J. D. and Pischke, J. S. (2009). Mostly Harmless Econometrics: an Empiricist's Companion. Priceton University Press, Princeton, NJ.

Ansell D., Gibson F. and Salt D., (2016). Learning from agri-environment schemes in Australia: Investing in biodiversity and other ecosystem services on farms. ANU Press, The Australian National University, Canberra, Australia. Chapter 6, Rob Fraser "Agricultural land use policy in the European Union: A brief history and lessons learnt".

Areté srl. (2008). Evaluation of the set-aside measure 2000-2006. Final report No Agri/2006-G4-16. Available at: http://ec.europa.eu/agriculture/sites/agriculture/files/evaluation/market-and-income reports/2008/setaside/fulltext_en.pdf [Accessed 20 Jan. 2017].

Campbell, D. (2007) 'Willingness to pay for rural landscape improvements: Combining mixed logit and random effects models', *Journal of Agricultural Economics*, 58 (3): 467– 483.

Carlo, F. and Bateman, I. J. (2011). "Structural Agricultural Land Use Modeling for Spatial Agroenvironmental Policy Analysis." *American Journal of Agricultural Economics* 93(4): 1168-88.

Chabé-Ferret, S., & Subervie, J. (2013). How much green for the buck? Estimating additional and windfall effects of French agro-environmental schemes by DID-matching. *Journal of Environmental Economics and Management*, *65*(1), 12-27.

Cooper, T., Hart, K. and Baldock, D. (2009) The Provision of Public Goods Through Agriculture in the European Union, Report Prepared for DG Agriculture and Rural Development, Contract No 30-CE 0233091/00-28, Institute for European Environmental Policy: London.

European Commission. 2003. Council Regulation (EC) No. 1782/2003 of 29 September 2003 on establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers and amending Regulations (EEC) No 2019/93, (EC) No 1452/2001, (EC) No 1453/2001, (EC) No 1454/2001, (EC) 1868/94, (EC) No 1251/1999, (EC) No 1254/1999, (EC) No 1673/2000, (EEC) No 2358/71 and (EC) No 2529/2001.

____. 2009a. Council Regulation (EC) No. 72/2009 of 19 January 2009 on modifications to the Common Agricultural Policy by amending Regulations (EC) No 247/2006, (EC) No 320/2006, (EC) No 1405/2006, (EC) No 1234/2007, (EC) No 3/2008 and (EC) No 479/2008 and repealing Regulations (EEC) No 1883/78, (EEC) No 1254/89, (EEC) No 2247/89, (EEC) No 2055/93, (EC) No 1868/94, (EC) No 2596/97, (EC) No 1182/2005 and (EC) No 315/2007.

____. 2009b. Council Regulation (EC) No. 73/2009 of 19 January 2009 on establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers, amending Regulations (EC) No 1290/2005, (EC) No 247/2006, (EC) No 378/2007 and repealing Regulation (EC) No 1782/2003.

____. 2013a. Council Regulation (EC) No. 1307/2013 of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009.

____.2013b. Evaluation of the structural effects of direct support. EEGI Agrosynergie. Available at: https://ec.europa.eu/agriculture/sites/agriculture/files/evaluation/market-and-income reports/2013/structural-effects-direct-support/fulltext_en.pdf [Accessed 20 Jan. 2017].

FADN. 2010. Farm Accounting Data Network: An A to Z of methodology. Ministry of Agriculture and Rural Development, European Commission. Available at: http://ec.europa.eu/agriculture/rica//pdf/site_en.pdf [Accessed 20 Jan. 2017].

Fraser, R. (1993). Set-aside premiums and the may 1992 CAP reforms. *Journal of Agricultural Economics*, *44*(3): 410-417.

Fraser, R. (1997). Land heterogeneity and the may 1992 reform of CAP cereal price support. *Journal of Agricultural Economics*, *48*(1-3): 65-70.

Fraser, R. W. (2002). 'Moral hazard and risk management in agri-environmental policy', *Journal of Agricultural Economics*, 53(3): 475–487.

Fraser, R. W. (2004) 'On the use of targeting to reduce moral hazard in agri-environmental schemes', *Journal of Agricultural* Economics, 55 (3): 525–540.

Fraser, R. (2009). Land heterogeneity, agricultural income forgone and environmental benefit: An assessment of incentive compatibility problems in environmental stewardship schemes. *Journal of agricultural economics*, *60*(1), 190-201.

Fraser, R. W. (2012) 'Moral hazard, targeting and contract duration in agri-environmental policy', *Journal of Agricultural Economics*, 63(1): 56–64.

Fraser, R. (2013). To cheat or not to cheat: moral hazard and agri-environmental policy. *Journal of Agricultural Economics*, 64(3): 527–536.

Fraser, R. W. and Fraser, I. M. (2005). 'Targeting monitoring resources to enhance the effectiveness of the CAP', *Euro Choices*, 4(3): 22–27.

Froud, J., Roberts, D. and Fraser, R. W. (1996). Participation in set-aside: What determines the opting in price? *Journal of Agricultural Economics*. 47(1-4), 89-108.

Garrod, G. (2009) Greening the CAP: how the improved design and implementation of agri-environment schemes can enhance the delivery of environmental benefits, *Journal of Environmental Planning and Management*, 52:5, 571-574.

Gay S.H., Osterburg B., Baldock D., Zdanowicz A. (2005). Recent evolution of the EU Common Agricultural Policy (CAP): state of play and environmental potential. MECAP WP6 D4b, special target research project SSPE-CT-2004-503604.

Hanley, N., Colombo, S., Mason, P., & Johns, H. (2007). The reform of support mechanisms for upland farming: paying for public goods in the severely disadvantaged areas of England. *Journal of Agricultural Economics*, *58*(3), 433-453.

IEEP (2008). The Environmental Benefits of Set-Aside in the EU: A Summary of Evidence. London: Institute for European Environmental Policy. [Accessed 20 Jan. 2017].

Jaime, M. M., Coria, J., & Liu, X. (2016). Interactions between CAP Agricultural and Agri-Environmental Subsidies and Their Effects on the Uptake of Organic Farming. *American Journal of Agricultural Economics*, 98(4):1114-1145.

Jaraite, J. and Kazukauskas, A. (2012). The Effect of Mandatory Agro-environmental Policy on Farm Fertilizer and Pesticide Expenditure. *Journal of Agricultural Economics* 63 (3): 656–76.

Kleijn, D. and Sutherland, W.J., (2003). How effective are European agri-environment schemes in conserving and promoting biodiversity? *Journal of applied ecology*, 40, 947–969.

Kleijn, D., Berendse, F., Smit, R., Gilissen, N., Smit, J., Brak, B., Groeneveld, R., (2004). Ecological effectiveness of agri-environmental schemes in different agricultural landscapes in the Netherlands. *Conservation Biology* 18, 775-786.

Kleijn, D. & A. Baldi (2005), 'Effects of Set-Aside Land on Farmland Biodiversity: Comments on van Buskirk and Willi ', *Conservation Biology* 19(3): 963-966.

Knowler, D. and Bradshaw, B. (2007) 'Farmers' adoption of conservation agriculture: A review and synthesis of recent research', *Food Policy*, 32(1): 25–48.

Koster, Ulrich (2011). "Greening – a return to compulsory set-aside", www.capreform.eu, 1 November 2011, [Accessed March 2017].

Mann, S. (2005). Farm Size Growth and Participation in Agri-environmental Schemes: A Configural Frequency Analysis of the Swiss Case. *Journal of Agricultural Economics*, *56*(3), 373-384.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Animal Production Science*, *46*(11), 1407-1424.

Pufahl, A and Walsh, J. (2009) Evaluating the effects of farm programmes: Results from propensity score matching. *European Review of Agricultural Economics*, 36: 79-101.

Quillerou, E. and Fraser, R. W. (2010). Adverse selection in the Environmental Stewardship Scheme: Does the Higher-Level Stewardship Scheme design reduce adverse selection? *Journal of Agricultural Economics*, 61 (2): 369–380.

Quillerou, E., Fraser, I. M. and Fraser, R. W. (2011). 'Farmer compensation and its consequences for environmental benefit provision in the Higher-Level Stewardship Scheme', *Journal of Agricultural Economics*, 62 (2): 330–339.

Rygnestad, H., & Fraser, R. (1996). Land Heterogeneity and the effectiveness of CAP set-aside. *Journal of Agricultural Economics*, *47*(1-4), 255-260.

Schmid, E., & Sinabell, F. (2007). On the choice of farm management practices after the reform of the Common Agricultural Policy in 2003. *Journal of Environmental Management*, *82*(3), 332-340.

Schmid, E., F. Sinabell, and M. Hofreither. (2007). Phasing out of Environmentally Harmful Subsidies: Consequences of the 2003 CAP Reform. *Ecological Economics* 60 (3): 596–604.

Serra, T., Zilberman, D., Gil, J. M., and Featherstone, A. (2009). The effects of decoupling on land allocation. *Applied Economics*, *41*(18), 2323-2333.

Wu, J. and Babcock, B. A. (1996) 'Contract design for the purchase of environmental goods from agriculture', *American Journal of Agricultural Economics*, 78(4): 935–945.

Zeijts, H., Overmars, K., Bilt, W., Schulp, N., Notenboom, J., Westhoek, H., Helming, J., Terluin, I., Janssen, S., (2011). " Greening the common agricultural policy: impacts on farmland biodiversity on an EU scale policy studies". PBL Netherlands Environmental Assessment Agency. Report nr: 500136005. Pages:62.

Appendix A. Descriptive statistics

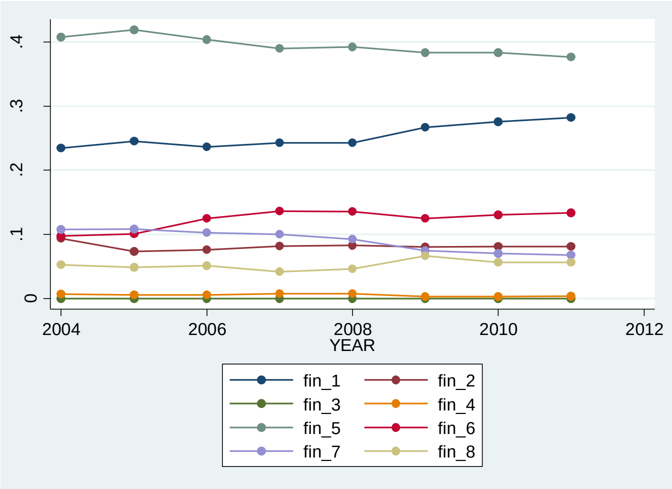

Figure 1. Farming sectors in Finland

Note: Finland Milk>Field crop> Other grazing livestock

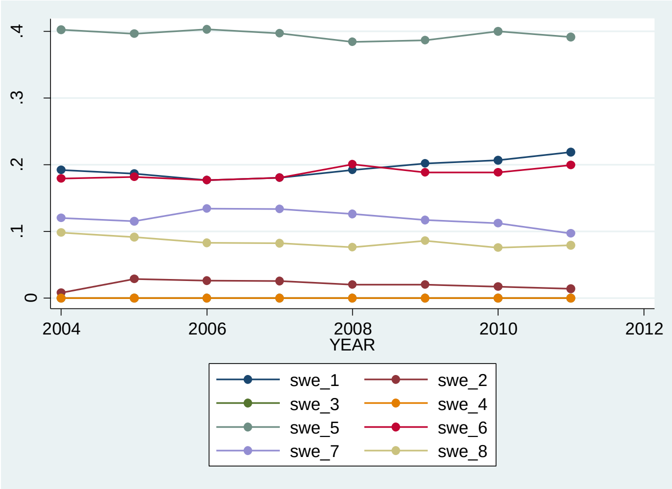

Figure 2. Farming sectors in Sweden

Note: Sweden Milk>Other grazing livestock, Field crop> Granivores.

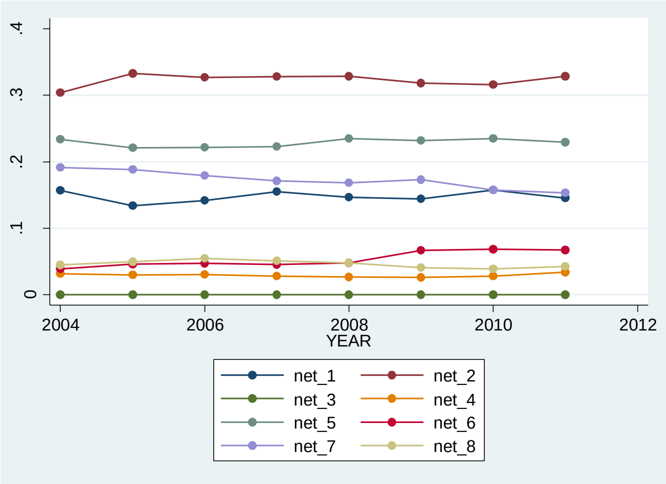

Figure 3. Farming sectors in the Netherlands

Note: The Netherlands Horticulture>Milk>Granivores>Field crop.

Description of the farming sectors:

1= Field crop
2= Horticulture
3= Wine
4= Other permanent crops
5= Milk
6= Other grazing livestock
7= Granivores
8= Mixed.

Table A1

CPI index (2004=100)					
	2004	2005	2006	2007	2008
Netherlands	100	101,4824	103,1665	104,7913	107,1157
Finland	100	100,7722	102,0593	103,6651	107,7347
Sweden	100	100,8225	102,3401	104,0547	107,5417

Table A2

Fertiliser Price Real Index (2004=100)					
	2004	2005	2006	2007	2008
Netherlands	100	105,5	111,1	118,6	**202,6**
Finland	100	103,3	107,0	110,8	**189,8**
Sweden	100	103,3	106,3	111,8	**170,7**

Table A3

Pesticide Price Real Index (2004=100)					
	2004	2005	2006	2007	2008
Netherlands	100	99,6	96,0	93,8	**92,1**
Finland	100	96,3	90,8	88,0	**94,7**
Sweden	100	96,3	89,5	95,2	**111,5**

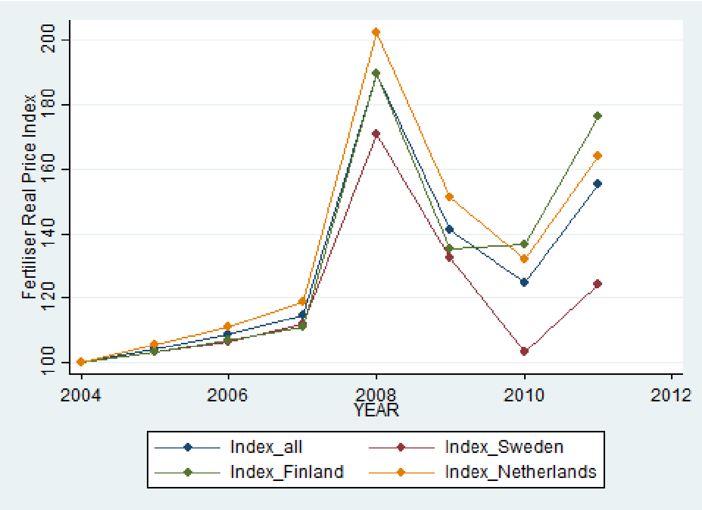

Figure 4. Development of Fertiliser price over time.

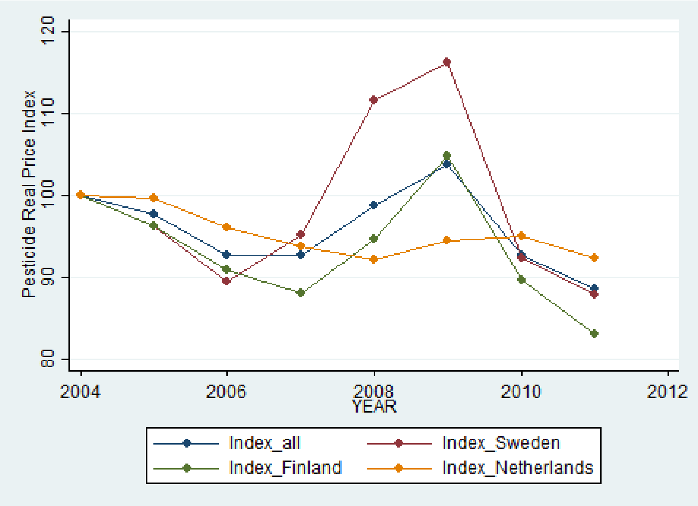

Figure 5. Development of Pesticide price over time.

Appendix B. Baseline model DD estimates analysis

Table B1

Baseline model with inclusion of results of all controls, excluding year, sector and country dummies.

	Fertiliser				Pesticide			
Variables	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)
T	2,348*	1,497**	1,864**	1,867**	-5,335***	-5,024***	-4,629***	-4,624***
	(993.2)	(434.7)	(579.6)	(580.3)	(739.9)	(1,025)	(573.8)	(575.3)
Y*T	-600.9***	-666.7***	-739.3***	-729.5***	-3,133***	-2,914***	-3,009***	-2,991***
	(168.4)	(131.7)	(136.7)	(138.0)	(95.22)	(144.6)	(195.9)	(189.8)
Economic size, ESU		8.964***	8.833***	8.833***		13.81***	13.72***	13.72***
		(0.281)	(0.314)	(0.314)		(0.600)	(0.573)	(0.573)
Land, ha		51.35***	53.80***	53.81***		30.68	32.92	32.94
		(7.567)	(7.986)	(7.988)		(20.65)	(21.92)	(21.93)
Yield wheat		45.19**	40.30**	40.23**		102.2***	102.6***	102.5***
		(14.95)	(13.21)	(13.22)		(23.25)	(24.30)	(24.20)
Land owner occupation =1		617.6	480.2	482.5		-2,901**	-2,781*	-2,777*
		(978.1)	(904.8)	(904.5)		(1,126)	(1,231)	(1,228)
Organic =1			-4,376***	-4,371***			-2,478**	-2,469**
			(872.3)	(871.1)			(827.8)	(823.7)
LFA =1			580.1	581.2			2,533	2,535
			(468.7)	(468.9)			(1,404)	(1,403)
ENV=1			59.10	59.94			-719.1	-717.5
			(358.7)	(359.5)			(1,529)	(1,528)
dpr				-84.80**				-161.5
				(30.54)				(114.2)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	8,962***	738.8	996.1	1,002	16,635***	8,346***	8,607***	8,619***
	(680.2)	(703.0)	(757.1)	(756.5)	(3,454)	(1,944)	(2,257)	(2,260)
Observations	16,791	16,504	16,504	16,504	16,791	16,504	16,504	16,504
R-squared	0.095	0.461	0.477	0.477	0.207	0.408	0.412	0.412

Robust standard errors in parentheses, clustered at a region level.
*** p<0.01, ** p<0.05, * p<0.1

Table B2

Baseline model with inclusion of results of all controls, excluding year, sector and country dummies.

	Fertiliser				Pesticide			
Variables	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)
T	2,348***	1,497***	1,864***	1,867***	-5,335***	-5,024***	-4,629***	-4,624***
	(211.7)	(210.4)	(246.3)	(246.3)	(254.5)	(348.8)	(376.8)	(376.8)
Y*T	-600.9*	-666.7**	-739.3***	-729.5***	-3,133***	-2,914***	-3,009***	-2,991***
	(361.5)	(274.4)	(272.1)	(272.1)	(718.0)	(626.1)	(623.9)	(623.8)
Economic size, ESU		8.964***	8.833***	8.833***		13.81***	13.72***	13.72***
		(0.508)	(0.508)	(0.508)		(0.852)	(0.853)	(0.853)
Land, ha		51.35***	53.80***	53.81***		30.68***	32.92***	32.94***
		(3.190)	(3.169)	(3.170)		(2.687)	(2.774)	(2.774)
Yield wheat		45.19***	40.30***	40.23***		102.2***	102.6***	102.5***
		(2.887)	(2.838)	(2.839)		(5.106)	(5.175)	(5.174)
Land owner occupation =1		617.6***	480.2**	482.5**		-2,901***	-2,781***	-2,777***
		(229.3)	(230.1)	(230.1)		(444.9)	(451.2)	(451.3)
Organic =1			-4,376***	-4,371***			-2,478***	-2,469***
			(191.3)	(191.3)			(213.5)	(213.5)
LFA =1			580.1***	581.2***			2,533***	2,535***
			(125.4)	(125.4)			(162.6)	(162.6)
ENV=1			59.10	59.94			-719.1**	-717.5*
			(190.8)	(190.8)			(366.5)	(366.5)
dpr				-84.80*				-161.5*
				(48.67)				(90.53)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	8,962***	738.8**	996.1***	1,002***	16,635***	8,346***	8,607***	8,619***
	(253.0)	(308.2)	(304.1)	(304.1)	(447.9)	(523.3)	(540.4)	(540.4)
Observations	16,791	16,504	16,504	16,504	16,791	16,504	16,504	16,504
R-squared	0.095	0.461	0.477	0.477	0.207	0.408	0.412	0.412

Robust standard errors in parentheses (no clusters)
*** p<0.01, ** p<0.05, * p<0.1

Table B3

Baseline DD on *fertiliser and pesticide*, using Sweden as **treatment group**.

Variables	Fertiliser (Model 1)	(Model 2)	(Model 3)	(Model 4)	Pesticide (Model 5)	(Model 6)	(Model 7)	(Model 8)
T	2,909**	1,926***	2,583***	2,590***	-4,596***	-4,592**	-4,148**	-4,137**
	(814.2)	(218.8)	(233.1)	(233.3)	(759.0)	(1,310)	(933.7)	(935.3)
Y*T	-451.0	-623.5*	-726.9*	-722.0*	-3,284***	-3,238***	-3,367***	-3,359***
	(221.4)	(219.2)	(229.0)	(228.7)	(45.89)	(251.8)	(350.0)	(344.8)
Structure controls	-	Yes	Yes	Yes	-	Yes	Yes	Yes
Other controls	-	-	Yes	Yes	-	-	Yes	Yes
Pillar 1 dependency	-	-	-	Yes	-	-	-	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	10,204***	1,957*	2,321*	2,325*	19,378**	11,405**	11,452**	11,457**
	(148.4)	(682.4)	(750.4)	(749.1)	(4,930)	(3,071)	(3,404)	(3,405)
Observations	12,305	12,018	12,018	12,018	12,305	12,018	12,018	12,018
R-squared	0.118	0.471	0.483	0.483	0.214	0.409	0.412	0.412

Note: ***Sub sample***; only Sweden as treatment group and Netherlands as control group. Robust standard errors in parentheses, clustered at a region level *** p<0.01, ** p<0.05, * p<0.1

Table B4

Baseline DD on *fertiliser and pesticide*, using Finland as **treatment group**.

Variables	Fertiliser (Model 1)	(Model 2)	(Model 3)	(Model 4)	Pesticide (Model 5)	(Model 6)	(Model 7)	(Model 8)
T	-648.9	1,700***	1,539**	1,544**	-7,935***	-4,241**	-4,233***	-4,219***
	(378.7)	(184.5)	(428.4)	(433.8)	(837.8)	(995.6)	(744.4)	(723.4)
Y*T	-755.8**	-751.8**	-764.9**	-748.1**	-2,997***	-2,973***	-3,121***	-3,077***
	(270.3)	(182.0)	(180.0)	(184.4)	(198.1)	(356.8)	(412.5)	(377.4)
Structure controls	-	Yes	Yes	Yes	-	Yes	Yes	Yes
Other controls	-	-	Yes	Yes	-	-	Yes	Yes
Pillar 1 dependency	-	-	-	Yes	-	-	-	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	8,182***	190.3	440.0	449.5	18,314**	3,953***	4,972**	4,997**
	(1,005)	(1,261)	(1,415)	(1,416)	(4,727)	(817.1)	(1,109)	(1,118)
Observations	11,740	11,487	11,487	11,487	11,740	11,487	11,487	11,487
R-squared	0.094	0.440	0.449	0.449	0.201	0.442	0.449	0.449

Note: ***Sub sample***; only Sweden as treatment group and Netherlands as control group. Robust standard errors in parentheses, clustered at a region level *** p<0.01, ** p<0.05, * p<0.1

Appendix C. Parallel trend test and graphs

Table C1

Test for pre-reform differences between treatment and control group (period 2004-2007)

	Fertiliser			Pesticide		
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Treatment	1,731	844.6	1,104	-4,071***	-3,793***	-3,414***
	(1,043)	(475.5)	(667.2)	(643.2)	(877.3)	(579.5)
Treatment*05	-99.00	-121.4	-9.403	41.61	76.29	66.67
	(181.2)	(171.6)	(164.5)	(105.0)	(159.2)	(222.1)
Treatment*06	1,345***	1,470***	1,563***	-1,320***	-1,015***	-1,040***
	(92.27)	(65.11)	(98.79)	(85.08)	(172.6)	(268.9)
Treatment*07	1,513***	1,733***	1,774***	-3,924***	-4,093***	-4,178***
	(291.9)	(173.6)	(165.6)	(223.3)	(314.7)	(435.9)
Structure Controls	-	Yes	Yes	-	Yes	Yes
Other Controls	-	-	Yes	-	-	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes
Constant	9,230***	998.9	1,290*	15,365***	7,627**	7,865**
	(682.2)	(607.2)	(654.3)	(3,503)	(2,191)	(2,511)
Observations	13,353	13,117	13,117	13,353	13,117	13,117
R-squared	0.094	0.452	0.469	0.206	0.400	0.404

Robust standard errors in parentheses, clustered at the region level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table C2

Test for pre-reform differences between treatment and control group (period 2004-2007)

	Fertiliser			Pesticide		
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Treatment	1,731***	844.6***	1,104***	-4,071***	-3,793***	-3,414***
	(346.7)	(322.6)	(357.7)	(460.8)	(513.1)	(548.4)
Treatment*05	-99.00	-121.4	-9.403	41.61	76.29	66.67
	(461.9)	(377.8)	(375.0)	(682.3)	(634.6)	(633.5)
Treatment*06	1,345***	1,470***	1,563***	-1,320*	-1,015*	-1,040*
	(443.1)	(366.1)	(363.5)	(686.8)	(614.4)	(614.2)
Treatment*07	1,513***	1,733***	1,774***	-3,924***	-4,093***	-4,178***
	(565.9)	(378.9)	(375.4)	(804.4)	(719.7)	(721.9)
Structure Controls	-	Yes	Yes	-	Yes	Yes
Other Controls	-	-	Yes	-	-	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes	Yes	Yes
Constant	9,230***	998.9***	1,290***	15,365***	7,627***	7,865***
	(328.6)	(384.1)	(381.6)	(563.4)	(649.5)	(662.7)
Observations	13,353	13,117	13,117	13,353	13,117	13,117
R-squared	0.094	0.452	0.469	0.206	0.400	0.404

Robust standard errors in parentheses (no clusters)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

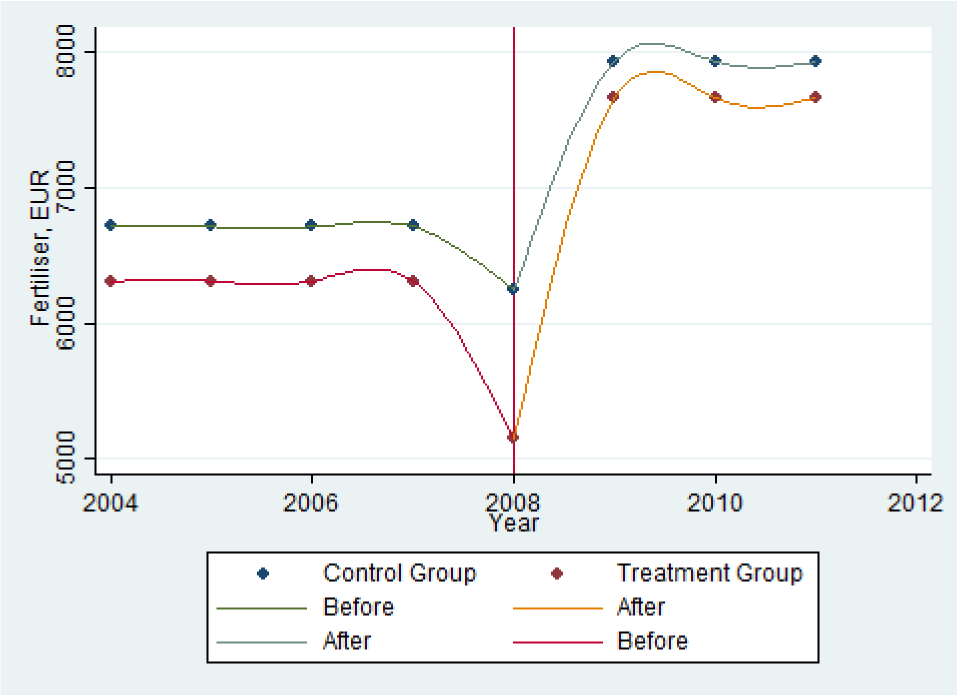

Figure 6. Parallel trend for fertiliser

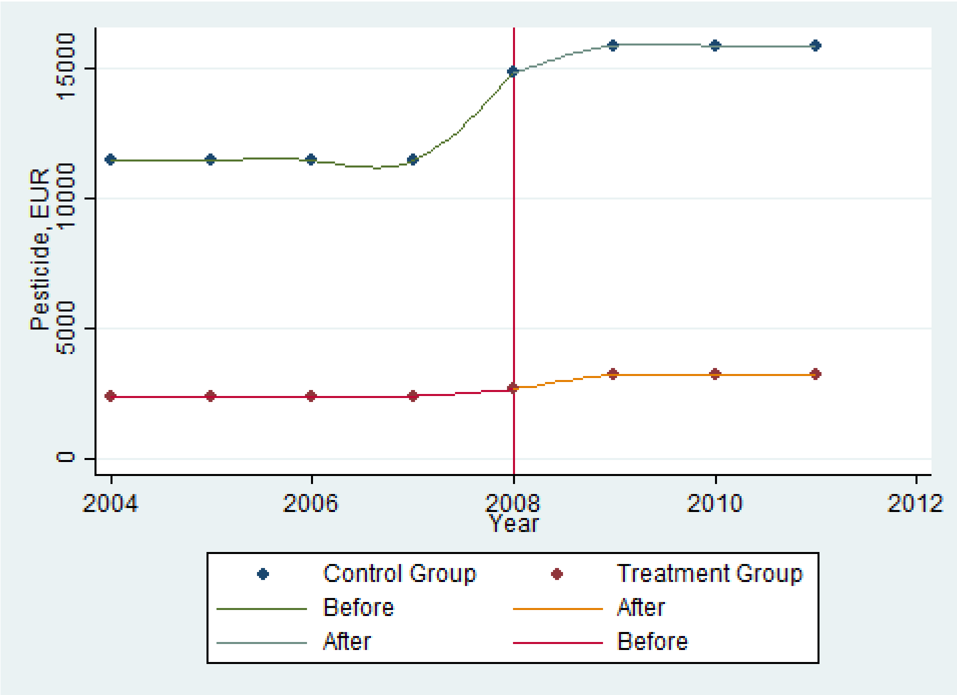

Figure 7. Parallel trend for pesticide

Appendix D. Triple DD results

Table D1

Triple DD estimator on fertilisers and pesticide, *Pillar One dependency*

Variables	Fertiliser		Pesticide	
	(Model 1)	(Model 2)	Model (3)	Model (4)
T	1,096**	1,441**	-5,084***	-4,695***
	(432.1)	(552.1)	(1,350)	(697.8)
Y*T	-440.8**	-504.1***	-3,240***	-3,328***
	(141.3)	(134.5)	(97.91)	(155.1)
Triple DD				
dpr*T*Y	-13,483***	-14,027***	6,538	6,167
	(1,285)	(1,424)	(8,284)	(8,175)
dpr*Y	13,555***	14,073***	-6,440	-6,076
	(1,265)	(1,401)	(8,378)	(8,275)
dpr*T	14,308***	14,971***	770.4	1,140
	(867.5)	(1,111)	(12,368)	(12,302)
dpr	-14,432***	-15,067***	-967.8	-1,326
	(861.5)	(1,096)	(12,507)	(12,437)
Structure controls	Yes	Yes	Yes	Yes
Other controls	-	Yes	-	Yes
Year effects	Yes	Yes	Yes	Yes
Sector indicators	Yes	Yes	Yes	Yes
Country indicators	Yes	Yes	Yes	Yes
Constant	1,045	1,315	8,403***	8,674**
	(692.7)	(738.3)	(2,174)	(2,502)
Observations	16,504	16,504	16,504	16,504
R-squared	0.463	0.479	0.408	0.412

Robust standard errors in parentheses, clustered at region level. *** p<0.01, ** p<0.05, * p<0.1, where model 4 and 8, as in the baseline model, are excluded as dpr is included in all models here.