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Regulatory Impact on Corn Farming

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Abstract

As part of a cooperative agreement with the United States Department of Agriculture (USDA), the George Washington University Regulatory Studies Center produced a five-chapter report on regulatory differences between the United States (U.S.) and the European Union (EU) and their effects on agricultural production and productivity. Those chapters are published here as a working paper series with five parts. This chapter examines the impact of environmental and food safety regulations on corn production in the U.S. and EU. We provide quantitative estimates for differences in farm-level outcomes that result from different regulatory requirements between jurisdictions. The chapter begins by identifying and discussing regulations affecting corn production and proceeds to estimate the economic impact of each regulation at the farm level. We selected France and Spain as case studies to illustrate the differences that result from EU member states' translation and implementation of agricultural regulations at the country level. Our use of a typical farm approach is meant to demonstrate relative differences in outcomes for

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farms among different jurisdictions rather than provide an exhaustive list of the costs facing a representative corn farm within any particular geographic region.

This chapter does not include a detailed discussion of either the effects of regulation on agriculture or the institutional differences in regulatory systems between the U.S. and EU. These aspects are addressed in Chapter 2: Agricultural Productivity and the Impact of Regulation and Chapter 3: Translantic Approaches to Agriculture Policy.

Background

Corn is a major crop grown in the U.S., Spain, and France. In 2014, overall production in the U.S. was 397 million tons compared to 84 million tons in the EU.[3,4] At the country level, France produced 20 million tons compared to 5 million tons produced in Spain.[5] Although the EU produces less corn than the U.S., both jurisdictions have similar yields per acre. Figure 1 below illustrates yields in each country between 2004 and 2014. As of 2014, the yield per acre was 171 bushels in the U.S., 160 bushels in France and 182 bushels in Spain.

France and Spain are selected because the two neighboring countries are among the highest corn producing countries in the EU (Figure 2),[6] while having distinct biotechnology regulations and agri-environmental measures. France is opposed to cultivation of genetically modified (GM) crops and closely regulates many agri-environmental practices. The intensive use of pesticides in France is an exception, although it is worth noting that France is currently implementing a comprehensive plan aimed at reducing its pesticide use by 2018. Interestingly, Spain is the EU's top grower of GM corn, with approximately 30% of its corn cultivation area planted with *Bacillus thuringiensis* (Bt) corn[7] in 2013.[8] Most other member states, including France, have banned GM crop cultivation. See Chapter 3 of this report for an extensive overview of regulatory practices in the U.S. and EU.

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3 All European units are converted to U.S. units in this chapter. The following conversions are used throughout this chapter: 1 hectare = 2.47 acres; 1 tonne = 1.1023 ton = 39.368 bushels; €1 = $1.3350 (2011-2013 average exchange rate).

4 FAOSTAT. *Food and Agriculture Organization of the United Nations.* June 13, 2016. http://www.fao.org/faostat/en/#data/GT (accessed December 9, 2016).

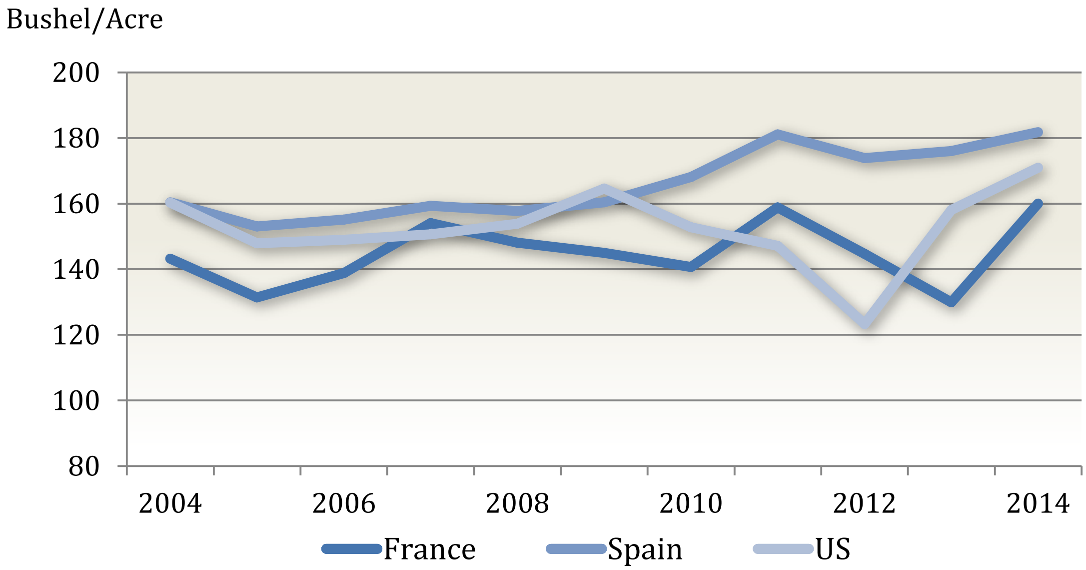
5 *Ibid*

6 *Ibid*

7 A type of genetically modified corn that is resistant to certain insect pests.

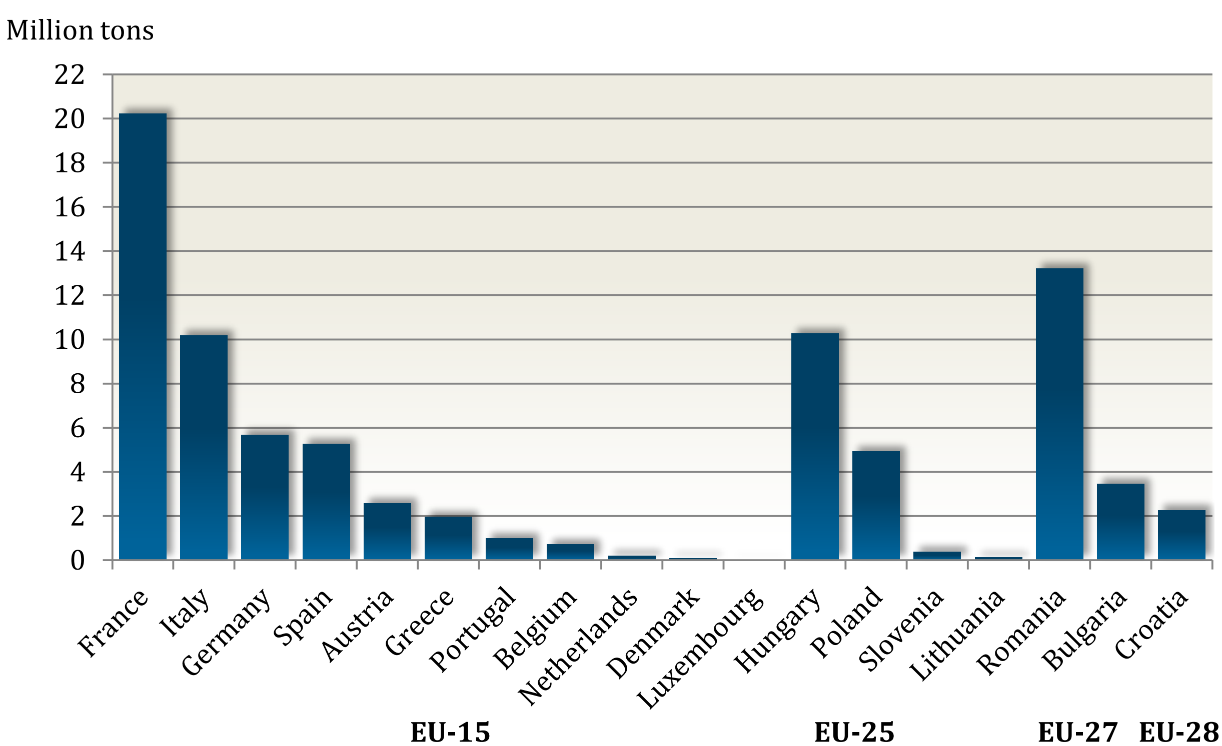
8 USDA FAS. *EU-28 Grain and Feed Annual 2015.* GAIN Report, Washington, DC: USDA Foreign Agricultural Service, 2015.

Figure 1: Corn Yield, 2004-2014



Source: Figure created by the authors based on data from FAOSTAT (2016)

Figure 2: EU Member States Corn Production Quantity, 2014



Source: Figure created by the authors based on data from FAOSTAT (2016)

The rest of this chapter proceeds as follows: it begins by detailing the scope and methodology used in this study with an emphasis on describing the steps we took to estimate the impact of regulations on corn production. It explains our focus on a typical farm approach[9] for calculating the regulatory impact for each farm. It then presents a list of the relevant regulations within each country and looks at their operational requirements at the farm level. Based on that, regulatory impacts are quantified in terms of private costs and benefits that result from the identified regulations on corn farms. Finally, estimated regulatory costs are compared across the three countries to assess the regulatory burden in each country.

Scope and Methodology

Scope

This chapter estimates the economic impact of environmental and food safety regulations affecting corn farmers in the U.S., France, and Spain. It quantifies the incremental private regulatory costs and benefits incurred by corn farmers in each country using partial budgeting principles. Private costs include cost increases and reduced income resulting from compliance with regulations while private benefits include increases in income and reductions in production costs. Due to data limitations, social welfare impacts such as benefits to public safety and the environment are not quantified in the study but are discussed in qualitative terms in subsequent sections.

Environmental and food safety regulations affecting corn farming are identified in a manner consistent with Chapter 3 of this report and focus on four categories: genetically modified crops, pesticides, fertilizers, and agri-environmental practices. In assessing the impact of these regulations, only compulsory regulatory requirements from rulemakings are considered. Other forms of regulation such as incentive-based voluntary programs are not included in the analysis.

The study is primarily concerned with U.S. federal and EU-level regulations. Regional regulations at the U.S. state level or EU member state level are taken into account only where responsibility is delegated to these jurisdictions to develop and implement their own regulations. These cases are more prevalent in the EU as member states must often transcribe EU-level directives and implement them at the country level. Additionally, this study confines its scope to

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9 Centro Ricerche Produzioni Animali. “Assessing farmers' cost of compliance with EU legislation in the fields of environment, animal welfare and food safety.” *European Commission*. 2011. http://ec.europa.eu/agriculture/sites/agriculture/files/external-studies/2014/farmer-costs/fulltext_en.pdf (accessed December 30, 2016); Ian Craven & Meyers Norris Penny. *Environmental and Economic Impact Assessments of Environmental Regulations for the Agriculture Sector: A Case Study of Potato Farming.* Agriculture and Agri-Food Canada, 2006.

existing regulations that have been implemented to estimate the actual regulatory impacts on corn farmers' production costs and income. Although recently issued or proposed amendments to several key existing regulations are discussed, only regulations that were in effect during the time period analyzed (2011-2013) are quantified.[10]

As previously noted, we select France and Spain as case studies to reflect variations in regulatory impacts among EU member states. Considering the significant differences in farm structure, geographical conditions, and regulatory environments across countries, "typical farm" cases are developed to reflect the most representative corn farming profile and farm-level regulatory impacts for the U.S., France and Spain. This approach is also appropriate for our comparative analysis of regulatory impacts between countries as it averages out within-country differences that result from subnational variations in regulatory regimes. However, it is worth noting that one limitation of the typical farm approach is that the regulatory impacts estimated in this study may not apply to corn farms with different features, and the findings are not necessarily representative of costs faced by farms within other jurisdictions.

Methodology

As part of the comparison of the regulatory impacts on agricultural production between the U.S. and the EU, this chapter aims to estimate the economic impacts of major environmental and food safety regulations on farmers' corn production in the U.S., France, and Spain. The approach entails five steps.

First, "typical" corn farm cases are developed for the U.S., France, and Spain, and their production costs, revenue, and net farm income are estimated accordingly. A typical corn farm is defined as one that has the country's typical structural features, which is approximated to contain the average number of acres planted, corn yield per acre, corn production, and corn price in the country rather than a specific geographic region. Annual corn production costs and income for a typical corn farm are calculated using data on the average costs and returns from both the USDA Economic Research Service (ERS) and the European Commission. The next section elaborates on this approach.

Second, the set of regulations affecting agricultural production in the U.S. and the EU identified in Chapter 3 of this report is further narrowed to those relevant to corn production in the U.S., France, and Spain. To understand the farm-level impacts of these regulations, specific provisions

[10] Although the 2011-2013 time period contains the most recently available, comparable data across jurisdictions, it is worth noting that the data are not necessarily representative of average productivity or output for a given jurisdiction. For example, 2012 was a drought year for U.S. agriculture. Therefore, certain data used within our calculations, such as corn yields, are lower relative to historical averages.

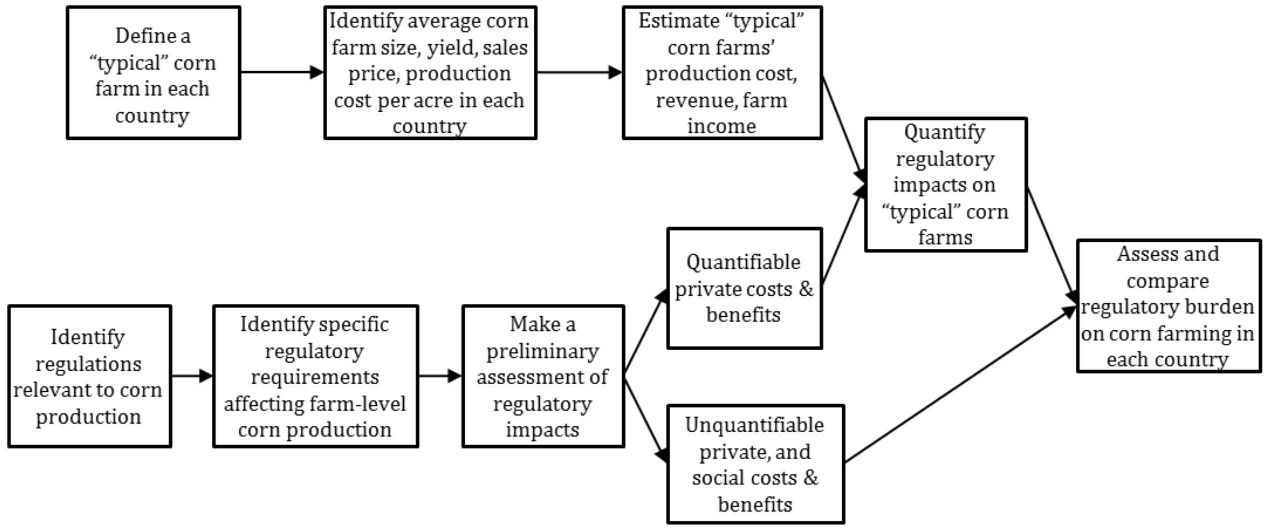
and programs that affect farmers' corn production are identified under each regulation. Those provisions and programs are then translated into operational requirements at the farm level, that is, specific measures that corn farmers need to take in order to fully comply with the corresponding regulatory requirements.

Third, a preliminary assessment of the economic impact of each operational requirement on farmers' corn production is conducted. Specifically, we assess whether a requirement incurs incremental private costs and/or benefits to farmers' corn production and compare this to a baseline scenario—which we define to be the absence of a regulatory requirement. Wherever empirical studies are not available for estimating the *ex post* costs of regulatory requirements, agency regulatory impact analyses (RIAs in the U.S.) and impact assessment (IAs in the EU) are used.

Fourth, the incremental private costs and benefits are quantified, whenever possible, for each regulatory requirement. As a result, total annual regulatory costs and benefits for a typical corn farm are calculated for the U.S, France, and Spain. Data for these calculations are derived from various sources, including agency RIAs, IAs, peer-reviewed studies, government websites, and other publicly available data. Several assumptions are necessary wherever sufficient public information is not available; these are discussed below. Due to the variation in existing estimates and assumptions, a sensitivity analysis is conducted to see how estimates might vary given different values. Although most regulatory costs are estimated, many private benefits are difficult to quantify, partly due to data limitations. As noted above, social costs and benefits are not estimated.

Finally, a comparative analysis is conducted to estimate the cumulative impact of regulations on each typical corn farm's production costs and net income. This provides the basis for an evaluation and comparison of the regulatory burden at the farm level in each country.

Figure 3: Study Approach



A Typical Corn Farm Approach

The study uses a typical farm approach to analyze the impact of regulations. A typical farm for corn production is defined based on the planted area, total production, yield per acre, and corn price. This section elaborates on the method used to identify typical corn farms in the U.S., France, and Spain. The process of defining a typical corn farm involves two steps: (i) determining typical structural features; and (ii) establishing production costs and income per farm. Data used are derived from USDA ERS databases and the EU's Farm Accountancy Data Network (FADN).

Typical Corn Farm Profile

The U.S. and EU use different measurement standards for farm accountancy data. To employ a typical corn farm approach, a comparable unit of analysis is developed for both jurisdictions. For example, the area harvested in the U.S is measured in acres whereas in the EU it is in hectares; corn production is weighed in bushels in the U.S. and tonnes in the EU. Even within each country, there is variation in the farm size and geographical areas that produce corn.

First, information on structural features is identified for corn farms. Data specific to corn production are available only for certain years. The study relies on the EU's Cereal Farms Report based on FADN data[11] and the USDA ERS' Commodity Costs and Returns database.[12] Both

[11] EU. *EU Cereal Farms Report: Based on 2013 FADN Data.* Brussels: European Commission Directorate-General for Agriculture and Rural Development, 2016.

sources include national data on corn production up to 2013, which allows for a comparative analysis. National averages over the period of 2011-2013 are used to adjust for weather and other short-term effects. The following statistics are identified for a typical corn farm: corn acres planted per farm, yield per acre, total production, and corn prices at harvest.

Table 1: Profile of Typical Corn Farms (2011-2013 National Averages)

	U.S.	France	Spain
Corn acres planted	280.00	118.31	36.80
Yield per acre (bushel/acre)[13]	140	161	175
Production (bushel)	39,200	18,975	6,430
Corn price at harvest ($/bushel)	5.71	6.26	6.80

Source: Table created by the authors based on data from ERS (2016) and EU (2016)

Table 1 shows that the U.S. has the largest corn farm size, while the average corn yield per acre was relatively lower than France and Spain during 2011-2013; Spain has the highest yields and the smallest farm size during this time period. Corn prices are relatively higher in the EU countries than in the U.S during this period.

Production Costs

Second, production costs are estimated for typical corn farms. Production costs include input costs, operating costs, and capital costs for farming. These are costs directly incurred by farmers. Only direct costs are included in the assessment with the assumption that indirect costs of regulations are already absorbed in the costs borne by farmers. For example, fertilizer costs paid by farmers account for regulatory costs incurred by other supply chain actors such as fertilizer manufacturers or retailers. The costs included in the analysis are:

- Input costs: seed, fertilizer, water, and chemicals;

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[12] ERS. *Commodity Costs and Returns.* October 3, 2016. https://www.ers.usda.gov/data-products/commodity-costs-and-returns/commodity-costs-and-returns/#Recent Costs and Returns: Corn (accessed December 30, 2016).

[13] Corn yields during the analyzed time window (2011-2013) may not reflect typical U.S. productivity, since 2012 was a drought year for U.S. agriculture. Due to the higher average temperatures and lower average precipitation rates during the growing season, corn yields were lower relative to historical averages in the U.S. in 2012 (118 bushel/acre). For example, when considering a ten-year average (2004-2013), U.S. corn yield is estimated at 153 bushel/acre while yields for 2014 were estimated at 171 bushel/acre (ERS, 2016). Corn yields can vary substantially from year to year due to forces that are exogenous to the impact of regulations. Ultimately, our analysis is meant to contrast how different regulatory approaches can affect agriculture rather than derive estimates that control for such exogenous effects.

- Operating costs: custom operations,[14] fuel, electricity, labor, repairs, insurance, taxes, and general overhead;
- Capital costs: depreciation and interest received on operating capital.

The average production costs per acre from 2011 to 2013 are identified in the U.S., France, and Spain, based on data from the EU's report and USDA ERS database. The following table provides a breakdown of costs in each country.

Table 2: National Average Corn Production Costs for 2011-2013

Costs	U.S.	France	Spain
Input costs ($ per acre)	**271**	**346**	**339**
Seed	91.33	89.90	115.84
Fertilizer	152.40	171.51	131.88
Chemicals/crop protection	27.48	67.74	40.72
Water	0.11	16.76	47.20
Other specific costs	0	0.54	3.42
Operating costs ($ per acre)	**106**	**375**	**241**
Custom operations*	17.20	94.40	37.47
Fuel, lubricant, and electricity	31.77	86.12	109.18
Repairs	25.35	67.74	28.65
Hired labor	3.02	23.24	36.03
Taxes, Insurance and general overhead	28.24	103.41	29.55
Capital costs ($ per acre)	**94**	**213**	**92**
Interest on operating capital	0.19	23.60	7.75
Capital recovery of machinery and equipment	93.50	189.89	83.78
TOTAL	**471**	**935**	**671**

Subtotals and totals are rounded to dollar.

Source: Table created by the authors based on data from ERS (2016) and EU (2016)

[14] Custom operations are farm work completed by others, often referred to as "custom farm work" or, more simply, "custom work."

Data reveal that the average cost of production in the U.S., France, and Spain is approximately $471, $935, and $671 per acre, respectively. The variation in costs between France and Spain is primarily due to differences in the cost of fertilizer, pesticide, machines/repair, other farming overhead, and capital recovery of machinery and equipment. Seed costs are higher in Spain than in France—likely in part due to Spain's use of GM seeds. Also because the majority of Spanish corn is mostly grown under irrigation, costs for water and electricity are higher in Spain.

The data on average production costs and corn farm profiles are used to estimate costs and income for a typical corn farm in the U.S., France, and Spain. Production costs are calculated for the typical corn farm in each country using data on average corn acres planted. In addition, estimates for revenue and net farm income from corn production are calculated based on production per farm and corn prices. The costs and income do not include any government payments (e.g. subsidies). It is reasonable to assume that the above production costs and revenue at the farm level incorporate regulatory impacts. Corn production costs, revenue, and net income for a typical corn farm are estimated respectively for each country (Table 3). The costs do not include land and rental prices, which may represent a significant portion of the overall costs.

Table 3: Annual corn production costs and income for a typical corn farm (2011-2013 averages)

	U.S.	France	Spain
Total Costs ($ per farm)	**131,766**	**110,603**	**24,710**
Input Costs	75,971	40,989	12,478
Operating Costs	29,563	44,356	8,864
Capital Costs	26,232	25,258	3,368
Revenue ($ per farm)	**223,832**	**118,784**	**43,724**
Net Farm Income ($ per farm)	**92,066**	**8,180**	**19,014**

Source: Table created by the authors based on data from ERS (2016) and EU (2016)[15]

Regulations Affecting Corn Farming

This section describes the major regulatory requirements related to genetically modified crops, pesticides, fertilizers, and agri-environmental practices and their impacts on corn farming in the U.S., France, and Spain. Since France and Spain are subject to many of the same EU-level regulations, the following discussion is primarily divided between the U.S. and the EU. However, regulatory impacts in France and Spain are assessed separately whenever there are substantive differences between the two countries.

[15] These figures do not include land or rental costs.

United States

Genetically Modified Crops

1. Introduction of GM Crops

Authorized by the Plant Protection Act (PPA), USDA's Animal and Plant Health Inspection Service (APHIS) regulates the introduction of genetically modified organisms (GMOs) that may pose a pest risk to plants under the regulations at 7 CFR Part 340. Importation, interstate movement, and release into the environment of certain GMOs defined in 7 CFR Part 340 require an authorization by APHIS through either permitting or notification.GM corn varieties that have received a determination of non-regulated status following APHIS regulatory review are no longer regulated under 7 CFR part 340. GM corn containing plant incorporated protectants (pesticides or PIPs) are subject to EPA regulations even after deregulation by APHIS. The costs associated with the current regulatory process are borne by the developers of GMO during the approval process. Therefore, the assumption is that the introduction/release of GMO regulations does not generate direct incremental costs or benefits compared to the baseline since they do not constitute a change of operational requirements for compliance at the farm level. A more detailed description of our methodology including our assumptions concerning baseline estimates is provided on page four.

2. Premarket Approval of Food Additives

The food additive provisions of section 409 in the Federal Food, Drug, and Cosmetic Act (FFDCA) require premarket approval of food additives by the Food and Drug Administration (FDA) unless they are "generally recognized as safe." Substances that are intentionally added to or modified in food via genetic engineering are also defined as food additives. The FDA provided guidance to industry on getting a GMO food to market; developers voluntarily submit food and feed assessments. Prior to commercialization, GMO foods are approved. However, such substances to date have been proteins and fats that are considered "substantially equivalent to" non-GMOs, and thus have not been subject to the premarket approval requirement.[16]As GM modifications to date have been considered to be Generally Regarded as Safe (GRAS) and not to be food additives under the FFDCA premarket approval process, no incremental costs or benefits are incurred over the baseline of no regulation.

[16] Landa, Michael M. "FDA's Regulatory Program for Genetically Engineered (GE) Food." *U.S. Food and Drug Administration.* December 10, 2014. http://www.fda.gov/NewsEvents/Testimony/ucm426541.htm (accessed November 7, 2016).

3. Insect Resistance Management

Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Environmental Protection Agency (EPA) requires insect resistance management (IRM) for *Bt* corn. One of the requirements is to plant and manage a 20% non-*Bt* corn refuge if *Bt* corn is grown.[17] It specifies the configuration of this refuge and prescribes methods for the use of non-*Bt* insecticide treatments on refuge corn. However, these requirements do not directly apply to corn farmers; there is an existing agreement between EPA and private companies that register and/or supply *Bt* corn traits. These companies are obligated to educate and oversee farmers' implementation of appropriate IRM practices including use of a refuge.

Requirements for IRM practices changed during the time period examined (2010 – 2013). The EPA required refuge requirements to be printed on the seed bag label in 2010 so that it was included on 50% of all bags in 2012 and 100% by 2013.[18] In addition, EPA required that all Bt corn registrations by monitored by independent, third-parties who conduct on-farm assessments.

While insect resistance management is known to be beneficial for long-term productivity improvement, survey results show that farmers would not implement a refuge in the absence of regulatory requirements.[19] Assuming that as the baseline, the refuge requirements generate both costs and benefits to corn farmers. Studies indicate that higher labor costs and lost yield due to acreage and configuration requirements lead to increased compliance costs.[20] The private benefits are mostly experienced in the long term as a result of less insect resistance leading to increased productivity. Reducing insect resistance allows certain active ingredients or biotechnological modifications to remain effective. Without appropriate insect resistance management, farmers could face risks of up to 100% yield losses as well as substantial quality losses that lead to rejection or downgrading of their harvest. Those avoided losses result in likely result in substantial long-term benefits for farmers as a result of compliance with the regulation. Additionally, there might also be immediate private benefits such as savings in seed costs.

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[17] This requirement applied during the time period examined (2010-2013). Currently, there are additional options allowing farmers to remain in compliance.

[18] EPA. *Biopeticides Registration Action Document: Optimum AcreMax™ B.t. Corn Seed Blends*. Washington, D.C.: U.S. Environmental Protection Agency, 2010.

[19] Alexander, Corinne. "Insect Resistance Management Plans: The Farmers' Perspective." *AgBioForum* 10, no. 1 (2007): 33-43.

[20] Hurley, Terrance M., Ines Langrock, and Ken Ostlie. "Estimating the Benefits of Bt Corn and Cost of Insect Resistence Management Ex Ante." *Journal of Agricultural and Resource Economics* 31, no. 2 (2006): 355-375; Hyde, Jeffrey, Marshall A. Martin, Paul V. Preckel, Craig L. Dobbins, and C. Richard Edwards. "The Economics of Within-Field Bt Corn Refuges." *AgBioForum* 3, no. 1 (2000): 63-68.

Pesticides

1. Registration of pesticides

FIFRA covers the majority of regulations related to pesticides, which begins with their registration. Section 3 of FIFRA requires that EPA register all pesticides before they are sold or distributed in the U.S. While complying with FIFRA is a requirement for pesticide registrants and distributors, farmers can be significantly affected if a commonly used pesticide product is cancelled or its uses modified by EPA. The U.S. has cancelled (or limited the use of) pesticide historically used in corn production (e.g. Carbofuran). However, to illustrate major differences in pesticide bans between the U.S. and the EU countries, only the three most prevalent pesticide substances used in corn production are examined in this study; these are: atrazine, glyphosate, and lambda-cyhalothrin. To date, the use of all three pesticides is permitted at the federal level, but many pesticide products containing atrazine and lambda-cyhalothrin are classified as "restricted use" pesticides which require application by or under the direct supervision of a certified pesticide applicator with special training on the use of these pesticides.[21] The registration process may increase corn farmers' pesticide costs as it increases pesticide prices. However, these costs are not significant since the three major pesticide substances for corn production are not banned in the U.S. A regulatory impact analysis issued by EPA estimated that the total cost for farmers was negligible.[22] There are no incremental benefits because corn farmers would still have unrestricted access to these pesticides in the baseline scenario.

2. Certification of pesticide applicators

Pesticides are generally classified as restricted use pesticides (RUPs) or general use pesticides by EPA. While general use pesticides are available to the general public, RUPs can only be used by or under the direct supervision of a certified pesticide applicator, in accordance with section 11 of FIFRA. Certification can be obtained through training and/or exams via certification programs established by states and approved by EPA, while specific hours and fees needed for training and/or exams vary by state.[23]

Twenty-nine states currently have additional supervision standards such as training for noncertified application working under the supervision and communication between application

[21] EPA. "Restricted Use Products (RUP) Report." *U.S. Environmental Protection Agency*. January 19, 2016. https://www.epa.gov/pesticide-worker-safety/restricted-use-products-rup-report (accessed Janaury 28, 2017).

[22] EPA. *Regulatory Impact Analysis: Data Requirements for Registering Pesticides under the Federal Insecticide, Fungicide and Rodenticide Act.* Washington, D.C.: U.S. Environmental Protection Agency, 1982.

[23] EPA. *Economic Analysis of Proposed Amendments to 40 CFR Part 171: Certification of Pesticide Applicators.* Washington, DC: U.S. Environmental Protection Agency, 2015.

worker and supervisor.[24] However, assessment of the impacts of these additional state requirements is beyond the scope of this analysis. It is worth noting that a revision to the Certification of Pesticide Applicators rule was finalized by EPA on January 4, 2017 to enhance federal requirements for certification and supervision. This rule is expected to have a significant impact on farms but is not included here because it falls outside the temporal scope of our analysis. On June 2, 2017, EPA delayed the effective date of this rule until May 22, 2018.[25]

As mentioned above, many pesticide products containing atrazine and lambda-cyhalothrin are classified as RUPs in the U.S. Therefore, it is likely that a typical corn farm in the U.S. uses RUPs and requires certification of pesticide applicators. The private costs of obtaining the certification include certification fees and time spent on required training and/or exams. In terms of private benefits, the certification process may to lead to improved efficiency of pesticide use and thus reduce overall costs for corn farmers.

3. Storage of pesticides

Under FIFRA, EPA regulates the storage of pesticides[26] to prevent potential hazards to the environment and public health. Specific requirements for pesticide users are shown on pesticide labels, and farmers are required to store pesticides in a manner consistent with their labeling. For example, label restrictions usually require storing pesticides in a locked storage area such as a pesticide cabinet.

While farmers may store pesticides in different ways depending on the amount of pesticides they hold on-hand, this analysis assumes that a typical corn farm in the U.S. stores a moderate amount of pesticides, requiring it to secure an appropriate storage area. Meanwhile, there should be minor private benefits from lower medical expenses and insurance premiums due to increased safety from the use of pesticide storage.

4. Agricultural Worker Protection Standard

Under the authority of FIFRA, EPA established the Agricultural Worker Protection Standard (WPS) in 1992[27] to protect agricultural workers and handlers from potential pesticide exposure. The WPS requirements consist of three elements: training, protection, and mitigation. Specifically, the WPS requires farmers to train workers and handlers about pesticide safety, set

[24] *Ibid*

[25] EPA. *Pesticides: Certification of Pesticide Applicators; Delay of Effective Date.* Washington, DC: U.S. Environmental Protection Agency, 2017.

[26] 40 CFR Part 156 and 165

[27] 40 CFR part 170

up protective equipment and restricted entry intervals following pesticide applications, and conduct mitigation measures to safeguard against pesticide exposures. In 2015, EPA issued a final rule revising the 1992 WPS which took effect on January 1, 2016.

EPA's economic analysis of the revised WPS indicates that the 1992 WPS created compliance costs for farmers.[28] The revised WPS is expected to further increase these costs, but it is not included in this analysis as it had not been implemented during our reference period. EPA estimates substantial private and social benefits from the WPS, including fewer time losses, lower medical expenses, and changes in insurance premiums.[29]

5. *Recordkeeping of pesticide use*

Under FIFRA, states have broad authority to regulate pesticides including recordkeeping of pesticide applications. However, state regulations do not necessarily apply to farmers who are considered private pesticide applicators. For example, Iowa – one of the top corn producing states in the U.S. – requires commercial applicators to keep records of all pesticide applications for 3 years, but does not impose these requirements on private applicators.[30] In such cases, the Federal Pesticide Recordkeeping Program[31] applies to private applicators. The program is administered by USDA's Agricultural Marketing Service (AMS) and was authorized by the 1990 Farm Bill. It requires certified private pesticide applicators to keep records of applications of RUPs for 2 years. Specific items that are required to be recorded include the product name, EPA registration number, total quantity of the pesticide applied, date, and location, to name a few.

Either the state recordkeeping requirement or the Federal Pesticide Recordkeeping Program is likely to impose minor costs to corn farmers due to their time spent on recordkeeping. There may be minor private benefits as well due to monitoring the use of pesticide

6. *Disposal of pesticides*

While FIFRA covers the registration, sale, storage, application, and several other issues related to the use of pesticides, disposal of pesticides is regulated by the Resource Conservation and Recovery Act (RCRA). Specifically, farmers are required to dispose of excess/unwanted

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[28] EPA. *Economic Analysis of the Proposed Agricultural Worker Protection Standard Revisions.* Washington, DC: U.S. Environmental Protection Agency, 2014.

[29] *Ibid*

[30] Iowa Agriculture and Land Stewardship Department. "Iowa Administrative Code - 02/05/2014." *The Iowa Legislature.* February 5, 2014. https://www.legis.iowa.gov/law/administrativeRules/rules?agency=21&chapter=45&pubDate=02-05-2014 (accessed November 8, 2016).

[31] 7 CFR Part 110

pesticides through states' pesticide disposal programs, which are often referred to as "Clean Sweep" programs. While specific requirements vary by state, most states collect excess pesticides at specified facilities or events for free of charge.[32] As for the disposal of pesticide containers, farmers are generally required to recycle empty containers at state specified collection sites after triple rinsing or pressure rinsing, in accordance with the instructions on pesticide labels.[33]

Private costs incurred to corn farmers mostly come from two aspects of the disposal requirements: time spent on the disposal procedure and fees required for disposal. While the collection of excess pesticides or empty pesticide containers is free of charge, rinsing and transporting them to an appropriate facility can generate costs to farmers. Therefore in assessing the impact on a typical corn farm, it is assumed that private costs are primarily incurred by the time spent on rinsing and transportation. Additionally, there may be social benefits to the environment and public health because of decreased hazards from pesticide wastes but no direct private benefits to corn farmers.

7. Pesticide tolerances

Under the authority of Section 408 of FFDCA, EPA establishes tolerances for the maximum amount of pesticide residues allowed to remain in or on a food consumed in the United States (40 CFR Part 180). FDA is responsible for the enforcement of tolerances for raw agricultural commodities. For example, tolerances for the three primary pesticide substances used on corn are glyphosate (0.1 mg/kg), atrazine (0.2 mg/kg), and lambda-cyhalothrin (0.05 mg/kg).

While corn farmers are subject to tolerances, they typically do not need to implement additional practices for compliance as long as they follow the instructions on pesticide labels and use proper equipment. Further, since the majority of corn produced in the U.S. is not for direct human consumption, the impact of tolerances is also limited for corn farming. Thus the tolerance requirement does not impose incremental costs on corn farmers. There are possibly social benefits for public health, but few private benefits for corn farmers.

Fertilizers

The registration, labeling, sale, and handling of fertilizers are mostly regulated at the state level, and the use of fertilizers in agriculture is typically governed through nutrient management plans

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[32] EPA. "Requirements for Pesticide Disposal." *United States Environmental Protection Agency*. June 17, 2016. https://www.epa.gov/pesticide-worker-safety/requirements-pesticide-disposal (accessed January 28, 2017).

[33] *Ibid*

which are primarily implemented in the form of incentive-based voluntary programs.[34] Therefore for the purpose of this study, no regulations on fertilizers are examined. EU-level fertilizer regulations are discussed further—qualitatively—but are excluded within our final quantitative cost estimates.

Agri-Environmental Practices

While agriculture is considered a source of pollution in both water and air, agricultural activities are generally exempt from federal-level water quality regulations. There are three regulatory programs that are relevant to farmers' corn production.

1. NPDES Pesticide General Permit

Pursuant to section 402 of the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) is a program that regulates point sources that discharge pollutants to waters of the U.S. Issued by EPA in 2011, the NPDES Pesticide General Permit (PGP) covers point source discharges of biological or chemical pesticides. Farms applying pesticides that will lead to a discharge to U.S. waters as defined in Appendix A of the permit are subject to the program and must apply for a PGP from EPA or authorized states. Furthermore, entities that apply pesticides in excess of the annual treatment area thresholds defined in the PGP are required to implement integrated pest management (IPM) practices to reduce pesticide use. For example, an entity must implement IPM practices if it applies pesticides for weed and algae pest control on more than 20 linear miles or 80 acres of water within a calendar year.[35]

For certain farms with point sources discharges to water, the NPDES PGPs are likely to generate significant costs. According to EPA's economic analysis of the PGP, the potential costs affecting farmers are primarily administrative and monitoring costs, including time spent on submitting a Notice of Intent, producing a pesticide discharge management plan, recordkeeping, reporting, and site monitoring.[36] The PGP requirement, with its aim to control pollutant discharges to water, is likely to generate significant social benefits to the environment. However, since a very limited number of corn farms are subject to PGPs,[37] the regulatory requirement is excluded in the following quantitative analysis.

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[34] For details on a comprehensive list of regulations on fertilizers, please refer to chapter 4 of this report.

[35] EPA. "EPA's 2011 Pesticide General Permit." *U.S. Environmental Protection Agency.* October 31, 2011. https://www.epa.gov/npdes/epas-2011-pesticide-general-permit-pgp-documents.

[36] EPA. *Economic Analysis of the Pesticide General Permit (PGP) for Point Source Discharges from the Application of Pesticides.* Washington, D.C.: U.S. Environmental Protection Agency, 2010.

[37] ERS staff, personal communication, January 24, 2017

2. Endangered Species Protection Program

EPA implements the Endangered Species Protection Program (ESPP) under FIFRA in compliance with the Endangered Species Act (ESA) to ensure that pesticide use does not affect any threatened or endangered species or their habitats. The program sets pesticide use limitations in certain areas and for certain time periods. Specific limitations are described in the Endangered Species Protection Bulletins, including application areas, pesticide products, and time periods. Farmers are directed to the Bulletin by relevant information referenced on pesticide labels.

ESPP has the potential to significantly impact farms using certain pesticide products in specific areas during certain periods. It is reasonable to assume that only a small proportion of corn farms are currently subject to the ESPP restrictions. Although this analysis attempts to make conservative assumptions with respect to regulatory costs, there has been no assessment or quantification of the impact of ESPP on farms' production costs or income. Therefore, this analysis may underestimate the costs associated with ESPP. As with other agri-environmental regulations, ESPP may lead to welfare benefits by conserving the environment but not to any private benefits for corn farmers.

3. Conservation Compliance

Conservation compliance, including the Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) provisions,[38] serves as a prerequisite for farmers to participate in many USDA voluntary programs including loans and disaster assistance payments, conservation program benefits, and federal crop insurance premium subsidies. To comply with the HELC and WC provisions, farmers must not "plant or produce an agricultural commodity on highly erodible land without following a USDA Natural Resources Conservation Service (NRCS) approved conservation plan or system; plant or produce an agricultural commodity on a former wetland; or convert a wetland which makes the production of an agricultural commodity possible."[39] Noncompliance may cause farmers to lose their eligibility for the aforementioned benefits.

Costs due to HELC are primarily the costs of implementing a conservation plan or system, which may include conservation cropping practices, conservation tillage, and crop residue use.[40] The

[38] 7 CFR Part 12

[39] NRCS. *Highly Erodible Land Conservation Compliance Provisions.* 2016. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/alphabetical/camr/?cid=nrcs143_008440 (accessed November 10, 2016).

[40] Heimlich, Ralph E., Roger Claassen, Paul Johnston, Mark A. Peters, and Dwight Gadsby. *Implementation of Conservation Compliance Provisions: Experience in the U.S. with Highly Erodible Land and Wetlands Conservation.* October 5-7, 2000. http://aceheimlich.com/EUcommissionpaper.pdf (accessed November 14, 2016).

estimates of compliance costs in prior studies are mixed, while some show that the per-acre cost for treatment of highly erodible cropland is considerable for farmers.[41] The benefits of conservation systems may include long-term productivity growth and social benefits to the environment due to reduced rates of soil erosion. The impact of the WC provision for a typical corn farm is relatively limited, as long as farmers do not produce crops on converted wetlands or convert a wetland to an agricultural land.

Nevertheless, compliance with the HELC and WC provisions is flexible and mostly reimbursed. Farmers may choose to enroll in a USDA voluntary program (e.g. Conservation Reserve Program) that provides resources and compensation to restore and protect HEL or wetlands.[42] Given that the farm income estimates for typical corn farms do not include any government payments, these additional private benefits are not taken into account in this analysis.

European Union

Genetically Engineered Crops

1. *Authorization of release of GMOs*

Directive 2001/18/EC on the deliberate release of GMOs (Article 5 and 6) mandates member states to take steps to ensure safety to human health and the environment before placing GMOs on the market. According to the rule, member states are required to introduce national laws to regulate GMO products on the market. The EU directive establishes common requirements for conducting risk assessments, reviewing applications from organizations, and submitting GMO applications to the European Commission. The overall purpose of this regulation is to ensure that legal requirements for GMOs are similar across member states.

GMOs used to produce food and feed must also be authorized by member states under Regulation (EC) 1829/2003. The scope of this regulation covers "(i) GMOs for food use; (ii) food containing or consisting of GMOs; and (iii) food produced from or containing ingredients

[41] Govindasamy, Ramu, and Mark J. Cochran. "The Conservation Compliance Program and Best Management Practices: An IntegratedApproach for Economic Analysis." *Review of Agricultural Economics* 17, no. 3 (1995): 369-381; Barbarika, Jr., Alexander, and Michael R. Dicks. "Estimating the Costs of Conservation Compliance." *The Journal of Agricultural Economics Research* 40, no. 3 (1988): 12-20.

[42] USDA. *Wetland Conservation Compliance.* October 30, 2014. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwj2lM33lanQAhVG34MKHT6IBHwQFggbMAA&url=http%3A%2F%2Fwww.nrcs.usda.gov%2Fwps%2FPA_NRCSConsumption%2Fdownload%3Fcid%3Dstelprdb1260881%26ext%3Dpdf&usg=AFQjCNFK5pOYKOnDfI (accessed November 14, 2016).

produced from GMOs".[43] The regulation describes the role of member states and the European Union, identifies required GMO risk-assessment documents, and sets the time frame for authorizing GMOs. Upon receiving an application from a producer of GMOs, the member-state coordinates with the European Commission and the European Food Safety Authority for EU level authorization.

This regulation does not have a direct impact on farmers as the rules are applicable to manufacturers of GMOs and member-states themselves. Manufacturers are responsible for requesting permission to place GM products on the market. It is worth noting here that although we estimate no direct effect on farmers there may be substantial impacts in the form of opportunity costs and other costs not directly related to operational, farm level requirements for compliance—which are generally omitted from our analysis.

2. *Prohibition of GM crop cultivation*

The EU authorizes which GMOs are allowed to be placed on the market for cultivation under a common framework. However, in 2015, the European Commission established that cultivation of GMOs requires more flexibility to align with local agricultural practices. Directive (EU) 2015/412 was passed to enable member states to restrict or prohibit the cultivation of GMOs in their respective territories, even if these GMOs have been approved at the EU-level. Thus far, nineteen EU member countries have restricted GMO authorization.[44] Earlier, member states could use the safeguard clause in Directive 2001/18/EC to restrict GMO cultivation but they had to demonstrate that GMO cultivation posed human and environmental safety concerns. In France, cultivation of GM corn has been banned since 2008. Three decrees were successively released by the Government and cancelled by the Supreme Court between 2007 and 2014; then a law was passed in June 2014.[45] Since 2015, France has prohibited GMO cultivation under the new directive. Spain, on the other hand, continues to grow GM corn.

Corn is the only GM crop authorized for cultivation by the EU. Therefore, a prohibition on GMO cultivation can have a negative impact on farmers who may lose the benefits[46] of planting GM

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43 EU. *Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetially modified food and feed.* October 18, 2003. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:268:0001:0023:EN:PDF (accessed January 04, 2017).

44 European Commission. "Restrictions of geographical scope of GMO applications/authorisations: Member States demands and outcomes." *European Commission.* January 4, 2017. http://ec.europa.eu/food/plant/gmo/authorisation/cultivation/geographical_scope_en (accessed January 4, 2017).

45 https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000029035842&categorieLien=id

46 There may be several lost indirect benefits as a result of GM crop prohibition. For example, there is evidence suggesting that glyphosate-tolerant crops complement conservation tillage; thus, a ban on GM corn cultivation

crops, such as increased yields or reduced use of pesticides. Benefits as a result of GM crop prohibition are estimated to be the lower price of conventional corn seeds relative to GM seeds.

3. *GM traceability and labeling*

The EU emphasizes traceability and labeling of GMO products. Under Article 5 of Regulation (EC) 1830/2003, all producers and suppliers of GMOs have to print certain information on their product. In particular, farmers are required to identify products that contain GMOs and include a unique identifier, assigned by the EU. Farmers have to pass the information in writing to GMO product handlers. Similarly, under Articles 12 and 24 of Regulation 1829/2003, products "produced from materials consisting of more than 0.9 percent of GMOs" must be labeled: "This product contains genetically modified organisms [or the name of the GMO]." The regulation is applicable across the EU, and member states must follow similar requirements.

This regulation increases the burden on farmers in Spain that grow GM corn and must segregate GM from non-GM varieties. Minor costs are incurred in terms of resources spent to gather necessary information and to create labels for packaging, while the primary costs for corn farmers come from segregation and storage. Farmers in France are not affected by this regulation since they are prohibited from cultivating GM crops.

It is worth noting here that mandatory labeling of GMOs in the EU has led manufacturers of many food products to reformulate their products away from the use of GM ingredients such that GM labeling requirements are not triggered. This limits markets for EU farmers' GM crops to feed uses, denying higher value markets to GM supply chains. The opportunity cost of this reduced market for EU corn farmers is not included in our in our analysis.

Pesticides

1. *Authorization of pesticides*

Farmers may use pesticides only after the approval of member states according to Regulation (EC) No 1107/2009. Although the European Commission, with inputs from the European Food Safety Authority, provides initial authorization for active substances, member states can restrict the use of certain pesticides. Atrazine, glyphosate, and lambda-cyhalothrin are the three most

could negatively impact other management practices (ERS staff, personal communication, January 24, 2017). However, estimates of these indirect benefits and costs are beyond the scope of this study.

widely-used pesticides for corn production. In 2003, the EU deregistered Atrazine, stating health safety concerns.[47]

Bans on pesticides can have significant impact on farmers, who are forced to identify reasonable substitutes. In the case of atrazine, farmers could experience increased costs of alternative pesticides or decreased yields and changes in production practices or application methods required by using alternatives. Reducing the number of active ingredients available increases the likelihood of resistance developing.

2. *Recordkeeping of pesticide use*

Article 67(1) of Regulation (EC) No 1107/2009 sets forth requirements for keeping records of pesticides used in crop production. Those considered "professional users" of pesticides are obliged to maintain the following information for 3 years: (i) date of use, (ii) full commercial product name, (iii) dosage, (iv) identification of treated plants, (v) identification of areas treated, and (vi) customer identification. At the member-state level, the regulation is applicable to farmers as well; they adhere to the requirements of professional users.[48]

In both France and Spain, farmers spend additional time maintaining pesticide records. This creates costs in terms of hours required for record keeping. Possible private benefits also include reduced medical expenses due to proper use of pesticides.

3. *Certification of pesticide use*

Under Article 5 of Directive 2009/128/EC on the sustainable use of pesticides, member states are required to develop a national plan to contain the use of pesticides according to its priorities.

In France, Ordinance No 2011-1325 is implemented as part of Ecophyto 2018 plan.[49] Training and certification are required for distributors and applicators providing services including, retailers, repackers, and professional users of pesticides. Since 2011, repackers, advisers and professional users (farmers and their staff) must acquire an additional certificate called

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[47] European Commission. "Review report for the active substance atrazine." September 10, 2003. http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.ViewReview&id=108 (accessed January 3, 2017).

[48] Ministry of Agriculture and Fisheries, Food and Environment. *Sustainable use of plant protection products.* 2016. http://www.mapama.gob.es/es/agricultura/temas/sanidad-vegetal/productos-fitosanitarios/uso-sostenible-de-productos-fitosanitarios/ (accessed December 30, 2016).

[49] Ministry of Agriculture, Food, Fisheries, Rural Affairs and Regional Planning. "Decree No. 2011-1325 of 18 October 2011." *Legifrance.* October 18, 2011. https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000024686203&fastPos=1&fastReqId=239567645&categorieLien=id&oldAction=rechTexte (accessed December 30, 2016).

"Certiphyto" for distribution and application of pesticides. Certificates are awarded to those who pass a test or attend training courses. The certificate is valid for 10 years for farmers.

In Spain, Royal Decree (RD) 1311/2012 of 14 September 2012 outlines the requirements for the sustainable use of pesticides.[50] Professional users (including farmers who apply pesticides) need to meet the required training and certification standards. There are four levels of certification: (i) Básico (basic) (ii) Cualificado (skilled) (iii) Fumigador (fumigator) (iv) Piloto Aplicador (for aerial applicator). Training hours vary from 25 hours for Básico to 90 hours for Piloto Aplicador. A training certificate is valid for a period of 10 years under the national law. However, individual provinces can have additional requirements.

Training and certification requirements create costs for farmers in France and Spain. Farmers have to spend additional time and money (e.g., fees) to get the mandatory training and apply for a certificate. These costs are included in our analysis.

4. Handling and storage of pesticides

Directive 2009/128/EC on the Sustainable Use of Pesticide describes specific handling and storage requirements for pesticides. The pesticide handling instructions are often specified on the package label, but some member states have additional requirements. In France, pesticides are mandated to be stored and handled following the information listed on pesticide labels. In Spain, however, RD 1311/2012 specifies storage requirements for pesticides. Spanish farmers are required to store pesticides in cabinets or ventilated rooms with a lock and in isolation from surface water or water extraction wells.

The requirements for pesticide storage and handling impose additional costs on farmers compared to the baseline.

5. Disposal of pesticides

Under Article 13 of Directive 2009/128/EC, farmers must comply with specific procedures for pesticide disposal. These requirements are determined at the member state level by national governments. In France, retailers, distributors, and users can join the "Adivalor" program (i.e., the Farmers, Distributors, Industrials for the Valuation of Agricultural Wastes) initiated by the pesticides industry "Agriculteurs, Distributeurs, Industriels pour la Valorisation des Dechets Agriocles."[51] Under the program, pesticide containers are collected at regular intervals without

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[50] Ministerio De agricultura. "National Action Plan for the Sustainable Use of Plant Protection Products." November 2012. http://c-ipm.org/fileadmin/c-ipm.org/Spanish_NAP__in_EN_.pdf (accessed January 3, 2017).

[51] Adivalor. *Adivalor.* 2017. http://www.adivalor.fr/ (accessed January 4, 2017).

any additional fee; farmers have to triple rinse the containers. However, this free service is restricted to pesticide brands that are part of the Adivalor program. Pesticide containers/packages have a unique logo to identify participation in the Adivalor program. In Spain, farmers follow a similar approach of triple rinsing empty containers but have to deliver the empty containers to specific collection points.

Farmers incur costs to meet the requirements of these regulations. While disposal is free of charge, farmers spend additional time transporting containers to collection points. Also, farmers must triple rinse containers and store them in plastic bags, which can create minor operational costs.

6. *Inspection of pesticide equipment*

Under Article 8(5) of Directive 2009/128/EC, professional users are required to conduct regular calibrations and technical checks of pesticide application equipment. In Spain, these requirements are the same across most regions with the exception of Andalusia and Murcia which have stricter equipment inspection requirements and require farmers to register their pesticide equipment.

To adhere to these requirements, farmers conduct regular checks of their equipment. These create reoccurring costs for farmers. In the absence of regulations, farmers may conduct less frequent equipment checks.

7. *Maximum Residue Levels*

Regulation (EC) No 396/2005 sets the maximum residue levels (MRL) of pesticides in or on food and feed of plant and animal origin. The European Commission has harmonized MRLs for 315 fresh agricultural products for food and feed. The two pesticides relevant for corn production include glyphosate (1 mg/kg), and lamda-cyhalothrin (.02 mg/kg)—atrazine is currently banned in EU. Although member states can impose stricter MRLs, France and Spain follow the limits imposed by the European Commission.

In the EU, farmers are required to follow pesticide labeling instructions for application. Pesticide dosage, based on MRLs, is prescribed on pesticide labels. Farmers are required to heed this information while applying pesticides.

Fertilizers[52]

1. *Traceability, markings, labeling, and packaging of fertilizers*

Articles 7, 8, 9 and 10 of Regulation (EC) No 2003/2003 on fertilizers require manufacturers and distributors to ensure identification markings and labels on packages for traceability. Specifically, manufacturers are responsible for labeling fertilizers: "EC FERTILISER," specifying the type of fertilizer, identifying blended fertilizer separately, and printing the contents of the fertilizer on the package. These rules are similar for all member states. Labels are required to be printed at least in the national language of the member state and must be clearly legible. This regulation applies to manufacturers and distributors of fertilizers.

2. *Fertilizer application*

The European Commission regulates fertilizer through its Nitrates Directive 91/676/EEC, which is mostly applicable for fertilizers containing nitrogen. The regulation requires member states to develop "action programmes" to be implemented by farmers within designated nitrate vulnerable zones (NVZs) on a mandatory basis. Action programmes include specific limitations on fertilizer application. However, the decision to specify exact standards is delegated to member states due to variation in climatic and soil conditions. As such, the requirements for application of fertilizer are different in France and Spain (Table 4).

France has designated 63,000 farms, covering almost 57% of its utilized agricultural area as NVZ. There are prohibition periods for nitrogen-based fertilizers based on the proportion of nitrogen in the fertilizer; the government has issued national and regional agricultural practice guidelines to disseminate methods for calculating the nitrogen balance in the soil.[53] Manure application is capped at 170 kg N/ha/year.

Similarly, Spain has enacted national-level regulations to implement the Nitrates Directive. Unlike France, Spain has only designated 17% of its utilized agricultural area as a NVZ. During these prohibition periods, the limit for fertilizer is based on different carbon-to-nitrogen levels being higher or lower than 10. The total limit on fertilizer application is specified to be 170 kg

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[52] Note: due to the fact that fertilizers are not regulated within the U.S. at the federal level, the proceeding quantitative assessment excludes their consideration within our calculations. Fertilizers in the EU are discussed here, qualitatively.

[53] Gault, Jean, Muriel Guillet, Francois Guerber, Claire Hubert, and François Paulin et Marie Christine Soulié. *Analysis of implementation of the Nitrates Directive by other Member States of the European Union.* September 2015. http://www.cgedd.developpement-durable.gouv.fr/IMG/pdf/010012-01_rapport_cle2cc1e3.pdf (accessed January 27, 2017).

total/N/ha/year for dry corn and 210 kg total N/ha/year for irrigated corn.[54] The restrictions on applying nitrogen fertilizer increase compliance costs for farmers in France and Spain. Farmers are required to ensure that they only apply up to the applicable annual limit.

Table 4: GAEC Requirements in France and Spain

	France	Spain
Designation of NVZs	57% of utilized agricultural area	17% of utilized agricultural area
Application prohibition periods	• High C/N and low proportion of mineral nitrogen: July – Jan. • Low C/N with organic nitrogen: Sep. – Jan. • Mineral fertilizer: July 15 – Feb. 15	• Organic fertilizer C/N>10: June 15 – Dec. • Organic fertilizer C/N<10: Aug. – Jan. 15 • Industrial nitrogen fertilizer: Sep. – Feb.
Limitation of fertilizer application based on fertilizer balance	Calculation of the nitrogen balance according to the methods and rules defined in the National AP and regional guidelines (http://www.comifer.asso.fr/index.php/fr/bilan-azote.html)	• 170 kg total N/ha/year for dry corn: 170 kg/N from organic and 120 kg/N from chemical and irrigation; • 210 kg total N/ha/year for irrigated corn: 170 kg/N from organic and 150 kg/N from chemical and irrigation.
Limitation of livestock manure application	170 kg N/ha/year	170 kg N/ha/year

Source: Table created by the authors based on Gault, et al. 2015

Agri-environmental Practices

Good Agricultural and Environmental Conditions

Regulation (EU) No 1306/2013[55] requires member states to determine Good Agricultural and Environmental Conditions (GAECs) as part of the cross-compliance requirement of the Common Agricultural Policy (CAP). This EU regulation outlines seven specific GAEC requirements

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[54] *Ibid*

[55] GAEC requirements were earlier defined under Council Regulation (EC) No 73/2009. Regulation (EU) No 1306/2013 was not implemented until 2014; therefore, our quantitative analysis uses estimates for the impact of the 2009 regulation derived by Jongeneel, Poux and Fox (2012). Jongeneel, Roel, Xavier Poux, and Glenn Fox. “Good Agricultural and Environmental Conditions in the EU and Their Implications for International Trade in Cereals.” In *The Economics of Regulation in Agriculture*, by Floor Brouwer, Glenn Fox and Roel Jongeneel, 147-164. Oxfordshire, UK: CAB International, 2012.

related to water, soil and carbon stock, and landscape soil protection. Member states decide the operational requirements based on their geographic conditions, climate, and farming practices. This results in variation among member states. Further, within each country, requirements may differ between the national and regional levels.

Table 5 below lists the operational requirements applicable to French corn farmers. These GAECs standards require farmers to maintain certain landscape features and avoid soil erosion; otherwise CAP subsidies will be deducted based on the extent of noncompliance. While these requirements are expected to have large social benefits in the long-term, they create constraints which impose costs on farmers. For example, creating buffer strips along watercourses or planting rows of trees on farms reduces the amount of land available for growing crops.

The GAEC requirements in Spain emphasize soil erosion and landscape features. Regulations impose restrictions on farms that have slopes greater than 10 and 15 percent. The landscape requirements in Spain seem to suggest general "best practices" and are not as prescriptive as France. The exact measures to be followed by farmers are unclear.

The agri-environmental practice imposes several restrictions on farming and creates constraints for farmers. It is likely that these regulations increase farmers' costs of production. However, these costs are not expected to be very high because GAEC consolidates existing legislation.[56]

Table 5: GAEC Requirements in France and Spain

Requirement	Description
FRANCE	
Buffer zone for watercourse	Establish 5-meter wide buffer strips along watercourses
Protection of groundwater against hazardous substance	No release of prohibited substances in water and safe storage of manure by maintaining 35 meters distance from groundwater
Minimum land cover	Maintain seedling on arable land or agriculture surface after uprooting vineyards
Use of Irrigation	Obtaining certificate for use of irrigation and using assigned volume of water
Prevent soil erosion	Ensure tillage and no flooding or waterlogging
No burning of crop residue	Farmers that grow cereals, oilseeds and oil and protein-rich plants cannot burn crop residue

[56] Hart, Kaley, Martin Farmer, and David Baldock. "The Role of Cross Compliance in Greening EU Agricultural Policy." In *The Economics of Regulation in Agriculture*, by Floor Brouwer, Glenn Fox and Roel Jongeneel, 9-27. Oxfordshire, UK: CAB International, 2012.

Maintaining the landscape features	Farmers have to maintain hedges 10 meters wide (hedge is a row of trees, shrubs etc.)
SPAIN	
Soil erosion control	Prohibition against growing herbaceous crops on slopes greater than 10%.
	Compulsory maintenance vegetation row lines on slopes greater than 15% are required.
Landscape features	Take all measures to retain terraces and existing ridge in good conditions, avoiding ruins and collapse.

Quantitative Impact Assessment

This section quantifies the regulatory costs and benefits identified above for a typical corn farm. Because no regulation related to fertilizers is identified at the U.S. federal level, the quantitative assessment only focuses on GM crops, pesticides, and agri-environmental practices to provide a side-by-side comparison between the U.S. and EU countries.

This section describes the data, assumptions, and calculations used in this analysis. The regulatory impact estimates are provided in "current" values for the production years of 2011-2013. As a result of the data availability, data published later than January 2011 are considered to approximate "current" values, and data published prior to 2011 (for which there are no more recent estimates available) are adjusted for inflation. A sensitivity analysis is conducted to demonstrate reasonable lower and upper-bound estimates of the respective results to account for uncertainties related to data and necessary assumptions. Appendix C presents a detailed view of these estimates. The following key assumptions are made throughout the calculations:

- Changes in farmers' production costs are not transferred to consumers; therefore farmers bear the full amount of the regulatory costs.
- Corn farmers' annual production costs and income are not affected by changes in market supply or demand due to regulation.

United States

Genetically Modified Crops

As discussed above, the primary costs of GM crop-related regulations on corn farmers are due to insect resistance management (IRM).

Insect Resistance Management

Several studies[57] have assessed, both qualitatively and quantitatively, the costs of complying with the refuge requirement, which is a key component of IRM. Among others, Hurley, Langrock, and Ostlie estimated the farmer compliance cost of the current refuge requirements to be $0.74 per acre with a confidence interval of $0.10 to $1.39 per acre, using 2002 data.[58] Adjusted for inflation, the compliance cost is approximately $0.925 with a confidence interval of $0.125 to $1.738 in 2011 dollars. As defined in section 3, a typical corn farm in the U.S. grows 280 acres of corns per year. Therefore, we estimate the annual regulatory cost for a typical corn farm at approximately 0.925 * 280 = $259.[59]

As previously discussed, the long-term private benefits generated by IRM can be considerable; however, they are unlikely returned to corn farms within a year and thus are not reflected in the annual production costs and income. The immediate private benefits due to seed cost savings are relatively negligible, and there is insufficient information to quantify these benefits.

Pesticides

A typical corn farm faces a series of regulatory requirements related to pesticides, from their application to their disposal. A typical corn farm will incur both private costs and benefits from these requirements, although benefits are mostly not quantifiable due to limitations in data availability.

1. *Certification of Pesticide Use*

Costs to farmers include certification fees and time spent on training and/or exams. According to EPA's economic analysis, a farm with sales between $100,000 and $1 million per year will only need one certified private pesticide applicator.[60] Specific requirements for private applicator certification vary by state. To reflect the U.S. national average requirement, we examined the ten states with the highest corn production quantity during 2011-2013 (representing 80% of U.S. total corn production).[61] Generally, a private certification is valid for 3-5 years, which means that a private applicator needs to get recertified every 3-5 years. EPA economic analysis summarized the time required for training and/or exam and the recertification frequency per year for all the

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[57] Hurley, Langrock and Ostlie (2006); Alexander (2007)

[58] Hurley, Langrock and Ostlie (2006)

[59] These estimates are valid for the years under consideration in our analysis (2010-2013); it is worth mentioning that currently farmers have other methods at their disposal to comply with IRM.

[60] EPA (2015)

[61] NASS. *USDA National Agricultural Statistics Service.* 2015. https://www.nass.usda.gov/index.php (accessed January 04, 2017).

states.[62] Following EPA's economic analysis,[63] the mean hourly wage rate for managerial farmers from the BLS Occupational Employment Statistics (BLS employment category 11-9013) is used as the wage rate for private pesticide applicators. The national mean hourly wage rate from 2011 to 2013 was $34.77.[64,65] Additionally, information on certification fees is collected from states' Department of Agriculture or authorized institutions. In sum, the following assumptions are made to calculate the annual regulatory cost:

- A typical U.S. corn farm needs only one certified private applicator;[66]
- The wage rate for a private applicator is $34.77 per hour;[67]
- The average regulatory cost in the ten top corn producing states reflects the national average cost.

Using the above data, the annual regulatory cost is calculated as following:

$$Cost = (Fee + Wage * Time) * Frequency$$

As shown in Table 6, the average cost over the ten states is $59 per year. Although private benefits may be accrued as a result of a reductions in pesticide costs, there is insufficient information available to quantify such benefits.

Table 6: Private Recertification Requirements for 10 Top Corn Producing States

State	Fee ($)	Wage ($/hour)	Time (hours)	Frequency (per year)	Cost ($/year)
Iowa[68]	15	34.77	6	0.333	74.47
Illinois[69]	30	34.77	8	0.333	102.62
Nebraska[70]	25	34.77	2.5	0.333	37.27

62 EPA (2015)

63 *Ibid*

64 It is important to note that this may be considered a lower-bound estaimtes as it does not account for all costs that may be incurred by an applicator, such as: travel costs, travel time, opportunity costs associated with studying for exams.

65 BLS. *Occupational Employment Statistics: OES Data.* August 25, 2016. https://www.bls.gov/oes/tables.htm (accessed December 16, 2016).

66 EPA (2015)

67 BLS (2016)

68 Iowa State University. "Private Pesticide Applicator Training and Certification." *Iowa State University Pesticide Safety and Education Program.* December 7, 2016. http://www.extension.iastate.edu/psep/PrAp.html (accessed January 28, 2017).

69 Illinois Department of Agriculture. "Certification and Licensing." *Illinois Department of Agriculture.* 2014. https://www.agr.state.il.us/certification-and-licensing (accessed January 28, 2017).

Minnesota[71]	75	34.77	3.5	0.333	65.50
Indiana[72]	20	34.77	6	0.200	45.72
South Dakota[73]	0	34.77	3	0.200	20.86
Ohio[74]	30	34.77	5	0.333	67.88
Wisconsin[75]	30	34.77	8	0.200	61.63
Kansas[76]	25	34.77	8	0.200	60.63
North Dakota[77]	30	34.77	4	0.333	56.30
Average	28	34.77	5.4	0.280	**59.29**

Other sources: EPA (2015)

2. *Storage of Pesticides*

A web search indicates that the market price of a pesticide cabinet with a capacity of up to 30 gallons ranges from $500 to $1,600.[78] This is used as a proxy in calculating the costs of complying with the pesticide storage requirements. The following assumptions are made:

- A typical U.S. corn farm needs only one pesticide cabinet;
- A pesticide cabinet has a life span of 10 years, and the annualized cost is calculated using a discount rate of 3%;

[70] Nebraska Department of Agriculture. "Pesticide Applicator Certification and Licensing." *Nebraska Department of Agriculture.* 2017. http://www.nda.nebraska.gov/pesticide/cert.html (accessed January 28, 2007).

[71] Minnesota Department of Agriculture. "Pesticide and Fertilizer License/Certification Fees." *Minnesota Department of Agriculture.* 2017. http://www.mda.state.mn.us/licensing/licensetypes/pesticideapplicator/pestfertlicensefees.aspx (accessed January 28, 2017).

[72] Office of Indiana State Chemist. "FARMERS - Private Applicators." *Office of Indiana State Chemist.* 2017. https://www.oisc.purdue.edu/pesticide/private_applicators.html (accessed January 28, 2017).

[73] South Dakota Department of Agriculture. "Pesticide Applicator and Dealer Certification, Licensing and Education." *South Dakota Department of Agriculture.* 2012. https://sdda.sd.gov/ag-services/pesticide-program/certification-licensing-registration/licensing-and-education/ (accessed January 28, 2017).

[74] Ohio Department of Agriculture. "Pesticide & Fertilizer Regulation Section." *Ohio Department of Agriculture.* 2017. http://www.agri.ohio.gov/apps/odaprs/pestfert-PRS-index.aspx (accessed January 28, 2017).

[75] University of Wisconsin. "Registration." *Pesticide Applicator Training.* 2017. http://ipcm.wisc.edu/pat/certification/registration/ (accessed January 28, 2017).

[76] Kansas Department of Agriculture. "Pesticide Applicator." *Kansas Department of Agriculture.* 2016. https://agriculture.ks.gov/divisions-programs/pesticide-fertilizer/pesticide-applicator (accessed January 28, 2017).

[77] North Dakota State University. "Certification Info." *NDSU Agriculture and University Extension.* September 16, 2016. https://www.ag.ndsu.edu/pesticide/certification-info-1 (accessed January 28, 2017).

[78] Google. *Global Pesticide Storage Cabinet - Manual Close Double Door 30 Gallon.* November 30, 2016. https://www.google.com/shopping/product/6368992912554431033?q=pesticide+cabinets&rlz=1C1OPRA_enUS586US586&espv=2&biw=1095&bih=858&dpr=1.1&bav=on.2,or.&bvm=bv.139782543,d.cGw&ion=1&tch=1&ech=1&psi=KP0-WIz2KoKPmQHyioS4DA.1480523127688.3&prds=paur:ClkAsKraXw.

- The average cost of a pesticide cabinet in the U.S. is $1,000, while the upper and lower bounds are used in the sensitivity analysis.

As a result, the annualized cost for a typical corn farm is $88. The private benefits from increased safety of pesticide storage are not quantifiable given the limited data availability. Finally, the space required to install a pesticide cabinet is assumed to be minimal.

3. Agricultural Worker Protection Standard

Estimates from EPA's economic analysis[79] are used in estimating the costs of the WPS requirements for a typical corn farm. Annual per-farm costs for small farms with annual revenue less than $750,000 range from $190 to $260 depending on varied state requirements, with a national average of $210.[80] The national average is used, while the estimated range is discussed in the sensitivity analysis. The private benefits, however, are not quantifiable.

4. Recordkeeping of Pesticide Use

Time spent on recordkeeping is used to estimate the costs of the requirements. In a request for information collection for pesticide recordkeeping, USDA Agricultural Marketing Service estimated that certified private applicators made an average of 16 restricted use pesticide applications per year, which took on average 1.31 hours annually per record keeper.[81] In addition, this analysis assumes:

- A typical U.S. corn farm needs only one certified private applicator;[82]
- The wage rate for handlers conducting recordkeeping is $34.77 per hour.[83]

Thus, the annual cost for a typical corn farm is the total wage paid: $1 * 1.31 * 34.77 = \$46$. The possible private benefits from proper use of pesticides are not quantifiable.

5. Disposal of pesticides

Time spent on triple rinsing and transportation of pesticide containers is the primary cost of complying with the disposal requirements. The average hourly wage rate of farmworkers in the

79 EPA (2014)
80 *Ibid*
81 Agricultural Marketing Service. "Request for an Extension and Revision to a Currently Approved Information Collection." *Regulation.gov*. December 14, 2007. https://www.regulations.gov/document?D=AMS-ST-07-0149-0001 (accessed Janauary 04, 2017).
82 EPA (2015)
83 BLS (2016)

U.S. (BLS employment category 45-0000) from 2011-2013 is $11.68.[84] The following assumptions are made in the calculation:

- A typical U.S. corn farm spends 10 hours per year for disposal of pesticide containers.
- The wage rate for farmworkers conducting container disposal is $11.68 per hour.[85]

The total annual cost is: $11.68 * 10 = \$117$. There are no direct private benefits associated with this regulatory requirement.

Agri-environmental Practices

While the NPDES Pesticide General Permit (PGP) and Endangered Species Protection Program may generate considerable private costs, the impact of these programs on a typical corn farm is limited due to the fact that they only apply to a limited number of corn farms. Therefore, only the Highly Erodible Land Conservation is examined in the quantitative assessment.

Highly Erodible Land Conservation

Govindasamy and Cochran estimated that producers had to forego $2-$12 per acre to comply with the HELC depending on soil types,[86] while Barbarika Jr. and Dicks suggested that treatment of highly erodible cropland would cost an average of $14.63 per acre, or $6.15 in the mountain states and $20.86 in the corn belt.[87] Estimates by Barbarika and Dicks are used in this analysis. After adjusting for inflation, the average cost is approximately $34.1 per acre in 2011 dollars. While it is difficult to determine how much land in a typical corn farm is subject to HELC, the USDA's 2010 Natural Resource Inventory indicates that 26% of all cropland in the U.S. was highly erodible land.[88] Based on that, the following assumption is made in the base case:

- 26% of planted acres in a typical corn farm must comply with the HELC requirements.

The annual private cost for a typical corn farm is $\$34.1 * 280 * 0.26 = \$2{,}482$. There are no private benefits associated with the HELC.

84 *Ibid*
85 *Ibid*
86 Govindasamy and Cochran (1995)
87 Barbarika, Jr. and Dicks (1988)
88 USDA. *Summary Report: 2010 National Resources Inventory*. Washington, D.C.: Natural Resources Conservation Service, 2013.

European Union

Genetically Modified Crops

The French government prohibited GM crop cultivation in its territory beginning in 2008; French corn farmers are expected to face significantly higher production costs and income losses. On the other hand, Spain allows GM corn cultivation; corn farmers are likely facing costs due to GM labeling requirements.

1. Prohibition of GM crop cultivation

Although GM corn seeds are generally more costly than conventional seeds, many studies have shown that higher seed costs are offset by higher yields and lower pesticide costs, thereby leading to a net benefit of GM corn compared to conventional corn. The net costs for corn farming due to the prohibition of cultivation can be considered equivalent to the net benefits of planting GM corn. Brookes and Barfoot indicates that planting GM insect resistant (IR) corn in Spain leads to a cumulative increase in farm gross margin of $118.43 per acre from 1998 to 2014, while planting GM IR corn in other EU countries (Portugal, Czech Republic, and Slovakia) increases gross margin by $44.96 to $64.11 per acre over the period 2005-2014.[89] A meta-analysis by Finger et al. indicates that planting GM IR corn in Spain increases yields by 5.6% and seed costs by 9.9%, and decreases pesticide costs by 56.2%.[90]

As few studies have examined the net benefits of growing GM corn in France, the estimates for Spain are considered as a proxy because of the two countries' geographical proximity. Therefore in the base case, the calculation of the net regulatory costs in France uses estimates for Spain from Finger et al., as shown in Table 7.

Table 7: Estimated effects of planting GM corn in France

	Yield	Pesticide Costs	Seed Costs
Values observed	161 bushels/acre	$67.74/acre	$89.90/acre
% change	+5.6%	-56.2%	+9.9%
Values changed	+9.02 bushels/acre	-$38.07/acre	+$8.90/acre

Source: Table created by the authors based on estimates from Finger, et al. (2011)

89 Brookes, Graham, and Peter Barfoot. *GM crops: global socio-economic and environmental impacts 1996-2014.* Dorchester, UK: PG Economics Ltd, 2016.

90 Finger, Robert, et al. "A Meta Analysis on Farm-Level Costs and Benefits of GM Crops." *Sustainability*, May 10, 2011: 743-762.

Another parameter needed to estimate the total net costs for a typical corn farm is the planted area of GM corn per farm. From 2011 to 2013, Spain grew an average of 116,865 hectares (288,780 acres) of GM corn, which was approximately 29% of its total corn area.[91] Because it is impossible to know how many acres of GM corn French farmers would grow in a counterfactual scenario without regulatory restrictions, we make the following assumption based on Spain's statistics:

- If there was no GM ban (baseline)92, a typical corn farm in France would grow 29% of its planted area ($118.31 * 29\% = 34.31\ acres$) with GM corn.

Therefore, due to banning GM corn, a typical corn farm in France bears private costs of $(9.02 * 6.26 + 38.07) * 34.31 = \$3{,}243$ and benefits of $8.90 * 34.31 = \$305$. As a result, the net regulatory costs are \$2,938.

2. GM Labeling and Segregation

In Spain, GM corn is planted and harvested mainly for the production of domestic compound feed, which is by default labelled as containing GMOs since all marketed feed contains GM soybean. Costs related to GM labeling and segregation are therefore more relevant for farmers producing corn for food. Based on the national average mentioned above, a typical corn farm in Spain is assumed to grow GM corn on 29% of its planted corn area in the base case, although practically the percentage may be much smaller for farms growing GM corn for food.

Costs of segregating non-GM corn during the planting and harvesting processes depend on labor costs and corn prices.[93] Specifically, these include on-farm costs of planter and combine cleaning in maintaining non-GM corn purity. The EU Structure of Earnings Survey 2010 and 2014 indicates that the mean hourly wage rate of farmworkers (ISCO-08 OC6[94]) in Spain is \$11.69.[95]

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91 USDA FAS (2015)

92 Our baseline estimate assumes that there are no regional regulatory restrictions on GM corn. Although there are municipalities in Spain that have declared themselves to be GM free zones, there is no legal obligation to comply. See:https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Agricultural%20Biotechnology%20Annual_Madrid_Spain_6-9-2015.pdf

93 Bullock, David S., Marion Desquilbet, and Elisavet Nitsi. "The Economics of Non-GMO Segregation and Identity Preservation." *American Agricultural Economics Association Annual Meeting.* Tampa, Florida, 2000.

94 International Standard Classification of Occupations (ISCO-08) OC6: Skilled agricultural, forestry and fishery workers.

95 Eurostat. *Structure of Earnings Survey.* December 07, 2016. http://ec.europa.eu/eurostat/web/labour-market/earnings/database (accessed January 03, 2017).

In accordance with Bullock et al.'s approach,[96] the following assumptions are made to measure the segregation costs:

- A hour of farm labor ($11.69) is needed to clean out a planter, and the cleaning is only needed once per planting season;
- Two farmworkers working 15 minutes each are needed to clean out a combine during harvesting, and 70 bushels of non-GM corn need to be harvested and unloaded to "flush" the combine.

After harvesting, non-GM corn needs to be stored separately from GM corn, which requires extra storage space compared to growing non-GM corn only.

- 29% of a typical corn farm's annual corn production is GM corn ($29\% * 6{,}430 = 1{,}865\ bushels$);[97]
- A new grain bin with 10 years of life span costs $2 per bushel to install.[98]

Table 8 shows the calculation of the segregation and storage costs, based on the above assumptions. The total annual cost for a typical corn farm in Spain is $867.

Table 8: Costs of GM Corn Segregation and Storage[99]

	Segregation Costs		Storage Costs
	Planter cleaning	Combine cleaning	
Labor	1 hour * $11.69/hour = $11.69	0.25 hour * 2 workers * $11.69/hour = $5.85	$2 * 29% * 6,430 bushels/ 10 years = $372.94
Materials	n/a	70 bushels * $6.80/bushel = $476	
Subtotal:	$12	$482	$373
		Total:	**$867**

The subtotal and total are rounded to the nearest dollar.
Source: Table created by the authors

96 Bullock, Desquilbet and Nitsi (2000)
97 This may serve as an upper-bound estimate in the event that farms grow only either GM or non GM corn.
98 The Foodie Farmer. *The Costs of GMO Labeling.* April 8, 2014. http://thefoodiefarmer.blogspot.com/2014/04/the-costs-of-gmo-labeling.html.
99 Estimates assume that farms have adequate storage facilities for their additional corn requirements.

Pesticides

Corn farmers in France and Spain bear many similar costs associated with pesticide regulations, which cover activities from registration to disposal.

1. *Prohibition of atrazine use*

Prior studies indicate varied estimates on the costs of banning atrazine use in corn production in the U.S. Ackerman summarized several key estimates which are detailed in Table 9.[100] It should be noted that some of the studies examined by Ackerman calculated yield losses if no treatment is used while other studies calculated losses based on use of alternative herbicides.

Table 9: Cost Estimates of Atrazine Bans from Key Studies

	USDA 1994[101]	EPA 2002[102]	Fawcett 2006[103]	Coursey 2007[104]
Year of data	1991	2000	1986-2005	2005
Increased herbicide costs ($/acre)	1.08	5.43	10.07	4.86
Yield loss (%)	1.19%	6.4%	3.8%	5.8%

Source: Table created by the authors based on Ackerman (2007)

While both France and Spain have banned the use of atrazine, few studies have estimated the resulting costs for farmers in these two countries. The atrazine ban is considered a regulatory action in the context of this chapter. Therefore in this analysis, estimates for the U.S. are used as a proxy. Converting these unit costs to per-farm costs: the increased herbicide costs for a typical corn

$$costs\_per\_acre * planted\_corn\_acres;$$

[100] Ackerman, Frank. "The Economics of Atrazine." *International Journal of Occupational and Environmental Health* 13 (2007): 441-449.

[101] Ribaudo, Marc, and Aziz Bouzaher. *Atrazine: Environmental Characteristics and Economics of Management*. Agricultural Economic Report No. AER-699. Washington, DC: Economic Research Service, U.S. Department of Agriculture, 1994.

[102] EPA. *Assessment of Potential Mitigation Measures for Atrazine*. Washington, DC: Biological and Economic Analysis Division, U.S. Environmental Protection Agency, 2002.

[103] Fawcett, Richard S. *Two Decades of Atrazine Yield Benefits Research*. Huxley, IA: Triazine Network, 2006.

[104] Coursey, Don. *Illinois Without Atrazine: Who Pays?* Chicago, IL: Harris School of Public Policy, University of Chicago, 2007. https://www.mda.state.mn.us/news/publications/chemfert/atrazinecostofban02272007.pdf (accessed October 19, 2017).

the costs from yield loss for a typical corn farm are:

$$observed\_yield/(1 - yield\_loss\ \%) - observed\_yield$$

Using defined features of typical corn farms in France and Spain, the estimates of total annual costs are presented in Table 10.

Table 10: Cost Estimates of Atrazine Bans in France and Spain (in 2011 dollars)

	USDA 1994	EPA 2002	Fawcett 2006	Coursey 2007
***France**: Yield = 161 bushel/acre*				
Increased herbicide costs ($/acre)	1.78	7.09	11.60	5.60
Yield loss (bushel/acre)	1.94	11.01	6.36	9.91
Total annual costs ($)	1,648	8,995	6,084	8,007
***Spain**: Yield = 175 bushel/acre*				
Increased herbicide costs ($/acre)	1.78	7.09	11.60	5.60
Yield loss (bushel/acre)	2.11	11.97	6.91	10.77
Total annual costs ($)	593	3,258	2,158	2,904

Source: Table created by the authors

Given the considerable variation among different studies, moderate estimates are chosen for the base case of the analysis. In this case, estimates from Fawcett are used as it gives an average estimate upon a review of 236 studies performed from 1986 to 2005.[105] Estimates from other studies are included in the sensitivity analysis.

2. *Certification of pesticide use*

An authorized French certification agency requires a 14-hour training course and a fee of €360 ($480.6) for a certification valid for 10 years.[106] It is unlikely that a typical corn farm in France needs more than one certified pesticide applicator due to its relatively smaller farm size compared to U.S. corn farms. The EU Structure of Earnings Survey 2010 and 2014 suggests the mean wage rate of managers (ISCO-08 OC1), including production managers in agriculture, is $40.10 in France.[107] Using a similar approach to the U.S., the following assumptions are made:

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[105] Fawcett (2006)

[106] TECOMAH. *Certiphyto Operator*. December 5, 2016. http://www.tecomah.fr/formations-adultes/certiphyto-operateur.

[107] Eurostat (2016)

- A typical corn farm in France needs only one certified applicator;
- The wage rate for private applicators in France is \$40.10 per hour.[108]

Thus the annual regulatory cost for a typical French corn farm is: $(14 * 40.10 + 480.6)/10 = \$104$.

Similarly, in Spain, a basic certification valid for 10 years requires 25-hour training and €90 (\$120.15). The mean wage rate of managerial farmers is \$31.71 in Spain.[109] The same assumptions are made:

- A typical corn farm in Spain needs only one certified private applicator;
- The wage rate for private applicators in Spain is \$31.71 per hour.[110]

The annual regulatory cost for a typical Spanish corn farm is: $(25 * 31.71 + 120.15)/10 = \$91$.

An impact assessment issued by the European Commission on the sustainable use of pesticides indicates that training and certification of pesticide users will lead to €30 (\$40.05 in 2005 dollars) in annual savings per farm in the EU-25 by reducing the quantity of pesticide use.[111] Converted to 2011 dollars, the annual savings per farm is \$44 in France and \$45 in Spain. This means a net cost of \$60 $(104 - 44)$ per year for a typical French corn farm and a net benefit of \$46 $(91 - 45)$ per year for a typical Spanish corn farm. However, since there are no estimates that quantify such private benefits associated with certification of pesticide applicators in the U.S., the benefit estimates are not included in the comparative analysis.

3. *Storage of pesticides*

Market prices of pesticide cabinets are similar in France and Spain, ranging from €370 to €560 (\$494-\$748).[112] Similar to our calculation for the U.S., the following assumptions are made:

- A typical corn farm in France or Spain needs only one pesticide cabinet;

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[108] *Ibid*
[109] *Ibid*
[110] *Ibid*
[111] European Commission. *The impact assessment of the thematic strategy on the sustainable use of pesticides.* Brussels: European Commission, 2006.
[112] Agram. *ARMOIRES ET CONTAINERS PHYTOSANITAIRES AVEC BAC RÉTENTION.* December 9, 2016. http://www.agram.fr/armoires-et-container-phytosanitaires-avec-bac-retention.html (accessed December 9, 2016); Conterol. *SISTEMAS ALMACENAMIENTO DE SUST. PELIGROSAS Y NO PELIGROSAS.* December 9, 2016. https://www.conterol.es/armarios-para-fitosanitarios_sec_15 (accessed December 9, 2016).

- A pesticide cabinet has a life span of 10 years, and the annualized cost is calculated using a discount rate of 3%;
- The average cost of a pesticide cabinet in France or Spain is $600, while the upper and lower bounds are used in the sensitivity analysis.

As a result, the annual cost for a typical French/Spanish corn farm is $53. Private benefits are not quantifiable.

4. Recordkeeping of pesticide use

Without large-scale surveys, it is difficult to estimate the exact hours a corn farm spends on recordkeeping. A typical U.S. corn farm is assumed to spend 1.31 hours per year based on the AMS estimates.[113] While the farm structure in France and Spain is significantly different from the U.S., the number of pesticide applications is mostly dependent on a crops' life cycle and planting seasons. Therefore in this analysis, the assumption of 1.31 hours on recordkeeping is considered as a proxy for French and Spanish corn farms. Assumptions underlying the calculation include:

- A typical French/Spanish corn farm needs only one certified applicator;
- The hourly wage rate of pesticide handlers conducting recordkeeping is $40.10 in France and $31.71 in Spain.[114]

The annual cost for a typical corn farm is $53 ($\$40.10 * 1 * 1.31$) in France and $42 ($\$31.71 * 1 * 1.31$) in Spain. The private benefits are not quantifiable.

5. Inspection of pesticide equipment

The European Commission's impact assessment shows that regular inspection of pesticide spraying equipment creates additional costs of €130 million ($173.55 million, in 2005 dollars) per year for farmers in the EU-25.[115] According to the Farm Structure Survey, there were approximately 9.69 million total farms in the EU-25 in the assessment year of 2005.[116] Thus the annual costs per farm is approximately $17.91 ($173.55/9.69$), or $19.55 in France and $20.12 in Spain in 2011 dollars.[117]

[113] Agricultural Marketing Service (2007)
[114] Eurostat (2016)
[115] European Commission (2006)
[116] Eurostat. *Farm Structure.* March 31, 2015. http://ec.europa.eu/eurostat/web/agriculture/data/database.
[117] Based on invidivual member state data.

The same impact assessment also indicates that the inspection requirements can save pesticide use by €230 to €460 million ($307.05 million-$614.10 million in 2005 dollars) in the long run.[118] Assuming the savings are realized in 10 years, the annual benefits are $30.7 million to $61.4 million, or $3.17 (30.7/9.69) to $6.34 (61.4/9.69) per farm. After adjusting for inflation, the annual benefits per farm are $3.46 to $6.92 in France and $3.56 to $7.29 in Spain (in 2011 dollars). If using the lower estimates in the base case, the net cost is $16.09 for a typical French corn farm, or $16.56 for a typical Spanish corn farm.

6. Disposal of pesticides

A similar approach is taken to calculate the costs for disposal of pesticides in France and Spain. Assumptions include:

- A typical French/Spanish corn farm spends 10 hours per year on disposal of pesticide containers;
- The hourly wage rate of farmworkers conducting disposal is $14.68 in France and $11.69 in Spain.[119]

The annual cost for a typical corn farm is $147 (14.68*10) in France and $117 (11.69*10) in Spain. There are no private benefits associated with this requirement.

Agri-environmental practices

The Good Agricultural and Environmental Conditions (GAECs) of the CAP cross-compliance contain the primary regulatory requirements related to environmental concerns. Due to data limitations in estimating the costs of individual GAEC standards, the quantitative impact assessment for a typical corn farm examines GAECs as a whole.

Good Agricultural and Environmental Conditions

While the GAECs contain a variety of mandatory standards, very few incremental costs at the farm level can be attributed to them because many practices had been previously adopted due to pre-existing national regulations.[120] A study estimated that GAECs increased costs for cereal farms by 1% to 4%.[121] Using the 1% cost increase in the base case, the annual cost can be calculated as:

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[118] European Commission (2006)
[119] Eurostat (2016)
[120] Hart, Farmer and Baldock (2012)
[121] Jongeneel, Poux, and Fox (2012)

$$observed\ production\ costs \quad - observed\ production\_costs/(1 + cost\_increase\%)$$

Thus the annual cost for a French typical corn farm is: $110{,}603 - 110{,}603/(1 + 1\%) = \$1{,}095$. The annual cost for a Spanish typical corn farm is: $24{,}710 - 24{,}710/(1 + 1\%) = \$245$. It is difficult to quantify the long-term economic and social benefits that result from the implementation of GAECs.

An extensive treatment of productivity costs is included in Chapter 2 of this report.[122]

Comparative Analysis of Regulatory Costs

Base Case Estimates

All estimates of regulatory costs and benefits for the U.S., France and Spain are summarized in Table 11. Since most of the benefits are not quantifiable, a comparative analysis of regulatory benefits is not possible. In terms of regulatory costs, a typical corn farm in the U.S. faces annual regulatory costs of $3,261, which is similar to Spain ($3,592) and significantly lower than France ($10,798). Divided by their respective farm size, the per-acre regulatory costs in the U.S. are $12 per acre, compared to $91 per acre in France and $98 per acre in Spain.

Table 11: Estimated Regulatory Impacts on Typical Corn Farms (in 2011 U.S. dollars per year)

	U.S.		France		Spain	
	Costs	Benefits	Costs	Benefits	Costs	Benefits
GM crops						
GM corn prohibition	$0	$0	$3,243	$305	$0	$0
IRM	$259	n.q.	n/a	n/a	n/a	n/a
GMO labeling	n/a	n/a	n/a	n/a	$867	$0
Subtotal:	**$259**	**n.q.**	**$3,243**	**$305**	**$867**	**$0**
Pesticides						
Pesticide bans	$0	$0	$6,084	$0	$2,158	$0
Certification of pesticide applicators	$59	n.q.	$104	$44	$91	$45
Storage of pesticides	$88	n.q.	$53	n.q.	$53	n.q.

[122] Prasad, Aryamala, and Zhoudan Xie. "Agricultural Productivity and the Impact of Regulation." *Transatlantic Agriculture & Regulation Working Paper Series* No. 2. Washington, DC: The George Washington University Regulatory Studies Center, 2017. https://regulatorystudies.columbian.gwu.edu/agricultural-productivity-and-impact-regulation-transatlantic-agriculture-regulation-working-paper.

Recordkeeping of pesticides	$46	n.q.	$53	n.q.	$42	n.q.
WPS	$210	n.q.	n/a	n/a	n/a	n/a
Pesticide equipment	n/a	n/a	$20	$3	$20	$4
Pesticide disposal	$117	$0	$147	$0	$117	$0
Subtotal:	**$519**	**n.q.**	**$6,460**	**$47+n.q.**	**$2,481**	**$49+n.q.**
Agri-environmental practices						
Conservation compliance	$2,482	$0	n/a	n/a	n/a	n/a
GAECs	n/a	n/a	$1,095	n.q.	$245	n.q
Subtotal:	**$2,482**	**$0**	**$1,095**	**n.q.**	**$245**	**n.q.**
Total:	**$3,261**	**n.q.**	**$10,798**	**$352+n.q.**	**$3,592**	**$49+n.q.**
Costs Per Acre:	**$12**		**$91**		**$98**	

Note: "n.q." refers to "not quantifiable" costs or benefits; "n/a" indicates that there are no relevant regulatory requirements. All estimates are rounded to the nearest dollar.
Source: Table created by the authors

Sensitivity Analysis

While the above base-case analysis draws on existing studies from a variety of sources, uncertainties exist due to varied estimates from different studies as well as assumptions made within each calculation. The sensitivity analysis examines how the results vary using different values for these uncertain parameters. Similarly, the sensitivity analysis only focuses on the estimation of regulatory costs. We develop reasonable lower- and upper-bound estimates using possible ranges of values for different component costs.

As shown in Table 12, most of the uncertainties result from different estimates among existing studies. The base-case analysis takes the average or relatively moderate values from these estimates, while the sensitivity analysis uses the upper and lower values to observe how results vary with these changes. In the upper-bound analysis, we rely on the higher cost estimates from the literature, while in the lower-bound analysis, we chose the lowest of the available cost estimates.

Table 1: Key Uncertainties in Estimation of Regulatory Costs

Uncertainty	Source	Base Case	Upper-bound Estimate	Lower-bound Estimate
United States				
IRM compliance costs ($/acre)	Hurley, Langrock, and Ostlie (2006)	0.74	1.39	0.1
Market price of a pesticide cabinet ($)	Google (2016)	1,000	1,600	500
WPS compliance costs ($/farm)	EPA (2014)	210	260	190
Time spent on pesticide disposal (hours/year)	Assumption based on EPA (2014)	10	10	5
HELC compliance costs ($/acre)	Barbarika, Jr. and Dicks (1988)	14.63	20.86	6.15
Percentage of land acres subject to HELC in a typical corn farm (%)	USDA (2013)	26	26	0
France & Spain				
Percentage of corn production a typical Spanish corn farm needs to segregate from non-GM corn (%)	USDA FAS (2015)	24	50	0
Increased herbicide costs due to atrazine bans ($/acre)	Ackerman (2007)	4.86	5.43	1.08
Yield loss due to atrazine bans (%)	Ackerman (2007)	5.8	6.4	1.19
Time spent on recordkeeping of pesticide applications (hours/year)	Assumption based on EPA (2014)	20	20	10
Market price of a pesticide cabinet ($)	Agram (2016); Conterol (2016)	600	750	500
Time spent on pesticide disposal (hours/year)	Assumption based on EPA (2014)	10	10	5
Cost increase due to GAECs (%)	Jongeneel, Poux and Fox (2012)	1	4	0

For example, Hurley, Langrock, and Ostlie indicate that the compliance cost for insect resistance management requirements is $0.74 per acre with a confidence interval of $0.1 to $1.39 per acre (in 2002 dollars).[123] The estimate of $0.74 is used in the base case, and $0.1 and $1.39 are used

[123] Hurley, Langrock, and Ostlie (2006)

in the lower- and upper-bound estimate, respectively. It should be noted that there is considerable uncertainty associated with estimates of yield losses attributed to the atrazine ban in the EU. Given the different weed pressure in the EU versus the U.S. and the lack of studies from the EU empirically demonstrating yield loss between atrazine alternatives available in the EU and atrazine, yield loss comparisons between jurisdictions are uncertain.

As a result, the regulatory costs for a typical corn farm in the U.S. are $4,648 per year in upper-bound estimate and $432 per year in the lower-bound estimate, compared to $3,261 in the base case. In France, the regulatory costs for a typical corn farm are $16,881 per year in the upper-bound estimate and $5,184 per year in the lower-bound estimate, compared to $10,798 in the base case. In Spain, the regulatory costs for a typical corn farm are $5,681 per year in the upper-bound estimate and $849 in the lower-bound estimate, compared to $3,592 in the base case. It is worth noting here that the per-farm costs do not fully reflect relative regulatory impacts, due to the distinct characteristics of a typical corn farm in each country. A comparison across the three countries is discussed in the following section.

Discussion

To facilitate a comparative analysis of regulatory costs across the U.S., France and Spain, we take both per-farm and per-acre perspectives. As previously noted, our goal is to use a typical corn farm approach to compare the relative costs of specific categories of regulations across jurisdictions. Our estimates are not intended to be representative of any particular farm nor are they an exhaustive list of costs borne by corn farmers. Finally, factors exogenous to the impact of regulations—such drought years that cause lower yields/acre—are likely to significantly affect outcomes for corn farmers.

As illustrated in Table 13, for a typical corn farm, regulatory costs are highest in France ($10,798), followed by Spain ($3,592) and then the U.S. ($3,261). To assess the impact of these regulatory costs on farm income, we relied on the following formula:

$$income\_decrease\% = reg\_costs/(observed\_income + reg\_costs)$$

The base case results indicate that the regulations quantified in this analysis reduced a typical corn farm's annual income by 3.42% in the U.S., 56.9% in France, and 15.89% in Spain. French corn farmers face the greatest regulatory burden.

However, the per-acre regulatory costs reveal a different picture. In all cases, U.S. corn farms have significantly lower per-acre regulatory costs than France and Spain. In the base case, U.S. regulatory costs are $12 per acre while French farmers face regulatory costs of $91 per acre and Spanish farmers face costs of $98 per acre.

As mentioned in the previous section, the average corn production cost in France is $935 per acre, significantly higher than both the U.S. ($471/acre) and Spain ($671/acre). Despite these production costs, France does not exhibit the highest per-acre regulatory costs in our analysis and this cost does not constitute the majority of corn production costs. This implies that the significantly higher corn production costs in France are not the result of EU-level regulations covered in this analysis. Higher labor costs and taxes are possible factors; national-level regulation could also play an important role in the observed increased corn production costs in France relative to Spain.

Further considering the cost breakdown, we find that GM crop and pesticide regulations together contribute approximately 90% of the total regulatory costs in France and Spain, whereas they only account for 24% of regulatory costs in the U.S. (Table 11). The largest regulatory costs in the U.S. are the result of regulations related to agri-environmental practices (76%); these are primarily compliance costs related to conservation compliance. However, this cost is highly dependent on the amount of land in a corn farm that is actually subject to compliance, and in reality, is cost-shared through USDA voluntary conservation programs.

Spain's highest per-acre regulatory costs are mostly due to its small farm size, its GMO labeling requirements and the EU-wide atrazine ban. Spain's GM labeling requirements explains its higher costs associated with GM crops relative to the U.S. France and Spain have similar pesticide regulations; the atrazine ban is the primary source of the observed differences in cost relative to the United States.

Table 13: A Comparison of Regulatory Costs in the U.S., France and Spain

	U.S.	France	Spain
Base Case			
Regulatory costs per farm ($)	3,261	10,798	3,592
Impact on farm income	-3.42%	-56.90%	-15.89%
Regulatory costs per acre ($)	12	91	98
Regulatory costs per bushel of corn produced ($)	0.08	0.57	0.56
Share of production costs	2.47%	9.76%	14.54%
Upper-bound Estimate			
Regulatory costs per farm ($)	4,648	16,881	5,681
Impact on farm income	-4.81%	-67.36%	-23.00%
Regulatory costs per acre ($)	17	143	154
Regulatory costs per bushel of corn produced ($)	0.12	0.89	0.88
Share of production costs	3.53%	15.26%	22.99%
Lower-bound Estimate			
Regulatory costs per farm ($)	432	5,184	849

Impact on farm income	-0.47%	-38.79%	-4.27%
Regulatory costs per acre ($)	2	44	23
Regulatory costs per bushel of corn produced ($)	0.01	0.27	0.13
Share of production costs	0.33%	4.69%	3.44%

To summarize, while French farmers seem to face the highest regulatory burden in corn production, per-acre regulatory costs suggest that Spain faces higher regulatory costs. This also suggests that EU-level regulations are not the primary source of significantly higher production costs in France compared to other countries. France and Spain both have much higher regulatory costs from GM crop and pesticide regulations, and the relatively small farm size in Spain leads to higher per-acre regulatory costs.

Appendices

Appendix A-1: Typical corn farm profile in the U.S., France, and Spain, 2011-2013

	2011	2012	2013	Average
U.S.				
Corn acres planted per farm	280.00	280.00	280.00	**280.00**
Yield per acre (bu/acre)	146	118	156	**140**
Production (bu)	40,880	33,040	43,680	**39,200**
Corn price ($/bushel at harvest)	5.73	6.79	4.61	**5.71**
Wage rate for managerial farmers ($/hour)	33.66	35.45	35.20	**34.77**
Wage rate for farmworkers ($/hour)	11.68	11.65	11.7	**11.68**
Spain				
Corn acres planted per farm	38.04	40.76	31.62	**36.80**
Yield per acre (bu/acre)	175	169	180	**175**
Production (bu)	6,693	6,929	5,669	**6,430**
Corn price ($/bushel at harvest)	6.68	7.39	6.34	**6.80**
Wage rate for managerial farmers ($/hour)	32.49	n/a	30.91	**31.71**
Wage rate for farmworkers ($/hour)	11.32	n/a	12.06	**11.69**
France				
Corn acres planted per farm	113.37	117.08	124.49	**118.31**
Yield per acre (bu/acre)	172	167	143	**161**
Production (bu)	19,566	19,605	17,755	**18975**
Corn price ($/bushel at harvest)	6.34	7.09	5.36	**6.26**
Wage rate for managerial farmers ($/hour)	39.28	n/a	40.92	**40.10**
Wage rate for farmworkers ($/hour)	13.87	n/a	12.48	**14.68**

Source: U.S. corn farm data are from ERS Commodity Costs and Returns (2010-2015); EU corn farm data are from EU cereal farms report (EU, 2016); wage data are sectoral averages from BLS Occupational Employment Statistics (2011-2013), and Eurostat Structure of Earnings Survey (2010 & 2014).

Appendix A-2: Average corn production costs per acre in the U.S., France, and Spain, 2011-2013

	United States				France				Spain			
	2011	2012	2013	Average	2011	2012	2013	Average	2011	2012	2013	Average
Input costs ($ per acre)	**258**	**276**	**280**	**271**	**335**	**363**	**342**	**346**	**228**	**368**	**421**	**339**
Seed	84.37	92.04	97.59	91.33	85.40	92.42	91.88	89.90	109.18	109.18	129.18	115.84
Fertilizer	147.36	156.51	153.33	152.40	161.06	184.85	168.63	171.51	70.80	158.36	166.47	131.88
Chemicals	26.35	27.52	28.57	27.48	70.26	69.18	63.78	67.74	29.73	40.00	52.43	40.72
Water	0.10	0.11	0.12	0.11	17.84	15.67	16.76	16.76	18.38	54.59	68.64	47.20
Other specific costs	n/a	n/a	n/a	n/a	0.54	0.54	0.54	0.54	0.00	5.95	4.32	3.42
Operating costs ($ per acre)	**105**	**105**	**108**	**106**	**373**	**410**	**342**	**375**	**132**	**248**	**342**	**241**
Custom operations*	16.77	17.07	17.77	17.20	85.94	111.34	85.94	94.40	31.89	27.56	52.97	37.47
Fuel, lube, and electricity	32.42	30.63	32.27	31.77	83.23	91.34	83.78	86.12	63.24	110.26	154.04	109.18
Repairs	24.79	25.48	25.79	25.35	70.26	73.51	59.45	67.74	15.13	30.27	40.54	28.65
Hired labor	2.92	3.02	3.12	3.02	23.78	25.40	20.54	23.24	10.27	44.32	53.51	36.03
Taxes, insurance, and other general farm overhead	27.65	28.32	28.73	28.23	109.72	108.64	91.88	103.41	11.89	35.67	41.08	29.55
Capital costs ($ per acre)	**90**	**94**	**97**	**94**	**203**	**219**	**218**	**213**	**64**	**97**	**114**	**92**
Interest on operating capital	0.17	0.23	0.16	0.19	25.40	24.32	21.08	23.60	1.62	16.21	5.40	7.75
Capital recovery of machinery and equipment	89.59	94.05	96.86	93.50	177.82	195.12	196.74	189.89	62.70	80.53	108.10	83.78
TOTAL:	452	475	484	**471**	911	992	901	**935**	425	713	877	**671**

Source: USDA ERS Commodity Costs and Returns (2010-2015); EU cereal farms report (EU 2016).

Appendix B-1: Environmental and food safety regulations affecting corn farming in the United States

	Regulation	Operational Requirements	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
GM CROPS	Introduction of GM crops Plant Protection Act APHIS regulations *7 CFR part 340*	Under the 7 CFR part 340, importation, interstate movement, or release into the environment (field test) of Genetically Modified (GM) organisms that may pose a pest risk to plants requires authorization by APHIS, USDA. Corn (HT, IR, AP, PQ) is with non-regulated status under 7 CFR Part 340.	No: GM corn planting is not regulated	No: No incremental benefits compared to the baseline	Farmers would have the freedom to grow any available type of GM corn
GM CROPS	Premarket approval of food additives Federal Food, Drug, and Cosmetic Act (FFDCA) *FFDCA section 409*	Food additive requires premarket approval by FDA, unless the substance added is "generally recognized as safe." Substances intentionally added to or modified in food via genetic engineering to date are considered "substantially equivalent to non-GM" and have not been subject to the approval process.	No: Neither GM nor non-GM corn farmers need pre-market approval	No: No incremental benefits compared to the baseline	Corn producers would not have to get pre-market approval.
GM CROPS	Insect resistance management Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) *FIFRA Section 3; 40 CFR parts 152 and 174*	As part of the registration of Plant-Incorporated Protectants (PIP), registrants of PIP are obligated to make Bt crop farmers plant and manage 20% non-Bt field corn refuge for Bt field corn grown in the Corn-Belt, in order to reduce the likelihood of insect resistance. The requirements also specify the configuration of refuge and the use of non-Bt insecticide treatments on refuge.	Yes: Compliance with the acreage and configuration requirements with higher labor costs and yield loss	Yes: Long-term productivity benefits due to less insect resistance, but minor immediate benefits	Farmers would not implement refuges if not required (Alexander 2007)
PESTICIDES	Registration of pesticides Federal Insecticide, Fungicide, and Rodenticide Act *FIFRA Section 3*	All pesticides sold or distributed in the U.S. must be registered with the EPA. Pesticides with Glyphosate, Atrazine, and Lambda-Cyhalothrin are permitted at the federal level. State may have stricter standards. For example, Iowa classifies Atrazine as restricted-use pesticide.	No: No major pesticides for corn are banned	No: No incremental benefits compared to the baseline	Farmers would have non-restricted access to all available types of pesticides.
PESTICIDES	Certification of Pesticide Use Federal Insecticide, Fungicide, and Rodenticide Act *FIFRA Section 11; 40 CFR part 171*	Applicators must get certification from an authorized agency or work under direct supervision of a certified applicator for restricted-use pesticides. Iowa requires pesticide applicator to pass an exam or attend a course to qualify for certificate.	Yes: Certification requires time and fees	Yes: Cost reduction from proper use of restricted use pesticides	Farmers would use restricted use pesticides without certification.

	Regulation	Operational Requirements	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
PESTICIDES *(continued)*	Storage of Pesticides Federal Insecticide, Fungicide, and Rodenticide Act *40 CFR Part 156*	Applicators must use and store a registered pesticide in a manner consistent with its label: Store in a locked storage area; label restrictions typically require protective clothing and engineering controls (e.g., tractors with enclosed cabs and air recirculation systems).	Yes: Securing a pesticide storage area, assuming farmers store moderate amount of pesticides	Yes: Benefits from reducing medical expenses	Farmers would handle or store in a fairly safe but casual manner
	Agricultural Worker Protection Standard (WPS) *(40 CFR Part 170)*	Requirements include (i) providing protection to workers and handlers from potential pesticide exposure (e.g. protective equipment, restricted entry intervals following pesticide applications); (ii) training them about pesticide safety; (iii) providing mitigations in case exposures may occur.	Yes: Protective equipment and training for farm workers	Yes: Benefits from reducing time lost, reducing medical expenses and insurance premiums (EPA 1992)	Farmers would not provide formal training or protection to workers.
	Recordkeeping of Pesticide Application 1990 Farm Bill *7 CFR Part 110*	Agriculture Marketing Service administers the program, which requires all certified private pesticide applicators to keep records of use of federally restricted use pesticides within 14 days of the application for 2 years, if there are no relevant state regulations.	Yes: Cost for record-keeping	Yes: Benefit from proper use of pesticides	Farmers would not keep records
	Pesticide Disposal Resource Conservation and Recovery Act	Farmers and commercial pesticide users need to dispose pesticides through states' pesticide disposal programs. Iowa requirements include (i) triple rinsing and recycling empty container in a licensed sanitary landfill (typically no collection fee) (ii) disposing small quantities of pesticides as per label instructions; farmers must contact relevant authorities to dispose large amounts of pesticides.	Yes: Cost from time required for disposal; container disposal is free of charge; large amount of excess pesticide disposal is occasional and avoidable	No: No incremental benefits for corn production	Farmers would dispose of pesticide containers or ruminants as regular wastes.
	Pesticide Tolerances Federal Food, Drug, and Cosmetic Act (FFDCA) *FFDCA Section 408* *(40 CFR Part 180)*	FDA is responsible for the enforcement of tolerances for raw agricultural commodities. For example, tolerances for the three primary pesticide substances used on corn are glyphosate (0.1 mg/kg), atrazine (0.2 mg/kg), and lambda-cyhalothrin (0.05 mg/kg).	No: No incremental cost if farmers use proper equipment and follow label instructions	No: Social benefits but no private benefits for corn production	Farmers would be moderately cautious about food safety but not subject to random inspections for tolerances.

	Regulation	Operational Requirements	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
AGRI-ENVIRONMENTAL PRACTICES	Clean Water Act *National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit (PGP)* *CWA Section 402; 76 FR 68750*	Point source discharges of biological pesticides and chemical pesticides that leave a residue into waters of the U.S. are required NPDES permits (PGPs).	No: Limited impacts because it only applies to certain farms with point source discharges	No: Welfare benefits but no incremental economic benefit for corn production	Farms would not need a NPDES for point source discharges.
	Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); Endangered Species Act (ESA) *Endangered Species Protection Program (ESA section 7(a)(2); 50 CFR Part 402; 69 FR 47732; 70 FR 66392)*	EPA implements the program under FIFRA in compliance with ESA. The program requires geographically specific pesticide use limitations set forth in the Endangered Species Protection Bulletins, referenced on a pesticide label.	No: Limited impacts because it only affects certain areas and pesticides	No: Welfare benefits but no economic benefits for corn production	Farmer would apply pesticides without limitations related to endangered species
	1985 Farm Bill *Conservation Compliance: Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) provisions* *(7 CFR Part 12)*	Farmers who participate in most voluntary USDA programs are required to comply with the provisions. It prohibits farmers to: (1) plant or produce an agricultural commodity on highly erodible land without following an NRCS approved conservation plan or system; (2) Plant or produce an agricultural commodity on a former wetland; or (3) Convert a wetland which makes the production of an agricultural commodity possible.	Yes: It applies to certain farms with HEL (26%)	No: Long-term welfare benefits but no immediate private benefits	Farmers might plant on erodible land or a converted wetland

Appendix B-2: Environmental and food safety regulations affecting corn farming in France

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
GM CROPS	Authorization of release of GMOs Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms *Article 5 and 6*	Release of GMOs must be authorized by member states. To implement member states are required to introduce national laws to regulate GMO products on the market. The EU directive states the common requirements for conducting risk assessments, reviewing applications from organizations, and submitting GMO applications to the European Commission. The overall purpose of this regulation is to ensure that legal requirements for GMOs are similar across countries.	No: Primarily affects manufacturers of GMOs	No: Primarily affects manufacturers of GMOs	No authorization would be required.
GM CROPS	Restricting GMO Use or Sale Directive 2001/18/EC *Safeguard clause* *Article 23*	Member state can temporarily prohibit or restrict use or sale of GM crop if there is new evidence of risk to human or environment. France triggered the safeguard clause to ban GM corn throughout its territory.	Yes: Ban on GM corn cultivation causes loss of benefits of planting GM corns	Yes: Ban on GM corn causes savings on GM corn seeds, compared to the baseline	Farmers would have the freedom to plant or not plant GM corn.
GM CROPS	Restricting or Prohibiting GMO cultivation Directive (EU) 2015/412 on the possibility for member states to restrict or prohibit the cultivation of GMOs in their territory	Since 2015, member states can officially restrict or prohibit GM Crop cultivation on their territory by opting out of the GMO authorization at EU. France announced ban of GM corn cultivation on its territory.	No: No additional costs to the safeguard clause	No: No additional benefits to the safeguard clause	French farmers would plant GM corns.
GM CROPS	Authorization of GMO for food and feed Regulation (EC) 1829/2003 on GM food and feed *Section 1*	GMOs for food and feed uses must be authorized by member states. The regulation describes the role of member-states and the European Union, identifies required GMO risk-assessment documents, and sets the time frame for authorizing GMOs. Upon receiving an application from a producer of GMOs, the member-state coordinates with the European Commission and the European Food Safety Authority for EU level authorization.	No: Primarily affects manufacturers of GMOs	No: Primarily affects manufacturers of GMOs	No authorization would be required.
GM CROPS	Traceability of GM Crops Regulation (EC) 1830/2003 on the traceability and labeling of GMOs and the traceability of food and feed products produced from GMOs *Article 5*	To ensure traceability, farmers are required to include unique identifier (issued by the EU) on GMO products and pass the information about GM Crops to product handlers.	No: Does not affect corn production in France as no GM crops are cultivated	No: Does not affect corn production in France as no GM crops are cultivated	Not relevant to corn production

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
GM CROPS *(continued)*	Labeling of GM Products Regulation (EC) 1830/2003 on the traceability and labeling of GMOs and the traceability of food and feed products produced from GMOs *Article 12 and 24*	Include label on package "This product contains genetically modified organisms" of nearly all GM foods and a labeling threshold of more than 0.9 GMO content.	No: French farms do not grow GM corns	No: French farms do not grow GM corns	Not relevant to French farms since GM corns are banned
PESTICIDES	Authorization of pesticides Regulation (EC) No 1107/2009 on the placing of PPPs on the market *Article 28*	The EU, based on application from member-states, authorizes pesticides after risk-assessment by European Food Safety Authority (EFSA). Three most widely used pesticide substances for corn: (1) Glyphosate: approved at EU level, but France is planning to ban it; (2) Atrazine: banned by EU in 2003; (3) Lambda-cyhalothrin: approved by both EU and France.	Yes: Ban on Atrazine causes increased cost on pesticides and decreased yield	No: Welfare benefits but no economic benefits for farms' corn production	Farmers would have non-restricted access to all available types of pesticides.
	Record-keeping of pesticide application Regulation (EC) No 1107/2009 on the placing of PPPs on the market *Article 67*	Professional users are required to keep records of the PPPs they use for 3 years. Information to be recorded include the date of use, the full commercial product name the dose used, the identification of treated plants, identification of areas treated, and customer identification in the case of service providers subject to approval. France may have extended it to farmers as well but it is unclear whether it is linked to EU regulation.	Yes: Time spent on record-keeping	Yes: Benefit from proper use of pesticides	Farmers would not keep records.
	Training and certification for pesticide application Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticide *Article 5 and 6* (France's Ordinance No 2011-840)	Distributors and applicators providing services must be approved at regional level. Since 2011 re-packers, advisers and professional users (farmers and their staff) must get a new certificate called "Certiphyto" for distribution and application of pesticides. Certificates must be obtained through a test, but it is not mandatory to attend training courses. The certificate is valid for 10 years for farmers.	Yes: Certification and training require time and fees	Yes: Benefit from more efficient use of pesticides (European Commission 2006)	No certification or training required
	Storage of pesticides Directive 2009/128/EC on the sustainable use of pesticides *Article 13 (1)*	Member states are required to implement measures to ensure proper storage, handling and mixing of pesticides before application In France, handling and storage of pesticide is required to be consistent with pesticide labels	Yes: Securing pesticide storage areas	Yes: Benefits from reducing medical expenses	Farmers would handle or store in a fairly safe but casual manner

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
PESTICIDES *(continued)*	Disposal of pesticides Directive 2009/128/EC on the sustainable use of pesticides *Article 13*	Member states are required to implement measures to ensure proper (i) disposal of tank mixtures (iv) cleaning to equipment used and (v) recovery or disposal of pesticide remnants and their packaging. In France, retailers, distributors and users to join the "Adivalor" system drawn up by the PPP industry. PPP packages and remnants are collected at regular intervals free of charge. However, it is limited to PPP brands that are part of the Adivalor program.	Yes: Minor costs for transporting the containers or storing the containers in plastic bags	No: No incremental benefits for corn production	Farmers would dispose of pesticide containers or remnants as regular wastes.
	Pesticide application equipment Directive 2009/128/EC on the sustainable use of pesticides *Article 8(5)*	Professional users are required to conduct regular calibrations and technical checks of the pesticide application equipment.	Yes: Regular checks costs	Yes: Benefits from more efficient use of pesticides	Farmers would conduct necessary checks to ensure equipment working well
	Maximum Residue Levels Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin	Maximum residue levels are decided at the EU Level with inputs from European Food Safety Authority. Harmonized MRLs for 315 fresh agricultural products for food and feed. MRL for Glyphosate (1 mg/kg); Lambda-cyhalothrin (.02 mg/kg). France follows EU MRLs	No: No additional costs if farmers use proper equipment and follow max label rates	No: Welfare benefits but no economic benefits for corn production	Farmers would be moderately cautious about food safety but not subject to inspections for MRLs.
FERTILIZERS	Traceability, markings, labeling and packaging of fertilizers Regulation (EC) No 2003/2003 on fertilizers *Articles 7-10*	Manufacturers and distributors are required to include identification markings and labels on packages for traceability. Specifically, manufacturers are responsible for labeling fertilizers: "EC FERTILISER," specifying the type of fertilizer, identifying blended fertilizer separately, and printing the contents of the fertilizer on the package. These rules are similar for all member states. Labels are required to be printed at least in the national language of the member state and must be clearly legible.	No: Does not affect corn farms as requirements are for manufacturers and distributors	No: Does not affect corn farms as requirements are for manufacturers and distributors	Not relevant to corn production

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
FERTILIZERS *(continued)*	Fertilizer application Nitrates Directive 91/676/EEC *Article 4 and Article 5(1)*	France has designated 63,000 farms as nitrate vulnerable zones (NVZs) (57% of Utilized Agriculture Area). It has also established following standards: • *Fertilizer application period*: High C/N and low proportion of mineral nitrogen: July-Jan; Low C/N with organic nitrogen: Sep-Jan; Mineral fertilizer: July 15-Feb 15. • *Limitation on fertilizer application:* Calculation of the nitrogen balance according to the methods and rules defined in the National AP and regional guidelines: http://www.comifer.asso.fr/index.php/fr/bilan-azote.html • *Limitation on manure application:* 170 kg N/ha/year	Yes: Compliance costs	Yes: Long-term welfare benefits but minor economic benefits from more efficient fertilizer use	Farmers would not implement the required activities
AGRI-ENVIRONMENTAL PRACTICES	Cross-compliance for Good Agriculture and Environmental Conditions Regulation (EU) No 1306/2013	EU mandates member states to identify 7 GAEC measures related to (i) water (ii) soil and carbon stock (iii) landscape. France has following requirements: (i) Establish 5 meter wide buffer strips along watercourses (ii) No release of prohibited substances in water and safe storage of manure by maintaining 35 meters distance from groundwater (iii) Maintain seedling on arable land or agriculture surface after uprooting vineyards (iv) Obtaining certificate for use of irrigation and using assigned volume of water (v) Ensure tillage and no flooding (vi) Farmers that grow cereals, oilseeds cannot burn crop residue (vii) Farmers have to maintain hedges 10 meter wide.	Yes: Very few additional costs at the farm level can be attributed to cross compliance because of the pre-existing legislative environment (Brouwer et al. 2012, chapter 2, pp. 22)	Yes: Long-term welfare benefits but minor economic benefits for corn production	Most GAEC standards had been adopted because of pre-existing national legislation and potential benefits (Brouwer et al. 2012, chapter 2)

Appendix B-3: Environmental and food safety regulations affecting corn farming in Spain

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
GM CROPS	Authorization of release of GMOs Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms *Article 5 and 6*	Release of GMOs must be authorized by member states. To implement member states are required to introduce national laws to regulate GMO products on the market. The EU directive states the common requirements for conducting risk assessments, reviewing applications from organizations, and submitting GMO applications to the European Commission. The overall purpose of this regulation is to ensure that legal requirements for GMOs are similar across countries.	No: Primarily affects manufacturers of GMOs	No: Primarily affects manufacturers of GMOs	No authorization would be required.
GM CROPS	Restricting or Prohibiting GMO cultivation Directive (EU) 2015/412 on the possibility for member states to restrict or prohibit the cultivation of GMOs in their territory	Since 2015, member states can officially restrict or prohibit GM Crop cultivation on their territory by opting out of the GMO authorization at EU. Spain allows GM corn cultivation on its territory.	No: GM corn planting is not regulated	No: No incremental benefits compared to the baseline	Farmers would have the freedom to grow any available types of GM corn
GM CROPS	Authorization of GMO for food and feed Regulation (EC) 1829/2003 on GM food and feed *Section 1*	GMOs for food and feed uses must be authorized by member states. The regulation describes the role of member-states and the European Union, identifies required GMO risk-assessment documents, and sets the time frame for authorizing GMOs. Upon receiving an application from a producer of GMOs, the member-state coordinates with the European Commission and the European Food Safety Authority for EU level authorization.	No: Primarily affects manufacturers of GMOs	No: Primarily affects manufacturers of GMOs	No authorization would be required.
GM CROPS	Traceability and Labeling of GM Crops Regulation (EC) 1830/2003 on the traceability and labeling of GMOs and the traceability of food and feed products produced from GMOs *Article 5, 12 and 24*	To ensure traceability, farmers are required to include unique identifier (issued by the EU) on GMO products and pass the information about GM Crops to product handlers. In addition, labels are required on GM products for GM foods with a threshold of more than 0.9% GMO content.	Yes: Cost for labeling may not be high, but segregation and storage of GM crops can increase costs	No: Welfare benefits but no economic benefits for corn production	Farmers would not label GM corns.

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
PESTICIDES	Authorization of pesticides Regulation (EC) No 1107/2009 on the placing of PPPs on the market *Article 28*	The EU, based on application from member-states, authorizes pesticides after risk-assessment by European Food Safety Authority. Three most widely used pesticide substances for corn: (1) Glyphosate: approved at EU level, but France is planning to ban it; (2) Atrazine: banned by EU in 2003; (3) Lambda-cyhalothrin: approved by both EU and France	Yes: Ban on Atrazine causes increased costs on pesticides and decreased yield	No: welfare benefits but no economic benefits for farms' corn production	Farmers would have non-restricted access to all available types of pesticides.
	Record-keeping of pesticide application Regulation (EC) No 1107/2009 on the placing of PPPs on the market *Article 67*	Professional users are required to keep records of the PPPs they use for 3 years. Information to be recorded include the date of use, the full commercial product name the dose used, the identification of treated plants, identification of areas treated, and customer identification in the case of service providers subject to approval. In Spain regulation is applicable to farmers as well under Royal Decree 1311/2012.	Yes: Time for record-keeping	Yes: Benefit from proper use of pesticides	Farmers would not keep records.
	Training and Certification Directive 2009/128/EC on the sustainable use of pesticides *Article 5* (Spain's Royal Decree 1311/2012 of 14 September 2012)	Training and certification are required for professional users of PPPs but these requirements are specified for four different levels of expertise - (i) Básico (ii) Caulificado (iii) Fumigador (iv) Piloto Aplicador (for aerial spraying). Training hours for different levels are 25 hours (Basico), 60 hours (Caulificado) and 25 hours (fumigador) and 90 hours (Piloto aplicador). Upon completion of training and taking a test, pesticide applicators can get a certificate/License. A training certificate for professional users is valid for a period of ten years as per the national law however provinces can have different standards.	Yes: Certification and training require time and fees	Yes: Benefit from more efficient use of pesticides	No certification or training required
	Storage of pesticides Directive 2009/128/EC on the sustainable use of pesticides *Article 13 (1)* (Article 40 of Spain's Royal Decree 1311/2012)	Member states are required to implement measures to ensure proper storage, handling and mixing of pesticides before application In Spain, pesticides are required to be stored in cabinets or ventilated rooms with lock, in isolation from surface water or water extraction wells	Yes: Securing pesticide storage areas	Yes: Benefits from reduced medical expenses	Farmers would handle or store in a fairly safe but casual manner
	Disposal of pesticides Directive 2009/128/EC on the sustainable use of pesticides *Article 13*	Member states are required to implement measures to ensure proper (i) disposal of tank mixtures (iv) cleaning to equipment used and (v) recovery or disposal of pesticide remnants and their packaging. In Spain, farmers are required to triple rinse empty	Yes: Container disposal is free of charge. Other costs include transporting the containers or storing the containers in plastic bags.	No: No incremental benefits for corn production	Farmers would dispose of pesticide containers or remnants as regular wastes.

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
PESTICIDES *(continued)*	(Article 41 of Spain's Royal Decree 1311/2012)	pesticide containers, and deliver to appropriate collection points. Farmers are required to keep the receipt of delivering empty containers to appropriate collection point.			
	Pesticide application equipment Directive 2009/128/EC on the sustainable use of pesticides *Article 8(5)* (Spain's Royal Decree 1702/2011)	Professional users are required to conduct regular calibrations and technical checks of the pesticide application equipment. (In Andalusia and Mursia, pesticide application equipment must be registered.)	Yes: Requires regular equipment checks	Yes: Benefits from more efficient use of pesticides	Farmers would conduct occasional checks to ensure equipment working well
	Maximum Residue Levels Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin	Maximum residue levels are decided at the EU Level with inputs from European Food Safety Authority. Harmonized MRLs for 315 fresh agricultural products for food and feed. MRL for Glyphosate (1 mg/kg); Lambda-cyhalothrin (.02 mg/kg) France follows the EU MRLs	No: No additional cost if farmers use proper equipment and follow application limits on pesticide labels	No: Welfare benefits but no economic benefits for corn production	Farmers would be moderately cautious about food safety but not subject to inspections for MRLs.
FERTILIZERS	Traceability, markings, labeling and packaging of fertilizers Regulation (EC) No 2003/2003 on fertilizers *Articles 7-10*	Manufacturers and distributors are required to include identification markings and labels on packages for traceability. Specifically, manufacturers are responsible for labeling fertilizers: "EC FERTILISER," specifying the type of fertilizer, identifying blended fertilizer separately, and printing the contents of the fertilizer on the package. These rules are similar for all member states. Labels are required to be printed at least in the national language of the member state and must be clearly legible.	No: Does not affect corn farms as requirements are for manufacturers and distributors	No: Does not affect corn farms as requirements are for manufacturers and distributors	Not relevant to corn production
	Fertilizer application Nitrates Directive 91/676/EEC *Article 4 and Article 5(1)*	Spain has designated 17% of UAA was designated as NVZs. It has also established following standards: • *Application prohibition periods:* Organic fertilizer C/N>10: June 15-Dec; Organic fertilizer C/N<10: Aug-Jan 15; Industrial nitrogen fertilizer: Sep-Feb. • *Limitation on fertilizer application:* 170 kg total N/ha/year for dry corn; 210 kg total N/ha/year for irrigated corn • *Limitation on manure application:* 170 kg	Yes: Compliance costs	Yes: Long-term welfare benefits but minor economic benefits from more efficient fertilizer use	Farmers would not implement the required activities

	Regulation	Operational Requirements (Activities required for compliance)	Preliminary Assessment of Impact on Farm-Level Corn Production		Baseline
			Cost	Benefit	No Regulation
		N/ha/year			
AGRI-ENVIRONMENTAL PRACTICES	Cross-compliance for Good Agriculture and Environmental Conditions Regulation (EU) No 1306/2013	EU mandates member states to identify GAEC requirements as per their climatic/geographical conditions. These 7 GAEC measures are related to (i) water (ii) soil and carbon stock (iii) landscape. Spain has introduced GAED related to soil erosion and landscape. Specific requirements include (i) Prohibition on growing herbaceous crops on slopes greater than 10% (ii) Compulsory maintenance vegetation row lines on slopes greater than 15% are required (iii) Taking all measures to retent terraces and existing ridges in good conditions, avoiding ruins and collapse.	Yes: Very few additional costs at the farm level can be attributed to cross compliance because of the pre-existing legislative environment (Brouwer et al. 2012, chapter 2, pp. 22)	Yes: Long-term welfare benefits but minor economic benefits for corn production	Most GAEC standards had been adopted because of pre-existing national legislation and potential benefits (Brouwer et al. 2012, chapter 2)

Appendix C-1: Estimated regulatory costs and benefits on a typical corn farm in the United States ($ per year)

Regulatory Reference	Calculation Formula: Cost	Calculation Formula: Benefit	Base-Case Estimates: Cost	Base-Case Estimates: Benefit	Sensitivity Analysis – Upper-Bound Estimates: Cost	Sensitivity Analysis – Upper-Bound Estimates: Benefit	Sensitivity Analysis – Lower-Bound Estimates: Cost	Sensitivity Analysis – Lower-Bound Estimates: Benefit	Data Sources and Assumptions
GM Crops									
Insect Resistance Management in Bt Crops	= farmer compliance costs per acre * planted acres per farm	*Not quantifiable*	$259	n.q.	$487	n.q.	$35	n.q.	Using Hurley, Langrock and Ostlie (2006) estimates (2002 data), adjusted for inflation.
		Subtotal:	$259	n.q.	$487	n.q.	$35	n.q.	
Pesticides									
Certification of pesticide applicators for use of Restricted Use Pesticides	= (certification fee + time spent on exam * hourly wage + exam registration fee) / valid years + license fee	*Not quantifiable*	$59	n.q.	$59	n.q.	$59	n.q.	Assuming a typical corn farm needs one certified private applicator (EPA 2015).
Storage of pesticides	= annualized cost of a pesticide cabinet (10 years; discount rate = 3%)	*Not quantifiable*	$88	n.q.	$141	n.q.	$44	n.q.	Assuming a typical corn farm needs only one pesticide cabinet with a life span of 10 years.
Agricultural Worker Protection Standard (WPS)	= average annual costs per farm	*Not quantifiable*	$210	n.q.	$260	n.q.	$190	n.q.	Using estimates of baseline costs in EPA (2014)
Pesticide record-keeping	= time spent on record keeping * hourly wage	*Not quantifiable*	$46	n.q.	$46	n.q.	$46	n.q.	Using estimated hours from AMS 2007.
Pesticide disposal	=time spent on disposal * hourly wage	n/a	$117	0	$117	$0	$58	$0	Assuming 10 hours a year spent on pesticide disposal.
		Subtotal:	$519	n.q.	$622	n.q.	397	n.q.	
Agri-Environmental Practices									
Conservation compliance	= compliance costs per acre * planted acres * % of highly erodible land	n/a	$2,482	$0	$3,539	$0	$0	$0	Assuming a typical corn farm is subject to conservation compliance and has 26% HEL; using Barbarika & Dicks 1988 estimates (1982 data), adjusted for inflation.
		Subtotal:	$2,482	0	$3,539	$0	$0	$0	
		TOTAL:	$3,261	n.q.	$4,648	n.q.	$432	n.q.	
		COSTS PER ACRE:	$12	–	$17	–	$2	–	
		COSTS PER BUSHEL OF CORN PRODUCED:	$0.08	–	$0.12	–	$0.01	–	
		SHARE OF PRODUCTION COSTS:	2.47%	–	3.53%	–	0.33%	–	
		IMPACT ON NET FARM INCOME:	-3.42%	–	-4.81%	–	-0.47%	–	

Appendix C-2: Estimated regulatory costs and benefits on a typical corn farm in France ($ per year)

Regulatory Reference	Calculation Formula		Base-Case Estimates		Sensitivity Analysis Upper-Bound Estimates		Sensitivity Analysis Lower-Bound Estimates		Data Sources and Assumptions
	Cost	Benefit	Cost	Benefit	Cost	Benefit	Cost	Benefit	
GM Crops									
Prohibition of GM corn cultivation	= (increased yield per acre + pesticide cost saving per acre) * planted acre * % of GM corn	= (increased seed cost per acre) * planted acres * % of GM corn	$3,243	$305	$3,243	$305	$3,243	$305	Using Finger et al. (2011) estimate in the base case, Brookes & Barfoot (2016) in the upper bound.
		Subtotal:	$3,243	$305	$3,243	$305	$3,243	$305	
Pesticides									
Ban on Atrazine	= (increased pesticide cost + yield loss * corn price) * planted acres	n/a	$6,084	$0	$8,995	$0	$1,648	$0	Using Fawcett (2006) estimate in the base case, assuming U.S. estimates apply to EU; EPA (2002) estimate in the upper bound; USDA (1994) estimate in the lower bound (see Ankerman 2007); adjusted for inflation.
Pesticide Record-keeping	= time spent on record keeping * hourly wage	*Not quantifiable*	$53	$n.q.	$53	$0	$53	$0	Using estimated hours from AMS 2007.
Training and certification of pesticide users	= (time spent on training * hourly wage + training fee)/ valid years	= estimated savings per farm	$104	$44	$104	$44	$104	44	Assuming a typical corn farm needs 1 certificate for pesticide application; Savings estimates using EC 2006 data, adjusted for inflation.
Storage of pesticides	= annualized cost of a pesticide cabinet (10 years; discount rate = 3%)	*Not quantifiable*	$53	n.q.	$66	$0	$44	0	Assuming a typical corn farm needs only one pesticide cabinet with a life span of 10 years.
Pesticide disposal	=time spent on disposal * hourly wage	n/a	$147	$0	$147	$0	$73	$0	Assuming 6 hours a year spent on pesticide disposal.
Pesticide application equipment	= EU-wide costs / number of farms in EU-25	= EU-wide savings / number of farms in EU-25	$20	$3	$20	$3	$20	$7	Using EC 2006 estimates, number of farms from 2005 farm survey; adjusted for inflation.
		Subtotal:	$6,460	$47	$9,384	$47	$1,941	$51	

Agri-Environmental Practices									
GAECs	= observed costs - observed costs / (1 + cost increase %)	*Not quantifiable*	$1,095	n.q.	$4,254	$0	$0	$0	Using Brouwer et al. 2012 estimates: 1% cost increase in the base case; 4% in the upper bound; 0% in the lower bound.
		Subtotal:	$1,095	n.q.	4,254	n.q.	$0	n.q.	
		TOTAL:	$10,798	352+n.q.	$16,881	352+n.q.	$5,184	352+n.q	
		COSTS PER ACRE:	$91	–	$143	–	$44	–	
		COSTS PER UNIT OF PRODUCTION:	$0.57	–	$0.89	–	$0.27	–	
		SHARE OF PRODUCTION COSTS:	9.76%	–	15.26%	–	4.69%	–	
		IMPACT ON NET FARM INCOME:	-56.90%	–	-67.36%	–	-38.79%	–	

Appendix C-3: Estimated regulatory costs and benefits on a typical corn farm in Spain ($ per year)

Regulatory Reference	Calculation Formula		Base-Case Estimates		Sensitivity Analysis: Upper-Bound Estimates		Sensitivity Analysis: Lower-Bound Estimates		Data Sources and Assumptions
	Cost	Benefit	Cost	Benefit	Cost	Benefit	Cost	Benefit	
GM Crops									
GMO labeling	= planter cleaning labor costs + combine cleaning labor costs + combine cleaning material costs + storage costs	n/a	$867	$0	$1,137	$0	$0	$0	Using Foodie Farmer 2014 estimates on cost of a new grain bin with a 10-year life span; Using 29% GM corn in the base case, 100% in the upper bound, and 0% in the lower bound.
		Subtotal:	$867	$0	$1,137	$0	$0	$0	
Pesticides									
Ban on Atrazine	= (increased pesticide cost + yield loss*corn price) * planted acres	n/a	$2,158	$0	$3,258	$0	$593	$0	Using Fawcett (2006) estimate in the base case, assuming U.S. estimates apply to EU; EPA (2002) estimate in the upper bound; USDA (1994) estimate in the lower bound (see Ankerman 2007); adjusted for inflation.
Pesticide record-keeping	= time spent on record keeping * hourly wage	*Not quantifiable*	$42	n.q.	$42	n.q.	$42	n.q.	Using estimated hours from AMS 2007.
Training and certification of pesticide users	= (time spent on training * hourly wage + training fee)/ valid years	= estimated savings per farm	$91	$45	$91	$45	$91	$45	Assuming a typical corn farm needs 2 certificates for pesticide application; Savings estimates using EC 2006 data, adjusted for inflation.
Storage of pesticides	= annualized cost of a pesticide cabinet (10 years; discount rate = 3%)	*Not quantifiable*	$53	n.q.	$66	n.q.	$44	n.q.	Assuming a typical corn farm needs only one pesticide cabinet with a life span of 10 years.
Pesticide disposal	=time spent on disposal * hourly wage	n/a	$117	$0	$117	$0	$58	$0	Assuming 6 hours a year spent on pesticide disposal.
Pesticide application equipment	= EU-wide costs / number of farms in EU-25	= EU-wide savings / number of farms in EU-25	$20	$4	$20	$4	$20	$7	Using EC 2006 estimates, number of farms from 2005 farm survey; adjusted for inflation.
		Subtotal:	$2,481	$49	$3,594	$49	$849	$52	

Agri-Environmental Practices									
GAECs	= observed costs - observed costs / (1 + cost increase %)	*Not quantifiable*	$245	n.q.	$950	n.q.	$0	n.q.	Using Brouwer et al. 2012 estimates: 1% cost increase in the base case; 4% in the upper bound; 0% in the lower bound.
		Subtotal:	$245	n.q.	$950	n.q.	$0	n.q.	
		TOTAL:	$3,592	46.94+n.q.	$5,681	46.94+n.q.	$849	50.55+n.q.	
		COSTS PER ACRE:	$98	–	$154	–	$23	–	
		COSTS PER UNIT OF PRODUCTION:	$0.56	–	$0.88	–	$0.13	–	
		SHARE OF PRODUCTION COSTS:	14.54%	–	22.99%	–	3.44%	–	
		IMPACT ON NET FARM INCOME:	-15.89%	–	-23.00%	–	-4.27%	–	