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Agricultural Statistics

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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 productivity. Those chapters are published here as a working paper series with five parts. This chapter provides an overview of key statistical comparisons between the agricultural sectors of the U.S. and the EU. Its purpose is to highlight key economic indicators, describe the role that agriculture plays in each economy, and highlight differences in each jurisdiction's respective factor endowments and trade patterns. In addition, this chapter updates key statistics contained within the USDA Economic Research Service's (ERS) 2004 report: *U.S. – EU Food and Agricultural Comparison*.[3]

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2 This five-part working paper series was sponsored by a cooperative agreement with the United States Department of Agriculture. This working paper reflects the views of the authors, and does not represent an official position of the GW Regulatory Studies Center, the George Washington University, or the United States Department of Agriculture. The Center's policy on research integrity is available at http://regulatorystudies.columbian.gwu.edu/policy-research-integrity.

3 Note that the report below generally uses the latest available data from sources such as USDA ERS and Eurostat (e.g. 2014 or 2015). However, data from earlier years are sometimes used to preserve the validity of comparisons between the U.S. and EU for which more recent data are not available from the same source.There is variation in the timing of data availability depending on the source organization. While USDA ERS and Eurostat provide very recent data, internationally comparable data available from FAO is only available up to 2013.

Introduction

The United States is a Federal Republic consisting of 50 States and the District of Columbia. Under the U.S. Constitution, governmental powers are shared between federal and state governments. Powers related to national security, monetary policy, foreign affairs, and the regulation of commerce are vested in the federal government; any powers not delegated to the federal government or prohibited to the states, are reserved to the states or to the people.[4] Thus the federal and state governments share responsibilities affecting agriculture. At the national level, the USDA is charged with implementing national agricultural policies, and state governments have their own departments of agriculture. The key agricultural policies of the federal government are established in a Farm Bill passed by the U.S. Congress every five years or so, which authorizes services and programs regarding farm support, rural development, trade and foreign agriculture, research, nutrition, and conservation, among others.

The EU's scope has expanded since its creation as the European Economic Community (EEC) in 1957. The initial six member states—Belgium, Germany, France, Italy, Luxembourg, and the Netherlands—came together to foster economic cooperation. Gradually, free movement of goods and services and adoption of a single currency by most member states strengthened the EU. The Union has increased its membership from six member states in 1958 to 28 member states in 2015 (EU-28) through six phases of enlargement. The largest expansion was in 2004 when ten countries—Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia, and Slovenia—joined the union, expanding EU-15 to EU-25. Croatia is the latest country to be included in the EU in 2013. The pending departure of the UK from the EU, as called for in the 2016 "Brexit" referendum, would be the first time any country separated from the union.

The initial six member-states adopted a Common Agriculture Policy (CAP) in 1962, which focused on market stabilization, productivity improvement and price support but subsequently included environmental measures during the late 1980s which became compulsory for member states as of 1992.[5] The European Commission's Directorate-General for Agriculture and Rural Development is responsible for implementation of all aspects of agriculture policies such as farm support, market measures, rural development policy, financial and legal matters, and agricultural trade.

Agriculture is an important sector, economically and politically, in both the U.S. and the EU. The share of agriculture as a percentage of the total economy is similar in both the regions. As of 2016 agriculture contributed approximately 1.6 percent and 1.1 percent to

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4 Government Printing Office. (n.d.). *Tenth Amendment Reserved Powers*. Retrieved from https://www.gpo.gov/fdsys/pkg/GPO-CONAN-1992/pdf/GPO-CONAN-1992-10-11.pdf

5 European Commission (2016c) Agri-trade in 2015. *Monitoring Agri-trade Policy*, MAP-2016-1: http://ec.europa.eu/agriculture/sites/agriculture/files/trade-analysis/map/2016-1_en.pdf

the EU and U.S. Gross Domestic Product (GDP), respectively.[6] It is also worth noting that farm outputs are essential inputs for several value-added industries such as food service, textiles, leather products, and forestry and fishing. In the U.S., agriculture and agricultural related industries, combined, contributed $835 billion, or 4.8 percent, to U.S. GDP[7] compared to 1.5 percent in the EU.[8]

Agriculture in the U.S. also produces significant quantities of renewable fuels; here ethanol is primarily derived from corn, while biodiesel is primarily produced from soy.[9] According to the U.S. Energy Information Administration (EIA), "approximately 40 percent of total domestic corn crops [were] diverted from food and animal feed to ethanol production" in 2012—a sizeable increase from just 14 percent in 2005.[10] However, the decline in the use of corn for feed is partly offset by the use of ethanol byproducts, such as distiller's dried grains with solubles (DDGS), which are used for feed and may offset a portion of the decline caused by diversion.[11]

In the EU ethanol is primarily derived from grains and sugar beet derivatives, but there are regional differences. Northwestern Europe relies on wheat; central Europe on corn; and France, Germany, and Belgium use sugar beets for the production of bioethanol.[12] Earlier, the EU imported corn from the U.S. but many member states now prefer to source non-GM (not genetically modified) corn from Ukraine because "producers…prefer to market their distillers dried grains (DDG) as non-GM to the domestic feed market".[13]

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6 U.S. Central Intelligence Agency (2016). *World Fact Book*. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html

7 USDA ERS (2016a). "What is agriculture's share of the overall U.S. economy?" *Ag and Food Sectors and the Economy* Retrieved from https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy.aspx

8 Eurostat (2016). Agriculture Statistics – family farming in the EU. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Agriculture_statistics_-_family_farming_in_the_EU

9 U.S. Energy Information Administration. (2012, October). Biofuels Issues and Trends. Retrieved from: http://www.eia.gov/biofuels/issuestrends/pdf/bit.pdf

10 Wisner, R. (2009). Corn, ethanol and crude oil prices relationships – implications for the biofuels industry (AgMRC Renewable Energy Newsletter) Retrieved from: http://www.agmrc.org/renewable-energy/ethanol/corn-ethanol-and-crude-oil-prices-relationships-implications-for-the-biofuels-industry/

11 Duffield, J., Johansson, R., & Meyer, S. (2015). *U.S. Ethanol: an examination of policy, production, use, distribution, and market interactions*. Page 16. Retrieved from United States Department of Agriculture website: https://www.usda.gov/oce/reports/energy/EthanolExamination102015.pdf

12 Flach, B., Lieberz, S., Rondon, M., Williams, B., & Wilson, C. (2016). *EU-28 Biofuels Annual*. Retrieved from USDA Foreign Agricultural Service website: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_6-29-2016.pdf

13 Flach, B., Lieberz, S., Rondon, M., Williams, B., & Wilson, C. (2016). *EU-28 Biofuels Annual*. Page 18. Retrieved from USDA Foreign Agricultural Service website: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_6-29-2016.pdf

The significance of agriculture in the EU is evident in the comprehensive CAP that provides price and income support to farmers and addresses environmental sustainability by promoting environmentally friendly farming practices. Agriculture as a policy area falls under the jurisdiction of the European Commission, with 38 percent of the EU budget allocated to the sector in 2015.[14] The 2004 and 2007 EU enlargements caused shifts within its agricultural sector – the inclusion of new countries increased the number of farmers and agricultural land area, and also diversified its agricultural products and practices.

Macroeconomic and Socioeconomic Data

On the whole, agricultural growth was positive for both the U.S. and the EU between 2001–2014. The short-term shock caused by the financial crisis in 2007–09 had significant consequences for both economies. The macroeconomic indicators revealed a decline in economic growth, increase in unemployment rate, high inflation rate and major fluctuation in exchange rates during that period. The agriculture sector, due to its dependence on trade, was not immune to short-term decline.[15] But both jurisdictions recovered from the crisis beginning in 2010 and continue to be major contributors to the world's agricultural production.

Gross Domestic Product

The United States is the largest economy in the world, as a single country, with a GDP of U.S. $16.67 trillion in 2015.[16] However, the European Union, with 28 member countries, collectively had a GDP of US $17.75 trillion in 2015.[17] Both the U.S. and the EU experienced a sharp decline in the GDP growth rate in 2007-2009 caused by the global financial crisis, although the decline started earlier, and the recovery happened more quickly, in the U.S. Figure 1 illustrates the GDP growth rate for both the U.S. and EU from 2001 to 2015.

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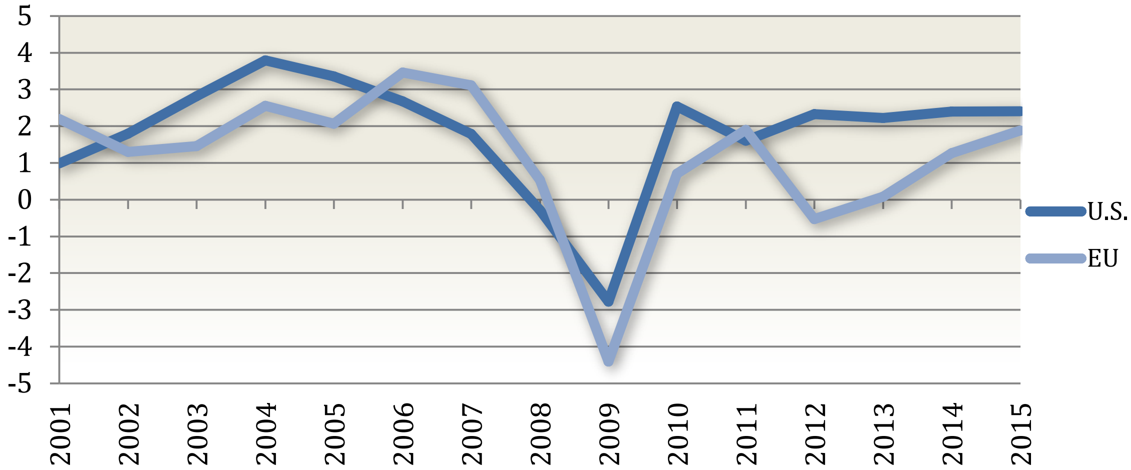
14 European Commission. (2015). *EU agricultural spending*. Retrieved from Agricultural and Rural Development, European Commission website: http://ec.europa.eu/agriculture/cap-funding/pdf/cap-spending-09-2015_en.pdf

15 Peter, M., Shane, M., & Torgerson, D. (2009). *What the 2008/2009 World Economic Crisis Means for Global Agricultural Trade* (WRS-09-05). Retrieved from United States Department of Agriculture website: https://www.ers.usda.gov/webdocs/publications/wrs0905/9377_wrs0905_1_.pdf

16 USDA ERS (2016a). "What is agriculture's share of the overall U.S. economy?" *Ag and Food Sectors and the Economy* Retrieved from https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy.aspx

17 *Ibid.*

Figure 1: U.S. and EU GDP Growth Rate, 2001-2014



Source: *USDA ERS international macroeconomic data*

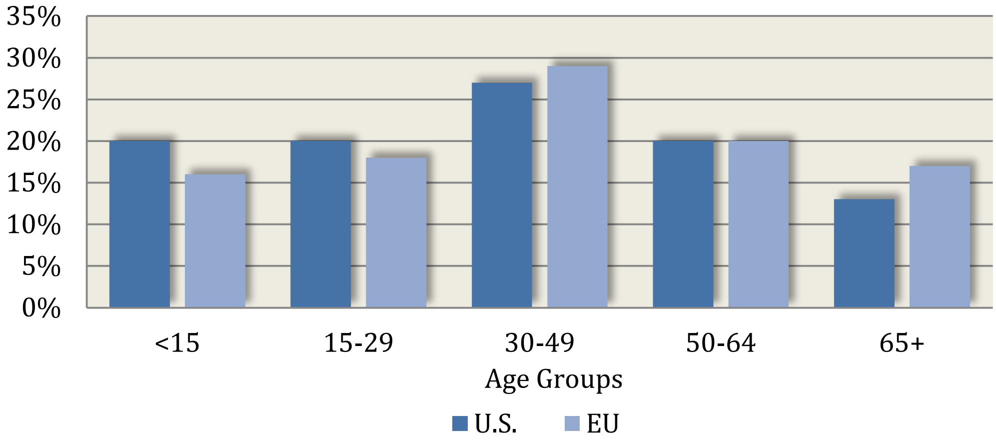
Population

As of 2015 the U.S. population was 321.2 million, compared to 508.5 million in the EU.[18] The number of inhabitants in the EU has increased significantly in the last decade due to the 2004 and 2007 enlargements that led to the admission of 12 new member states. However, the U.S. has maintained a higher average population growth rate than the EU. Between 1990 and 2015, the average annual growth rate of population in the U.S. was much higher at 1.02 percent compared to the annual average growth rate of 0.40 percent in the EU-15. In 2015, the population in the U.S. grew by 0.79 percent while the EU-28 grew by 0.25 percent.[19] As shown in Figure 2, however, the population distribution by age in the U.S. and EU is fairly similar, with close to 30 percent of the population between the ages of 30 and 49 years.

[18] World Bank Open Data (2016). *Population*, World Bank, Retrieved on June 16, 2016 from http://data.worldbank.org

[19] USDA ERS (2016b, December). International Macroeconomic Dataset. Retrieved September 3, 2016, from https://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx

Figure 2: Age Distribution in the U.S. and EU, 2010 for U.S. and 2011 for EU

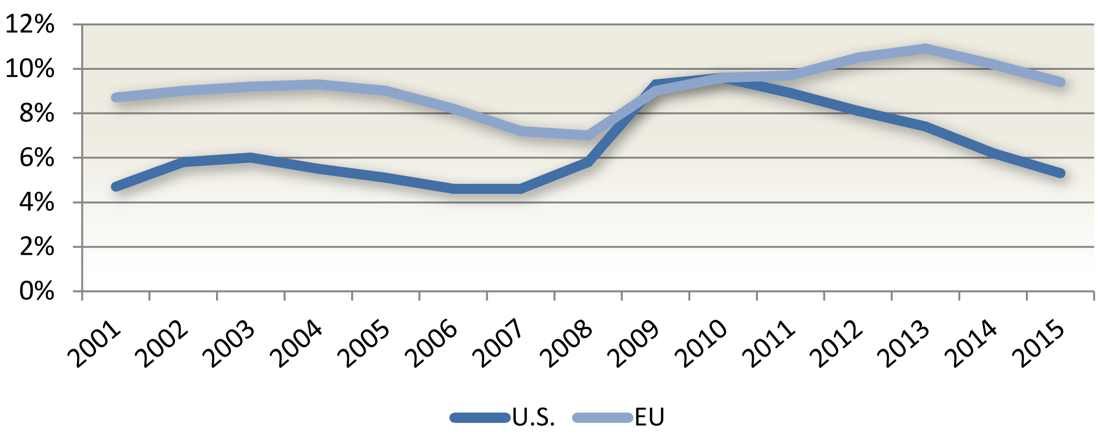


Source: *US Census and Eurostat*

Unemployment Rate

The unemployment rate in the EU has been higher than the U.S. with the exception of the period between 2009 and 2011, where it was slightly below the U.S. rate. The 2008 financial crisis resulted in an increased rate of unemployment in the U.S. However, since 2011, the U.S. unemployment rate has declined to 5.3 percent as of 2015 whereas the EU continues to experience a high rate of unemployment at 9.4 percent. There is a significant variation among the EU member states. For example, Greece and Spain experienced relatively higher levels of unemployment (24.9 percent and 22.1 percent respectively in 2014) compared to Germany, the country with the lowest rate of unemployment, at 4.6 percent.[20]

Figure 3: Unemployment Rate in the U.S. and EU



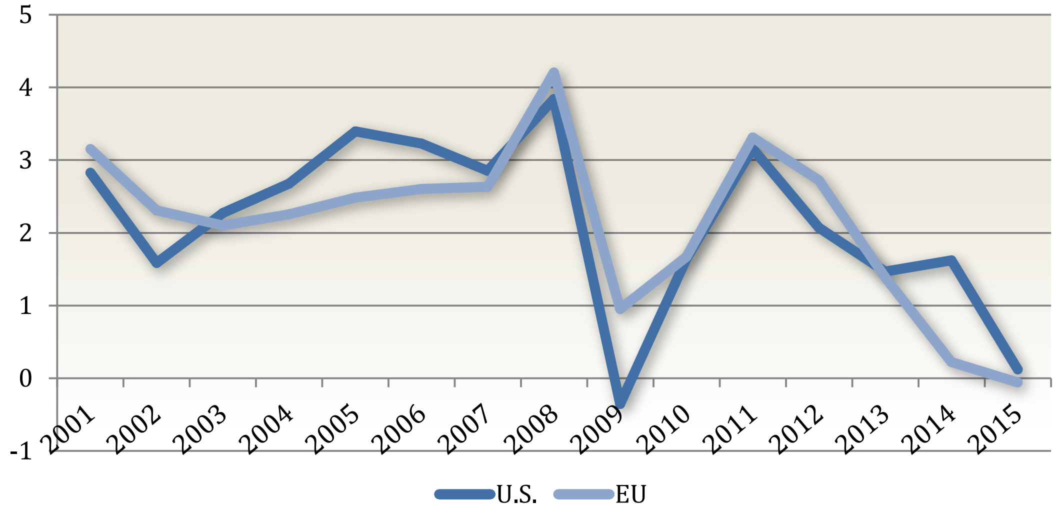
Source: *U.S. Bureau of Labor Statistics and Eurostat*

[20] Eurostat. (2016b, May 31). Unemployment statistics. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment_statistics

Inflation

Inflation rates in the U.S. and EU have fluctuated over the years. Between 2008 and 2012, the inflation rate in the United States mostly remained lower than the European Union. Before the financial crisis in 2008-09, the inflation rate in U.S. was mostly higher than the EU since 2003.

Figure 4: Inflation Rate: U.S. and EU

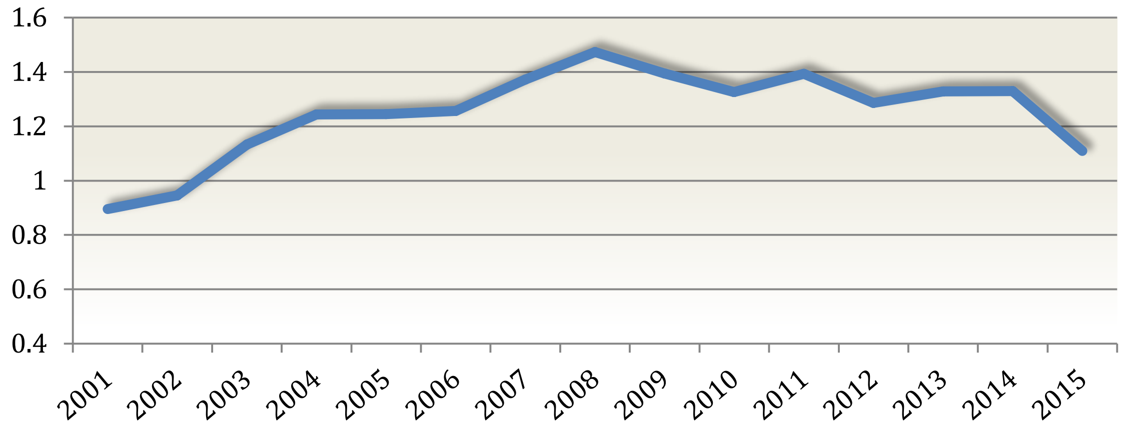


Source: *World Bank Open Data*

Exchange Rate

The exchange rate between the U.S. Dollar (USD) and Euro has fluctuated considerably between 2001 and 2008. In 2001, one dollar was equal to 0.89 Euros but by 2008, the same dollar was equal to 1.47 Euros. However, as illustrated in figure 5—USD per Euro from 2001 through 2015—the trend indicates that the Euro is once again losing value against the dollar.

Figure 5: U.S Dollar per Euro Exchange Rate



Source: *U.S. Federal Reserve; illustrating USD per Euro*

Overall, the macroeconomic indicators suggest economic recoveries underway in both the U.S. and EU relative to their 2008 levels. It is worth noting that the level of economic recovery within the EU varies significantly among member states. Countries such as Greece are still experiencing economic crises with relatively higher levels of sovereign debt and slower economic growth.

Agriculture in the United States and the European Union

The organization and structure of farmlands differ between the jurisdictions. The following section compares farm size, employment trends, and economic output of agricultural land and labor in the two jurisdictions.

Agriculture Inputs

Table 1: Farm Statistics in the U.S. and EU, 2013

	U.S.	EU
Agricultural land (million acres)	914	431
Number of farms (millions)	2	11
Average farm size (acres)	435	40

Note: *All units in non-U.S. measurements have been converted to U.S. units for comparison. For example, 1 hectare = 2.47105 acres.*

Source: *USDA Census of Agriculture and EU Farm Structure Survey*

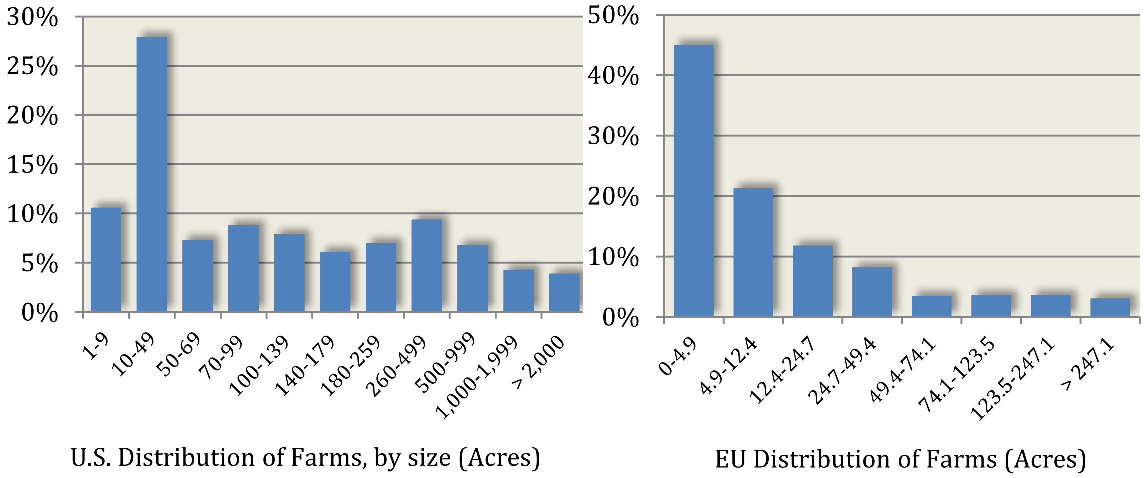
Farm Size

The average farm size in the U.S. is much larger than in the EU; the average farm size in the U.S. is 435 acres—about 10 times the average farm size in the EU of 40 acres. (Table 1) Figure 6 shows that 27.9 percent of farms in the U.S. are in the range of 10–49 acres while less than 15 percent of farms are larger than 500 acres. In the EU, 45 percent of farms are smaller than 4.94 acres.[21] The small farm size leads to the total number of EU farms of 10.84 million compared to 2.10 million in the U.S. In 2004, the addition of new member states increased the agricultural land area in the EU by 93.9 million acres. Currently, the EU contains approximately 430.8 million acres of agricultural land

[21] Eurostat (2015b). *Statistics Explained - Farm Structure Survey 2013*. European Commission. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Farm_structure_survey_2013_-_main_results

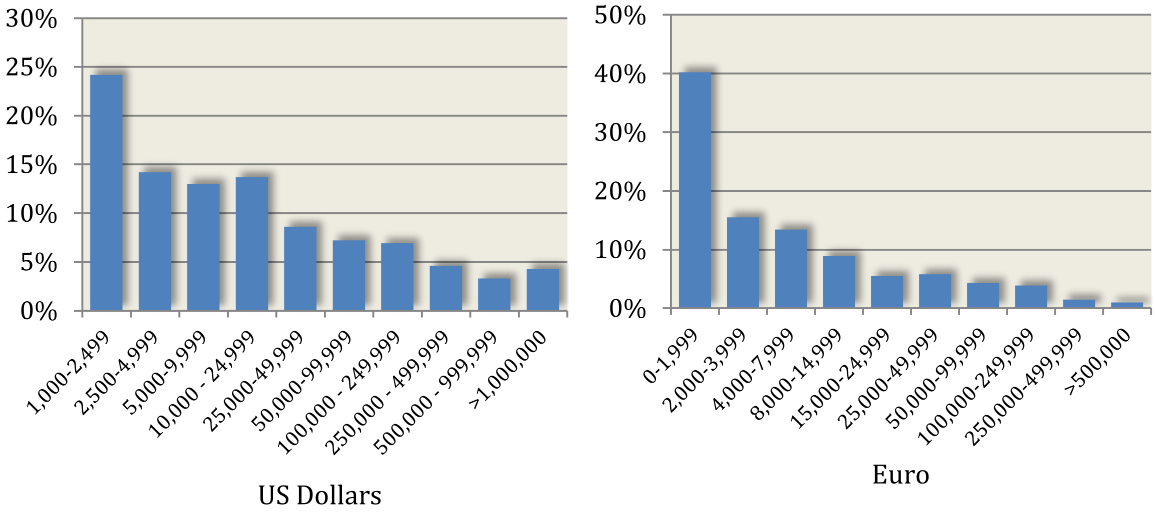
compared to 914 million acres in the U.S.[22,23] In terms of their distribution according to economic sales class, in 2013, 24.5 percent of the farms in the U.S make less than $2,500 in sales whereas in the EU, almost 40 percent of farms sales make less than €2,000 (around $2,600).[24,25]

Figure 6: Distribution of Farms in the U.S. and EU by size, 2012 for U.S. and 2013 for EU



Source: *U.S. Census of Agriculture, 2012; Eurostat, 2015b*

Figure 7: Distribution of Farms in the U.S. and the EU by sales class, 2013



Source: *National Agricultural Statistics Service 2014; Eurostat 2015b*

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[22] National Agricultural Statistics Service (2014). *Farms and land in farms*. Retrieved from USDA website: http://usda.mannlib.cornell.edu/usda/nass/FarmLandIn//2010s/2014/FarmLandIn-05-28-2014.pdf

[23] Eurostat (2015b).

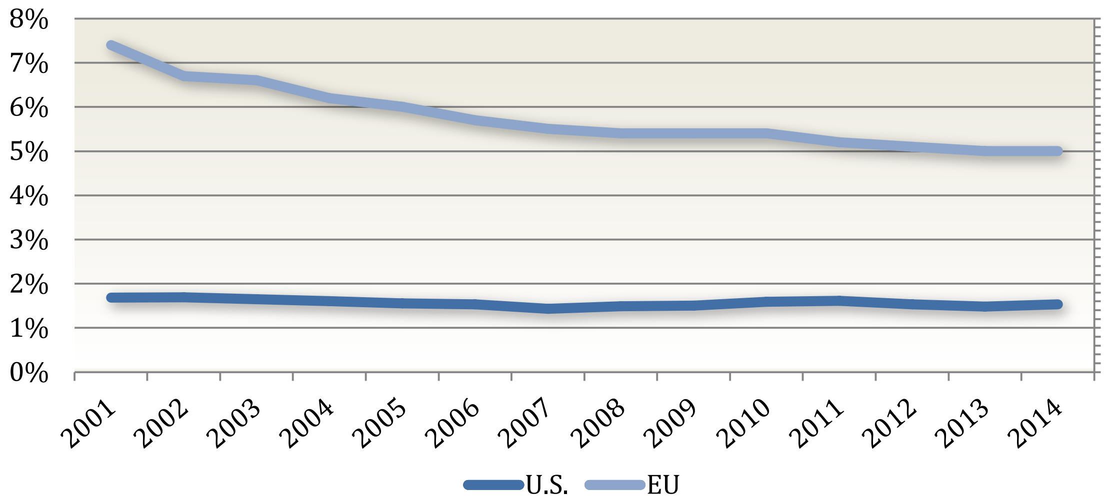
[24] National Agricultural Statistics Service 2014

[25] Eurostat (2015b).

Agricultural Labor Force

In both regions, agriculture is primarily family owned and operated.[26],[27] In 2015, agriculture provided employment to 1.63 percent of the labor force in the U.S., a slight decline from its 2001 level of 1.68 percent. Currently, roughly 5 percent of the labor force in the EU works in agriculture—again, a decline from its 2001 level of 7.4 percent. The greater labor-intensiveness of agriculture in the EU is consistent with the smaller average farm size and with smaller economies of scale; it may also reflect a residual technological lag in countries more recently admitted to the EU.

Figure 8: Agricultural employment as a percentage of employed civilian labor force, 2001-2014*



Source: *U.S. Bureau of Labor Statistics and Eurostat; *2015 data not available for the EU*

The information on agricultural labor rates is gathered through censuses in the United States and the European Union. The Census of Agriculture in the U.S. is conducted every five years, whereas the EU Census is carried out every ten years. The EU also conducts a Farm Structure Survey every three or four years to gather information on farms. Because data collection years in the two regions differ, it is challenging to accurately compare the two jurisdictions. Therefore, the following section is intended to suggest only general trends in respective regions.

[26] Eurostat (2016b). Agriculture Statistics – family farming in the EU. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Agriculture_statistics_-_family_farming_in_the_EU

[27] USDA Office of Communication (2015, March 7). Family Farms are the Focus of New Agriculture Census Data [Press Release] Retrieved from https://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2015/03/0066.xml&printable=true

Table 2: Age Distribution of Farmers in the U.S. and EU

United States (2012)	
Age	**Percent**
<35	5.7
36 – 45	10.2
46 – 55	22.1
56 – 65	28.8
>65	31.1

Source: USDA Census of Agriculture, 2012

European Union (2013)	
Age	**Percent**
<35	6.0
36 – 45	15.3
46 – 55	22.9
56 – 65	24.7
>65	31.1

Source: EU Farm Structure Survey, 2013

European Union

According to the EU Farm Structure Survey 2013, approximately 22.2 million people were employed on agricultural land; 75 percent of the agricultural workforce were farm owners or members of their family.[28] Of these, only 42 percent of farmers worked full time. Poland and Romania had the largest percentage of their labor force working in agriculture. According to the Farm Structure Survey 2013, the majority of farmers are above the age of 45.

United States

According to the USDA Census of Agriculture (2012), there are 3.1 million people working on the agricultural land. These include farm owners and secondary workers employed on the farm. At least 73 percent of the secondary operators are spouses.[29] With regard to age, 33 percent of the farmers are above the age of 65. There are only 5.68 percent of farmers below the age of 35.

Composition of Agricultural Output

The United States and the European Union have similar production patterns. Crop output accounts for 51 percent of total agricultural production in both jurisdictions. These primarily include food grains, feed grains, oilseeds, fruits, and vegetables. Animal products such as meat, eggs, and milk account for 40 percent of the output in the U.S. and

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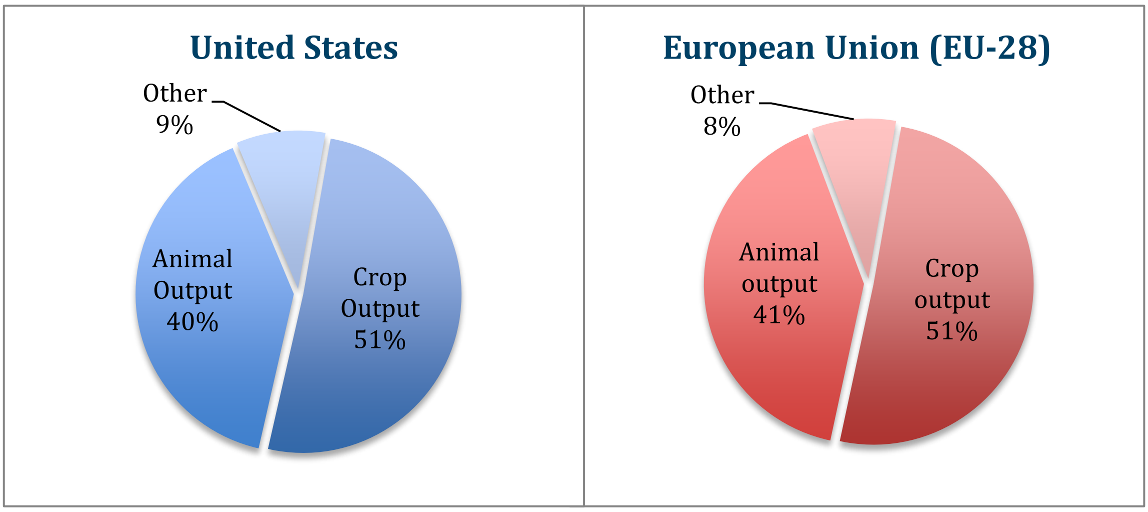
[28] Eurostat (2015b). *Statistics Explained - Farm Structure Survey 2013*. European Commission. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Farm_structure_survey_2013_-_main_results

[29] Hoppe, R. (2014). *Structure and Finances of U.S. Farms: Family Farm Report* (Economic Information Bulletin Number 132). Retrieved from USDA ERS website: http://www.ers.usda.gov/media/1728096/eib-132.pdf

41 percent in the EU. Notably, the composition of agricultural output has continued to be consistent between the two jurisdictions over the past decade.[30]

Figure 9: Composition of Agricultural Output, 2013



Source: *USDA ERS 2015; Eurostat 2016c*

The U.S. and EU are among the world's largest agricultural producers. The U.S. produces 35 percent of the world's corn, and more than 30 percent of its soybeans.[31] Other major crops include cotton and wheat. The EU is the main producer of sugar beets, accounting for almost 45 percent of world production in 2013.[32] Climatic conditions in Northern Europe make France, Germany, the United Kingdom and Poland conducive for sugar beet production.[33] Wheat and corn are also key agricultural outputs of the EU.

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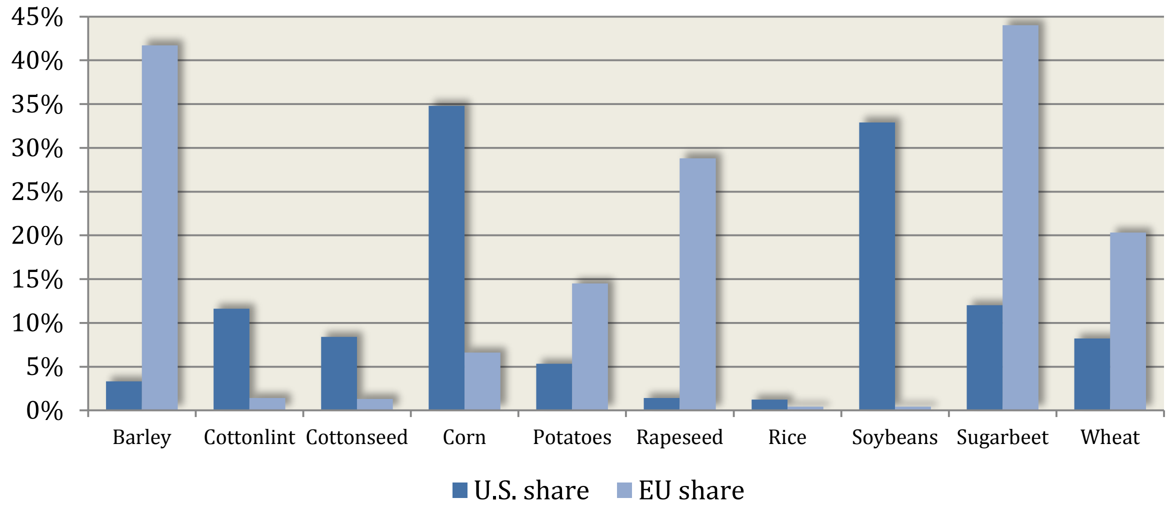
30 USDA ERS (2004). *U.S. - EU Food and Agricultural Comparison* (WRS 04-04). Retrieved from http://www.ers.usda.gov/media/881052/wrs0404_002.pdf

31 FAOSTAT (2016) Food and Agriculture Organization of the United Nations Statistics Division Retrieved from http://faostat3.fao.org

32 *Ibid*

33 European Commission. (2016b, June 7). Sugar - Agriculture and rural development. Retrieved from http://ec.europa.eu/agriculture/sugar/index_en.htm

Figure 10: Share of World Production in US and EU (Volume), 2013



Source: *FAOSTAT*

Trade in Agriculture

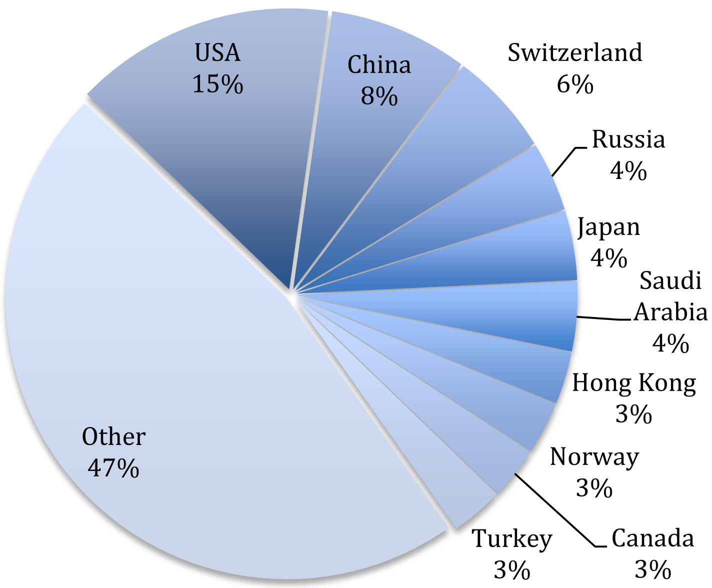
Both the U.S. and EU have recorded a positive trade balance over the last few years. Exports have increased, and imports have grown at a slower rate since the financial crisis. However, the trade patterns have evolved over the years.

Agricultural Exports

The U.S. and the EU are the largest exporters of agricultural products in the world. In 2013, U.S. exports were valued at $147 billion and EU exports were $151 billion.[34] Since 2004, the value of exports has nearly doubled for both jurisdictions. The gain in exports in both regions is attributed to increased demand from developing countries.

[34] FAOSTAT (2016) Food and Agriculture Organization of the United Nations Statistics Division Retrieved from http://faostat3.fao.org

Figure 11: Key Export Destination for EU-28 (2015)

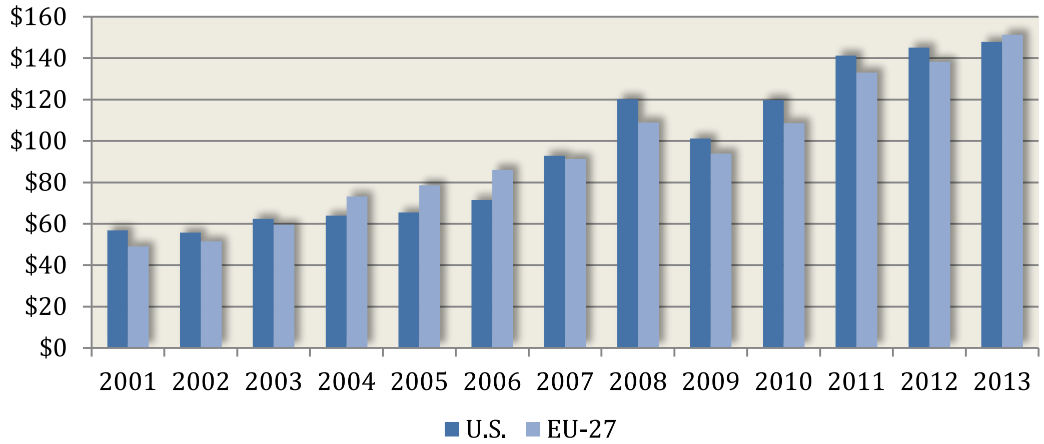


Source: *European Commission, 2016c*

The main trading partners for EU exports are the United States, followed by Russia, Switzerland, China, and Japan. As illustrated in figure 11, ten countries account for 53 percent of the exports from the EU. All of the EU statistics refer to trade external to the EU region. There is also internal agricultural trade among the EU member states. The external trade represents 26 percent of the total volume of agricultural trade in the EU.[35]

[35] Eurostat (2015c, February). Extra-EU trade in agricultural goods. *European Commission.* Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Extra-EU_trade_in_agricultural_goods

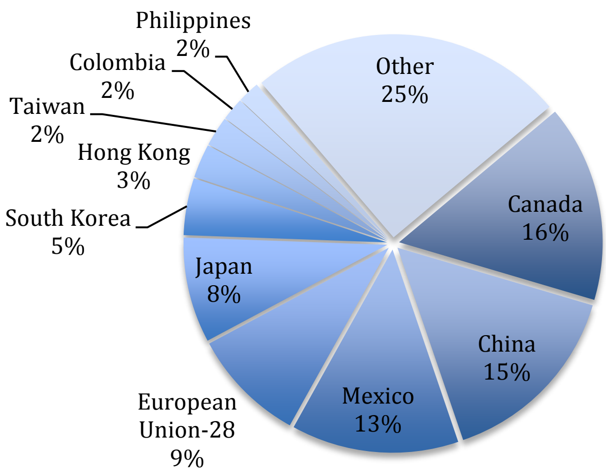
Figure 12: Agricultural Export (in USD millions)



Source: *Food and Agricultural Organization*

The U.S. exports 20.3 percent of its agricultural production.[36] The key countries for U.S. agricultural exports include China, Canada, Mexico, Japan, EU-28, and South Korea.[37] Historically, Canada was the top export destination for the United States; however, since 2009, there has been an increase in demand from China. Exports to the EU-28 accounted for 9 percent of all U.S. exports in 2015.

Figure 13: US: Key Export Destination



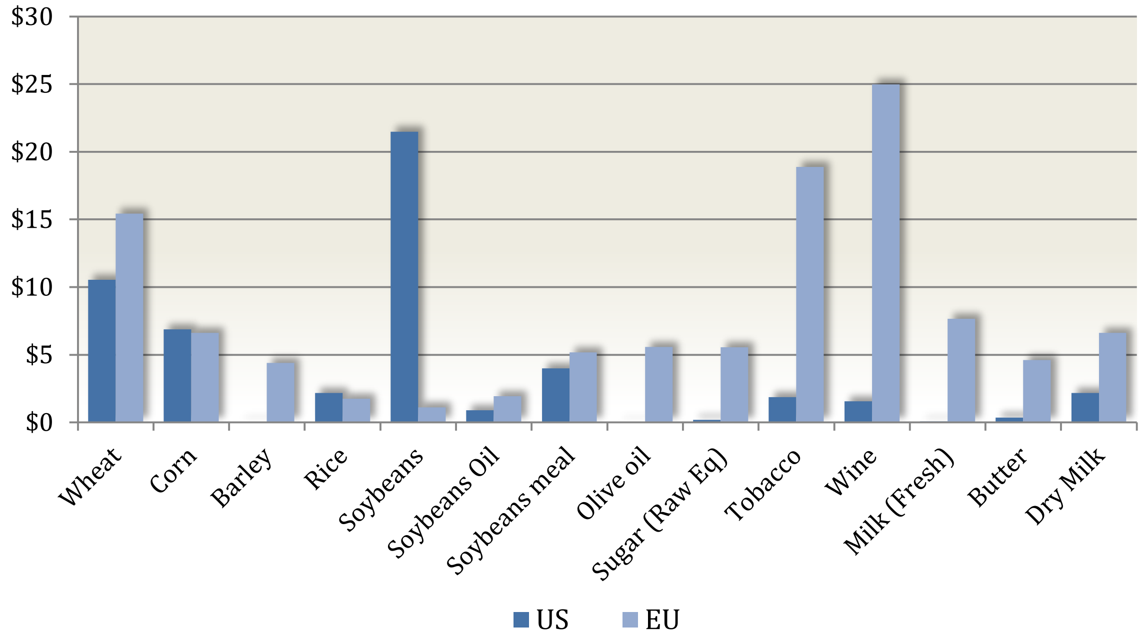
Source: *USDA ERS, 2016*

[36] USDA ERS (2016b, December). International Macroeconomic Dataset. Retrieved September 3, 2016, from https://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx

[37] *Ibid*

Top products exported from the U.S. include wheat and soybeans.[38] EU exports include tobacco, wheat, and corn (figure 14). The composition of agricultural exports has evolved with time. Export volumes have increased for the highest-value products. The European Union is the largest exporter of processed goods including wine and spirits.[39] The U.S. has experienced growth in dairy, animal meat, and oils in recent years.[40]

Figure 14: Agricultural exports by major categories (2013), in billions of USD



Source: *FAOSTAT 2015*

Agricultural Imports

Imports in the U.S. and EU constitute a significant share of the world market for agricultural goods. In 2013, U.S. imports accounted for $113.6 billion whereas imports to the EU-27 were valued at $138.8 billion. Although EU-27 imports are valued higher than the U.S., the overall trend suggests a decline in EU imports from 2011. On the other hand, imports to the U.S. have consistently increased since 2004. USDA data indicate that there is a significant increase in imports of live meat animals, animal meat, nuts, cocoa and chocolate, and vegetable oils.[41]

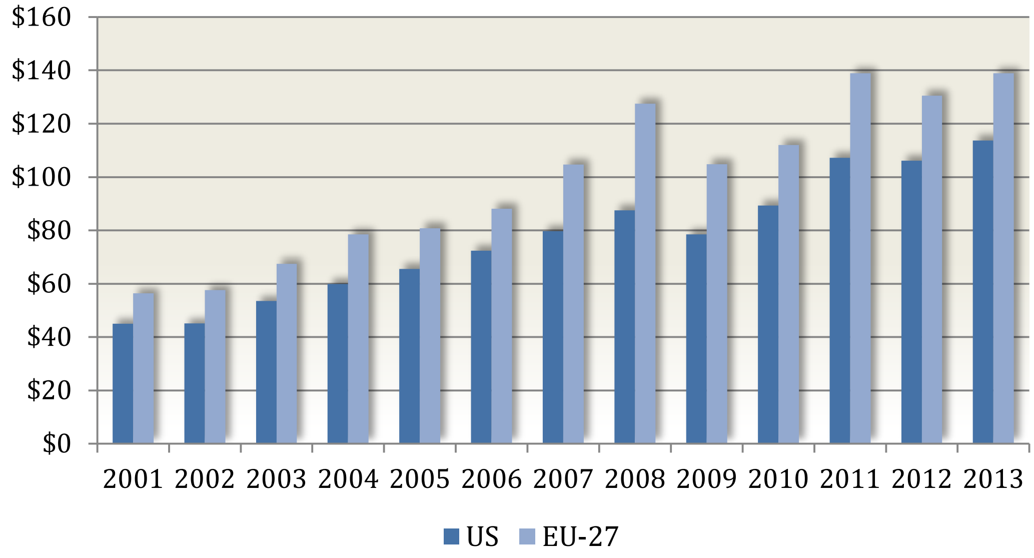
[38] USDA ERS (2015a, March 4). Exports. Retrieved June 16, 2016, from http://www.ers.usda.gov/topics/international-markets-trade/us-agricultural-trade/exports.aspx

[39] European Commission (2016c) Agri-trade in 2015. *Monitoring Agri-trade Policy*, MAP-2016-1: http://ec.europa.eu/agriculture/sites/agriculture/files/trade-analysis/map/2016-1_en.pdf

[40] USDA ERS 2015a

[41] USDA ERS (2015b, March 30). US Food Imports. Retrieved from http://www.ers.usda.gov/data-products/us-food-imports.aspx#25416

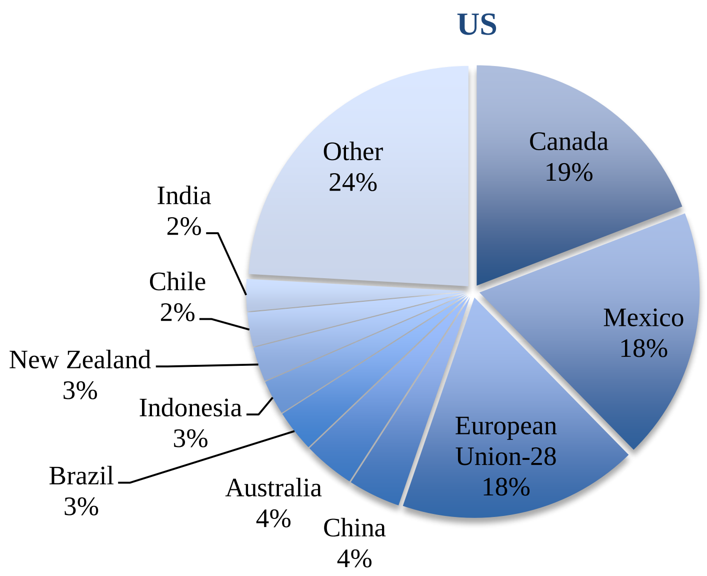
Figure 15: Agricultural Imports (in USD millions)



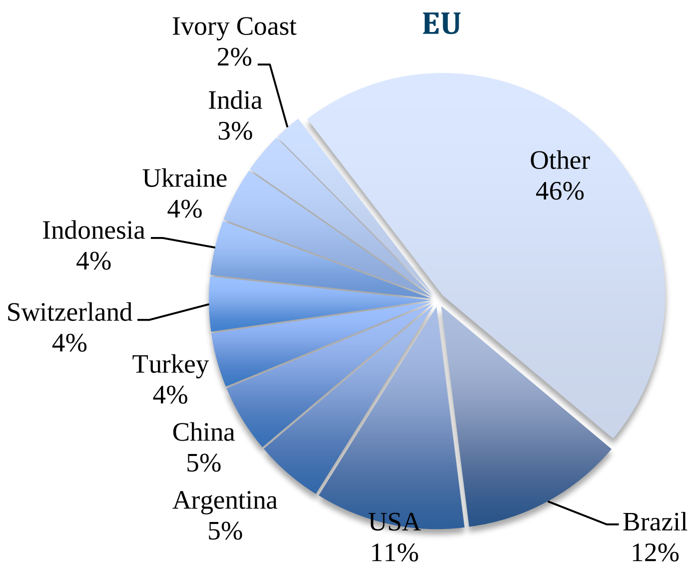
Source: *FAOSTAT, 2015*

Major imports in the EU include coffee, soybeans, oil cakes, oils, and fruits and vegetables. In 2015, fruits, nuts and spices was the largest commodity imported, accounting for 12 percent of the total share.[42] Brazil, U.S., China and Argentina are top exporters to the EU; whereas Canada, Mexico, the European Union, China, and India are the top exporters to the U.S.

Figure 16: Top agricultural import sources



[42] European Commission (2016c) Agri-trade in 2015. *Monitoring Agri-trade Policy*, MAP-2016-1: http://ec.europa.eu/agriculture/sites/agriculture/files/trade-analysis/map/2016-1_en.pdf

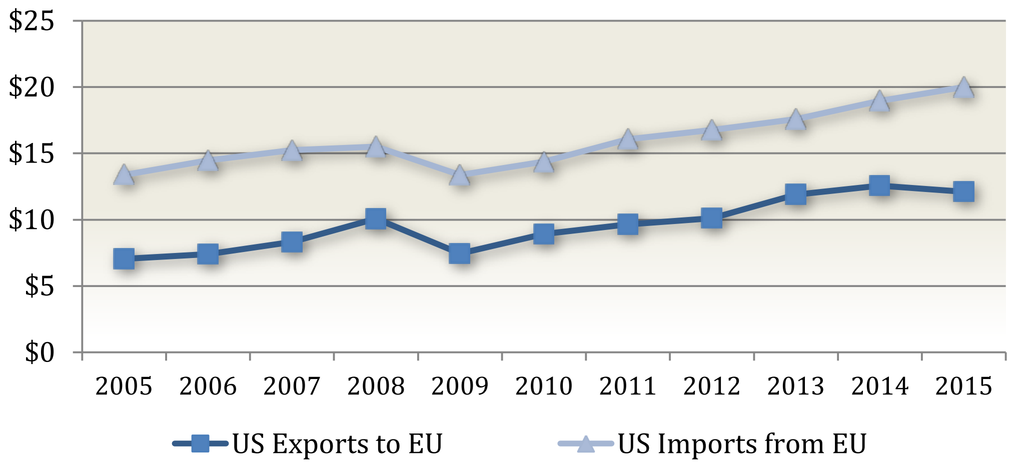


Source: *USDA ERS, 2016; European Commission, 2016c*

Bilateral trade

While the European Union and the United States are among each other's top trading partners, their share of trade has declined for several years. Between 2003 and 2007, the EU was the top source of imports for the U.S. However, the largest exporter to the U.S. is now Canada (USDA ERS 2016c). In 2015, agricultural products imported from the EU to the U.S. were valued around $20 billion. The relatively open market in the U.S. combined with high demand for European products have led to a consistent increase in imports since 2009 (USDA FAS, 2016). Exports to the European Union decreased slightly to 12.1 billion in 2015 from 12.5 billion in 2014. The market share of U.S. exports to the EU has decreased to roughly 13 percent of exports; this is mainly due to increased trade with emerging economies.

Figure 17: U.S. Imports and Exports to the EU (in billions USD)



Source: *USDA ERS 2016*

At present, the U.S. and the EU are negotiating the Translating Trade and Investment Partnership (TTIP) to reduce trade barriers including those in food and agricultural products. The terms of negotiation can have a significant impact on the quantity and type of products exported from the U.S. It is worth noting that both the Brexit vote and the 2016 U.S. election have created uncertainty about the direction of the TTIP negotiations.

Conclusion

The U.S. and the EU are globally competitive economies with positive trends in agricultural production. The farm structures in both jurisdictions vary significantly in terms of farm size and farm labor force. The U.S. has more than twice the amount of agricultural land as the EU and its farms are larger in size, on average. Smaller economies of scale in the EU are associated with greater labor intensiveness in agriculture. Despite differences in their profiles, both jurisdictions continue to be the world's two largest agricultural producers. The composition of agricultural output in the two jurisdictions is similar, but the relative strength in agricultural products differs. For example, the U.S. is a global leader in the production of corn whereas the EU leads in producing sugar beets. In terms of processed output, Europe is a major source of wine to the world.

Agricultural trade is strong in both the U.S. and the EU. The U.S. is a major exporter of wheatand soybean, whereas the EU leads exports of tobacco and wine. Both jurisdictions are also strong trade partners: U.S. agricultural imports from the EU-28 account for 18 percent of its total agricultural imports; 9 percent of its agricultural exports are sent to the EU. Similarly, agricultural imports from the U.S. constitute 11 percent of the EU-28 total, and 15 percent of the EU agricultural exports are traded to the U.S. Trading patterns between the two jurisdictions have changed over time; the on-going negotiations on TTIP, and the new administration's policy views, are likely to have significant implications for future agricultural trade.

Regulatory
Studies Center
THE GEORGE WASHINGTON UNIVERSITY

Agricultural Productivity and the Impact of Regulation

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The George Washington University Regulatory Studies Center[2]

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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 productivity. Those chapters are published here as a working paper series with five parts. This chapter provides focuses on the impact of agricultural policy, specifically regulation, in influencing agricultural productivity across jurisdictions. It begins by tracing agricultural growth in the EU and U.S. to illustrate their respective trends for agricultural productivity. Then, drawing from the literature, it identifies measures and methodologies used to estimate the impact of regulation on productivity. Finally, it outlines important differences regarding how regulations can affect agricultural productivity and other measures of agricultural performance such as output and production costs in the EU and the U.S.

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[2] This five-part working paper series was sponsored by a cooperative agreement with the United States Department of Agriculture. This working paper reflects the views of the authors, and does not represent an official position of the GW Regulatory Studies Center, the George Washington University, or the United States Department of Agriculture. The Center’s policy on research integrity is available at http://regulatorystudies.columbian.gwu.edu/policy-research-integrity.

Introduction

In recent years both the EU and the U.S. exhibit continued growth in agricultural output with simultaneous decreases in agricultural inputs. This suggests that productivity gains (increased output per unit of input) remain an important factor in the agriculture sector.

Unless otherwise noted, data for the EU include only the EU-15 countries prior to several rounds of enlargement that occurred after May 1, 2004. There are at least two reasons for this approach. First, holding the number of Member States constant for EU data allows for more useful comparisons between jurisdictions. For example, it allows us to illustrate changes in land area used for agriculture between jurisdictions that are likely the result of different policy choices rather than the result of adding additional member states to the EU. Second, EU-15 countries collectively make up over 80% of current EU-28 gross agricultural production value.[3] Additionally, the EU-15 countries are more similar to the U.S. (e.g., in their general economic profile) relative to other countries within the EU-28. This allows our comparisons to benefit from consistent jurisdictions while remaining highly representative of EU-wide trends.

Sources of Productivity Growth

Considering the important role of productivity in agriculture production, a crucial question is what contributes to productivity growth.[4] Wang, et al. pointed out that the major factor driving long-run productivity growth is innovation, including public and private R&D, extension activities and public infrastructure that enhance technological changes.[5] It is worth noting that in the short-term, productivity growth can be affected by a variety of random factors such as weather, pests & animal diseases, and short-term policy shifts. Furthermore, studies have decomposed agricultural productivity into technological change and technical efficiency. Sabasi and Shumway identified explanatory variables affecting each component through economic theory and prior literature.[6] They found that technological change was primarily affected by increased innovation, and efficiency change was driven by farm size, ratio of family to total labor, agro-climatic conditions, and weather.

Many of these factors are influenced, either directly or indirectly, by government regulation and policy. For example, land conservation regulations can affect farm size; pesticide use regulations

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[3] FAOSTAT. *FAOSTAT Database*. 2015. http://faostat3.fao.org/home/E (accessed May 30, 2016).

[4] There are several different measures of productivity, but all attempt to calculate a ratio of outputs to inputs.

[5] Wang, Sun Ling, Paul Heisey, David Schimmelpfennig, and Eldon Ball. *Agricultural Productivity Growth in the United States: Measurement, Trends, and Drivers*. Economic Research Report 189, Washington, DC: Economic Research Service, U.S. Department of Agrciulture, 2015.

[6] Sabasi, Darlington, and C. Richard Shumway. "Technical Change, Efficiency, and Total Factor Productivity Growth in U.S. Agriculture." 2014 Agricultural & Applied Economics Association Annual Meeting. Minneapolis, Minnesota, 2014.

can affect pest damages to crop yield; farm labor regulations can affect labor ratio; and market regulations can affect capital inputs and technological investments. Relevant regulations thus are expected to affect agricultural productivity. Leetmaa, Arnade and Kelch, in their comparative study of U.S. and EU agricultural productivity, noted that "relatively few studies have investigated the impact of government policy on agricultural productivity."[7] However, recent studies have drawn increasing attention to empirical evidence on the correlation between regulation and agricultural productivity. This chapter attempts to shed light on that relationship by summarizing the major measures and findings through literature review in the following sections.

Trends in Agricultural Growth

The EU and the U.S. are two of the largest agricultural producers in the world, and both jurisdictions have experienced continued growth in agricultural output. The following section compares agricultural output with the use of inputs in both jurisdictions to determine whether input use explains output growth. The findings demonstrate that the overall contribution of agricultural input use to output growth is negative for both the EU and the U.S from 1981 to 2013. This implies that increased output should be attributed primarily to gains in productivity.

Agricultural Output in the U.S. and EU

Figure 1 illustrates that both the EU and the U.S. have experienced growth in total agricultural production from 1981 to 2013. Possibly due to the U.S. farm financial crisis in the early 1980s, agricultural output in the U.S. fluctuated between 1980 and 1990, while agricultural output growth in the EU-15 were relatively steady. Beginning in 1990s, growth rates in the U.S. consistently exceeded those of the EU.[8] Over the 32-year period, agricultural output in the U.S. grew at an average annual rate of 1.28% compared to a 0.42% annual rate in the EU-15. By 2013, agricultural output in the U.S. was about 42% higher than it had been in 1981, whereas agricultural output in the EU-15 had only grown by approximately 13% over that same period.

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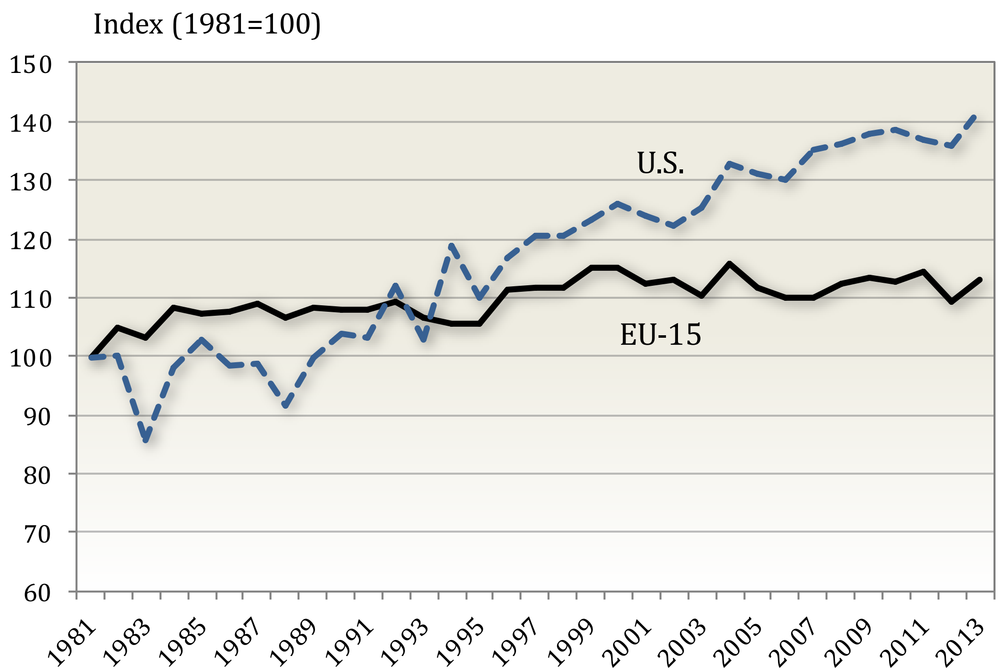
7 Leetmaa, Susan E., Carlos Arnade, and David Kelch. *Comparison of U.S. and EU Agricultural Productivity with Implications for EU Enlargement*. Agriculture and Trade Report, Washington, DC: Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture, 2004.

8 Two events may have played a role. In 1980, the U.S. halted grain shipments to the Soviet Union, which caused the collapse of grain prices and precipitated a 6-year decline in U.S. farmland values. (https://www.agclassroom.org/gan/timeline/1980.htm) (http://site.iptv.org/mtom/classroom/module/13999/farm-crisis?tab=background#background). In 1986 the U.S. adopted the Coordinated Framework for Biotechnology, which facilitated innovations that likely contributed to an increase in productivity beginning in the late 1980s.

Figure 1: U.S. and EU-15 indices of gross agricultural production, 1981-2013



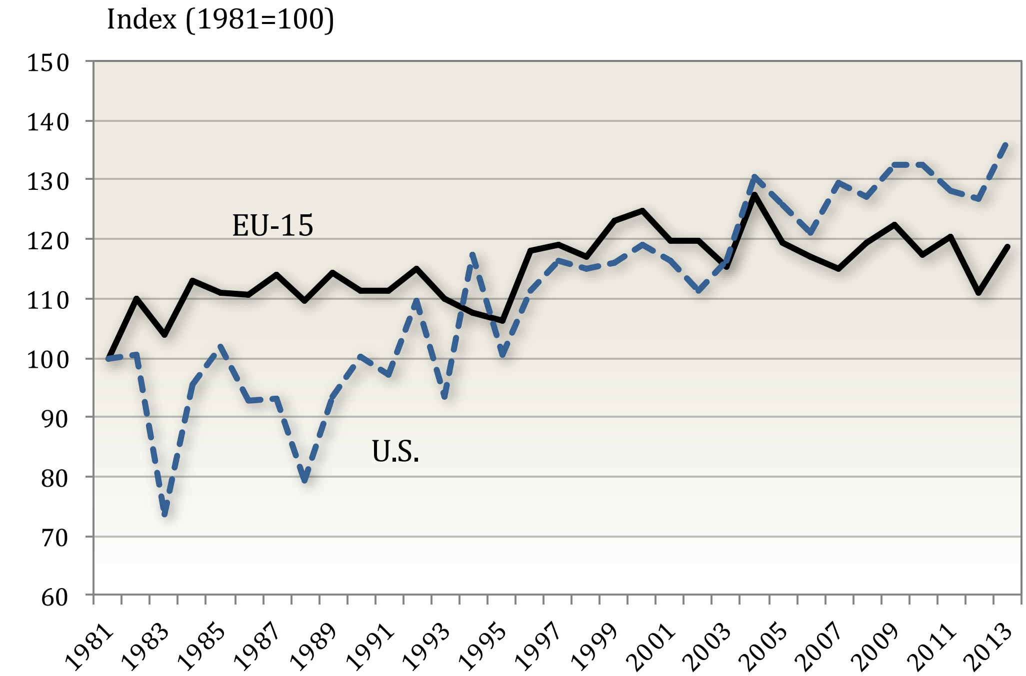
Indices are developed by FAO using agriculture production quantities weighted by 2004-2006 average international commodity prices and summed for each year.[9]

Source: *Calculated from FAOSTAT*

Crops are particularly sensitive to short-term shocks (e.g. pests or changes in weather), but Figure 2 shows that crop production in the EU and U.S. exhibited growth patterns similar to those displayed in Figure 1 for agricultural production broadly. Output within both jurisdictions increased overall between 1981-2013, but, starting in the 1990s, rates of change in the U.S. exceeded those in Europe. On average, crop output in the EU-15 and the U.S. grew by 0.66% and 1.59% per year, respectively.

9 Please see FAOSTAT metadata on production indices for details on the methodology http://www.fao.org/faostat/en/#data/QI/metadata

Figure 2: U.S. and EU-15 indices of gross crop production, 1981-2013



Indices are developed by FAO using agriculture production quantities weighted by 2004-2006 average international commodity prices and summed for each year.

Source: *Calculated from FAOSTAT*

It is common practice to attribute changes in agricultural output to two factors: changes in the use of agricultural inputs, and agricultural productivity growth.[10] Generally, agricultural inputs include labor, land, capital and intermediate inputs (such as fertilizer), while productivity is defined as the remaining changes in output that cannot be explained by changes in inputs.[11] The following sections further highlight the trend in agricultural inputs and productivity and their roles in driving output growth in the EU and the U.S.

Agricultural Input Use in U.S. and EU

Labor and land are two of the most important traditional inputs in agricultural production. Figures 3 and 4 show that, while output has increased since 1981, labor and land input have decreased overall in both the EU and the U.S. Agricultural land area in the EU declined by about 0.40% per year from 1981 to 2013. Similarly, the U.S. experienced a moderate but continued decrease in agricultural land area at an average annual rate of 0.17%.

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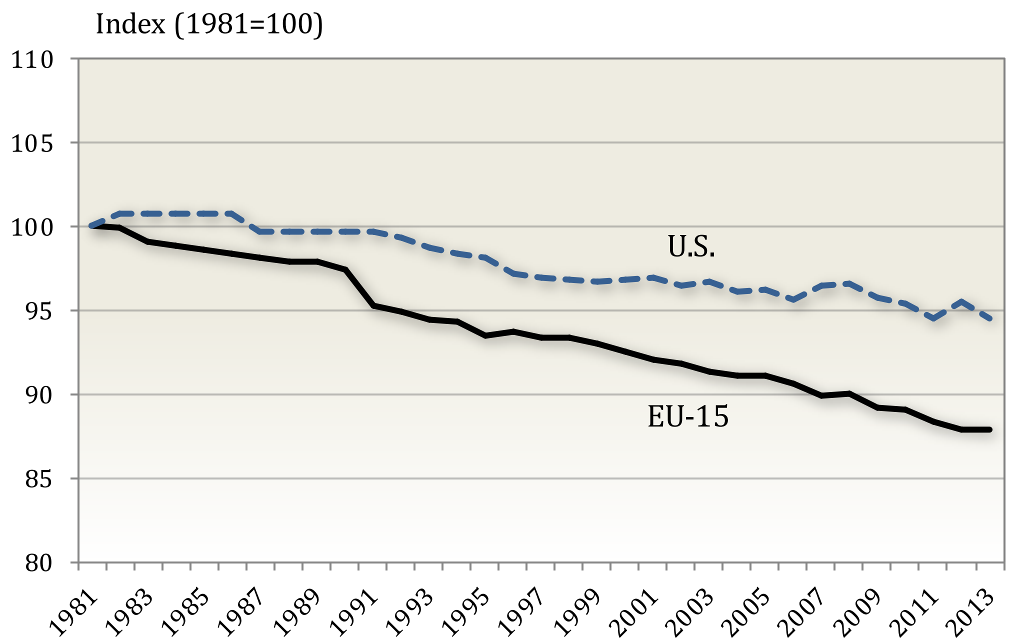
[10] Leetmaa et al (2004); Wang, et al. (2015)

[11] *Ibid*

Agricultural labor input exhibited a distinctly more significant decline in both jurisdictions beginning in 1994. Agricultural labor input[12] in the EU decreased by approximately 2.31% per year on average between 1991 and 2013. U.S. agricultural labor input decreased by 1.48% per year since 1981 and 1.09% per year since 1991.

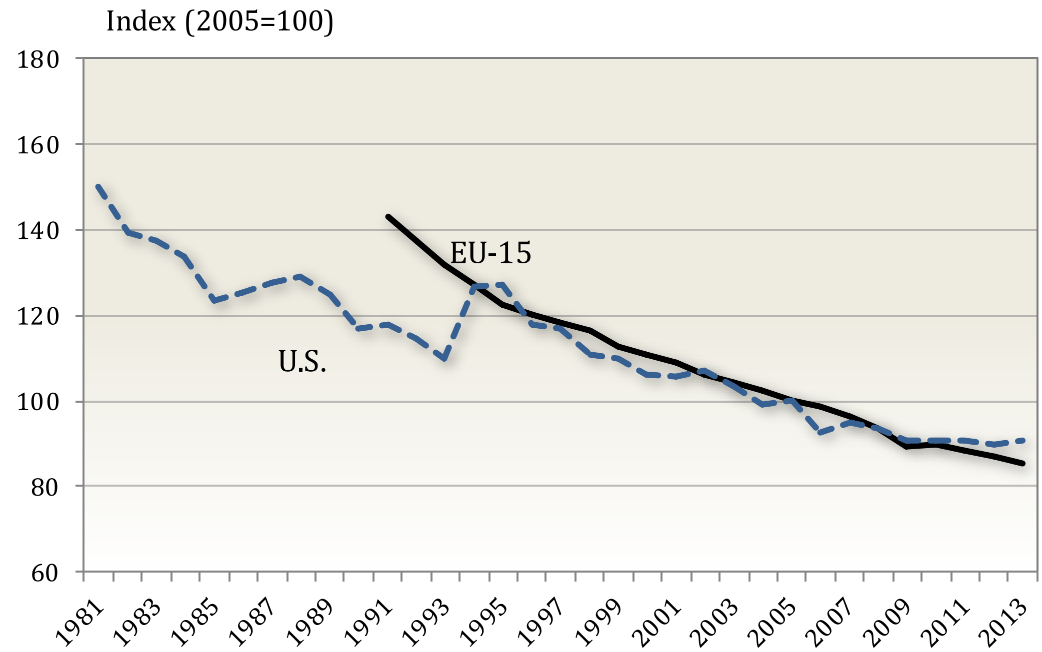
Figure 3: U.S. and EU-15 indices of agricultural land area, 1981-2013



Source: *Calculated from FAOSTAT*

[12] Labor input for the U.S. and the EU is measured from different sources therefore it is only meant to be indicative of individual trends, and not comparable measures due to possible differences in data and methods of calculation.

Figure 4: U.S. and EU indices of agricultural labor input 1981-2013 for U.S., 1991-2013 for EU-15



Note: Labor input for the U.S. and the EU is measured from different sources and may not be comparable measures because of possible differences in data and methods of calculation.

Source: *ERS Agricultural Productivity in the U.S.; EuroStat Economic Accounts for Agriculture*

Intermediate inputs in agricultural production include seed, feed, purchased livestock, fertilizer, pesticides, energy, and purchased services.[13,14] Unlike labor and land inputs, figure 5 shows an increasing trend in total intermediate input use in agricultural production. The EU's intermediate input use increased at an average annual growth rate of 0.73% from 1993 to 2013. Intermediate input use in the U.S. grew by 0.56% per year since 1981 and 0.95% per year since 1993.

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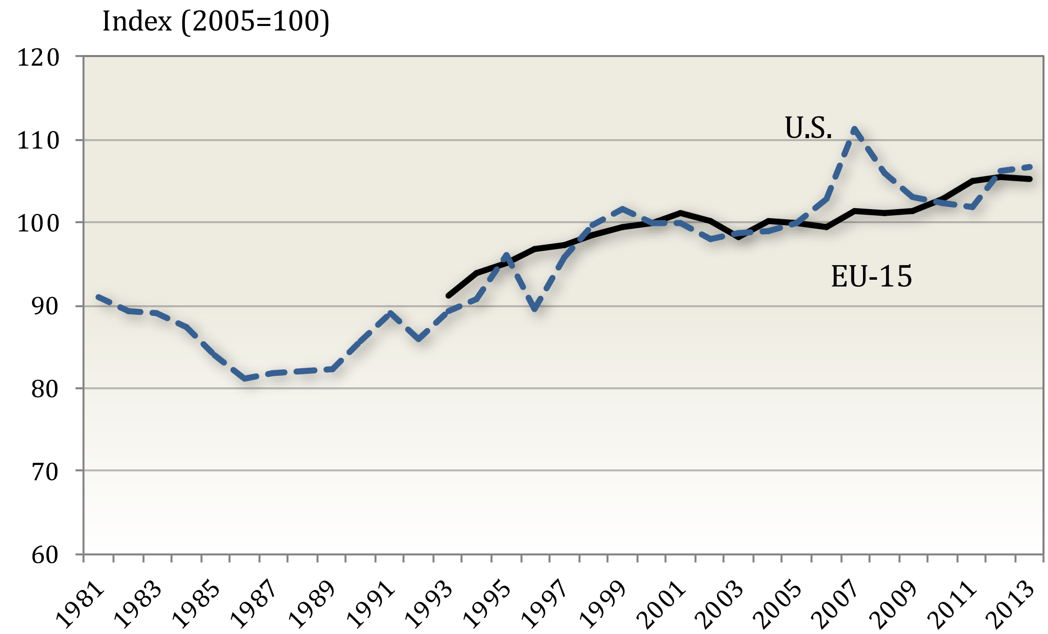
[13] Purchased services include contract labor service, capital equipment lease, custom machine work (such as tilling, plowing, field cultivation, mowing, planting, and fertilizer spreading), machinery repair, building repair, transportation and storage, veterinary services

[14] Wang, et al. (2015)

Figure 5: U.S. and EU indices of intermediate input consumption in agriculture, 1981-2013 for U.S., 1993-2013 for EU



* Intermediate inputs in the U.S. include feed and seed, energy, fertilizer and lime, pesticides, purchased services, and other intermediate. Intermediate inputs in the EU include purchases made by farmers for raw and auxiliary materials such as seeds and plantings, fertilizers, and plant protection products used for crop and animal production, and expenditure on veterinary services, repairs and maintenance, and other services. Agriculture input for indices are measured in dollars (U.S) and euro (EU) for base year 2005. The graph is intended to illustrate individual trends, not comparative perspective.

Source: *ERS Agricultural Productivity in the U.S.; EuroStat Economic Accounts for Agriculture*

The overall contribution of major agricultural input use to agricultural output growth remains slightly negative from 1981 through 2013 even accounting for increases in the use of intermediate inputs. Therefore, it is reasonable to assume that productivity increases explain recent agricultural output growth in the EU and the U.S.

Measuring Agricultural Productivity

To verify the assumption that productivity has been a major factor in agricultural output growth in the EU and the U.S., it is important to compare the trend in agricultural productivity in both jurisdictions over time. However, unlike agricultural outputs and inputs, agricultural productivity lacks a uniform definition or measure. Various measures of agricultural productivity are presented in the literature, including single-factor measures such as crop yield per acre, value-added per worker, and total factor productivity (TFP) which accounts for all agricultural inputs and outputs. Among these, TFP is considered to be the most informative and comprehensive measure.[15,16] However, there are differences in methods for measuring TFP in the U.S. and the EU.

The assumptions, data, and methods used to calculate TFP in the EU differ substantively from USDA-ERS IAP estimates, particularly in four areas: (i) measures of productivity; (ii) methodology; (iii) data sources; and (iv) subsamples. USDA-ERS measures of TFP estimate changes over time within a country, while COMPETE estimates differences in TFP levels over time between countries. Although both measures use the Törnqvist-Theil index[17] to aggregate multiple outputs and inputs, COMPETE employs a metafrontier approach[18] to estimate TFP levels, and USDA-ERS IAP uses the Cobb-Douglas production function[19] to estimate the difference between output and input growth.

Measures of TFP in the EU

In the EU, measurement of agricultural productivity has changed over the years. As part of the Common Agricultural Policy (CAP) "Agenda 2000" reform, Eurostat developed indicators for agricultural productivity, including a Multi-Factor Productivity (MFP) index that compares the growth in agricultural output to the growth in a bundle of, but not all, agricultural inputs.[20] Eurostat measured and published annual MFP growth rates for member states for several years in the early 2000s but later discontinued doing so due to a lack of data availability.

The EU expanded its efforts to develop methods for measuring agricultural productivity via COMPETE, a research project supported by the European Commission's Seventh Framework Programme between 2012 and 2015.[21] Under this project, indicators of competitiveness of European food chains including agricultural productivity were defined and estimated. Rather than measuring TFP growth rates, COMPETE estimates TFP levels using a comparative assessment of TFP differences among EU member states and data from the Farm Accounting

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15 USDA-ERS. Methodology for Measuring International Agricultural Total Factor Productivity (TFP) Growth. October 16, 2015. http://www.ers.usda.gov/data-products/international-agricultural-productivity/documentation-and-methods.aspx (accessed May 20, 2016).

16 Čechura, Lukáš, Aaron Grau, Heinrich Hockmann, Zdeňka Kroupová, and Inna Levkovych. "Total Factor Productivity in European Agricultural Production." *COMPETE*. October 9, 2014. http://www.compete-project.eu/publications/working-papers.html (accessed May 30, 2016).

17 A Törnqvist price index is a weighted geometric average of the price relatives using the arithmetic averages of the value shares in the two periods as weights.

18 A metafrontier approach calculates technical inefficiency by estimating the technology gaps between farms under different technologies and farms under potential technologies available to the industry as a whole.

19 The Cobb–Douglas production function is used to estimate the technological relationship between inputs and the output they produce.

20 Matthews, Alan. *What is happening to EU agricultural productivity growth?* May 4, 2014. http://capreform.eu/what-is-happening-to-eu-agricultural-productivity-growth/ (accessed May 30, 2016).

21 Čechura et al. (2014)

Data Network (FADN) provided by the European Commission. It is not clear if TFP levels will continue to be calculated after 2015, but EU member states recognize the need for indicators to continue measuring CAP's impact on the EU's agricultural sector.[22, 23]

Measures of TFP in the U.S.

The U.S. Department of Agriculture Economic Research Service (USDA-ERS) uses a "growth accounting" approach to measure changes in agricultural TFP over time. This calculates TFP growth rates by subtracting the aggregate input growth rate from the aggregate output growth rate. Two estimates of TFP reported by ERS are: Agricultural Productivity in the U.S. (USAP) and International Agricultural Productivity (IAP). USAP measures domestic agricultural TFP growth, whereas IAP is developed for cross-nation comparisons of growth rates. It is worth noting that TFP growth reflects trends in productivity over time within a jurisdiction; therefore, IAP estimates are limited in their ability to compare relative levels of agricultural productivity between jurisdictions. Although both measures include U.S. national TFP growth, the estimates are not identical due to differences in their underlying assumptions and methodology.[24] In general, the IAP simplifies its assumptions to adjust for limited availability of data. In particular, the two estimates differ in their measurement of: (i) output growth, (ii) agricultural labor, (iii) farm capital stock, and (iv) inclusion of material inputs, as discussed below.

IAP uses global average agricultural prices from FAOSTAT, while USAP calculates output growth based on prices received by U.S. farmers. Additionally, data on labor are quality-adjusted by labor's demographic characteristics—such as sex, age, education and employment class—in the U.S., producing a more detailed measure than estimates at the international level, where these data are not available. There are also differences in the capital measurement of the respective estimates: USAP measures farm capital stock as a function of past capital expenditures, discounted for depreciation, whereas IAP measures inventory based on the number of major pieces of machinery in use on farms. The difference between the two estimates of TFP growth is also reflected in the comprehensiveness of the data on material inputs used in the U.S compared to the global level. In summary, the estimate for U.S. domestic TFP growth is based on a more detailed accounting of material inputs in comparison to its international counterpart.[25]

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22 European Commission's Directorate General for Agriculture and Rural Development. CAP monitoring and evaluation indicators - agriculture and rural development. May 23, 2016. http://ec.europa.eu/agriculture/cap-indicators/ (accessed May 31, 2016).

23 For more information on EU TFP methodology refer to Čechuraet al. (2014) at http://www.compete-project.eu/publications/working-papers.html

24 USDA-ERS. Methodology for Measuring International Agricultural Total Factor Productivity (TFP) Growth. October 16, 2015. http://www.ers.usda.gov/data-products/international-agricultural-productivity/documentation-and-methods.aspx (accessed May 20, 2016).

25 For more information refer to USDA ERS IAP website: https://www.ers.usda.gov/data-products/international-agricultural-productivity/

There are also additional methodological differences in estimating EU TFP between IAP and COMPETE. IAP uses the FAOSTAT dataset on global average prices for farm output. In comparison, COMPETE uses data from FADN on farm income and the impact of CAP on 24 EU member states. Furthermore, both estimates use different samples in their calculations. COMPETE's estimates are derived from production data from three agricultural sectors—dairy, pork and cereals—whereas IAP's estimates are derived using 198 different crops and livestock.

Comparison of Agricultural Productivity

This section[26] compares agricultural productivity in the EU and the U.S. using multiple relevant TFP estimates. We compare relative levels of TFP to illustrate the differences between both jurisdictions. We then proceed to use estimates of TFP growth to highlight the development of agricultural productivity over time within each jurisdiction. Finally, the role of productivity growth in driving agricultural output growth is further discussed, and possible factors affecting agricultural productivity are briefly summarized.

Relative Levels of TFP in the U.S. and EU

As previously discussed, although IAP estimates agricultural TFP growth for multiple countries, these estimates cannot be used to directly compare agricultural productivity levels between countries. Ball, et al.[27] measured relative TFP levels for the EU and the U.S. from 1973 to 1993,[28] and updated the data in 2010. The latest results include levels of TFP for eleven EU member states relative to the U.S. from 1973 to 2002. The 1996 U.S. TFP level is used as the base year for comparison; table 1 displays the results from 1981 to 2002. The EU countries in the dataset account for roughly 75% of total EU-15 agricultural production value throughout this time period.[29]

Table 1: Comparison of relative levels of agricultural TFP in the EU and U.S. (relative to U.S. TFP in 1996), 1981-2002

	Belgium	Denmarl	Germany	Greece	Spain	France	Ireland	Italy	Nether -lands	Sweden	U.K.	EU	U.S.
1981	0.684	0.582	0.552	0.428	0.452	0.514	0.394	0.439	0.765	0.400	0.549	0.518	0.697
1982	0.692	0.624	0.592	0.446	0.486	0.560	0.423	0.448	0.785	0.430	0.562	0.548	0.720
1983	0.687	0.594	0.587	0.422	0.517	0.546	0.431	0.481	0.792	0.423	0.551	0.549	0.620

[26] Čechura, Grau, Hockmann, Kroupová, & Levkovych, 2014

[27] Ball, V. Eldon, J.-P. Butault, Carlos San Juan, and Ricardo Mora. "Chapter 13: Agricultural Competitiveness." In *The Economic Impact of Public Support to Agrciulture,* by V. Eldon Ball, Roberto Fanfani and Luciano Gutierrez, 243-271. New York: Springer, 2010.

[28] Leetmaa et al. (2004)

[29] FAOSTAT (2015)

	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	Nether -lands	Sweden	U.K.	EU	U.S.
1984	0.720	0.695	0.604	0.441	0.576	0.565	0.474	0.462	0.789	0.473	0.595	0.573	0.739
1985	0.717	0.683	0.585	0.455	0.609	0.576	0.467	0.472	0.778	0.466	0.573	0.574	0.789
1986	0.733	0.707	0.595	0.467	0.546	0.583	0.442	0.483	0.818	0.473	0.572	0.577	0.786
1987	0.714	0.672	0.576	0.472	0.607	0.596	0.467	0.493	0.804	0.448	0.571	0.582	0.813
1988	0.731	0.722	0.584	0.494	0.642	0.599	0.478	0.461	0.830	0.460	0.563	0.588	0.783
1989	0.739	0.757	0.592	0.511	0.606	0.604	0.451	0.479	0.850	0.494	0.578	0.593	0.854
1990	0.770	0.772	0.672	0.452	0.633	0.621	0.508	0.450	0.886	0.524	0.580	0.617	0.877
1991	0.775	0.780	0.596	0.550	0.632	0.606	0.516	0.489	0.896	0.508	0.587	0.609	0.877
1992	0.834	0.752	0.620	0.538	0.641	0.647	0.549	0.494	0.906	0.490	0.595	0.628	0.955
1993	0.841	0.802	0.620	0.516	0.645	0.638	0.525	0.515	0.914	0.523	0.579	0.631	0.913
1994	0.803	0.800	0.634	0.559	0.642	0.644	0.524	0.547	0.935	0.518	0.581	0.641	0.997
1995	0.801	0.812	0.646	0.575	0.597	0.657	0.526	0.579	0.940	0.539	0.568	0.647	0.928
1996	0.814	0.814	0.657	0.570	0.731	0.680	0.548	0.614	0.931	0.568	0.564	0.677	1.000
1997	0.818	0.817	0.666	0.590	0.773	0.687	0.555	0.636	0.903	0.587	0.568	0.690	1.005
1998	0.848	0.841	0.680	0.613	0.774	0.698	0.554	0.666	0.942	0.571	0.579	0.706	1.009
1999	0.871	0.851	0.714	0.629	0.725	0.717	0.550	0.715	0.969	0.573	0.596	0.721	1.006
2000	0.873	0.850	0.694	0.635	0.789	0.709	0.572	0.701	0.974	0.590	0.616	0.727	1.045
2001	0.833	0.854	0.666	0.636	0.816	0.691	0.573	0.699	0.954	0.586	0.592	0.719	1.039
2002	0.872	0.862	0.695	0.635	0.878	0.714	0.592	0.684	0.949	0.599	0.633	0.741	1.048

Source: *Ball et al. 2010; EU levels calculated by the authors using agricultural output data from FAOSTAT.*

In 1981, only the Netherlands had higher a level of agricultural TFP than the U.S. All countries in the dataset achieved growth in TFP levels from 1981 to 2002. Beginning in 1992, U.S. TFP surpassed the Netherlands and remained higher than all other EU countries. By 2002, several EU member states had significantly increased their TFP growth rates vis-à-vis U.S. growth rates, although their absolute levels of TFP still remain lower than the U.S. Spain achieved the most significant growth in TFP levels between 1981 and 2002 with an average growth rate of 2.8% per year, slightly higher than the U.S. average annual growth rate of 2.6%.

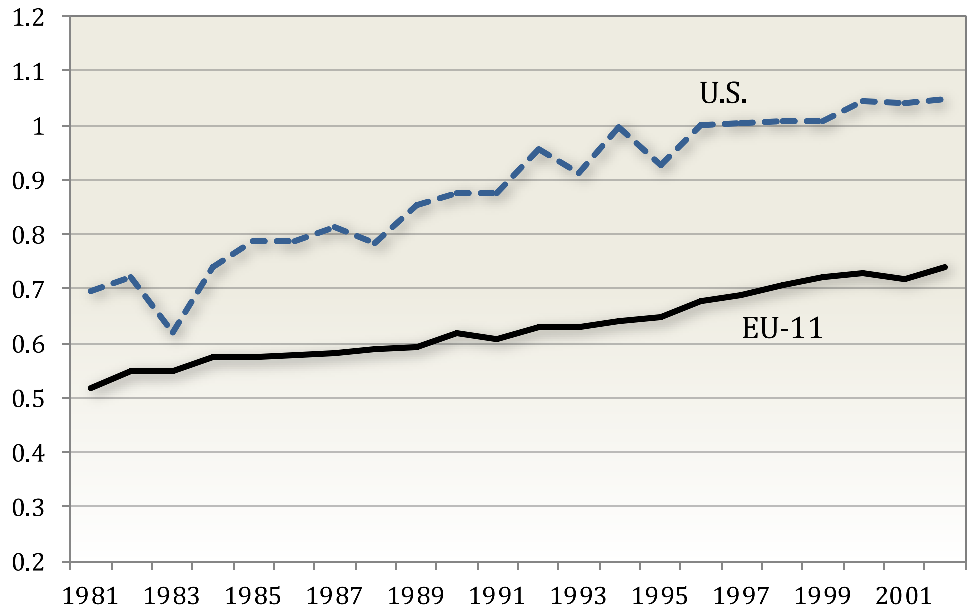
Leetmaa, Arnade and Kelch calculated a weighted average of TFP levels for the eleven EU countries by multiplying each member state's TFP level by its respective portion of the EU-11 gross agricultural production value in a given year using FAOSTAT data.[30] The result indicates

[30] Leetmaa et al. (2004)

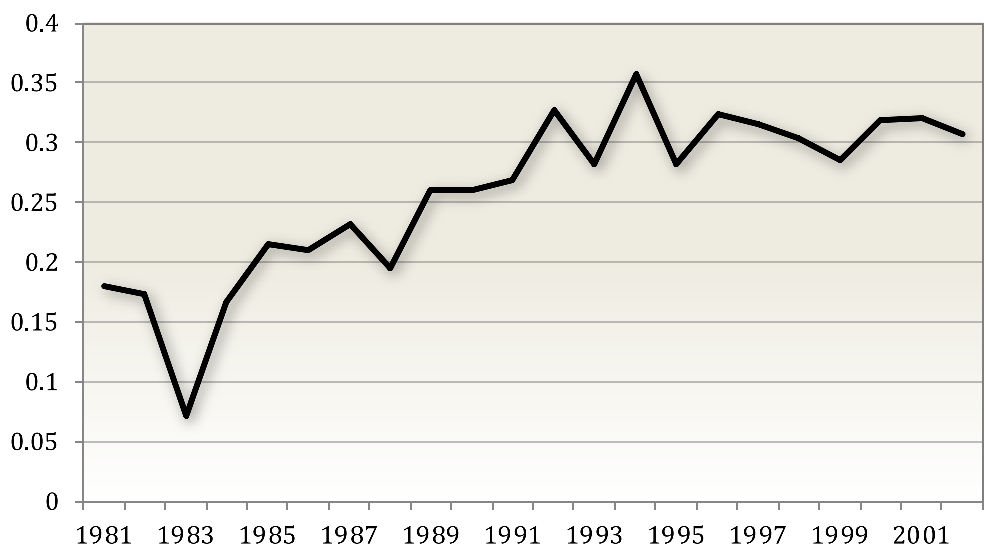
that the absolute TFP level of the EU-11 was consistently lower than that of the U.S. from 1981 through 2002. Moreover, figures 6.1 and 6.2 illustrate that the difference between the EU-11 and the U.S. appears to be slightly expanding over time.

Relative agricultural TFP levels, EU-11 and U.S., 1981-2002

Figure 6.1: TFP levels, relative to U.S. TFP in 1996



6.2: Difference in TFP levels between U.S and EU-11, 1981-2002



Source: *Ball et al. 2010; EU-11 levels calculated by the authors using agricultural output data from FAOSTAT.*

TFP Growth in the U.S. and EU

As previously mentioned, TFP growth is a more widely used measure that captures changes in agricultural TFP over time within a jurisdiction. The IAP database provides internationally consistent and comparable agricultural TFP growth rates and indices for 173 countries from 1961 to 2013. This includes the U.S. and the majority of the EU-28 member states, excluding Slovenia and Croatia. It calculates agricultural TFP growth rates by subtracting aggregate agricultural input growth rate from smoothed agricultural output[31] growth rate in a given year. Because of the different methodology, data and measurement, the IAP TFP growth estimates are not comparable with the Ball, et al. estimates.

Table 2 shows the indices of agricultural TFP growth in the U.S. and the EU-15 member states from 1981 through 2013. The indices are normalized to be 100 in the base year of 1981 for each country. As shown, all countries achieved TFP growth over the period and eight EU countries achieved cumulative TFP growth rates that exceeded the U.S. rate. These countries are Belgium-Luxembourg,[32] Denmark, Germany, France, Italy, the Netherlands, Portugal, and Spain. Denmark achieved the largest growth (119%). Since the base year TFP level differs across countries, the indices do not represent the relative TFP levels between countries. It is important to note that the countries with the largest TFP growth are likely to have had initially lower TFP levels.[33] This is due to the relatively lower cost of imitation vs innovation.[34]

Figure 7 displays the weighted average of TFP growth indices for EU-15 compared to the U.S. From 1981 to 2013, the agricultural TFP growth in the EU and the U.S. followed a similar trajectory. The cumulative TFP growth of the EU-15 since 1981 reached 73%, compared with a cumulative U.S. TFP growth of 63%. However the average annual growth rate was slightly higher in the U.S. (1.75%) than in the EU-15 (1.56%). Agricultural TFP levels in the EU have been consistently lower than the U.S., although both jurisdictions have enjoyed similar growth patterns throughout the same period.

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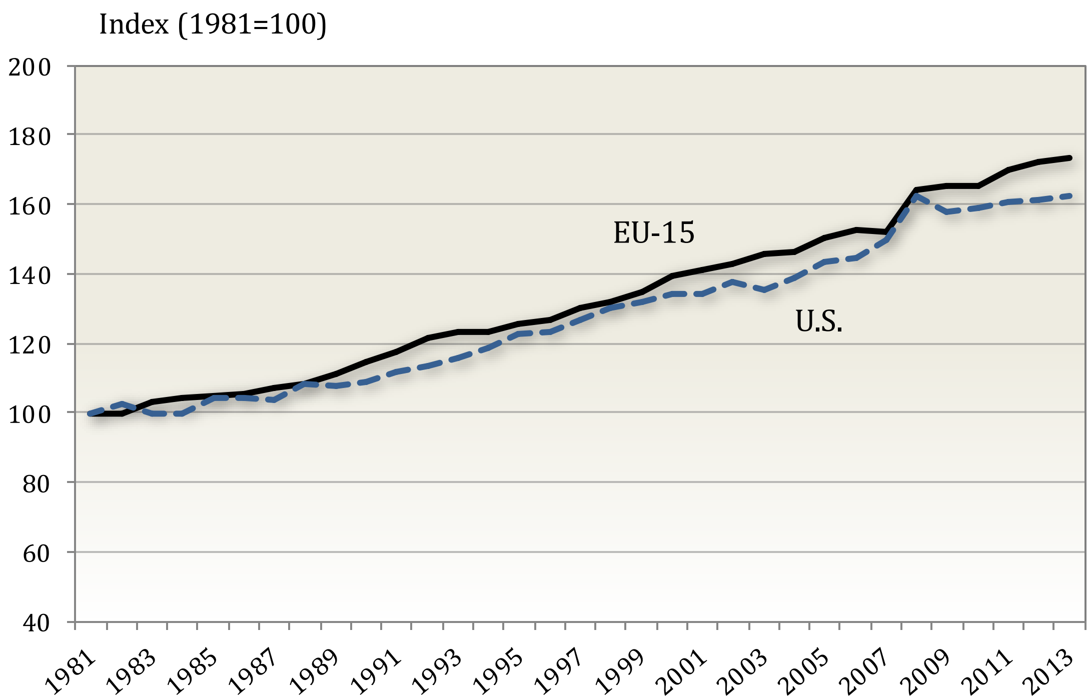
[31] Smoothed output is FAO gross agricultural output smoothed using the Hodrick-Prescott filter/decomposition (Lambda=6.25). (USDA IAP). The Hodrick-Prescott filter is a tool used to remove the cyclical component in a time-series in order to smooths the time series data to more accurately estimate a trend.

[32] Statistics in FAOSTAT are available for the Belgium-Luxembourg Economic Union as a combined entity until 1999, and for Belgium and Luxembourg respectively from 2000. Statistics in ERS IAP database are available for Belgium-Luxembourg as a combined entity for all available years.

[33] Leetmaa et al. (2004)

[34] Ball, V. Eldon, J.-P. Butault, Carlos San Juan, and Ricardo Mora. "Chapter 13: Agricultural Competitiveness." In *The Economic Impact of Public Support to Agrciulture*, by V. Eldon Ball, Roberto Fanfani and Luciano Gutierrez, 243-271. New York: Springer, 2010.

Figure 7: Indices of Agricultural TFP Growth, EU-15 and U.S., 1981-2013



Source: *Calculated from USDA-ERS IAP and FAOSTAT*

Table 2: Indices of Agriculture Total Factor Productivity Growth, EU-15 and U.S., 1981-2013

	Austria	Belgium-Luxembourg	Denmark	Germany	France	Finland	Greece	Ireland	Italy	Nether-lands	Portugal	Spain	Sweden	UK	U.S.
1981	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1982	103.03	96.24	103.06	102.70	100.64	98.86	100.58	99.87	101.31	101.93	102.92	101.06	101.38	97.40	103.04
1983	103.25	96.11	103.60	107.17	103.73	102.55	101.04	99.20	101.36	104.70	106.88	102.98	103.04	98.97	100.78
1984	101.82	101.41	107.73	108.31	105.84	106.11	102.50	102.44	100.60	102.45	112.09	103.09	104.24	101.17	101.24
1985	102.50	100.58	112.12	108.96	105.55	105.86	101.82	109.84	102.08	101.14	112.54	104.81	108.57	102.46	104.26
1986	109.71	103.38	109.03	111.28	105.96	106.69	103.64	108.62	100.72	103.86	114.64	106.95	108.88	100.49	104.35
1987	111.98	105.65	114.99	113.86	106.65	109.26	106.06	117.64	99.94	104.25	116.83	106.66	107.81	102.41	104.17
1988	108.54	108.06	116.77	114.86	106.80	111.01	105.57	116.94	103.46	103.80	118.83	108.69	110.01	103.52	108.48
1989	113.42	111.76	117.06	117.36	108.08	111.51	107.61	121.03	107.98	115.47	127.28	111.65	110.10	104.66	107.93
1990	109.50	115.69	119.98	127.35	111.53	118.16	109.75	122.06	109.69	109.02	128.97	114.03	114.12	106.49	109.19
1991	112.19	122.83	125.37	133.36	112.27	133.24	113.59	128.70	109.70	114.91	133.25	116.30	119.53	111.10	112.19
1992	114.99	130.57	130.76	135.74	122.51	136.50	115.36	128.18	113.03	112.62	138.01	121.51	117.40	113.20	113.88
1993	117.80	139.91	134.66	136.36	121.27	140.68	121.39	125.11	116.92	119.70	136.77	119.28	114.55	114.92	115.79
1994	119.36	141.40	140.94	132.43	121.54	136.67	120.93	119.77	120.37	116.09	138.46	121.68	115.59	112.91	118.89
1995	125.70	145.26	145.13	132.80	123.52	135.21	122.55	122.57	122.16	118.86	142.71	125.90	120.36	113.86	122.95
1996	124.67	149.59	147.68	136.67	125.73	139.90	120.14	127.63	123.31	119.22	143.36	126.92	119.43	111.16	123.55
1997	124.71	152.91	150.19	140.24	128.21	141.01	123.64	127.54	128.01	127.26	145.77	131.23	121.54	110.50	127.14
1998	128.36	152.38	156.63	141.73	129.86	116.65	126.38	127.11	129.29	129.54	143.64	134.31	125.88	113.07	130.45
1999	140.06	151.66	163.28	147.24	132.67	119.63	127.60	123.14	130.72	124.68	147.66	141.11	126.44	114.00	131.99
2000	140.02	156.61	169.05	153.41	138.26	125.46	127.35	131.58	133.29	128.62	151.67	147.62	129.24	115.91	134.48
2001	138.40	155.76	175.21	157.77	135.53	127.70	129.57	129.14	135.61	123.10	153.64	153.53	130.61	113.78	134.45

	Austria	Belgium-Luxembourg	Denmark	Germany	France	Finland	Greece	Ireland	Italy	Nether-lands	Portugal	Spain	Sweden	UK	U.S.
2002	144.89	154.41	178.84	162.01	136.90	130.83	129.01	124.19	136.18	125.96	157.43	155.08	132.20	115.11	138.04
2003	147.98	155.68	179.17	166.82	140.70	133.27	127.24	127.72	142.02	127.41	160.84	154.43	134.29	114.84	135.60
2004	146.82	151.10	181.84	167.44	139.99	137.09	128.09	126.30	144.33	129.34	165.02	155.70	137.19	116.24	139.17
2005	148.86	155.96	187.91	170.35	143.61	138.66	128.88	128.51	153.43	133.01	169.93	161.78	139.16	118.35	143.90
2006	152.25	155.14	189.71	176.43	146.46	142.55	130.24	129.46	155.33	132.68	175.11	161.44	145.25	118.31	144.92
2007	154.11	150.12	187.69	175.85	142.42	139.44	125.86	140.21	157.93	133.64	175.03	159.46	134.55	118.76	149.96
2008	170.70	160.97	209.09	194.41	152.86	152.73	131.33	130.00	168.59	136.47	184.08	177.07	140.88	123.67	162.42
2009	173.39	156.22	209.30	193.21	156.04	150.08	131.30	123.51	173.30	145.85	191.82	176.20	140.00	120.48	158.05
2010	162.33	159.47	209.63	192.23	152.49	149.63	131.33	126.13	175.02	149.55	194.60	177.57	145.53	121.45	159.11
2011	162.40	161.71	214.89	197.98	162.04	153.89	131.12	129.27	174.77	158.62	195.83	183.39	143.14	122.96	161.15
2012	162.50	163.31	217.20	197.80	170.29	156.06	132.23	124.65	175.09	162.09	194.80	184.93	144.51	122.11	161.44
2013	162.37	166.44	219.47	197.55	171.98	155.49	131.22	124.00	174.26	166.84	195.92	188.59	144.90	119.55	162.90

Source: *Calculated from USDA-ERS IAP*

Agricultural Output, Inputs and TFP

To further illustrate the relationship between agricultural production and productivity, we display agricultural output growth, input growth, and TFP growth using IAP data for the EU and the U.S. from 1981-2013 (table 3). As previously mentioned, limited data availability constrains the results to a weighted average of EU-15 member states.

Figure 8 shows the indices of EU-15 agricultural TFP, input, and output growth. Although it contains different data sources, the findings are mostly consistent with the above analysis: agricultural inputs decreased by nearly 34%, or 1.27% annually on average, while TFP growth drove agricultural output to increase by 13%, or 0.39% annually, between 1981 and 2013. Figure 9 indicates that the same pattern holds true for the U.S. Although the U.S. achieved slightly less growth in agricultural TFP compared to the EU, agricultural output increased by roughly 46%, or 1.20% annually on average—a much higher amount than the EU. This difference is mainly attributable to a smaller decrease in agriculture inputs in the U.S.—an approximately 10% cumulative decrease or an average annual growth rate of -0.31% from 1981 to 2013.

Table 3: Total change and average annual growth rate of EU-15 and U.S. agricultural output, input and TFP growth from 1981-2013

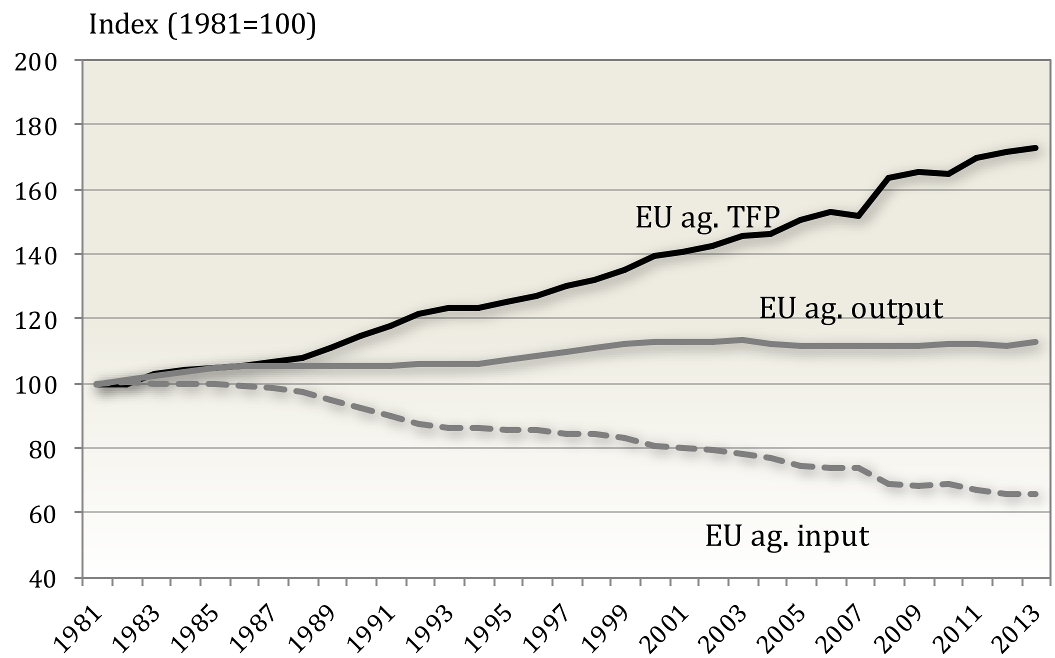
	EU-15		U.S.	
	Total changes (%)	Average annual growth rate (%)	Total changes (%)	Average annual growth rate (%)
Output growth	13.12	0.39	46.47	1.20
Input growth	-33.83	-1.27	-10.09	-0.31
TFP growth	73.44	1.56	62.90	1.75

Source: *USDA ERS IAP*

To summarize, increase in productivity was a primary factor in agricultural output growth in both the EU and the U.S. from 1981-2013. However, agricultural output increased at a significantly higher rate in the U.S. despite the fact that EU TFP growth rates were higher throughout this period. These results indicate that the much larger reduction in agricultural inputs in the EU relative to the U.S. (34% vs 10%, respectively) can explain much of the EU's lower level of output growth.

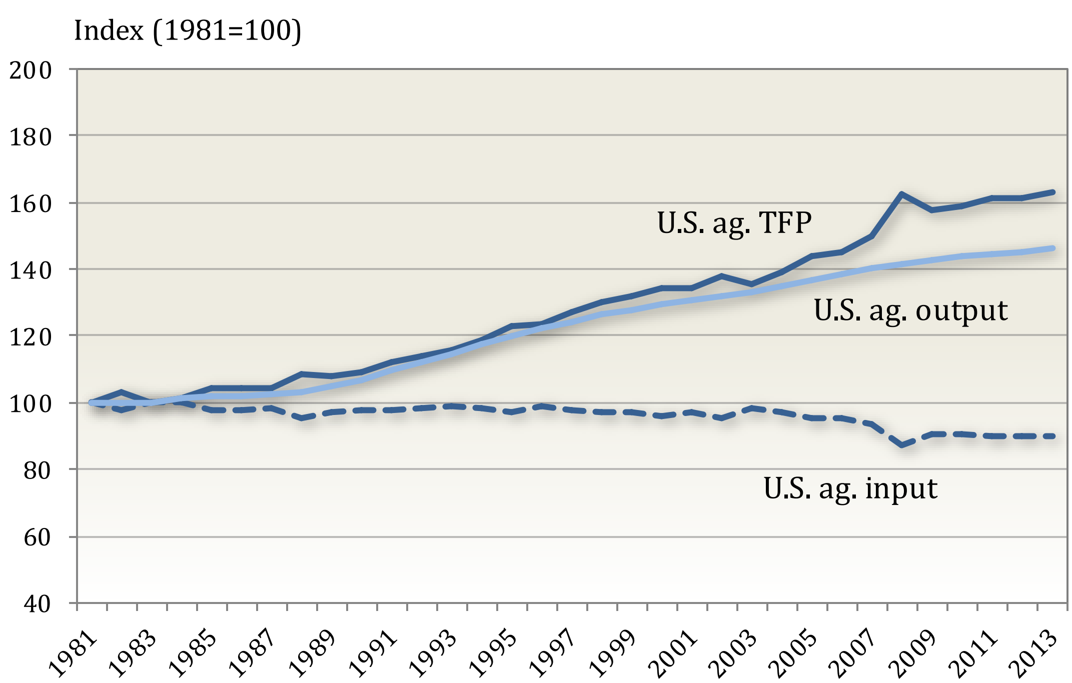
One likely contributor to differences in agricultural inputs is the level and type of regulation in the two jurisdictions. To the extent this is true, differences between regulatory regimes may be driving lower output growth in EU member states than in the U.S. This is discussed in the next section of this chapter.

Figure 8: EU-15 Agricultural TFP, Input and Output Growth, 1981-2013



Source: *Calculated from USDA-ERS IAP and FAOSTAT*

Figure 9: U.S. Agricultural TFP, Input and Output Growth, 1981-2013



Source: *Calculated from USDA-ERS IAP and FAOSTAT*

Approaches to measure the impact of regulation

The growing recognition that regulation can affect agricultural productivity and thus production has encouraged scholars to develop measures of regulatory activity that can be used in quantitative analysis. However, the complex nature of regulation makes it challenging to identify comprehensive measures and develop methods to estimate their impact. This section presents the results from a literature review conducted to understand the various measures of regulation identified by scholars and the methods used to calculate the impact of regulation on productivity and production. Its purpose is to provide an overview of measures and methods used to identify the impact of regulation on agriculture and highlight the findings on agriculture output and productivity.

The literature review specifically focused on regulations that affect agriculture production/or productivity in the U.S. and Europe. We understand that there is additional literature that measures impact of regulations on livestock, agriculture innovation, research and development, and marketing mechanism that also affect overall agriculture productivity.[35,36,37,38,39] While we acknowledge these are important areas of research, the focus of this review is limited to crop production.

Findings on Measures of Regulation

The literature on agriculture reveals a limited set of common global measures to capture the quantitative impact of government policies on agricultural productivity and/or production. These measures can be broadly categorized as: (i) subsidies and taxes, (ii) regulatory spending by government, (iii) regulatory compliance expenditures, (iv) regulatory content, and (v) binary indicators.

Subsidies or taxes can serve as an effective proxy to measure the effect of certain types of regulation. For example, Bridgman, Qi and Schmitz, Jr.[40] used the amount of U.S. subsidies

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[35] Alston, J., K. Bradford, and N. Kalaitzandonakes. 2006. The economics of horticultural biotechnology. *J. Crop Improvement* 18: 413-431.

[36] Gardner, Bruce. *American Agriculture in the Twentieth Century: How It Flourished and What It Cost*. Cambridge: Harvard University Press, 2002

[37] Kalaitzandonakes, N., J. Alston, and K. Bradford. 2007. Compliance costs for regulatory approval of new biotech crops. *Nature Biotechnology* 25:509-11.

[38] Ollinger, M., and J. Fernandez-Cornejo. 1998. "Sunk costs and regulation in the U.S. pesticide industry," *Int. J. Indust. Org*. 16: 139-168.

[39] Olmstead, A. L., and P. W. Rhode, *Arresting Contagion: Science, Policy, and Conflicts Over Animal Disease Control*, Cambridge: MA, Harvard University Press, 2015.

[40] Bridgman, Benjamin, Shi Qi, and James A. Schmitz, Jr. *Does Regulation Reduce Productivity? Evidence From Regulation of the U.S. Beet-Sugar Manufacturing Industry During the Sugar Acts, 1934-74*. Research Department Staff Report 389, Federal Reserve Bank of Minneapolis, 2007.

given to farmers and taxes levied on factory production of sugar to measure the effects of the Sugar Acts (1934–1974) on productivity. Bokusheva, Kumbhakar and Lehmann estimated the effects of environmental policy reforms implemented from 1991 to 2006 on Swiss farm productivity by using subsidies on farms' output as a proxy for the level of regulation.[41] Subsidy is the more commonly observed measure for evaluating the impact of the CAP in the EU since CAP uses the "cross-compliance method" (a combination of subsidies to reward desired behavior and taxes to discourage undesirable behavior) to implement agricultural standards and regulations.[42] However, the use of subsidies (or taxes) as a regulatory measure is limited to regulations that directly employ these tools (e.g., it does not capture the effects of a regulation restricting the use of a pesticide).

It is worth noting that the effects of regulatory cross-subsidies, such as the Renewable Fuel Standard (RFS)[43] in the U.S. or the role of carbon markets, do not appear in budgets. Different sectors often find themselves on the taxed side or the subsidized side of these regulatory cross-subsidies. Traditional metrics often miss these transfer effects.

Spending by government regulatory agencies is an additional measure used in evaluating the cumulative impact of different types of regulation in the U.S.. The on-budget costs and number of staff associated with administering regulatory agencies is available from 1960 to 2016.[44] However, there are drawbacks to using government regulatory spending as a proxy. It may not correlate well with actual regulatory impacts on productivity for several reasons, including that the forms of regulations that may be most burdensome (e.g., restrictions on use of certain products) may require relatively little regulatory spending to develop and enforce.

Compliance costs from survey data are often used to evaluate the impact of regulation on industries,[45] but these estimates can be inaccurate due to their reliance on respondents to report their costs. Another criticism is that compliance costs do not fully explain how regulation affects

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[41] Bokusheva, Raushan, Subal C. Kumbhakar, and Bernard Lehmann. "The Effect of Environmental Cross Compliance Regulations on Swiss Farm Productivity." The *84th Annual Conference of the Agricultural Economics Society*. Edinburgh, 2010.

[42] Costa, Catherine, Michelle Osborne, Xiao-guang Zhang, Pierre Boulanger, and Patrick Jomini. *Modelling the Effects of the EU Common Agricultural Policy*. Staff Working Paper, Melbourne: Productivity Commission, 2009.

[43] The RFS is a federal program in the U.S. that mandates transportation fuel sold in the U.S. to contain increasing percentages of renewable fuels. The program is administered by EPA.

[44] Dudley, Susan E., and Melinda Warren. 2016 Regulators' Budget: Increases Consistent with Growth in Fiscal Budget. May 19, 2015. https://regulatorystudies.columbian.gwu.edu/2016-regulators-budget-increases-consistent-growth-fiscal-budget (accessed May 20, 2016).

[45] Hurley, Sean P., and Jay Noel. "An Estimation of the Regulatory Cost on California Agricultural Producers." *American Agricultural Economics Association Annual Meeting*. Long Beach, 2006.

productivity because they don't capture the lost opportunity costs associated with disincentives for investment and innovation, for example.[46]

Analyzing the content of regulatory language is another proxy that scholars use to measure the effects of regulation.[47] Dawson and Seater used page counts from the CFR as a proxy to examine regulatory impacts on TFP and GDP in the U.S.[48] However, the word count measure also has limitations, as regulations that restrict output (such as the Environmental Protection Agency's ambient air quality standards) may not use the command words (shall, may not, etc.) counted in RegData. While RegData is valuable in that it provides word count data at the industry and agency level, as of now, it is only available for the U.S.; there is no comparable database for the EU.

Other studies measure regulation by constructing indices based on a weighted sum of binary indicators of whether or not given types of regulation exist.[49,50,51] This method is most commonly used in cross-nation comparisons. Many existing cross-nation indices are published and cited in the literature, including the Economic Freedom Index (The Fraser Institute), the Index of Economic Freedom (The Heritage Foundation), OECD cross-nation measures for employment and product-market regulations,[52] and the Doing Business Database (The World Bank Group).[53] However, these indices are often criticized because they capture the existence of a regulation but not their extent or complexity.[54] Another limitation is that almost all indices are built for business regulations such as product-market and employment regulations, so their application in the agricultural sector is limited. Finally, several of the indices are calculated using individual metrics that likely have little to no impact on long-term agricultural productivity, such as the time required for an entrepreneur to start a business (a measure contained in the Doing Business Database).

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[46] Crafts, Nichlas. "Regulation and Productivity Performance." *Oxford Review of Economic Policy* 22, no. 2 (2006): 186-202.

[47] This tool, Regdata, was created by Patrick McLaughlin and Omar Al-Ubaydli. It is available at: http://regdata.org/

[48] Dawson, John W., and John J. Seater. "Federal Regulation and Aggregate Economic Growth." *Journal of Economic Growth* 18, no. 2 (2013): 137-177.

[49] Djankov, Simeon, Rafael La Porta, Florencio Lopez-de-Silanes, and Andrei Shleifer. "The Regulation of Entry." *The Quarterly Journal of Economics* CXVII, no. 1 (2002).

[50] Djankov, Simeon, Caralee McLiesh, and Rita Ramalho. *Regulation and Growth*. Washington, DC: The World Bank, 2006.

[51] Loayza, Norman V., Ana María Oviedo, and Luis Servén. *The Impact of Regulation on Growth and Informality: Cross-Country Evidence.* Policy Research Working Paper, The World Bank, 2005.

[52] Crafts (2006)

[53] Loayza, Oviedo and Servén (2005)

[54] Dawson and Seater (2013)

Findings on Methods of Measuring the Impact of Regulation

Upon choosing a measure of regulation or relevant policy, the next question is how to measure the impact of regulation on agricultural productivity and/or production; more specifically, how to design an appropriate model to explain the relationship between regulation and output. The economic models developed in the literature can be broadly classified into four categories: (i) the traditional approach, (ii) two-step approach, (iii) facilitating approach, and (iv) the non-parametric approach.

The traditional approach treats regulation as one of the traditional inputs (e.g. land, labor and capital) in the production function to identify its direct influence on productivity. However, this approach has certain limitations, as policy is unlike traditional inputs in that it is not necessary for production of output, and it cannot produce any output.[55,56]

In contrast, the facilitating approach perceives regulation, measured using subsidies, as a "facilitating" input that affects the output indirectly by changing the productivity of traditional inputs, shifting the rate of technological change, and/or affecting technical efficiency.[57] Facilitating inputs are not considered essential for production. Bokusheva, Kumbhakar, and Lehmann[58] and Sipiläinen and Kumbhakar[59] used this approach to measure the impact of agricultural policy on farm productivity in European countries. However, the modeling design is often more complex and requires specific, farm-level data on subsidy payments.

The two-step approach is most commonly used in the literature. In this approach, productivity is first estimated or obtained from existing data sources and then regressed on factors expected to affect productivity, including regulation. For example, Arovuori and Yrjölä measured the impact of CAP reforms on agricultural labor productivity in the EU-15.[60] For this purpose, labor

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55 Kumbhakar, Subal C., and Gudbrand Lien. "Chapter 6: Impact of Subsidies on Farm Productivity and Efficiency." In *The Economic Impact of Public Support to Agriculture*, edited by V. Eldon Ball, Roberto Fanfani and Luciano Gutierrez, 109-124. New York: Springer, 2010.

56 Banga, Rashmi. *Impact of Green Box Subsidies on Agricultural Productivity, Production and International Trade*. Background Paper No. RVC-11, Geneva: Unit of Economic Cooperation and Integration among Developing Countries, UNCTAD, 2014.

57 Kumbhakar and Lien (2010)

58 Bokusheva, Raushan, Subal C. Kumbhakar, and Bernard Lehmann. "The Effect of Environmental Cross Compliance Regulations on Swiss Farm Productivity." *The 84th Annual Conference of the Agricultural Economics Society*. Edinburgh, 2010.

59 Sipiläinen, Timo, and Subal C. Kumbhakar. *Effects of Direct Payments on Farm Perfomance: The Case of Dairy Farms in Northern EU Countries*. Discussion Papers No. 43, Helsinki: University of Helsinki, 2010.

60 Arovuori, Kyösti, and Tapani Yrjölä. "The Impact of the CAP and its Reforms on the Productivity Growth in Agriculture." *The 147th EAAE Seminar 'CAP Impact on Economic Growth and Sustainability of Agriculture and Rural Areas'*. Sofia: European Association of Agricultural Economists, 2015.

productivity was first calculated as agricultural value added per worker.[61] Then labor productivity was regressed on policy variables that include the nominal rate of assistance, dummy variables indicating additional CAP reforms, as well as a vector of control variables that capture the economic and structural development. This approach has also been used in studies examining the effects of other types of regulation on productivity, both in the agricultural and non-agricultural sectors.[62,63,64] One limitation of this approach is that it does not account for the direct impact of regulation on agricultural output, since output and input are only used to estimate productivity but not included in the regression model. In addition, it does not measure the impact of regulation on disaggregated components of productivity (i.e. technical efficiency and technological change).

Finally, a non-parametric approach was used by Banga. Here, agricultural TFP growth was calculated for 26 countries for the period 1995-2007 using Malmquist indices, where total agricultural output and three inputs (land, labor and capital) were included.[65] The same method was then used with subsidies as an additional output along with the total agricultural output. The difference between the two TFP estimates yields the impact of subsidies on agricultural productivity.

Findings on the Impact of Regulation

Different methods and measures trying to capture the effects of regulation on agricultural performance lack a consensus regarding its effects. The regulatory frameworks for agriculture and the available data necessary to measure their outcomes vary between the U.S. and the EU. In the European Union, most agricultural regulations are embedded in the cross-compliance component of the CAP as opposed to the U.S. where agriculture requirements are set forth in several individual regulations administered by USDA, EPA, and state governments. Most studies examining U.S. regulations have focused on individual command-and-control measures (e.g. pesticide bans), while EU studies are mostly related to CAP, which combines regulatory

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61 Agriculture Value Added Per Worker is a measure of agricultural productivity. Value added in agriculture measures the output of the agricultural sector less the value of intermediate inputs. (Social and Economic Development Department 2005).

62 Zárate-Marco, Anabel, and Jaime Vallés-Giménez. "Environmental Tax and Productivity in a Decentralized Context: New Findings on the Porter Hypothesis." *European Journal of Law and Economics* 40, no. 2 (2015): 313-339.

63 Mary, Sebastien. "Assessing the Impacts of Pillar 1 and 2 Subsidies on TFP in Frech Crop Farms." *Journal of Agricultural Economics* 64, no. 1 (2013): 133-144.

64 Greenstone, Michael, John List, and Chad Syverson. *The Effects of Environmental Regulation on the Competitiveness of U.S. Manufacturing*. Working Paper No. 18392, Cambridge: National Bureau of Economic Research, 2012.

65 Banga, Rashmi. *Impact of Green Box Subsidies on Agricultural Productivity, Production and International Trade*. Background Paper No. RVC-11, Geneva: Unit of Economic Cooperation and Integration among Developing Countries, UNCTAD, 2014.

requirements with incentive-based measures. In general, the literature suggests that studies estimating the effects of EU regulations tend to find a positive impact on agricultural productivity while U.S. studies tend to find a negative correlation between increased regulation and productivity.

Findings of U.S.-Focused Studies

The cumulative impact of U.S. regulations on agricultural productivity is difficult to measure because of multiple individual regulations administered by different agencies. Therefore, the findings are presented separately for individual regulations such as pesticides and cumulative agri-environmental regulations.

Studies that focus on individual regulations in the U.S. generally find they have a negative impact on agricultural productivity. Fernandez-Cornejo, Jans, and Smith presented a synthesis of empirical evidence for understanding the economic effects on agricultural productivity if pesticide use is restricted.[66] They observed that in 1996 farmers in the U.S. spent $8.3 billion on pesticides with a marginal pesticide return of more than $1 for every dollar spent on pesticides. The economic loss of regulating pesticide is measured for general bans and limitations on pesticide use in agricultural production. The impact of regulations is estimated using a partial budgeting method in which the economic value of production lost is calculated assuming constant output prices.[67] Their findings indicate that a partial ban on the use of certain pesticides would lead to a production loss of $2–3 million for agriculture sector, and could result in a loss of several billions in the event of a complete ban.

Similarly, Carpenter, Gianessi, and Lynch conducted a study to understand the potential economic impact of phasing out methyl bromide on crop production and farm revenue.[68] The result for each crop was different based on the input costs and alternative production possibilities but all results indicated negative effects on production and revenue.

Findings of EU-Focused Studies

Agricultural production, particularly crop production, is considered to be primarily affected by environmental and food safety legislation in the EU. This legislation mostly takes the form of a Directive or a Regulation,[69] such as the Nitrates Directive (91/676/EEC), the Directive on the sustainable use of pesticides (2009/128/EC), the General Food Law Regulation (178/2002), and

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[66] Fernandez-Cornejo, Jorge, Sharon Jans, and Mark Smith. "Issues in the Economics of Pesticide Use in Agriculture: A Review of the Empirical Evidence." *Review of Agricultural Economic* 20, no. 2 (1998): 462-488.

[67] *Ibid*

[68] Carpenter, Janet, Leonard Gianessi, and Lori Lynch. The Economic Impact of the Scheduled U.S. Phaseout of Methyl Bromide. Washington, DC: National Center for Food and Agricultural Policy, 2000.

[69] For details concerning EU legislation, see Chapters 3 and 4 of this report.

the Regulation on the hygiene of foodstuffs (852/2004). Due to recent CAP reforms, many of these directives and regulations are currently implemented through cross-compliance mechanisms. In addition to these existing legislative requirements, cross-compliance also requires Good Agricultural and Environmental Conditions (GAECs)—a range of standards related to soil protection, habitat protection, and water management—on farms receiving direct payments. Because of the linkage between CAP and environmental and food safety legislation, few studies have examined the impact of individual directives or regulations on agricultural production in the EU, but most studies have focused on the impact of CAP or cross-compliance as a whole. A review of these studies suggests mixed empirical findings.

Several studies found that CAP had an overall positive impact on EU agriculture. Rhode used the 2004 EU enlargement as a natural experiment in examining the overall effects of CAP on agricultural productivity.[70] The model was based on the assumption that CAP would affect agricultural productivity through increases in returns of scale, input availability, and increases in the efficiency of land use due to the fact that CAP affects the average farm size, fallow land area, organic farming area, and GDP growth. The findings suggest that joining the EU (i.e. subject to CAP) leads to an increase in agricultural productivity. Costa, et al. found that CAP increased the size of agricultural output by about 8% in the EU-15 due to support for the agricultural sector through its direct payments, export subsidies, and border protection.[71]

Since cross-compliance was introduced in the 2003 CAP farms are required to comply with additional requirements in order to receive direct payments and certain rural development payments. Several studies have examined the effects of this change on agricultural performance. Sipiläinen and Kumbhakar found that the average overall effect of direct payments on the output of Danish, Finnish and Swedish dairy farms for the period 1997-2003 was small but positive in all regions except for Central Sweden.[72] They found that adoption of environmental cross-compliance had a negative effect on crop output after 1999, but caused an increase in the productivity of input use in crop farms. LMC International evaluated the GAEC requirements applied under cross-compliance in the cereal sector, and found that GAECs were correlated with small changes in the production of cereals.[73]

A study conducted by CRPA (commissioned by DG Agriculture) estimated the costs that EU farmers bear due to compliance with a comprehensive set of 40 directives and regulations as well

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[70] Rhode, Flemming Schneider. *The Impact of the Common Agricultural Policy on Agricultural Productivity*. Honors Theses, Richmond: University of Richmond, 2008.

[71] Costa, et al. (2009)

[72] Sipiläinen, Timo, and Subal C. Kumbhakar. *Effects of Direct Payments on Farm Perfomance: The Case of Dairy Farms in Northern EU Countries*. Discussion Papers No. 43, Helsinki: University of Helsinki, 2010.

[73] LMC International. *Evaluation of Measures Applied Under the Common Agricultural Policy to the Cereals Sector*. Brussels: European Commission, 2012.

as GAECs in the field of the environment, animal welfare and food safety.[74] The result suggests varied compliance costs across different products and countries. Specifically, with regard to the crop sector, the study found that: (i) typical crop farms (e.g. wheat, apples, and wine grapes) faced significant compliance costs with environmental legislation but limited influence from food safety legislation; (ii) the compliance costs ranged from 1% to 3.5% of total production costs, with the greatest effect from the Nitrates Directive (91/676/EEC) and the regulation on plant protection products (1107/2009/EEC); (iii) GAECs only had a minor impact on costs; and (iv) compliance with legislation did not increase costs of wheat and apple production in the EU relative to non-EU countries, but the EU faced higher compliance costs in wine grape production which might affect its competitiveness, internationally.[75]

[74] Menghi, Alberto, Kees de Roest, Andrea Porcelluzzi, and et al. *Assessing farmers' cost of compliance with EU legislation in the fields of environment, animal welfare and food safety*. Final Report, Brussels: European Union, 2011.

[75] *Ibid*.

Transatlantic Approaches to Agriculture Policy

Transatlantic Agriculture & Regulation Working Paper Series: No. 3

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The George Washington University Regulatory Studies Center[2]

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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 reviews the institutions and procedures governing regulatory development in the U.S. and EU, details several notable differences in their respective regulatory approaches towards agriculture, and then presents and compares relevant regulations affecting agricultural production in each jurisdiction. It first provides an overview of the U.S. and EU procedures for developing and implementing regulation and how they differ. It then describes how the jurisdictions approach regulation of the agricultural sector. Finally, it discusses five areas of agricultural policy: (i) agri-environmental regulations, (ii) organic farming, (iii) genetically modified organisms (GMO), (iv) pesticides, and (v) fertilizers. The regulations discussed are initiated at the EU level and the U.S. federal level. The roles of member states (in

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the EU) and states (in the U.S) are outlined wherever applicable, but a complete accounting of the effects of implementation and enforcement present at this level falls outside the scope of this paper.

Regulatory Procedures in the U.S. and EU

Overview of U.S. Regulatory Procedure

The United States and the European Union regulate agriculture in substantively different ways, but both emphasize reducing risks to health and the environment. In the U.S., Executive branch departments and agencies write federal regulations pursuant to authority delegated to them by statutes passed by the two houses of congress and signed by the president. Regulations are constrained by a) authorizing statutory language, b) executive principles for regulatory impact analysis (RIA),[3] and c) procedural rules regarding consideration of public comment.[4] Generally, under the Administrative Procedure Act of 1946, agencies must solicit and consider public comment on draft regulations before they are issued in final form. Once regulations become effective after final publication, it is generally the issuing regulatory agency that is responsible for monitoring and enforcing compliance.[5]

The legislative branch, comprising the U.S. Senate and the House of Representatives, generally passes broad legislation and delegates to regulatory agencies the power to "fill up the details" by issuing regulation.[6] While legislators can provide oversight over regulatory development (e.g., through hearings, letters and budget restrictions), Congress does not have a role in approving new regulations.[7,8]

3 Executive Order 12866 "Regulatory Planning and Review." September 30, 1993 https://www.reginfo.gov/public/jsp/Utilities/EO_12866.pdf and Executive Order 13563 "Improving Regulation and Regulatory Review." January 18, 2011 https://www.reginfo.gov/public/jsp/Utilities/EO_13563.pdf

4 Administrative Procedure Act (5 U.S.C. Subchapter II) https://www.archives.gov/federal-register/laws/administrative-procedure

5 Dudley, S., & Wegrich, K. (2015). Achieving Regulatory Policy Objectives: An Overview and Comparison of U.S. and EU Procedures. The George Washington University Regulatory Studies Center, Working Paper March 2015. Retrieved from https://regulatorystudies.columbian.gwu.edu/achieving-regulatory-policy-objectives-overview-and-comparison-us-and-eu-procedures

6 Wayman v. Southard, 10 Wheat. (23 U.S.) 1, 41 (1825). https://supreme.justia.com/cases/federal/us/23/1/case.html

7 It has a mechanism for overturning individual regulations, though it is typically only used after presidential transitions.

8 Dudley, S. (2015). Improving Regulatory Accountability: Lessons from the Past and Prospects for the Future. *Case Western Reserve Law Review*, 65 (4), 1027-1057. Retrieved from http://regulatorystudies.columbian.gwu.edu/improving-regulatory-accountability-lessons-past-and-prospects-future

While some federal statutes, such as the Clean Air Act, envision a role for states in compliance and enforcement, they usually provide federal agencies (e.g., EPA) authority to ensure that their standards are met. Affected parties may seek redress from the judicial branch on final regulations, and courts often remand them to agencies for reconsideration. Judicial review looks to the administrative record developed by the regulating agency,[9] including its analysis of the facts and its response to public comment.[10] Thus, the administrative record, which includes all supporting documentation and public comment, is an important element of accountability and transparency.[11]

Overview of EU Regulatory Procedure

In the EU, the European Commission initially drafts legislative acts (comparable to statutory law in the U.S.), and then the political bodies, the European Parliament and European Council, vote to approve them. In practice, these institutions consult informally to reach a policy consensus. The Commission generally must provide an impact assessment (IA) and consult the public and stakeholders before submitting a proposed legislative act to the Parliament and Council.[12,13]

EU member states are involved through the comitology process, and provide a counterweight to the supranational-oriented Commission. With few exceptions, the Commission is not responsible for implementing EU law; implementation and enforcement are delegated to the member states and their bureaucracies, although the Commission is in charge of overseeing the implementation process.[14] Judicial review is not as important in the EU as in the U.S.

Similarities and Differences

In the U.S., executive branch agencies, accountable to the President, develop and implement regulation pursuant to rulemaking powers delegated by Congress (via legislation). In the EU, regulation is a process driven by the executive (EU Commission) but ultimately decided by the Council and the Parliament. Rulemaking powers are delegated to the European Commission rather than to regulatory agencies. Independent expert bodies such as the European Committee

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9 Administrative Procedure Act (5 U.S.C. Subchapter II) section 706 http://www.archives.gov/federalregister/laws/administrative-procedure/

10 Parker and Alemanno point out that while this encourages agencies to develop a full and robust record to defend the rule in court, ironically, it may constrain agencies' ability to take international trade impacts into consideration if the enabling statute does not mention those factors. Parker, R., & Alemanno, A. (2014). *Towards Effective Regulatory Cooperation under TTIP: A Comparative Overview of the EU and US Legislative and Regulatory Systems*. Brussels: European Commission.

11 Dudley, S., & Brito, J. (2012). *Regulation: A Primer*, 2nd ed. (pp. 48-50). Washington, D.C.: The George Washington University Regulatory Studies Center and the Mercatus Center at George Mason University.

12 Dudley and Wegrich (2015)

13 It has increasingly conducted IA and public consultation for non-legislative acts, as well.

14 For more detail, see Dudley and Wegrich (2015 pp. 28).

for Standardization and the European Telecommunications Standards Institute provide input on technical regulation under broad policy principles defined at EU level.

Stakeholder consultation is an important element of both regimes, however, the mode, timing, and role of consultation differ. In the U.S., consultation is a means of gathering input and increasing the accountability of delegated agency rulemaking to the public. It allows interested parties to voice concerns, and has a long tradition of transparency concerning procedures and the role of comments in decision making and in judicial review. Both regulatory text and supporting analysis are available for review and comment.

In the EU, consultation is a means of gathering input and evidence that politically accountable decision-makers will use to assess policy options. Stakeholder input is solicited earlier in the rulemaking process to develop and support the IA and identify options, but is generally not invited on the IA or regulatory text.

Regulatory Approaches to Agriculture in the U.S. and EU

Approaches to agri-environmental policies, in particular, differ substantially between the two jurisdictions. The U.S. relies more on a voluntary, incentive-based approach to encourage environmental protection efforts in the agricultural sector. In contrast, the EU regulates the environment and agricultural practices mostly through cross-compliance mechanisms within its Common Agricultural Policy (CAP). This section expands on several of these differences before proceeding to compare key components of the agri-environmental policies in both jurisdictions.

Conservation and Agri-Environmental Policies

Agri-environmental policies—a wide range of policies that integrate environmental concerns into agricultural practices—have gained increasing attention in the United States and the European Unions. Agri-environmental policies in both jurisdictions fall into two categories: voluntary incentive-based programs and cross-compliance mechanisms. Voluntary incentive-based programs provide additional financial incentives for farmers to encourage environmentally friendly agricultural practices; cross-compliance mechanisms require farmers to comply with certain regulatory standards as a prerequisite to be eligible for income support and/or other program benefits (e.g. crop insurance).

Differing Objectives and Implementation

Although both jurisdictions aim to address environmental concerns while recognizing the important role of agriculture in their respective economies, the U.S. and EU differ substantively in their approach to targeting and implementing their respective policies. Generally, EU agri-environmental policies consist of a broader set of desired outcomes relative to U.S. policy. They focus not only on reducing negative externalities (e.g. environmental harm) but also in promoting the provision of what Europeans broadly consider to be positive externalities produced by farming such as: extensive tracts of open countryside, and the "scenic value of landscapes [that] make rural areas attractive for the establishment of enterprises, for paces to live, and for the tourist and recreation businesses."[15]

Citing a report from the UK's Ministry of Agriculture, Fisheries and Food, Baylis et al. point out that, relative to the U.S., the EU:

> "take[s] a wider view of what constitutes an agricultural externality; in particular, many aspects of traditional farming such as terraces, stone fences…are perceived as being desirable outcomes in and of themselves… EU member states consider it legitimate to offer compensation in return for their provision"[16]

Although there are notable exceptions to U.S. agri-environmental policies focused solely on reducing negative environmental externalities, the bulk of U.S. programs do not promote the production of positive externalities related to agriculture.[17] Additionally, EU policies are more prescriptive in promoting certain methods thought to improve environmental outcomes whereas U.S. policies focus more on compensation for the attainment of improved environmental outcomes regardless of the methods employed.[18]

Scholars point out that EU efforts to improve environmental outcomes in agriculture may be hampered by several of its approaches related to rural development under CAP.[19] For example, Rickard illustrates that EU policies that sustain the use of traditional, smaller-sized farms with attractive landscapes are not likely to remain competitive compared to more modern, industrialized approaches with regard to either their yield or environmental performance.[20]

The United States

The major agricultural policy instrument in the U.S.—the Farm Bill[21]—authorizes a number of voluntary conservation programs that address a wide range of environmental issues influenced by agricultural activities such as soil quality, water quality, biodiversity and landscape. The

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[15] European Commission. (2017). Agriculture and the Environment: Introduction. Retrieved from https://ec.europa.eu/agriculture/envir_en

[16] Baylis, K., Peplow, S., Rausser, G., & Simon, L. (2008). Agri-environmental policies in the EU and United States: A comparison. *Ecological Economics*, 65 (4), 753-764.

[17] Baylis et al. (2008); Such exceptions include land conservation programs that provide incentives to prevent farmland from being converted to non-agricultural uses; further detailed below on page 6 of this report.

[18] Baylis et al. (2008, pp. 754)

[19] Rickard, S. (2004). CAP Reform, Competitiveness and Sustainability. *Journal of the Science of Food and Agriculture*, 84 (8), 745-756.

[20] *Ibid*

[21] The Farm Bill is a comprehensive omnibus bill that is passed roughly every 5 years by Congress.

major conservation programs can be classified into three categories: land retirement programs, working land conservation programs, and agricultural land preservation programs.[22] Additionally, U.S. agriculture policy includes a cross-compliance mechanism known as conservation compliance that targets soil erosion and wetlands.

Land Retirement Programs

Land retirement programs temporarily remove land from agricultural production, usually for a set number of years that range between 10 and 15. Two such programs that apply to row crops are: the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). CRP and CREP are administered by the Farm Service Agency of USDA Introduced in 1985, the CRP is a voluntary, private-land conservation program to improve water quality, reduce soil erosion, and protect habitats for endangered and threatened species. Participants receive an annual payment in exchange for removing environmentally sensitive land from agricultural production and introducing plant species that improve the environment. The program includes specific initiatives such as Bottomland Hardwoods Initiative, Duck Habitat Initiative, Floodplain Wetland Initiative, Highly Erodible Land Initiative, and Longleaf Pine Initiative.[23]

The CREP, an enhancement program associated with CRP, is the largest private-land conservation program in the United States. The CREP targets only high-priority conservation issues identified by local, state or tribal government and non-government organizations (NGO). The participants are expected to remove environmentally sensitive land from agricultural production and introduce conservation practices.[24] Unlike CRP, the CREP operates as a partnership between federal and state and/or tribal governments. It is worth noting that states often use their portion of the contribution under CREP—typically in the form of an initial lump sum payment—to secure permanent easements longer than the average set-aside (i.e. closer to 30 years than 10 or 15).

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[22] Bernstein, J., Cooper, J., & Claassen, R. (2004). Agriculture and the Environment in the United States and European Union. In M. A. Normile & S. E. Leetmaa (Eds.), *U.S.-EU Food and Agriculture Comparisons* (pp. 66-77). Agriculture and Trade Report, WRS-04-04. Washington, D.C.: Market and Trade Economics Division, Economic Research Service, USDA.

[23] A complete list of initiatives can be accessed at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index. Initiatives can vary from year to year and from Farm Bill to Farm Bill.

[24] United States Department of Agriculture, Economic Research Service [USDA ERS]. (2014). Conservation Programs. Retrieved from http://www.ers.usda.gov/topics/natural-resources-environment/conservation-programs.aspx

Working Land Conservation Programs

The Conservation Stewardship Program (CSP) and Environmental Quality Incentives Program (EQIP) are part of the working land conservation programs to incentivize the adoption and maintenance of conservation practices on agricultural land. These programs are administered by the National Resources Conversation Service (NRCS) within the USDA. CSP provides farmers the opportunity to continue ongoing conservation practices and institute new conservation activities to deal with resource concerns.[25] In this incentive-based model, the payment is proportional to the conservation performance of the participants. The land eligible for the program includes private and tribal agricultural land, cropland, grassland, pastureland, rangeland, and non-industrial private forestland. The program is available to producers in all 50 states, the District of Columbia, and Caribbean and Pacific Island areas. In short, this program aims to support farmers that are already involved in conservation practices.

Under EQIP, technical assistance and financial incentives are provided to individuals to improve water and air quality, conserve ground and surface water, reduce soil erosion and sedimentation or improve or create wildlife habitat in agricultural or non-industrial private forestland.[26] As part of the program, federal and state governments assist the participant in planning and implementing conservation practices.[27] Additionally, EQIP differs from CSP in its method for targeting payments; EQIP payments are tied to a fixed rate per action taken while CSP pays based on the level of achieved benefit.[28]

Agricultural Land Preservation Programs

The Agricultural Conservation Easement Program is a consolidation of different easement programs with two aims: 1) conserve agricultural land from being converted to non-agriculture uses and 2) protecting wetlands. The first goal of the program aims to sustain agriculture by ensuring availability of productive land for farming. The second aims to conserve wetlands from either agricultural or non-agricultural use. Both provide technical assistance and financial

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25 United States Department of Agriculture, Natural Resource Conservation Service [USDA NRCS]. (2017a). Conservation Stewardship Program. Retrieved from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/

26 *Ibid*

27 United States Department of Agriculture, Natural Resource Conservation Service [USDA NRCS]. (2017b). Environment Quality Incentives Program. Retrieved from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

28 As of January 2017, USDA's Natural Resources Conservation Service website states that: "CSP participants…receive an annual land use payment for operation-level environmental benefits they produce. Under CSP, participants are paid for conservation performance: the higher the operational performance, the higher their payment" (USDA NRCS, 2017b)

incentives for conservation.[29] The program is open to American Indian tribes, state and local governments and NGOs with farmland, rangeland or grassland protection programs. These groups can, in turn, purchase easements from individuals.

Conservation Compliance

The cross-compliance mechanism in the U.S., commonly known as "conservation compliance," is primarily aimed at protecting highly erodible lands (HEL) and wetlands that are currently or have previously been in production. The use of certain conservation practices on farmed HEL and wetlands is required in order for famers to be eligible to participate in certain federal agricultural programs provided by the FSA and the Natural Resources Conservation Service (NRCS), such as crop insurance premium subsidies, disaster assistance payments, farm loans, and conservation program payments.[30] If a farmer violates the compliance requirements, he or she may be excluded from the farm payments or even required to pay back current or previously awarded benefits.[31] The USDA protects against soil erosion on HEL through its Sodbuster provisions and prevents the conversion of wetlands into land for agricultural production through its Swampbuster provisions.[32]

The European Union

The Common Agricultural Policy (CAP) is the primary policy tool that administers agricultural practices and agri-environmental standards in the European Union. The CAP uses what the EU refers to as the "polluter pays" principle and the "provider gets" principle to integrate environmental goals into agriculture policy. The "polluter pays" principle takes a "sticks" approach to associate the costs of environmental damage to those that cause it.[33] While the "provider gets" principle takes a "carrots" approach and rewards those that go above and beyond the legal, environmental requirements with payments.

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29 USDA NRCS (2017b)

30 United States Department of Agriculture, Natural Resource Conservation Service [USDA NRCS]. (2017c). Highly Erodible Land Conservation and Wetland Conservation Compliance. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/alphabetical/camr/?cid=nrcs143_008440

31 *Ibid*

32 *Ibid*

33 European Commission. (2016a). Integrating Environmental Concern into the CAP. Retrieved on April 21, 2016 from http://ec.europa.eu/agriculture/envir/cap/index_en.htm

Environmental Regulations via Cross-compliance

Environmental regulations refer to a set of compulsory standards and requirements that aim to protect the environment from human activities.[34] Although the EU has long emphasized the importance of environmental regulations, this cross-compliance mechanism for direct payments was introduced only in 2003 under Council Regulation (EC) No 1782/2003, providing a more flexible means for implementing the "command and control" environmental regulations in the agricultural sector.[35] The cross-compliance mechanism includes two components: Statutory Management Requirements (SMRs) and Good Agricultural and Environmental Conditions (GAECs) that operate across three issue areas: (i) environment, climate change, and good agricultural condition of land; (ii) public, animal, and plant health; and (iii) animal welfare. Non-compliance by farmers results in an administrative penalty, which is a reduction in direct payments, decided at the member-state level, based on the provisions listed in Regulation (EU) No 1306/2013 on the financing, management and monitoring of the CAP.

The rules for cross-compliance specify 20 standards and requirements: 13 SMRs and 7 GAECs. The Statutory Management Requirements for the environment, climate change, and good agricultural condition of land are linked to requirements established in three preexisting EU directives. SMR 1 makes it mandatory to comply with the requirements outlined in Council Directive 91/676/EEC, also known as the Nitrates Directive, on the protection of waters against pollution caused by nitrates from agricultural sources.[36] SMR 2 and SMR 3 concern Directive 2009/147/EC on the conservation of wild birds and Council Directive 92/43/EEC on the protection of natural habitats and wild flora and fauna.

Regulation (EU) No. 1306/2013 specifies a broad framework for each GAEC. Member states have the flexibility to define national minimum standards for good agricultural practices based on the specific characteristics of the area such as climatic conditions, soil characteristics, land use, and farming practices. In particular, there are seven GAECs regarding water, soil and carbon stock and landscape, which set out legal requirements in addition to SMRs.

Voluntary Agri-Environmental Measures

The EU also uses voluntary programs to reward producers for adopting additional environmentally friendly farming practices, which are called "agri-environmental measures" as a

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[34] European Commission. (2016b). Cross-Compliance. Retrieved on April 21, 2016 from http://ec.europa.eu/agriculture/envir/cross-compliance/index_en.htm

[35] Council Regulation (EC) 1782/2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers [2003] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32003R1782

[36] Regulation (EU) 1306/2013 on the financing, management and monitoring of the common agricultural policy [2013] http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32013R1306

key element in member states' rural development plans under CAP. The agri-environment measures provide financial incentives for adopting practices across a broad set of policy areas.[37] The payments made to farmers cover commitments that are not included as part of the mandatory standards under the cross-compliance mechanism or requirements under the national legislation of the member states. Farmers are required to commit themselves for at least five years.[38] These payments are similar to the U.S. EQIP program where producers receive payments to offset the costs of adopting practices that improve the environment.

37 European Commission. (2016c). Agri-environment Measures. Retrieved on April 21, 2016 from http://ec.europa.eu/agriculture/envir/measures_en

38 *Ibid*

Table 1: U.S. and EU Conservation and Agri-Environmental Policies

	United States	European Union
Voluntary Incentive-based Programs		
Policy Instrument	Conservation Programs: ▪ Land Retirement Programs ▪ Working Land Conservation Programs ▪ Agricultural Land Preservation Programs	Agri-Environmental Measures
Regulatory Authority	Initially authorized by Farm Bill in different years; all reauthorized in 2014 Farm Bill	Regulation (EU) No 1305/2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)
Administering Institution	USDA's National Resources Conservation Service (NRCS) & Farm Service Agency (FSA)	Directorate General for Agricultural and Rural Development & Member States
Practices	▪ Retirement of environmentally sensitive land from agricultural production (CRP & CREP) ▪ Adoption and maintenance of conservation practices on agricultural land (CSP & EQIP) ▪ Conservation of agricultural land and wetlands (ACEP)	Practices vary across member states, which include: ▪ Environmentally favorable intensification of farming ▪ Integrated farm management and organic agriculture ▪ Conservation of high-value habitats and biodiversity
Cross-Compliance Mechanisms		
Policy Instrument	Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) provisions	▪ Statutory Management Requirements (SMRs) linked to 13 preexisting EU regulations/directives ▪ Good Agricultural and Environmental Conditions (GAECs)
Regulatory Authority	Initially authorized in 1985 Farm Bill, and reauthorized in the consecutive farm bills	Regulation (EU) No 1306/2013 on the financing, management and monitoring of the common agricultural policy
Administering Institution	USDA's National Resources Conservation Service (NRCS), Farm Service Agency (FSA), & Risk Management Agency (RMA)	Directorate General for Agricultural and Rural Development & Member States
Requirements	Participating farmers shall not: ▪ Plant or produce agricultural commodities on a highly erodible land or a converted wetland ▪ Convert a wetland to agricultural land	Participating farmers must: ▪ Comply with 13 SMRs established under preexisting directives/regulations, including the Nitrates Directive, the Birds Directive, and the Habitats Directive; ▪ Comply with 7 GAECs established by member states concerning water, soil and carbon stock and landscape.

Organic Farming

Organic farming has gained popularity in both the United States and the European Union, causing the "Organic" label to have marketing value with consumers, which creates a need for definitional standards. The U.S. and the EU reached an organic certification equivalence agreement in 2012.[39] Due to this agreement and trade requirements, there is a growing convergence of organic standards in the U.S and the EU.

United States

In the United States, organic crop production is regulated under the National Organic Program (NOP) by USDA's Agriculture Marketing Service (AMS). The Organic Food Production Act created the organic program in the United States in 1990.[40] This act tasked AMS with creating a certifying body for products claiming to be organic, developing organic crop production and livestock standards, and developing standards for labeling, processing, and packaging of organic products.[41]

Organic Standards

The NOP establishes the standards required for a product to be labeled as organic.[42] These rules follow certain farming philosophies defined by USDA as agricultural commodities that are produced using,

> "Cultural, biological and mechanical practices that support the cycling of on-farm resources, promote ecological balance, and conserve biodiversity in accordance with the USDA organic regulations. This means that organic operations must maintain or enhance soil and water quality, while also conserving wetlands, woodlands, and wildlife. Synthetic fertilizers, sewage sludge, irradiation, and genetic engineering may not be used"[43]

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[39] United States Department of Agriculture, Agriculture Marketing Service [USDA AMS]. (2016a). International Trade Polices: European Union. Retrieved from https://www.ams.usda.gov/services/organic-certification/international-trade/European%20Union

[40] 7 U.S.C. §94 Organic Certification

[41] United States Department of Agriculture, Agriculture Marketing Service [USDA AMS]. (2016b). About the National Organic Program. Retrieved from https://www.ams.usda.gov/sites/default/files/media/About%20the%20National%20Organic%20Program.pdf

[42] 7 C.F.R. §205

[43] USDA AMS (2016b)

These concepts are further explained in an agency guidance document titled, the *National Organic Farming Handbook.*[44] This handbook gives more detailed examples and resources to help producers better understand how to comply with organic standards.

Certification of Producers

To be a certified organic producer, one must be certified by a USDA accredited third-party certifier.[45] Individuals must present organic production or processing plans to the certifier for review and must submit their production or handling operation to a full inspection. USDA accredited third-party certifiers may issue an organic certification if an operation meets all of the standards laid out in the regulation or if only minor noncompliance issues need to be resolved. In the latter case, the certifier would give the certified operation a time limit for coming into compliance with organic standards.[46] Certified operations are listed in the USDA Annual List of Certified Organic Operations and maintained in an online database called the Organic INTEGRITY Database.[47]

Prohibited Substances

To specify the synthetic and non-synthetic substances that can be used in an organic operation, the NOP created the National List of Allowed and Prohibited Substances (The National List or the list). It lists substances that are disallowed in an organic operation, but also identifies some synthetic materials that can be used in the production or processing of organic products.[48] Substances can refer to any product applied to a crop including but not limited to, pesticides, herbicides, compost, and pheromones.[49] The synthetic substances on the National List may be allowed for specific uses, situations, or for a pre-determined time limit. General guidelines for when a synthetic substance may be allowed include: if there are no organic substitutes; if it does not adversely affect the environment; if the substance or its breakdown product does not harm

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44 United States Department of Agriculture, Agriculture Marketing Service [USDA AMS]. (2015). *National Organic Farming Handbook* (pp. D1-D14). Washington, D.C.: U.S. Department of Agriculture. Retrieved from https://policy.nrcs.usda.gov/OpenNonWebContent.aspx?content=37903.wba

45 United States Department of Agriculture, Agriculture Marketing Service, National Organic Program. (2015). *Accreditation Policies and Procedures* (pp. 5-16). Washington, D.C.: U.S. Department of Agriculture. Retrieved from https://www.ams.usda.gov/sites/default/files/media/General%20Accreditation%20Policies%20and%20Procedures.pdf

46 7 C.F.R. §205

47 United States Department of Agriculture, Agriculture Marketing Service [USDA AMS]. (2016c). U.S. Organic Integrity Database. Retrieved on April 26, 2016 from https://apps.ams.usda.gov/integrity/

48 United States Department of Agriculture, Agriculture Marketing Service [USDA AMS]. (2016d). The National List. Retrieved on April 26, 2016 from https://www.ams.usda.gov/rules-regulations/organic/national-list

49 Coleman, P. (2012). *Guide for Organic Crop Producers* (pp. 37-41). Washington, D.C.: U.S. Department of Agriculture, Agriculture Marketing Service. Retrieved from https://www.ams.usda.gov/sites/default/files/media/Guide-OrganicCropProducers.pdf

human health and is generally recognized as safe by the Food and Drug Administration (FDA); if it is not primarily a preservative; and in cases where the substance is essential for organic handling.[50]

Labeling

USDA accredited agents certify organic products or farms.[51] There is an exemption for producers whose total income from sales of organic products is below $5,000 per year. These producers may claim organic status without going through certification; this allows producers to use the term "organic" but not the official USDA Organic logo. NOP regulations specify when and how the word "organic" can be used on the front panel or information panel of a product. There are four categories of labeling:[52]

1. "100 percent organic" can only be used for products that contain only organic ingredients.
2. "Organic" may be used for products that contain a minimum of 95 percent organic ingredients. The non-organic ingredients must not be commercially available in organic form.
3. "Made with Organic ___" may be used for products that have at least 70 percent organic ingredients. The non-organic ingredients must still meet certain standards.
4. Organic ingredients can be listed as such on the information panel if a product contains less than 70 percent organic ingredients.

European Union

The Directorate General for Agricultural and Rural Development implements Council Regulation (EC) No. 834/2007 for organic farming. In 1991, the EU first introduced Regulation (EEC) No 2092/91 on organic farming and labeling for organic farm produce and foods, and animal products. Subsequently, a new organics program was created in 2007 with Council Regulation (EC) No. 834/2007 "on organic production and labeling of organic products and repealing regulation (EEC) No. 2092/91."[53] The aims of the legislation were to create an organic farming environment that uses, "sustainable cultivation systems, a variety of high-quality products, a greater emphasis on environmental protection, more attention to biodiversity, consumer confidence, and protecting consumer interests."[54] The aforementioned policies

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50 7 C.F.R. §205.600

51 7 C.F.R. §205.400

52 Coleman, 2012

53 Council Regulation (EC) No 834/2007 on organic production and labelling of organic products [2007] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:189:0001:0023:EN:PDF

54 European Commission. (2016d). EU Law on Organic Production: An Overview. Retrieved on May 4, 2016 from http://ec.europa.eu/agriculture/organic/eu-policy/eu-legislation/brief-overview/index_en.htm

generally encourage closed systems that use internal inputs rather than external inputs.[55] The regulation applies to living or unprocessed products, processed foods, animal feed and seeds, and propagating material.

Organic Standards

The EU organics regulation determines specific standards and accepted practices for organic production.[56] Rules for plant production can be organized into four categories: the life of the soil, crop rotation, prevention of pests and disease, and the collection and use of wild plants. The standards require that plant production should "maintain or increase soil organic matter, enhance soil stability and soil biodiversity, and prevent soil compaction and soil erosion."[57] The regulation specifies that one way to preserve and improve the soil is through intentional crop rotation and the application of other organic materials from compost or animal refuse. To prevent pests and disease, producers can use approved fertilizers and soil conditioners along with the "protection by natural enemies, the choice of species and varieties, crop rotation, cultivation techniques and thermal processes."[58] Finally, the regulation specifies when and how wild plants can be used in commercial production.

Certification of Producers

In the EU, the process for certification of producers is decentralized. The producers of organic goods must go through either a private or public control body in their country to be certified. Each member-state is required to designate a private control body, a public entity that regulates organic certification, or both. Authorities in each member-state supervise these control bodies. To be certified, producers must notify the control body of their intent to produce under an organic label, and the control body conducts an audit of their operation.[59] Certified operations are listed in online databases by each individual certifier. In the case of non-compliance, producers are not allowed to label or advertise their production as organic.

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55 *Ibid*

56 Council Regulation (EC) 834/2007

57 *Ibid*

58 Council Regulation (EC) 834/2007

59 European Commission, Directorate General for Agriculture and Rural Development. (2011). Working document of the Commission Services on Official Controls in the Organic Sector, Version 8. Retrieved on May 9, 2016 from https://ec.europa.eu/agriculture/organic/sites/orgfarming/files/docs/body/controls-working-document-20110708_en.pdf

Prohibited Substances

Commission Regulation (EC) No 889/2008 specifies the list of substances allowed in organic production and processing.[60] Only substances mentioned in the annex of the regulation can be used for organic farming. The substances contained in the regulation include fertilizers, pesticides, products and substances for use in production such as food additives and processing aids, and products for cleaning and disinfection. In 2011, the EU convened an Expert Group for Technical Advice on Organic Production (EGTOP) to review the substances listed in the regulation. This group of scientific experts used a combination of evidence-based practice and precautionary risk assessments to evaluate whether certain additives and non-organic ingredients should be allowed in organic production.[61] Based on the recommendation of EGTOP, Commission Regulation (EC) No 889/2008 has been amended to include additional substances.[62]

Labeling

The labeling requirements are set out in Council Regulation (EC) No. 834/2007 and Commission Regulation (EC) No 889/2008. In the EU, the term organic is sometimes interchangeable with the words 'eco' short for ecological or 'bio' short for biodynamic. Items labeled as any organic, bio, or eco, that use the EU organic logo must satisfy the requirements established in the regulation. The organic items must have ingredients that are at least 95% organic by weight and that only include approved additives. Products labeled as organic must also be free of GMO. Further, the label needs to include a code referencing the appropriate control body and place of origin. Member states are charged with enforcing labeling requirements but the EU regulation mandates an annual verification.[63]

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[60] Commission Regulation (EC) 889/2008 on laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control [2008]. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R0889

[61] European Commission, Directorate General for Agriculture and Rural Development. (2013). Expert Group for Technical Advice on Organic Production (EGTOP): Final Report III. Retrieved on May 9, 2016 from https://ec.europa.eu/agriculture/organic/sites/orgfarming/files/docs/body/2013_05_19_permanent_group_egtop_food_mandate_3_en.pdf

[62] Commission Implementing Regulation (EU) 2016/673 on organic production and labelling of organic products with regard to organic production, labelling and control [2016] http://eur-lex.europa.eu/legal-content/en/TXT/?uri=uriserv%3AOJ.L_.2016.116.01.0008.01.ENG

[63] European Commission, Directorate General for Agriculture and Rural Development, 2011

Table 2: U.S. and EU Organic Farming Regulations

	United States	European Union
Regulatory Authority	USDA organic regulations established under the National Organic Program (NOP), authorized by the Organic Food Production Act	Regulation (EC) No. 834/2007 on organic production and labeling of organic products (repealing Regulation (EEC) No 2092/91) Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Regulation (EC) No 834/2007
Administering Institution	USDA's Agriculture Marketing Service (AMS)	Directorate General for Agricultural and Rural Development
Organic Standards	Organic farming is defined as plant production practices that: **i.** support the cycling of on-farm resources **ii.** promote ecological balance **iii.** conserve biodiversity	Organic farming is defined as plant production practices that: **i.** maintain or increase soil organic matter **ii.** enhance soil stability and soil biodiversity **iii.** prevent soil compaction and soil erosion
Certification of Producers	An organic producer must: **i.** be certified by a USDA accredited third-party certifier **ii.** submit organic production or processing plans to the certifier for review **iii.** submit production or handling operation to a full inspection	An organic producer must: **i.** be certified by either a private or public control body designated by member states **ii.** notify the intent to produce under an organic label to the control body **iii.** accept an audit of operation conducted by the control body
Prohibited Substances	The National List of Allowed and Prohibited Substances specifies substances that are disallowed in an organic operation, and synthetic materials that can be used in production or processing of organic products.	Regulation (EC) No 889/2008 specifies substances that can and cannot be used for organic farming.
Labeling	▪ Products labeled as "100% organic" must: **i.** contain only organic ingredients ▪ Products labeled as "Organic" must: **i.** contain at least 95% organic ingredients **ii.** contain non-organic ingredients only if they are not commercially available in organic form ▪ Products labeled as "Made with organic ___" must: **i.** contain at least 70% organic ingredients **ii.** contain non-organic ingredients only if they meet certain standards	▪ Products labeled as "Organic," "Eco," or "Bio" must: **i.** contain at least 95% organic ingredients by weight **ii.** contain only approved additives **iii.** be free of GMO **iv.** include a code referencing the appropriate control body and place of origin

Genetically Modified Organisms

Over time, GMO regulations in the European Union have become more restrictive in comparison to the United States. Public opinion in the EU has led to stringent controls on GMOs, whereas the United States has a relatively tolerant approach towards this newer technology. This section highlights the divergent approaches followed in the U.S. and the EU towards GMO crops.

The United States

GMO crops are not regulated under a specific federal legislation in the United States. In the 1986 "Coordinated Framework for Regulation of Biotechnology," the Office of Science and Technology Policy (OSTP), under the Executive Office of the President, indicated that the U.S. would approach regulating GMO's through existing federal law.[64] Therefore, GMOs are regulated under legislation concerning health, safety, and environmental issues.[65] The framework characterizes U.S. policy towards GM production as one that focuses on the end product of genetic modification and not the development process.[66] A recent review of the coordinated framework has updated some aspects of it, but retained its original principles.[67]

Current federal regulation covering GM crops falls under the jurisdiction of three primary agencies: USDA's Animal Plant Health Inspection Service (APHIS), The Environmental Protection Agency (EPA), and the FDA.[68]

APHIS is responsible for implementing the Plant Protection Act (PPA). Under this legislation, APHIS regulates the entry of pests and noxious weeds through importation, transportation, or introduction of new crops and seeds.[69] GM crops are regulated under this federal legislation because they are introduced to the environment and interact with other plants and insects. Under

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[64] Coordinated Framework for Regulation of Biotechnology, 51 Fed. Reg. 23, 302 (June 26, 1986). Retrieved from http://www.aphis.usda.gov/brs/fedregister/coordinated_framework.pdf

[65] Acosta, L. (2014, March). Restrictions on Genetically Modified Organisms: United States. *Library of Congress*. Retrieved from https://www.loc.gov/law/help/restrictions-on-gmos/usa.php

[66] Pew Initiative on Food and Biotechnology. (2001, September). Guide to U.S. Regulation of Genetically Modified Food and Agricultural Biotechnology Products. Pew Research Trust. Retrieved from http://www.pewtrusts.org/~/media/legacy/uploadedfiles/wwwpewtrustsorg/reports/food_and_biotechnology/hhsbiotech0901pdf.pdf

[67] Barbero, R., Boling, T., Doherty, J., Goldstein, M., & Kim, J. (2016, September 16). Building on 30 Years of Experience to Prepare for the Future of Biotechnology. Retrieved on September 31, 2016 from https://www.whitehouse.gov/blog/2016/09/16/building-30-years-experience-prepare-future-biotechnology

[68] *Ibid*

[69] 7 U.S.C. § 7712(a) (2012) http://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title7-section7712&num=0&edition=prelim

PPA, APHIS grants permits for the sale of GM crops and through that permitting oversees the containment of those crop varieties.[70]

FDA is responsible for implementing the Federal Food, Drug and Cosmetic Act (FFDCA). Through this act, FDA evaluates whether food products are safe for human consumption.[71] In 1992, foods derived from GMOs were deemed to be "generally recognized as safe" (GRAS) and therefore do not have to be approved for each use unless a new variety "differs significantly in structure, function, or composition from substances found currently in food."[72]

EPA is responsible for implementing the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Toxic Substances Control Act (TSCA),[73] and the National Environmental Policy Act (NEPA).[74, 75] Under FIFRA, EPA regulates pesticide manufacture, sale, and use. GM Crops that are engineered to produce pesticide products (called plant-incorporated protectants) are covered under this regulation. EPA also has jurisdiction to regulate GM crops through TSCA. TSCA regulates chemicals that pose an unreasonable risk to human health or the environment. Finally, NEPA regulations require agencies to submit Environmental Assessments or Environmental Impact Statements for any federal action that is likely to have a significant impact on the environment. Agencies that register GM crops may have to prepare these assessments as a part of their approval process.[76]

Labeling and Traceability

Products that contain genetically modified ingredients are not currently required to be labeled in the U.S. In November 2015, FDA published a guidance document detailing ways to label non-GMO products. The voluntary labeling practices suggested by FDA aim to help industry better understand how to distinguish non-GMO products for consumers without misleading the

70 Acosta (2014)

71 Acosta (2014)

72 United States Food and Drug Administration [US FDA]. (1992, May 29). Guidance to Industry for Foods Derived from New Plant Varieties**.** *Statement of policy - foods derived from new plant varieties.* Retrieved from http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/%20Biotechnology/ucm096095.htm

73 The Toxic Substances Control Act was amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act, signed by President Obama on June 22, 2016. The new act provides new risk-based safety standard, increased public transparency, and consistent source of funding for EPA (see footnote 74).

74 United States Environmental Protection Agency [US EPA]. (2016). The Frank R. Lautenberg Chemical Safety for the 21st Century Act. *Assessing and managing chemicals under TCSA.* Retrieved from https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/frank-r-lautenberg-chemical-safety-21st-century-act

75 Acosta (2014)

76 Acosta (2014)

public.[77] On July 29, 2016, President Barack Obama signed the National Bioengineered Disclosure Law, amending the Agricultural Marketing Act of 1946. The legislation authorizes the USDA AMS to develop a "national mandatory bioengineered food disclosure standard" for GMO disclosure and labeling.[78] The related rulemaking process is expected to be finalized within two years. A few states had introduced legislation requiring labeling of GMOs at the state level prior to the law's passage. These include Vermont, Maine, and Connecticut. At least 13 other states have proposed bills to require labeling, but have yet to enact them.[79] The recently passed legislation will preempt any state labeling standards.

European Union

Four key regulations set out the rules for GMO production, labeling and use in the European Union: Directive 2001/18/EC (deliberate release of GMOs in the environment), Regulation (EC) 1829/2003 (authorization and release of GMOs for feed and food), Directive (EU) 2015/412 (member states' right to restrict GMOs), Directive 2009/41/EC (contained use of GM microorganisms), and Regulation (EC) 1830/2003 (traceability and labeling).[80] GMO legislation in the EU has four stated goals:

1. "To protect human and animal health and the environment by introducing safety assessment of the highest possible standards at EU level before any GMO is placed on the market."
2. "Put into place harmonized procedures for risk assessment and authorization of GMOs that are efficient, time-limited and transparent."
3. "Ensure clear labeling of GMOs placed on the market in order to enable consumers as well as professional to make an informed choice."
4. "Ensure the traceability of GMOs placed on the market"[81]

Regulation (EC) 1829/2003 and Regulation (EC) 1829/2003 establish procedures for GMO authorization for cultivation, feed, and food. This legislation requires strict testing and approval processes before a product is approved for cultivation and sale. Member states may submit

[77] United States Food and Drug Administration [US FDA]. (2015, November). Guidance for Industry: Voluntary Labeling Indicating Whether Foods Have or Have Not Been Derived from Genetically Engineered Plants. Retrieved on May 10, 2016 from http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm059098.htm

[78] United States Department of Agriculture, Agricultural Marketing Services [USDA AMS]. (2016e). GMO Disclosure & Labeling. Retrieved on May 16, 2016 from https://www.ams.usda.gov/rules-regulations/gmo

[79] Center for Food Safety. (2016). 2016 State Labeling Legislation. Retrieved on May 10, 2016 from http://www.centerforfoodsafety.org/issues/976/ge-food-labeling/state-labeling-initiatives#

[80] European Commission. (2016e). GMO Legislation. *Genetically Modified Organisms*. Retrieved from http://ec.europa.eu/food/plant/gmo/legislation_en

[81] *Ibid*

applications to the European Food Safety Administration which conducts risk assessments. These risk assessments and approval processes are an example of the EU's use of the precautionary principle for regulation; this philosophy that requires the EU and its member states to do everything possible to prevent harm to human health and the environment.[82] No member-state can use GMOs unless authorized under EU legislation. During the process of authorization and following approval, GMOs are listed in the "EU Register of GM Food and Feed." This database provides the name, company, a unique identifier, and the relevant genetic information for the product along with whether it is approved for food, feed, or both.[83]

Though GMOs are registered by the European Commission, individual member states can restrict the cultivation of GMOs they consider a risk, even if they are in the database of approved products.[84] In 2015, the European Commission passed a directive to allow member states to restrict GMO production within their countries. This directive was introduced to accommodate disparate policy preferences of member states within the EU. Per Directive (EU) 2015/412, member states can decide to restrict cultivation within their respective region during an EU-wide authorization process by asking to restrict the geographic scope of the GMO authorization application. Additionally, a member state can continue its ban on the cultivation of a GMO within their borders by citing environmental policy, socio-economic impact or public policy concerns. When this Directive was introduced in April 2015, the EU Parliament and the Council allowed member states to request geographic amendments to GMO authorizations granted prior to April 2015.[85] As of October 2015, Austria, France, Germany, Greece, Luxembourg, Bulgaria and Hungary have decided to ban cultivation of Monsanto's MON810 corn. Nevertheless, the member states cannot restrict the sale of GMO products—a proposal recommending the use of import bans was rejected by the EU parliament in 2015.[86] At present, corn is the only GM crop that is cultivated commercially in the EU, and there are 58 GMO varieties approved for sale for corn, cotton, rapeseed, sugar beet and soybean.

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[82] Papademetriou, T. (2014, March). Restrictions on genetically modified organisms: European Union. *Library of Congress.* Retrieved on May 10, 2016 from https://www.loc.gov/law/help/restrictions-on-gmos/eu.php

[83] European Commission. (2016f). EU Register of authorized GMOs. *Genetically Modified Organism.* Retrieved from http://ec.europa.eu/food/dyna/gm_register/index_en.cfm

[84] Proposal for a Regulation of the European Parliament and of the Council Amending Directive 2001/18/EC as Regards the Possibility for the Member States to Restrict or Prohibit the Cultivation of GMOs in Their Territory, at 3, COM (2010) 375 final (July 13, 2010); European Commission (2016g). *Genetically Modified Organisms*. Retrieved from http://ec.europa.eu/food/plant/gmo_en

[85] Directive (EU) 2015/412 amending Directive 2001/18/EC as regards the possibility for the Member States to restrict or prohibit the cultivation of genetically modified organisms (GMOs) in their territory Text with EEA relevance [2015] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2015_068_R_0001

[86] European Parliament News. (2015, October 13). Environment MEPs oppose national GMO import bans proposal [Press Release]. Retrieved from http://www.europarl.europa.eu/news/en/news-room/20151012IPR97161/environment-meps-oppose-national-gmo-import-bans-proposal

Labeling and Traceability

The identification of products that contain GMO ingredients and the ability of officials and companies to trace those ingredients are major goals of EU legislation. Traceability refers to the capacity of professionals to know which products contain GMO ingredients so that they can properly label them and the ability of officials to monitor environmental risks and make effective recalls when necessary. To ensure that each GMO ingredient can be distinguished, each is given a unique numeric or alphanumeric identifier. According to Regulation (EC) 1830/2003, food containing or produced from GMO ingredients must specify the presence of GMO and include the assigned unique identification number for traceability. The labeling requirements include a specific provision of adding "This product contains genetically modified organisms or [name of the organism]."[87] These terms must be clearly visible in or near the list of ingredients. Products that contain 0.9 percent or less of GMO ingredients are exempt from this labeling requirement.[88]

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87 Regulation (EC) 1830/2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms [2003] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:268:0024:0028:EN:PDF

88 *Ibid*

Table 3: U.S. and EU GMO Regulations

	United States	European Union
GM Plant Cultivation (Release to the Environment)		
Regulatory Authority	Plant Protection Act (PPA)	Directive 2001/18/EC on the deliberate release of GMOs into the environment (repealing Directive 90/220/EC); Regulation (EC) 1829/2003 on GM food and feed; Directive (EU) 2015/412 amending Directive 2001/18/EC as regards the possibility for member states to restrict or prohibit the cultivation of GMOs in their territory
Administering Institution	USDA Animal and Plant Health Inspection Service (APHIS)	European Commission authorizes GMO cultivation; Member States have the freedom to restrict or prohibit the cultivation of GMOs in their territory.
Scope of Application	Importation, interstate movement, and field testing of GE plants and organisms that are or might be plant pests.	Commercial use of a GM plant (that is able to reproduce); release into the environment involved with growing the plant or importing plant material.
Food and Feed (Release to the Market)		
Regulatory Authority	Federal Food, Drug and Cosmetic Act (FFDCA) Public Health Service Act (PHSA)	Regulation (EC) 1829/2003 on GM food and feed
Administering Institution	Food and Drug Administration (FDA)	European Food Safety Authority assesses risks; Standing Committee on the Food Chain and Animal Health accepts the proposal; European Commission adopts the proposal.
Scope of Application	Food, animal feed additives, and human and animal drugs, including those from biotechnology.	GMOs used in food or in animal feed; food or animal feed containing GMOs; food or feed made with or containing ingredients made using GMOs.
Contained Use of GM Microorganisms (GMMs)		
Regulatory Authority	Toxic Substances Control Act (TSCA)	Directive 2009/41/EC on the contained use of GMMs (repealing Directive 90/219/EEC)
Administering Institution	Environmental Protection Agency (EPA)	Member States
Scope of Application	Use of GMMs for chemical purposes requires EPA notification.	Use of GMMs requires an examination of the containment and protection measures taken, in order to avoid a release.
Use of GM Pesticides		
Regulatory	Federal Insecticide, Fungicide, and	Directive 2001/18/EC on the deliberate release

Reference	Rodenticide Act (FIFRA)	of GMOs into the environment (repealing Directive 90/220/EC) Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market
Administering Institution	Environmental Protection Agency (EPA)	European Commission authorizes the use of GM pesticides; Member States have the freedom to restrict or prohibit them under Directive (EU) 2015/412.
Scope of Application	Use of all pesticides, including those genetically engineered into plants (plant-incorporated protectants (PIPs))	Placing on the market and use of pesticides containing a GMO
Traceability and Labeling		
Regulatory Authority	National Bioengineered Disclosure Law, amending the Agricultural Marketing Act of 1946	Regulation (EC) 1830/2003 concerning the traceability and labeling of GMOs and the traceability of food and feed products produced from GMOs
Administering Institution	USDA Agricultural Marketing Service (AMS) is responsible for the rulemaking under the new law.	Member States carry out inspections and enforcement; European Commission gives technical guidance and keeps a central register.
Scope of Application	Rulemaking for “a national mandatory bioengineered food disclosure standard” is in progress.	GMOs and products containing GMOs or produced from GMOs are all subject to compulsory labeling and/or traceability; only food or feed containing less than 0.9% GMOs may be exempted.

Pesticides

The United States

Both federal and state laws govern the production and use of pesticides in the United States. At the federal level, the key statutes governing pesticides include the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Federal Food, Drug and Cosmetic Act (FFDCA), the Food Quality Protection Act (FQPA), the Pesticide Registration Improvement Act (PRIA), the Clean Water Act, and the Endangered Species Act (ESA). The FQPA and PRIA amended the FIFRA and FFDCA to include provisions for pesticide registration. EPA regulates and approves pesticides but the FDA, USDA, the Department of Interior's Bureau of Land Management and U.S. Fish and Wildlife Service, as well as state agencies work with EPA to ensure food and environmental safety and compliance.[89] Although EPA establishes pesticide regulations, a state government may set rules that are more stringent than federal regulations and standards for pesticide use.[90] Each state has its own set of pesticide regulations but works in close collaboration with EPA to ensure compliance with the federal standards.

Manufacturing, Distribution and Labeling

Under FIFRA, EPA must approve all pesticides that are sold or distributed in the United States. EPA conducts risk assessments aimed at both ecological risks and human health hazards. This risk assessment process is performed both before a pesticide enters the market and no less than every 15 years.[91] Despite the federal approval, states have the right to restrict the use of a pesticide if they deem it to be harmful.

Application to the Land

EPA also regulates the information that must be included on pesticide labels and the safety procedures that must be included in pesticide handling instructions. In the U.S., allowable uses for a pesticide are determined at the federal level. States are tasked with enforcing compliance with pesticide labeling requirements.[92] Farms must comply with EPA pesticide labeling instructions, which place limits on application rates to the land.

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89 National Pesticide Information Center. (2016a, February 22). Federal Pesticide Regulation. Retrieved from http://npic.orst.edu/reg/regfed.html

90 National Pesticide Information Center. (2016b, February 22). State Pesticide Regulation. Retrieved from http://npic.orst.edu/reg/regstate.html

91 United States Environmental Protection Agency. (2016a, October 17). Overview of Risk Assessment in the Pesticide Program. Retrieved on May 12, 2016 from https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/overview-risk-assessment-pesticide-program

92 United States Environmental Protection Agency. (2011). *Label Review Manual*. Washington, D.C.: US EPA. Retrieved from https://www.epa.gov/sites/production/files/2015-08/documents/lrm-chap1-18-aug-2015.pdf

Food Tolerance Levels

Section 408 of FFDCA tasks EPA with setting tolerance levels for pesticides—limits on the amount of pesticides that may remain in or on foods—while the FDA is responsible for the enforcement of tolerances.[93] The tolerance level is established based on the toxicity of a pesticide and "its break-down products, aggregate exposure to the pesticide in foods and from other sources of exposure, and any special risks posed to infants and children. Some pesticides are exempted from the requirement to have a tolerance".[94] EPA is required to state a tolerance level or tolerance exemption when a pesticide is registered with the agency.

Further, in compliance with the ESA, EPA implements the Endangered Species Protection Program (ESPP) under the authority of FIFRA. The ESPP sets limits for pesticide applications in certain areas and time periods with the intent of protecting threatened or endangered species and their habitats from potential harms related to pesticide use. These limitations are specified in Endangered Species Protection Bulletins, which are referenced on pesticide labels.

Since pesticides are a potential pollutant to waters of the U.S., certain pesticide applications are also regulated by the National Pollutant Discharge Elimination System (NPDES) permitting program, pursuant to section 402 of the Clean Water Act. As of 2011, farms applying biological and chemical pesticides that will lead to point source discharges to U.S. waters must apply for NPDES Pesticide General Permits (PGPs). Within the 47 states and territories authorized by EPA to administer NPDES permits, state environmental protection regulatory agencies issue PGPs.[95] In other areas, EPA is the PGP permitting authority. The PGP requires eligible entities to minimize pesticide discharges by implementing pesticide management measures.

The European Union

The European Union has a multilayer approach to pesticide authorization and risk assessment. Three key laws governing pesticides are (i) Regulation (EC) 1107/2009 on placing on the market of Plant Protection Products, (ii) Directive 2009/128/EC on the sustainable use of pesticides, and (iii) Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin.[96]

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93 United States Environmental Protection Agency. (n.d.). About Pesticide Registration. Retrieved on May 12, 2016 from https://www.epa.gov/pesticide-registration/about-pesticide-registration#laws

94 *Ibid*

95 United States Environmental Protection Agency. (2016b, October). Pesticide Permitting – 2016 PGP. *National Pollutant Discharge Elimination System*. Retrieved from https://www.epa.gov/npdes/pesticide-permitting-2016-pgp

96 European Commission. (2016h). EU legislation on MRLs. Retrieved on May 10, 2016 from http://ec.europa.eu/food/plant/pesticides/max_residue_levels/eu_rules_en

Manufacturing, Distribution and Labeling

Pesticides, commonly referred to as Plant Production Products (PPPs) in the EU, are made of several ingredients, but the key component used against pests/plant diseases is termed the "active substance." Based on the distinction between active substances and PPPs, an independent registration process is followed. The European Commission and the member states are jointly responsible for approval of each active substance, in accordance with Regulation (EC) 1107/2009.[97] The member state carries out the initial risk evaluation of the substance, and submits the draft assessment report to the European Food Safety Authority (EFSA) for peer review. EFSA, in consultation with the public, provides its conclusions to the Commission concerning its opinion that the substance should either be approved or disapproved. The Commission makes its final decision based on the result of votes cast by the Standing Committee for Food Chain and Animal Health. Initial approval is given for 10 years, and subsequent renewals are valid for 15 years.

The new EU chemicals legislation—Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)—requires manufacturers and importers of substances to submit a registration to the European Chemicals Agency for each chemical substance manufactured or imported into the EU. However, REACH provides exemptions from the general obligation for a number of substances that are considered adequately controlled under pre-existing EU legislation. Active substances included in Regulation (EC) 1107/2009 fall into this category. Article 15 of REACH articulates that "active substances and co-formulants manufactured or imported for use in plant protection products only … shall be regarded as being registered and the registration as completed."[98]

PPPs (compounds of active substances and other ingredients) are authorized at the member-state level. This provision rests on the idea that member states have a better understanding of the environmental needs of their localities.[99] Regulation (EC) No 1107/2009 lays out standard procedures for member states to consider and approve PPPs. Furthermore, Commission Regulation (EU) No 547/2011 (implementing Regulation (EC) No 1107/2009 as regards labelling requirements for PPPs) sets the information required on pesticide labels.[100] The required information includes safety and usage information as well as toxicological information.

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[97] Regulation (EC) 1107/2009 concerning the placing of plant protection products on the market [2009] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R1107&from=ENb

[98] Regulation (EC) 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency [2006] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20140410

[99] European Commission (2016h)

[100] Commission Regulation (EU) No 547/2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards labeling requirements for plant protection products [2011] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0547&from=EN

The regulation specifies standard phrases to be used to identify safety risks to human or animal health or the environment. Since the allowed pesticide products are determined at the member state level, labels may differ from one to the next.

In addition, the EU requires each pesticide to have a Maximum Residue Level (MRL) (equivalent to the U.S. tolerance level), which is established under Regulation (EC) No 396/2005.[101] To set a MRL for a pesticide, an application needs to be submitted to the EU along with information on use (quantity, frequency, etc.) of pesticide on the crop, expected residue when the pesticide is applied, and toxicological data.[102] The Commission adopts MRLs based on risk assessments for residues conducted by EFSA.

Application to the Land

Regulation (EC) No 1107/2009 concerning the placing of PPPs on the market prescribes the conditions for pesticide use. The use of pesticides in any manner other than that instructed on the product package label is prohibited. To ensure compliance with these provisions, the directive is linked to the SMR requirements of the cross-compliance rules in CAP.

To promote the sustainable use of pesticides, the EU introduced Directive 2009/128/EC, which sets out the general principles of integrated pest management to be followed when using pesticides. In particular, the legislation charges member states with developing a national action plan to set up their quantitative objectives, targets, measures and timetables to reduce risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides. These targets may cover different areas of concern, for example worker protection, protection of the environment, residues, use of specific techniques or use in specific crop.[103]

Articles 8 and 9 of the directive require member states to inspect pesticide application equipment and to prohibit aerial spraying of pesticides, although they allow for certain exemptions.

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[101] European Commission. (2016i). Maximum Residue Levels. Retrieved on May 10, 2016 from http://ec.europa.eu/food/plant/pesticides/max_residue_levels/index_en.htm.

[102] European Commission. (2016j). How are EU MRLs set?. Retrieved on May 10,2016 from http://ec.europa.eu/food/plant/pesticides/max_residue_levels/application_en

[103] Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides [2009] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:309:0071:0086:en:PDF

Table 4: U.S. and EU Pesticide Regulations

	United States	European Union
Introducing pesticides to the market		
Regulatory Authority	Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Regulation (EC) No 1107/2009 on the placing of plant protection products (PPPs) on the market (repealing Directive 79/117/EEC and 91/414/EEC)
Administering Institution	EPA	Directorate General for Health and Food Safety
Scope of Application	▪ All pesticides sold or distributed in the U.S. must be registered by EPA; ▪ States may ban the sale or use of any federally registered pesticides; ▪ States may register a new pesticide for general use, or a federally registered product for an additional use, if there is "special local need."	▪ The Regulation specifies a list of approved substances that are allowed in pesticides at EU level; ▪ Pesticides must be authorized by member states before they can be placed on the market; ▪ Member states may ban the listed active substances at national or local level.
Application of pesticides on farmland		
Regulatory Authority	Endangered Species Act; Clean Water Act	Directive 2009/128/EC on the sustainable use of pesticides
Administering Institution	EPA	Directorate General for Health and Food Safety & Member States
Scope of Application	▪ EPA sets limitations on pesticide application for protection of endangered species and their habitats; ▪ Farms applying pesticides that will lead to discharges to U.S. waters must apply for NPDES Pesticide General Permits.	▪ Member states are required to adopt National Action Plans (NAPs) that set objectives and timetables to reduce risks and impacts of pesticide use.
Pesticide Maximum Residue Level (Tolerance)		
Regulatory Authority	Federal Food, Drug and Cosmetic Act (FFDCA)	Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin (amending Directive 91/414/EEC)
Administering Institution	EPA establishes tolerance levels; FDA enforces tolerances.	Directorate General for Health and Food Safety
Scope of Application	▪ EPA sets pesticide tolerances for all pesticides used in or on food (several exemptions apply).	▪ The Regulation sets MRLs for 315 fresh agricultural products intended for food or feed; ▪ Where a pesticide is not listed, a general default MRL of 0.01 mg/kg applies.

Fertilizer

Fertilizers are primarily composed of three essential plant nutrients (nitrogen, phosphorous and potash) but may also contain micronutrients[104] and other macronutrients.[105] Regulations covering fertilizers establish standards for manufacturing, labeling, and the application of commercial fertilizers (chemical and organic). Biosolids (treated sewage sludge) and livestock manure used in agriculture also fall within the regulatory framework.

The United States

Manufacturing, Distribution and Labeling

The registration, labeling, handling, and risk assessments of fertilizers are mostly regulated at the state level. State regulations define fertilizer standards (i.e. limits of nutrients or chemicals used in their composition), and specify the prerequisites for registration and labeling.

At the federal level, the Emergency Planning and Community Right-to-Know Act requires disclosure and reporting of environmental and safety hazards posed by toxic chemicals. Under the act, the public has access to information on chemicals at individual facilities and their potential impact on the neighboring environment if released.

Application to the Land

Given the environmental concerns for water and air due to fertilizer use, fertilizer application for farmland is controlled under environmental regulations. Federal legislation such as the Clean Water Act (CWA) and the Clean Air Act (CAA) authorize EPA to establish regulations to reduce water and air pollutants from various sources.

The CWA, administered by the EPA, governs the pollutants released into U.S. waters and provides guidance for states to establish surface water quality standards. Fertilizer use in agriculture is a leading cause of water pollution due to the excess nutrients in the soil entering into the surrounding water, mostly through surface runoff. The policy approach of the CWA to address nonpoint source pollution[106] is primarily accomplished through voluntary programs and grants. A key component is the Section 319 Nonpoint Source Management Program established by the 1987 amendment of CWA that provides grant money to states to support nonpoint source

[104] Micronutrients used in commercial fertilizer include copper, iron, zinc, manganese, and molybdenum.

[105] In addition to Nitrogen, Phosphorous and Potash, nutrients such as calcium, magnesium and sulphur is used.

[106] Nonpoint sources refer to diffuse sources of pollution caused by land runoff, soil erosion, or leaching, etc. In contrast, point sources apply to identifiable sources of pollution such as fertilizer manufacturing units.

solutions such as nutrient management practices.[107] The Farm Bill conservation programs, introduced in section 1, also encourage farmers to implement nutrient management to optimize fertilizer use. While there are no limits on fertilizer application rates established at the federal level, states may set regulatory standards based on local soil conditions and environmental objectives.

Biosolids are treated sewage sludge applied to land; they are nutrient-rich organic materials used as an alternative to commercial fertilizer. The use and disposal of biosolids is regulated under EPA Part 503 Biosolids Rule,[108] as authorized by Section 405 of the CWA. The regulation specifies general requirements, pollutant limits, management practices, and operational standards for biosolids applied to the land, in addition to those for sewage sludge used for other purposes or disposed in other ways.[109]

The European Union

The European Union regulates fertilizers via Regulation (EC) No 2003/2003 relating to the introduction of fertilizers on the market, but the use of fertilizers is covered under environmental legislation—the Nitrates Directive in particular.

Manufacturing, Distribution and Labeling

Regulation (EC) No 2003/2003 frames the standards for fertilizers in the European Union. Member states have to adhere to EU-level standards. A member state is allowed to prohibit a fertilizer only if there is a risk to the environment or health. If such a claim was made, the European Commission would undertake a study on the fertilizer and temporarily ban the product. The regulation establishes minimum requirements for nutrient fertilizers containing nitrogen, phosphorus, and potash.

Regulation (EC) No 2003/2003 also harmonizes the rules on labeling and packaging for fertilizers in the EU. In particular, fertilizer packages are required to have labels printed at a visible position, which include details on the nutrient or micro-nutrients, information about the manufacturer, and information regarding blends.

Fertilizer labeled as "EC Fertiliser" allows for free circulation on the EU market. Member states can conduct inspections for compliance of fertilizer labeled "EC Fertiliser" according to the

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[107] For more details on policy approaches addressing nutrient pollutions in the U.S and EU, please refer to chapter 5 of this report.

[108] United States National Archives and Records Administration (1993). *Code of Federal Regulations*. Title 40, Part 503. Standards for the Use or Disposal of Sewage Sludge.

[109] United States Environmental Protection Agency (2016c, July 26). Biosolids Laws and Regulations. Retrieved on May 10, 2016 from https://www.epa.gov/biosolids/biosolids-laws-and-regulations

provisions of Regulation (EC) No 2003/2003. However, checks can be carried out only by designated laboratories in each member state and must follow the procedure set out within the Regulation. Member states set penalties for any infraction related to the labeling of fertilizers.

Contrary to the registration of active substances in pesticides, fertilizer ingredients do not have a separate registration process. Fertilizer manufactures and importers in the EU are therefore subject to REACH requirements that obligate them to collect and report information on the properties and uses of all the chemical substances involved.

Application to the Land

Fertilizer use and soil nutrient content are primarily regulated under the Nitrates Directive[110] introduced to protect water quality from agricultural activities. The Nitrates Directive requires member states to monitor nitrate concentrations in surface and ground water, designate Nitrate Vulnerable Zones (NVZs), and establish "Action Programmes" to be implemented by farmers on a mandatory basis within NVZs as well as Codes of Agricultural Practice to be implemented on a voluntary basis outside NVZs. Member states have the freedom to establish specific requirements of Action Programmes; however, the Nitrates Directive specifies some minimum measures that must be included in the national Action Programmes, such as application prohibition periods, minimum storage capacity for livestock manure, and maximum manure application rate (170 kg N/ha/year).[111]

Member states are expected to report every four years on: (i) nitrate concentrations in groundwater and surface waters; (ii) eutrophication[112] of surface waters; (iii) assessments of the impact of Action Programmes on water quality and agricultural practices, and (iv) revisions of NVZs and Action Programmes that include estimations of future trends in water quality.

The use of biosolids in agriculture is regulated under the Sewage Sludge Directive 81/278/EEC. It aims to encourage the use of biosolids while preventing the negative effects on soil, vegetation, animals, and human beings. The requirements include the prohibition of the use of untreated sludge on agriculture land, and limit the application of sludge to specified vegetables and fruits.

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[110] Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources [1991] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31991L0676

[111] Chapter 5 of this report discusses details on the Nitrates Directive.

[112] Eutrophication refers to the enrichment of a water body in nutrients.

Table 5: U.S. and EU Fertilizer Regulations

	United States	European Union
Placing of fertilizers on the market		
Regulatory Authority	Regulated by states	Regulation (EC) No 2003/2003 relating to fertilizers
Administering Institution	U.S. States	European Commission
Scope of Application	▪ State regulations cover registration, labeling, handling, application, and consumer protection of fertilizers.	▪ The Regulation specifies the definition, traceability, markings, labelling, packaging for different types of fertilizers; ▪ It lists "EC fertiliser" that may circulate freely on the European market; ▪ Member states may not prohibit or limit "EC fertiliser" on the market unless the fertilizer represents a danger for health or a risk to the environment.
Application of fertilizers on the farmland		
Regulatory Authority	Regulated through environmental regulations (e.g. Clean Water Act), Farm Bill conservation programs	Directive 91/676/EEC (Nitrates Directive) on the protection of waters against pollution caused by nitrates from agricultural sources
Administering Institution	EPA & USDA	Directorate General for Environment & Member states
Scope of Application	▪ Under CWA, Section 319 Nonpoint Source Management Program provides grant money to states to support voluntary nonpoint source management practices; ▪ Conservation programs encourage farmers to take nutrient management practices that prevent nutrient runoff from farmland; ▪ States set maximum fertilizer application rates based on local conditions and environmental objectives (e.g. water quality criteria).	▪ Member states are required to designate Nitrates Vulnerable Zones (NVZs) for the water bodies with nitrate concentration exceeding 50 mg/l; ▪ Farmers within NVZs must comply with the Action Programmes established by member states, which must include: **i.** Application prohibition periods; **ii.** Minimum storage capacity for livestock manure; **iii.** Maximum manure application rate (170 kg N/ha/year), etc.

Regulatory Studies Center

THE GEORGE WASHINGTON UNIVERSITY

Water Pollution from Agriculture

Transatlantic Agriculture & Regulation Working Paper Series: No. 4

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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 reviews how the U.S. and EU regulate water pollution from agriculture, particularly nutrient contamination from fertilizer use on crops and from the management of manure from livestock. The chapter first reviews the core environmental problem—the process by which nutrient pollution occurs and the adverse environmental and human health consequences it causes. It also provides a broad overview of the institutions and policy frameworks that shape water quality polices relevant to agriculture in the two jurisdictions and proceeds by characterizing the specific policy instruments used in the U.S. and the EU to implement these broader policy frameworks. The chapter concludes by describing the on-the-ground implementation experience and the degree to which retrospective program evaluations are performed.

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Scope of the Environmental Problem

Water pollution from agriculture poses unique challenges for regulators. Agricultural runoff is largely a nonpoint source of pollution and traditional point-source pollution control policies may be unsuitable.Further, wide variations in agricultural practices and local environmental conditions can make it difficult for policymakers to set a single, jurisdiction-wide standard that meets varied needs. Another challenge, not addressed here, is that the agriculture sector, in both the U.S. and EU, has considerable influence in the political sphere.

Nutrient Use in Agriculture

More than anything else, a nutritious diet for humans and animals must include sufficient energy, typically measured in Calories, to support life. It also must include chemical compounds, such as vitamins or essential amino acids that cannot be manufactured metabolically. In contrast, plants derive their energy from sunlight, and they often have metabolic pathways that are capable of making any necessary chemical compounds. For these reasons, a list of plant nutrients generally will focus on the chemical elements that are critical to a plant's growth. They include non-mineral nutrients and mineral nutrients. Non-mineral nutrients are hydrogen (H), oxygen (O), and carbon (C), which plants obtain from the air[3] and water.

Mineral nutrients can be further divided into macronutrients and micronutrients. Macronutrients refer to nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), which plants typically require in relatively large amounts, while micronutrients, such as iron (Fe), chloride (Cl), and manganese (Mn), are needed by plants in much smaller amounts. Among these nutrients, nitrogen, phosphorus, and potassium are most important for crop production, and supplementation in the form of intentional addition to the soil can substantially increase crop yield.

Animal wastes often are applied to croplands to provide needed nutrients. Poultry litter tends to be relatively high in phosphorous, and is highly valued where that nutrient tends to be scarce. Waste from hog farms tends to be higher in nitrogen, as does human waste. Treated human waste, called biosolids, may be applied to some crops.

In addition to animal and human waste streams, U.S. and EU agriculture uses synthetic fertilizer on a large scale. Atmospheric nitrogen can be "fixed" using a process invented by the German

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[3] Nitrogen is also abundant in the air as N_2, but is generally not available to plants unless they are legumes. Throughout this chapter, any reference to nitrogen will mean "fixed" nitrogen—that is, nitrogen contained in a chemical compound, often a nitrate, which is metabolically available to plants.

chemist Fritz Haber. Today, the amount of nitrogen fixed by the Haber process, including a number of nonagricultural uses, has transformed the earth's natural nitrogen cycle.[4]

Nutrient Pollution from Agriculture

When nutrients are added to the soil in excess of the amount taken up by crops, the excess nutrients enter the surrounding environment, potentially causing harmful contamination of surface waters or groundwater. Potassium is often found in abundance in soils and is less often required in fertilization; as a consequence, nitrogen and phosphorus tend to be the two primary nutrient pollutants in water resulting in part from the use of fertilizers.

Waste from livestock operations, particularly animal manure, is another important source of nitrogen and phosphorus pollution in water. In some cases, such pollution results from point source[5] discharges from concentrated animal feeding operations (or CAFOs) while in other cases, livestock operations over larger land areas can lead to nonpoint runoff as animal wastes make their way to adjacent surface or groundwater.

Agricultural nutrient pollutants can reach water in a number of ways. In addition to point source discharges from CAFOs, nonpoint pollution can be caused by soil erosion, runoff to surface water, and leaching into groundwater. Soil erosion occurs when soil particles on the farmland containing nitrogen or phosphorus are moved by water or wind into the surrounding environment. Dissolved nitrogen or phosphorus on the surface of farmland can be washed into nearby waters by moving water such as rainfall, snowmelt, stormwater, and irrigation water. Last, dissolved nitrogen or phosphorus can also leach into groundwater or subsurface drains through the soil and then enter into surface waters. Phosphorus is mostly transported through soil erosion or runoff.[6]

Too much nitrogen or phosphorus in water can cause negative ecological and human health effects. The most significant problem is eutrophication—enrichment of a water body with nutrients—in surface waters including streams, rivers, lakes, bays, and coastal waters. High levels of nitrogen or phosphorous in surface waters cause excessive growth of algae, which can

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4 Galloway, J. N., Townsend, A. R., Erisman, J., Bekunda, M., Cai, Z., Freney, J. R.,…Sutton, M. A. (2008). Transformation of the Nitrogen Cycle: Recent Trends, Questions, and Potential Solutions. *Science, 320*, 889-892. Retrieved from https://www.researchgate.net/profile/Jan_Willem_Erisman/publication/5363687_Transformation_of_the_Nitrogen_Cycle_Recent_Trends_Questions_and_Potential_Solutions/links/0fcfd5080f64094f9d000000.pdf

5 Point sources refer to "any single identifiable source of pollution" such as industrial and sewage treatment plants, defined by EPA. In contrast, nonpoint sources refer to diffuse sources of pollution such as water runoff from land.

6 Stubbs, M. (2015). *Nutrients in Agricultural Production: A Water Quality Overview.* Washington, DC: Congressional Research Service.

lead to algal blooms that deplete oxygen in the water. Algal blooms can kill fish and other aquatic life and elevate levels of toxins and bacteria in water. In addition, human health can be threatened if humans eat fish or drink water contaminated with toxins. Furthermore, nitrate pollution in groundwater used for drinking can itself be a human health concern.[7]

State of Agricultural Nutrient Pollution in the EU and the U.S.

This section summarizes the available assessments of water quality in the U.S. and the EU, and discusses the nutrient-related water contamination reflected by these assessments.

United States

There is little doubt that nutrient runoff from agricultural lands adversely affects water quality in rivers, streams, lakes, wetlands, and coastal areas. Quantifying such effects at a national scale in the United States is, however, subject to both methodological and data constraints. Causal attribution of environmental impacts can be difficult when there are multiple sources with the potential to pollute a particular water body. More importantly, when it comes to evidence about the magnitude of agriculture's impact on water, sufficient national data are unavailable to draw definitive conclusions.

Nonetheless, information from two EPA data sets allows some conclusions to be drawn. First, EPA's National Aquatic Resource Surveys (NARS) periodically study a probability-based random sample of sites within each of four types of water bodies.[8] These surveys are designed to permit inferences about national conditions in the lower 48 states. In the NARS program, water quality is assessed using several criteria, two of which—total nitrogen and total phosphorus concentrations—are linked to agricultural activities. Because of other non-agricultural sources of these two pollutants, however, NARS results cannot be used to definitively draw a causal connection between agriculture and water conditions in specific locations.

The second EPA dataset compiles information provided by the states as part of their implementation of the Clean Water Act (CWA).[9] The Act requires that states designate their

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7 EPA. (2016f, December 5). *Nutrient Pollution: The Problem*. Retrieved from United States Environmental Protection Agency: https://www.epa.gov/nutrientpollution/problem

8 The four types of water bodies are lakes, rivers and streams, wetlands, and coastal areas. EPA. (2009). *National Lakes Assessment: A Collaborative Survey of the Nation's Lakes.* Washington, DC: U.S. Environmental Protection Agency; EPA. (2015d). *National Coastal Condition Assessment 2010.* Washington, DC: U.S. Environmental Protection Agency; EPA. (2016d). *National Rivers and Streams Assessment 2008-2009: A Collaborative Survey.* Washington, DC: U.S. Environmental Protection Agency; EPA. (2016e). *National Wetland Condition Assessment 2011: A Collaborative Survey of the Nation's Wetlands.* Washington, DC: U.S. Environmental Protection Agency.

9 EPA. (2017, January 26). *Water Quality Assessment and TMDL Information / National Summary of State Information*. Retrieved October 20, 2016, from https://iaspub.epa.gov/waters10/attains_nation_cy.control

waters for certain uses, such as fish and wildlife protection, recreation, fishing, drinking water, or industrial use. States must set these designations based on the highest valued use and no lower than any actual use of the water since November of 1975.[10] States then assess the degree to which water quality supports the designated use. Water bodies are characterized as impaired, threatened, or good with respect to the designated use.

Though subject to EPA oversight, states have different approaches to selecting waters for assessment, designating uses, or deciding which pollutants to sample. Only 32% of rivers and streams, 44% of lakes, and 1% of wetlands have been assessed by the states. For those water bodies that have been characterized as impaired, states typically report the type of impairment (e.g., pathogens, nutrients, mercury) and the probable source of impairment (e.g., agriculture, municipal sewage, industry, unknown). Because they do not represent a random, probability-based sample, nor follow a consistent methodology, these state reports cannot be aggregated to draw inferences about national conditions.

Highlights of the NARS findings—which do allow valid inferences about national conditions—are presented in Table 1. The results shown in the table were generated by the George Washington Regulatory Studies Center based on data provided directly by EPA. Just under a third of lakes and rivers and streams show total nitrogen in excess of 1.0 mg/l while roughly a quarter of these water bodies show total phosphorous over 0.1 mg/l. Given the nature of the NARS data set, however, it is not possible to identify the source of these nutrient concentrations.

Table 1: Results of EPA's National Aquatic Resource Surveys for 2016

	Total Nitrogen				Total Phosphorus			
	> 10 mg/l	1-10 mg/l	0.1-1 mg/l	<0.1 mg/l	> 1 mg/l	0.1-1 mg/l	0.01-0.1 mg/l	<0.01 mg/l
Lakes (number)	0.1%	29.5%	68.9%	1.5%	1.3%	22.2%	69.7%	6.7%
Rivers & Streams (miles)	2.0%	30.1%	58.6%	9.0%	1.9%	26.1%	61.9%	9.9%

Sources: GWRSC analysis of NARS data provided by EPA (2016d); EPA. (2016i). *National Lakes Assessment 2012: A Collaborative Survey of Lakes in the United States.* Washington, DC: U.S. Environmental Protection Agency.

As shown in Table 2, data reported by states under the CWA provide a somewhat clearer picture of the link between agriculture and water, albeit without the benefit of being a nationally representative sample. For example, about 55% of assessed rivers and streams and 71% of

[10] United States National Archives and Records Administration (1993). *Code of Federal Regulations*. Title 40, Part 131. Water Quality Standards.

assessed lakes are impaired for their designated uses. And, for those water bodies assessed as being impaired, 12% (or 141,161 miles) of rivers and streams, and 6% (or 1.1 million acres) of lakes, have agriculture as one of their probable sources of impairment.

While these are modest numbers, agriculture is the most prevalent source of impairment for rivers and streams, and the third-ranked source of impairment for lakes.[11] It is important to note also that for 20% of impaired lakes, and 12% of impaired rivers and streams, EPA reports the source of impairment as "unknown."

Table 2: EPA Summary of Water Quality Information Provided by States under the CWA

	Of Assessed Water Bodies				Of Impaired & Threatened Water Bodies		
	% of Water Bodies Assessed	Good	Threatened	Impaired	Threatened or Impaired by Nutrients	Probable Source of Impairment: Agriculture	Among Impairment Sources: Rank of Agriculture
Lakes	44%	29%	0%	71%	21%	6%	#3
Wetlands	1%	46%	0%	54%	5%	16%	#2
Rivers & Streams	32%	45%	0%	55%	10%	12%	#1

Source: (EPA, 2017)

European Union

In the EU, in order to set long-term objectives for water protection, the European Commission's Water Framework Directive (WFD, or Directive 2000/60/EC) requires member states to identify the status of waters in each river basin and to report on water quality in River Basin Management Plans (RBMPs). To support this process, in 2012, the European Environment Agency (EEA) published a synthesis report *European Waters – Assessment of Status and Pressures* based on the RBMPs and data reported by member states.[12] Among the 13,000 groundwater bodies and 127,000 surface water bodies included in the report, nonpoint source pollution from agriculture was identified as a "significant pressure" on more than 40% of rivers and coastal waters and on one third of lakes and estuaries; 25% of groundwater was classified as in "poor chemical status,"

[11] These results reflect the fact that, given EPA's methodology, individual water bodies may have more than one probable source of impairment. In addition, EPA applies a typology of approximately two dozen categories to characterize probable sources of impairement.

[12] The report covers RMBPs reported by 23 member states as of May 2012.

which was mostly caused by excessive levels of nitrates.[13] However, lack of monitoring data meant that information on the chemical status of waters was limited and inconsistent; more than 40% of the surface water bodies were reported as having unknown pollution status, and the water bodies with known status were not fully comparable because many of them were based on expert judgement in respective member states.[14]

In addition, the Nitrate Directive (Directive 91/676/EEC)—the main EU legislation that protects water quality against nitrates from agricultural sources—requires member states to monitor all water bodies with regard to nitrate concentration and trophic state[15] and report to the Commission every four years. Nitrate concentrations are monitored by a network of sampling stations covering groundwater, rivers, lakes and dams, and coastal and marine waters. According to the most current Commission report for the EU-27, between 2008 and 2011, there were about 33,000 groundwater monitoring stations, 29,000 fresh water monitoring stations, and 3,200 monitoring stations in saline waters.[16,17]

According to the report, between 2008 and 2011, 14.4% of groundwater monitoring stations in the EU-27 exceeded 50 mg/l nitrate (11.3 mg/l NO_3-N) and 5.9% were between 40-50 mg/l nitrate (9.0-11.3 mg/l NO_3-N) (Table 3).[18] In fresh surface waters, 2.4% of the reported stations showed annual average concentrations exceeding 50 mg/l nitrate and 2.4% were between 40-50 mg/l nitrate. Nitrate concentrations in saline waters were generally lower, with only 1.4% of the stations exceeding 25 mg/l nitrate (5.6 mg/l NO_3-N) and 72.5% of the stations below 2 mg/l nitrate (0.5 mg/l NO_3-N). Member states also reported the trophic status for fresh surface waters; however, the parameters and methodologies used in the assessment varied widely. Of all

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13 EEA. (2012). *European waters — assessment of status and pressures.* Copenhagen: European Environment Agency.

14 *Ibid*

15 Trophic state has several categories: waters with high nutrient levels, high plant production rates, and an abundance of plant life are termed eutrophic, whereas waters that have low concentrations of nutrients, low rates of productivity and generally low biomass are termed oligotrophic; waters that fall in between are mesotrophic, and those on the extreme ends of the scale are termed hypereutrophic or ultra-oligotrophic. (EPA, 2009.) However, there are no consistent specifications across different types of waters or countries in determining the trophic state.

16 "Saline waters" in the EU refers to transitional, coastal and marine waters. Transitional waters are defined by the WFD as "bodies of surface water in the vicinity of river mouths which are partially saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows."

17 EC. (2013a). *Report from the Commission on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2008-2011.* Brussels: European Commission. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0683

18 The EU measures nitrogen concentrations as nitrate (NO_3) or nitrite (NO_2), while the U.S. uses nitrate-nitrogen (NO_3-N) or nitrite-nitrogen (NO_2-N). All units have been converted to NO_3-N or NO_2-N for consistency:
NO_3-N (mg/l) = 0.2259 * NO_3 (mg/l) NO_2-N (mg/l) = 0.3045 * NO_2 (mg/l)
NH_4-N (mg/l) = 0.7765 * NH_4 (mg/l)

reported river monitoring stations, 16.3% and 6.3% were eutrophic and hypertrophic respectively, and of all reported lake monitoring stations, 24.1% and 12.7% were eutrophic and hypertrophic respectively.[19] With regard to pollution sources, farming is responsible for over 50% of the total nitrogen discharge into surface water.[20]

Table 3: Nitrates Concentration at all monitoring stations in EU 27 for the period 2008-2011

	Annual Average Nitrate Concentration				
	> 50 mg/l	40-50 mg/l	25-40 mg/l	2-25 mg/l	0-2 mg/l
Groundwater	14.4%	5.9%	12.7%	67.0%	67.0%
Fresh surface waters	2.4%	2.4%	9.3%	64.5%	21.3%
Saline waters	1.4%	1.4%	1.4%	26.1%	72.5%

Source: (EC, 2013a)

In summary, it is not possible to directly compare the U.S. and the EU with respect to the observed water quality impacts of agriculture. Data are collected using different protocols in the two jurisdictions and, in addition, when it comes to readily accessible national data, the U.S. reports total nitrogen, while the EU reports nitrates (thereby excluding nitrogen in the form of nitrites and ammonia.)

Institutions, Policy Frameworks, and Objectives

Policy and Institutional Frameworks

The U.S. and EU share some similarities in their policy frameworks for addressing nutrient contamination of water from agricultural sources. Both rely on a cooperative approach with states (member states), whereby ambient water quality guidelines or standards are set at the broader jurisdiction level, but more detailed implementation decisions rest with the states. Both the U.S. and EU have binding (and nearly identical) jurisdiction-wide nitrogen standards for drinking water, and both use agricultural policy programs to incentivize (rather than require) farmers to take action to protect against nutrient pollution of water.

Controlling nonpoint sources of contamination poses challenges in each jurisdiction. While the U.S. sets regulatory standards for point sources of pollution (which affect CAFOs in the agricultural sector), it does not directly regulate nonpoint source pollution, including agricultural

[19] EC (2013a)

[20] EC. (2010b, January). *The EU Nitrates Directive.* Retrieved May 20, 2016, from European Commission: http://ec.europa.eu/environment/pubs/pdf/factsheets/nitrates.pdf

nutrient runoff, at the federal level. Instead, it relies on voluntary conservation programs implemented by states and USDA. As explained earlier, the EU Nitrates Directive does set compulsory requirements for farmers in member states, which are mostly transformed into cross-compliance requirements under the Common Agricultural Policy (CAP).

U.S. Legislation

EPA and USDA are the two main federal institutions responsible for the implementation of environmental and agricultural policy in the United States. Recognizing that solutions to water quality concerns vary with local conditions, the CWA adopts a cooperative federalism approach to protecting water quality, recognizing "the primary responsibilities and rights of States to prevent, reduce and eliminate pollution…".[21] Further, regulations affecting agriculture have always been controversial, so many national environmental policies specifically exempt agriculture from binding requirements. As a result, most efforts to control water pollution caused by agricultural activities in the U.S. take place at the state level and are often on a voluntary basis.

The CWA establishes the overarching framework for efforts to protect waters in the U.S. The CWA includes the Federal Water Pollution Control Act Amendments adopted in 1972 and a series of amendments since then. It authorizes EPA to guide states to establish surface water quality standards and set limits on effluent discharges from point sources. Generally, EPA issues guidelines containing mandatory effluent standards for various industry categories, while states are authorized to specify standards and grant permits to point source dischargers. Currently 46 states are authorized to implement the permitting program.[22] The CWA exempts nonpoint agricultural sources of contamination from these permitting requirements. This means that point source effluent discharges from animal feeding operations are the only farm activity covered by the permitting requirements.

EPA's Nonpoint Source Management, or Section 319, Program (established in 1987 amendments to the CWA) encourages states to address nonpoint source pollution including excess nutrients from agricultural runoff. Under the Section 319 program, states receive grants to support local nonpoint source control practices, such as best management practices for nutrient use, aimed at preventing excess nutrients from entering the surrounding environment.

The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) aims to reduce polluted runoff to coastal waters. It directs EPA and the National Oceanic and Atmospheric Administration (NOAA) to recommend a set of management measures for states to control

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[21] 33 U.S.C. § 1251(b) (2012) http://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title33-section1251&num=0&edition=prelim

[22] EPA. (2016b, February 4). *About NPDES*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/npdes/about-npdes

polluted runoff from six main sources: agriculture, forestry, urban areas, marinas, hydromodification (e.g. shoreline and stream channel modification), wetlands, and riparian and vegetated treatment systems. States are required to develop coastal nonpoint programs based on the recommended management measures and are responsible for implementation.

Congress enacted the Safe Drinking Water Act (SDWA) in 1974 to set federal drinking water quality standards. Under the SDWA, regulated entities include any water systems that deliver drinking water to customers. EPA sets binding contaminant-specific “maximum contaminant levels” (MCLs) that drinking water systems must meet. These standards are referred to as the National Primary Drinking Water Regulations (NPDWRs). The NPDWRs also include standards for nitrate and nitrite levels in drinking water, a large part of which comes from agricultural runoff. These standards are achieved through a partnership between EPA, states, and water systems. States are required to adopt the NPDWRs but can set more stringent standards. Currently all states except Wyoming and the District of Columbia have received the authority from EPA to implement the SDWA.[23]

While the SDWA requires drinking water systems to meet MCLs at the point of distribution and focuses on treatment at that point, EPA is also authorized to address the quality of water at the source. The primary source water protection approach is source water assessments which were completed by states in 2012 for all public water systems. Using the information gathered through the assessments, local communities implement measures to prevent or reduce contamination of their drinking water supplies, which include prohibitions on land uses that might release pollutants into source waters and educational events that increase public awareness of the need to protect source waters.[24]

The Farm Bill, comprehensive legislation that Congress passes every five or so years, is a mechanism for setting and implementing U.S. agricultural policy. It typically includes an array of efforts to address water pollution from agriculture by authorizing a number of voluntary conservation programs. USDA agencies administer conservation programs to provide financial and technical support for farmers who adopt environmentally-friendly agricultural practices. In contrast with the EU, U.S. federal direct payments comprise a relatively small proportion of total farm income. During 2013-2015, the total federal government direct farm program payments accounted for 11% of net farm income, of which payments for conservation programs represented roughly 30%.[25] These conservation programs cover a wide range of environmental

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[23] EPA. (2015f, November 30). *Understanding the Safe Drinking Water Act.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sdwa/overview-safe-drinking-water-act

[24] EPA. (2015c, November 17). *Conducting Source Water Assessments*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sourcewaterprotection/conducting-source-water-assessments

[25] ERS. (2016, November 30). *Farm Income and Wealth Statistics*. Retrieved from United States of Department of Agriculture Economic Research Service: https://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx

issues influenced by agricultural activities such as protection of soil quality, water quality, biodiversity and landscape. Those related to water pollution from nutrient runoff include land retirement programs and working land conservation programs, which are discussed below.

EU Legislation

In the EU, nutrient pollution from agriculture is primarily regulated through directives and the CAP. Directives establish objectives that all EU member states are required to achieve but gives member states the flexibility to devise the means to do so. For example, they set water quality standards for nutrient concentrations, as well as minimum measures member states must implement to control excess nutrients from agriculture. On the other hand, the CAP is binding on member states and applied uniformly across the EU.

The Water Framework Directive (WFD) is the primary EU-wide water legislation that entered into force in 2000. The WFD establishes a comprehensive, cross-border approach to water protection organized around river basin districts in the EU. The directive requires EU member states to monitor and assess water quality and to produce a River Basin Management Plan for each of the river basin districts within its territory. While not targeted specifically at nutrient pollution or agriculture, the WFD lists “substances which contribute to eutrophication (in particular, nitrates and phosphates)” in Annex VIII as “main pollutants” requiring control.

The WFD aimed to achieve “good status” for all European water bodies by 2015. For surface water, “good status” is defined as “good ecological and chemical status.” Recognizing ecological variability, the WFD does not set absolute standards for “good ecological status” for surface water at the European level. Instead member states must ensure that a given body of surface water is “in conditions of minimal anthropogenic impact.” In contrast, the WFD defines “good chemical status” for surface waters based on EU-wide quality standards.

The Groundwater Directive (GWD, or Directive 2006/118/EC), established in 2006 to achieve “good chemical and quantitative status” of groundwater, specifies EU-wide chemical quality standards for groundwater including nitrate concentrations. These standards serve as the minimum requirement for member states, but member states are allowed to set their own tighter limits taking into account their policy preference and hydrogeological conditions.

The Marine Strategy Framework Directive (MSFD, or Directive 2008/56/EC), adopted in 2008, aims to achieve good environmental status of Europe’s marine waters by 2020. “Good environmental status” is assessed with eleven qualitative indicators, including minimized human-induced eutrophication. Member states are required to develop a strategy for their marine waters that includes a baseline assessment, tailored objectives and targets, monitoring plans, and management measures to achieve “good” environmental status.

In addition, the EU also sets standards for drinking water. The Drinking Water Directive (DWD, or Directive 98/83/EC) was established in 1998 to ensure the quality of water intended for human consumption. It sets EU-wide minimum quality standards for drinking water, covering a total of 48 indicator parameters including nitrogen concentrations. Member states can set additional requirements such as tighter limits on substances listed in the DWD or limits on additional substances not listed in the DWD.

The Industrial Emissions Directive (IED, or Directive 2010/75/EU) is the main EU legislation regulating industrial pollutant emissions to air, water and soil. It was adopted in 2010, integrating seven previously existing directives. In particular, it replaced the Integrated Pollution Prevention and Control (IPPC) Directive (Directive 96/61/EC) which had been in place since 1996. The IED mostly retains the scope regulated by the IPPC, including controlling pollution from "intensive rearing of poultry or pigs" which sets certain thresholds on numbers of poultry, pigs, and sows. It requires the regulated facilities to operate with a permit issued by member states. The permit contains a set of conditions including effluent limit values that can be achieved through the use of the Best Available Techniques (BAT). No EU-wide effluent limit value has been set for livestock rearing, which means that the IED allows member states to define BAT differently depending on their circumstances. In addition, regulated facilities are subject to environmental inspections—conducted by each member state—at least every 1 to 3 years under the IED.

Prior to the above directives, the EU established the Nitrates Directive in 1991 to prevent nitrate pollution from agricultural sources, especially from agricultural land runoff and leaching. It requires member states to identify and designate "Nitrate Vulnerable Zones" (NVZs) for fresh surface water or groundwater bodies with a concentration of nitrates exceeding 50 mg/l. Member states must establish Codes of Good Agricultural Practices to be implemented by farmers on a voluntary basis throughout its territory, which must include but are not limited to periods when fertilizer application is banned and minimum manure storage capacity, as specified by the Nitrates Directive. Within the designated NVZs, all measures included in the Codes of Good Agricultural Practices become mandatory. In addition, member states must establish "Action Programmes" to be implemented by farmers within NVZs on a compulsory basis. The Nitrates Directive specifies several measures that must be included in Action Programmes such as limitation of fertilizer and manure application, but member states can define specific numeric limits and set additional measures based on local conditions. Alternatively, member states can choose to apply both Codes of Good Agricultural Practices and Action Programmes on a compulsory basis to the whole territory, instead of designating NVZs. The Nitrates Directives also requires member states to continuously monitor nitrates concentrations in their waters and report to the Commission every four years.

While member states may decide on different measures when they translate these directives into their national legislation, a key mechanism for implementing these measures across the EU is the Common Agricultural Policy. Launched in 1962, the CAP is the most important agricultural policy in the EU, containing various programs and standards concerning market support, income support and rural development that affect 22 million farmers and agricultural workers across the EU. CAP integrates environmental concerns into farming practices by establishing support schemes conditional on compliance with compulsory environmental requirements, and by providing additional financial incentives for voluntary good farming practices. With an annual budget of approximately €40 billion, CAP expenditure accounted for approximately 40% of total EU expenditure during 2010-2014.[26] All CAP subsidies represented 33% of total EU farm income, and its income support scheme—direct payments—was roughly 28% of farm income.[27]

Policy Objectives

To further illustrate the similarities and differences in EU and U.S. legislation and regulation, this section compares the water quality objectives, including both narrative and numeric standards, with regard to nutrient concentrations established in the above U.S. and EU policies. Policy objectives for control of nutrient pollution from agriculture vary between the U.S. and the EU, and across surface, ground, and drinking waters. In general, the U.S. does not set numeric nutrient limits for surface water quality. Numeric nitrogen criteria are only seen in select U.S. states, but EPA is encouraging states to issue more state-wide numeric criteria. While the EU does not set explicit nutrient standards for surface waters either, the Nitrates Directive specifies 50 mg/l of nitrates (or 11.3 nitrate-N) as the threshold value to identify NVZs, which means that member states must take measures to bring nitrate concentrations below this level.

Surface Water Quality

In the EU, the Nitrates Directive defines 50 mg/l of nitrates (equivalent to 11.3 nitrate-N) as the threshold value to designate Nitrate Vulnerable Zones for fresh surface waters across the EU, which serves as an implicit water quality objective.

In the U.S., pursuant to Section 303(c) of the CWA, states must designate uses of a water body such as agriculture, aquatic life, or recreation, and then decide on water quality criteria necessary to protect its designated uses, including nutrient criteria. These state-specific standards must be approved by EPA. In the case that no state-specific water quality standards have been developed or approved, water quality standards promulgated by EPA are applied.

Most of the state-specific standards related to nutrients are narrative criteria, which are expressed qualitatively, but EPA has been encouraging states and territories to promulgate statewide

[26] EC. (2016, July 06). *CAP post-2013: Graphs and figures*. Retrieved from European Commission: http://ec.europa.eu/agriculture/cap-post-2013/graphs/index_en.htm

[27] *Ibid*

numeric nutrient criteria. As of May 2016, EPA classified 28 out of 56 states and territories[28] as level 2 or above, meaning that they had set numeric total nitrogen and/or total phosphorus criteria for at least “some waters.”[29] Among the 50 states, Wisconsin, New Jersey, Minnesota, and Florida are identified with “2 or more watertypes with N and/or P criteria” (level 4), but no states currently have developed a “complete set of N and P criteria for all watertypes” (level 5).[30]

Table 4 illustrates how some different states have addressed nutrient limits in surface waters. Colorado has set numeric standards for nitrate, nitrite, and combined nitrogen concentrations (the sum of nitrate and nitrite measured as nitrogen) in surface waters by designated uses.[31] North Carolina has only numeric nitrate standards for fresh surface waters that are protected as water supplies in watersheds, but not for fresh surface water for recreation such as fishing or swimming.[32] New York currently uses narrative standards for nutrients in water, which limit the amount of phosphorus and nitrogen to a level that will not result in harmful growth of algae, weeds and slimes but plans to adopt numeric nutrient criteria by 2017.[33] It is worth noting that these examples are meant to be illustrative of different state approaches for addressing nutrient limits in surface water and not representative of nutrient limits, broadly.

Table 4: Examples of U.S. State-Specific Surface Water Quality Standards

Parameter	Colorado	North Carolina	New York
Nitrate-N (NO_3-N)	a. 100 mg/l for waters designated for agriculture; b. 10 mg/l for waters designated for domestic water supply.	10 mg/l for fresh surface waters that are protected as water supplies in watersheds	Narrative standards for phosphorus and nitrogen in fresh and saline surface waters – “none in amounts that will result in
Nitrite-N (NO_2-N)	a. Case-by-case calculation based on species present for waters designated for aquatic life; b. 10 mg/l for waters designated for agriculture;	No criteria	

28 Including 50 U.S. states, the District of Columbia, and five major territories (American Samoa, Commonwealth of Northern Marianas, Guam, Puerto Rico, and the US Virgin Islands).

29 EPA. (2016g, May 24). *State Development of Numeric Criteria for Nitrogen and Phosphorus Pollution*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/nutrient-policy-data/state-development-numeric-criteria-nitrogen-and-phosphorus-pollution

30 *Ibid*

31 Colorado. (2005, August 08). *The Basic Standards and Methodologies for Surface Water.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2014-12/documents/cowqs-no31-2005.pdf

32 North Carolina. (2003, April 01). *Surface Waters and Wetlands Standards.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2014-12/documents/nc-classifications-wqs.pdf

33 New York. (2008, June 12). *Water Quality Regulation.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2014-12/documents/nywqs-section1.pdf

	c. 1 mg/l for waters designated for domestic water supply.		growths of algae, weeds and slimes that will impair the waters for their best usages.”
Nitrate-N + Nitrite-N	a. 100 mg/l for waters designated for agriculture; b. 10mg/l at the point of intake to the domestic water supply.	No criteria	

Sources: (Colorado, 2005); (North Carolina, 2003); (New York, 2008)

Groundwater Quality

In the EU, the “good status” for groundwater bodies specified in the WFD refers to chemical and quantitative status. Groundwater quantitative status refers to the degree to which a body of groundwater is affected by abstractions.[34] Assessments of groundwater chemical status is further specified in the GWD, which sets minimum groundwater quality standards at the European level, including a nitrate criterion. The criterion—50 mg/l of nitrates—is also consistent with the threshold value specified in the Nitrates Directive, which applies to groundwater bodies as well. Some member states (Austria, Ireland, UK, Hungary, and Latvia) have set tighter threshold values (Table 5).[35]

As with surface waters, there is no national groundwater quality standard in the U.S. Since groundwater serves as a drinking water source in many regions, state-specific groundwater standards are mostly linked with drinking water standards. As Table 5 shows, the standards are similar in the EU and U.S.

Table 5: EU and U.S. Groundwater Quality Standards

Examples of EU Groundwater Quality Standards		
Parameter	**EU-wide minimum standard**	**EU member states threshold values**
Nitrate-N	11.3 mg/l	Austria: 10.2 mg/l Ireland: 8.5 mg/l UK: 4.1-9.5 mg/l * Hungary: 5.6-11.3 mg/l * Latvia: 11 mg/l

[34] Groundwater abstraction is the process of taking water from a ground source, either temporarily or permanently. Most water is used for irrigation or treatment to produce drinking water. Depending on the environmental legislation in the relevant country, controls may be placed on abstraction to limit the amount of water that can be removed. (http://www.eea.europa.eu/themes/water/wise-help-centre/glossary-definitions/groundwater-abstraction)

[35] EC. (2010a). *Report from the Commission in accordance with Article 3.7 of the Groundwater Directive 2006/118/EC on the establishment of groundwater threshold values.* Brussels: European Commission. Retrieved from http://ec.europa.eu/environment/water/water-framework/groundwater/reports.htm

Examples of U.S. Groundwater Quality Standards			
Parameter	**New Jersey**	**Washington**	**Utah**
Nitrate-N	10 mg/l	10 mg/l	10 mg/l
Nitrite-N	1 mg/l	-	1 mg/l
Nitrate-N + Nitrite-N	10 mg/l	-	10 mg/l

** A range of threshold values indicates different threshold values for different regions with in the country.*

Sources: (EC, 2010a); New Jersey. (2010, July 22). *Ground Water Quality Standards.* Retrieved from New Jersey Government: http://www.nj.gov/dep/rules/rules/njac7_9c.pdf; Utah. (2016). *Utah Ground Water Quality Protection Program*. Retrieved from Utah Department of Environmental Quality: http://www.deq.utah.gov/ProgramsServices/programs/water/groundwater/standards.htm; Washington. (1990, October 31). *Water Quality Standards for Groundwaters of the State of Washington*. Retrieved from Washington State Legislation: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-200.

Drinking Water Quality

As discussed above, both the EU and the U.S. set territory-wide drinking water standards. These standards have specific references to nitrogen concentrations (Table 6).

Table 6: EU and U.S. Drinking Water Quality Standards

Parameter	EU Standards	U.S. Standards
Nitrate-N	11.3 mg/l (50 mg/l NO_3)	10 mg/l
Nitrite-N	0.15 mg/l (0.50 mg/l NO_2)	1 mg/l
Nitrate + Nitrite	$[NO_3]/50 + [NO_2]/3 \leq 1$	-

Sources: EU Council. (1998). Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. *Official Journal of the European Communities*, 32-54; EPA. (2016h, May 3). *Table of Regulated Drinking Water Contaminants*. Retrieved May 24, 2016, from https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants#one

Policy Instruments

Authorized by the above-described legislation and seeking to achieve similar though not identical policy objectives, the EU and the U.S. have adopted a combination of different policy tools to protect water from agricultural nutrient pollution.

EU Policy Instruments

The WFD is the central policy instrument for all types of water pollution in the EU. It requires member states to develop a River Basin Management Plan (RBMP) for each individual river basin district. RBMPs are expected to include water quality monitoring reports and management measures that member states will undertake to achieve "good status." However, across the EU, very few RBMPs contain a detailed description of how nutrient targets are to be reached.[36] Accordingly, the primary mandatory control of nutrient pollution is achieved through the IED for point sources and the Nitrates Directive for nonpoint sources.

Livestock operations are the largest identifiable point source in the agricultural sector, and the EU regulates pollutant emissions from intensive livestock operations. The IED covers farms operating intensive rearing of poultry or pigs, which is defined as operations: (i) with more than 40,000 poultry, (ii) with more than 2,000 pigs (over 30 kg), or (iii) with more than 750 sows. Approximately 20% of the total number of pigs and 60% of the total number of poultry in the EU are over these thresholds.[37]

Farms covered by the IED are required to operate with a permit issued by member states. The permit must include all measures necessary for controlling pollution, including effluent limits for polluting substances set on the basis of the Best Available Techniques (BAT). The polluting substances specified in the IED cover a wide range of air and water pollutants, including "substances which contribute to eutrophication (in particular, nitrates and phosphates)." For livestock operations, the IED does not set EU-wide effluent limits, but allows member states to set their own values based on BAT. Furthermore, the IED also specifies that when the BAT-based limits are considered insufficient in achieving existing environmental quality standards (e.g. water quality standards), additional quality-based measures must be included in the permit.

The Nitrates Directive is the primary instrument for controlling agricultural nonpoint sources of nutrient pollution. It is specifically targeted towards nitrate losses from leaching and runoff, and requires member states to establish Action Programmes that apply within NVZs on a compulsory basis, and Codes of Good Agricultural Practices to be implemented throughout their territory on a voluntary basis. The voluntary, territory-wide, Codes of Good Agricultural Practice include measures: (i) limiting the time periods when nitrogen fertilizers can be applied on land; (ii) limiting the conditions for fertilizer application (on steeply sloping ground, frozen or snow covered ground, near water courses, etc.); (iii) requiring a minimum storage capacity for livestock manure; and (iv) implementing crop rotations, soil winter cover, and catch crops.[38]

The Action Programmes, which are mandatory within NVZs, include all measures included in Codes of Good Agricultural Practice and other measures such as the limitation of fertilizer

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[36] Boyle, S. (2014). The Case for Regulation of Agricultural Water Pollution. *Environmental Law Review, 16*(1), 4-20. doi:10.1350/enlr.2014.16.1.200

[37] EC. (2013b). *Report from the Commission on the reviews undertaken under Article 30(9) and Article 73 of Directive 2010/75/EU on industrial emissions addressing emissions from intensive livestock rearing and combustion plants.* Brussels: European Commission.

[38] EU Council. (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources . *Official Journal L 375*, 1-8.

application, including maximum amount of livestock manure to be applied (170 kg nitrogen per hectare per year).[39]

Beyond setting maximum amounts of manure application, the Commission has not set numeric values for the required measures, leaving member states a great degree of freedom to design operational requirements at the farm level. Member states are also responsible for enforcing these measures, although the cross-compliance requirement provides some assurance that codes are being met.

In general terms, cross-compliance requires a basic level of environmental compliance by farmers as a condition of eligibility for other important government programs. It shares characteristics with both regulatory standards and economic incentives. Introduced in the 2003 CAP reform, all farmers receiving direct payments have been subject to compulsory cross-compliance since 2005. It makes direct payments contingent upon farm compliance with specified environmental requirements, including: (i) Statutory Management Requirements (SMRs) concerning the environment, food safety, animal and plant health and animal welfare; and (ii) good agricultural and environmental condition (GAEC) covering additional standards related to soil protection, habitat protection, and water management. Hence, SMRs and GAEC constitute the two key components of cross-compliance.

Under current EU regulation, the Nitrates Directive is referred to as SMR 1, and is the only SMR that addresses the issue of water. SMR1 requires that farmers comply with the standards established in Action Programmes and/or Codes of Good Agricultural Practice. There are three compulsory GAECs, specified in Council Regulation (1306/2013), that address water quality. These include 1) buffer strips along water bodies, 2) approval by local authorities for irrigation water, and 3) prevention of direct and indirect agricultural discharge of ammonia and nitrates into groundwater.[40] GAECs are mostly narrative requirements at EU level, and member states are responsible for establishing operational requirements that farmers can implement.

Failure to comply with the SMR or GAEC requirements results in reduction or elimination of CAP payments. Non-compliance due to negligence can lead to a 5% reduction in CAP payments for first occurrence and 15% for reoccurrence. For intentional non-compliance, the penalty is a payment reduction of no less than 20%. The significant size of direct CAP payments creates powerful incentives for cross-compliance by farmers. Direct payments represent about 70% of CAP expenditure[41] in the EU-27 in 2009-2014, amounting to over €40 billion annually.[42] Direct

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[39] *Ibid*

[40] EU Council. (2013). Regulation (EU) No 1306/2013 of the European Parliament and of the Council of 17 December 2013. *Official Journal of the European Union L 347*, 549-607

[41] EC. (2016, July 06). *CAP post-2013: Graphs and figures*. Retrieved from European Commission: http://ec.europa.eu/agriculture/cap-post-2013/graphs/index_en.htm; The remaining 30% of CAP expenditure was spent on export subsidies, rural development, and other market support.

payments also represent an important share of EU farmers' income. In 2010-2014, the average share of direct payments agricultural income was 28%, ranging from 15% to 40% in individual member states.[43] Because of farmers' high dependence on direct payments, cross-compliance requirements are considered much more coercive instruments than voluntary incentive-based instruments.

Another critical component of CAP—agri-environment measures—is a voluntary incentive-based instrument that integrates environmental concerns into farming practices. Agri-environment measures were first introduced in the late 1980s as optional measures to be applied by member states, and have become compulsory for member states in the framework of their rural development plans since the 1992 CAP reform, but remain optional for farmers. Farmers get payments in return for environmental services to meet requirements above or beyond mandatory requirements as defined by SMRs and GAEC. Member states have a high degree of freedom in the design and implementation of agri-environmental measures. Examples include environmentally favorable intensification of farming, integrated farm management and organic agriculture, and conservation of high-value habitats and their associated biodiversity. According to Lankoski & Ollikainen,[44] most member states focus more on biodiversity and landscapes, but Denmark, Finland, and Sweden have developed ambitious voluntary policies addressing nonpoint source pollution.

The amount of funding for agri-environment measures is much less significant than cross-compliance. For the EU-27, the total spending on agri-environmental measures from 2007 to 2009 was about €6 billion annually, around 7% of total agricultural support. Agri-environmental programs covered 22% of the utilized agricultural area of the EU-27 in 2009, equivalent to approximately 38.3 million hectares (or 94.7 million acres).

U.S. Policy Instruments

The U.S. employs several policy instruments to address nutrient pollution in water from agriculture. Many of the key instruments are established by the CWA.

The Total Maximum Daily Load (TMDL) Program, established by Section 303(d) of the CWA, is a planning tool used by states to support restoration and protection activities for impaired waters (i.e., water bodies that do not meet applicable water quality standards for their designated uses).[45] States must develop a TMDL for each impaired body of water based on a calculation of

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42 *Ibid*

43 *Ibid*

44 Lankoski, J., & Ollikainen, M. (2013, 3rd Quarter). Innovations in Nonpoint Source Pollution Policy - European Perspectives. *CHOICES*, *28*(3).

45 It is worth noting that federal requirements may reduce the level of flexibility for states to designate waters for lower valued uses. For example, statutory and regulatory provisions such as anti-backsliding requirements

the maximum allowable amount of specific pollutants that may be discharged ("loaded") into the water from all sources in order to attain the relevant water quality standards. Pollutant load reduction levels are then allocated to point and nonpoint sources according to their actual pollutant load. As a means of achieving the load reduction targets, states may adjust point source discharge limits and/or encourage nonpoint source management practices. Accordingly, the TMDL process itself does not establish binding discharge limits and is not self-implementing, but it provides a pollution "budget" for effective pollution control. Since October 1995, there have been nearly 70,000 TMDLs submitted by states and approved by EPA, among which 6,200 TMDLs establish "budgets" for nutrient pollutants.[46]

In the U.S., point source discharge limits are implemented though the National Pollutant Discharge Elimination System (NPDES) permit program, established by section 402 of the CWA. Similar to the EU IED permit, permits issued under the NPDES program contains two levels of control: technology-based effluent limitations established by EPA on an industry-by-industry basis,[47] and water quality-based effluent limitations if technology-based limits are not sufficient to achieve water quality standards. While almost all agricultural nonpoint source discharges (e.g. stormwater discharge and irrigation return flows) are exempt from the NPDES program, CAFOs are regulated through the NPDES point source permitting requirements.

EPA regulation requires CAFOs to obtain NPDES permits to discharge manure, litter, and process wastewater pollutants. Compared to the EU IED, the NPDES covers a larger scope of animal operations in terms of animal species and sizes of operations. First, a CAFO refers to an operation rearing a wide range of animal species including cattle, pigs, poultry, horses, or sheep. Second, almost all sizes of CAFOs are subject to NPDES permits if they are found to be a significant contributor of pollutants, although EPA has defined size thresholds to distinguish large, medium, and small CAFOs that are subject to different effluent limitations.[48] The CAFO Effluent Guidelines published by EPA have specified national technology-based effluent limits that are applicable only to large CAFOs. Generally, discharge from most types of large CAFOs is prohibited. For example, the Guidelines regulate "no discharge of manure, litter, or process wastewater pollutants" for CAFOs with "more than 700 mature dairy cows or 1,000 cattle other

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prevent states from setting standards at a level that is less stringent relative to those previously established. See EPA (2016b).

[46] EPA. (2015b, September 30). *Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS)*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/waterdata/assessment-and-total-maximum-daily-load-tracking-and-implementation-system-attains

[47] EPA identifies the best available technology that is economically achievable for that industry and sets regulatory requirements based on the performance of that technology. (https://www.epa.gov/eg/learn-about-effluent-guidelines#levels)

[48] EPA. (2015e, November 16). *Regulatory Definitions of Large CAFOs, Medium CAFO, and Small CAFOs.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/sector_table.pdf

than mature dairy cows or veal calves."[49] With regard to medium and small CAFOs, states are authorized to determine effluent limits on a case-by-case basis. Anybody who discharges a pollutant from a point source CAFO into U.S. waters without an NPDES permit is in violation of the regulation and subject to a penalty.

Another important policy instrument in the U.S. is the Section 319 Nonpoint Source Management Program, established by the 1987 amendments to the CWA. Through the program, states receive grant money to support a wide variety of activities including technical assistance, financial assistance, education, training, and technology transfer for implementation of specific nonpoint source projects.[50] These projects are not targeted only at agricultural nonpoint sources, but also to pollution from urban runoff and atmospheric deposition. However, over 40% of the Section 319 grants (worth about $65 million per year) have been used to control nonpoint source pollution from farms.[51]

In addition to the Section 319 program, all coastal and Great Lakes states are required to participate in the Coastal Nonpoint Pollution Control Program established in 1990 by the CZARA. Under the program, EPA and NOAA have developed a set of recommended management measures to be implemented by states. Among the management measures applicable to agricultural sources are location-specific nutrient management plans, which comprise several core components, including: (i) realistic yield expectations for the crops to be grown; (ii) a summary of the nutrient resources available to farmers; (iii) an evaluation of field limitations such as soils with high leaching potential and highly erodible soils; and (iv) identification of timing and application methods for nutrients.[52] Many of the management measures for agricultural nonpoint sources are commonly practiced and recommended by USDA as components of other programs; therefore, many farms subject to CZARA may already be in compliance with the measures.[53]

The coastal nonpoint programs are implemented through changes to states' Section 319 programs and other coastal zone management programs. At the farm level, states can provide voluntary incentives for farmers to adopt nonpoint source pollution management practices, but must enforce adoption if voluntary approaches fail.

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[49] EPA. (2012, July 30). *Complied CAFO Final Rule.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/cafo_final_rule2008_comp.pdf

[50] EPA. (2016a, February 2). *319 Grant Program for States and Territories*. Retrieved May 20, 2016, from https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/319-grant-program-states-and-territories

[51] *Ibid*

[52] EPA. (1993, January). *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/guidance-specifying-management-measures-sources-nonpoint

[53] *Ibid*

Compared to the EU, the U.S. relies much less on cross-compliance mechanisms under which major reductions are made to farmers' agricultural support payments as a consequence of unsound environmental practices. A few compliance mechanisms in the U.S. are designed to protect highly erodible soils and wetlands, however, there is no requirement for compliance with nutrient-related standards. Instead, good farming practices are encouraged through voluntary programs.

Farm Bill conservation programs are voluntary programs designed to ensure good environmental practices and outcomes in agricultural production. The 2014 Farm Bill provided an estimated $28 billion in funding for conservation programs for 2014-2018.[54] Unlike the other programs implemented by states, conservation programs are administered by USDA agencies such as the National Resources Conservation Service (NRCS) and the Farm Service Agency (FSA). Eligible program participants receive financial and/or technical assistance to implement various conservation practices. While none of the conservation programs is targeted only towards water pollution or nutrient runoff, most of them aim to address multiple environmental problems caused by agricultural activity and thus are relevant here. The conservation programs that cover water quality issues include: (i) land retirement programs, such as the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP), which suspend agricultural activities on designated lands; (ii) working land conservation programs, such as the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP), which allow agricultural practices to continue but with added environmental protections; and (iii) other programs such as the Source Water Protection Program (SWPP). Details on each conservation program are described in Chapter 3 of this report.[55] For the sake of completeness, a brief summary of each program is provided below while Table 7 compares key features of these programs.

CRP is the largest land retirement program in the U.S. It pays farmers a yearly rental payment for removing environmentally sensitive land from agricultural production. CREP is an offshoot of CRP, which is a state-federal partnership program that targets high-priority conservation issues. Only land in states with approved CREP agreements—currently 33 states—can be enrolled in CREP. The 2014 Farm Bill reauthorized CRP with an annual enrollment cap of 24 million acres, declining from 32 million acres from the 2008 Farm Bill.[56] The 2016 budget for CRP is $1.8 billion.[57]

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[54] USDA. (2016). *FY2016 Budget Summary and Annual Performance Plan.* Washington, DC: U.S. Department of Agriculture.

[55] Susan E. Dudley, Lydia Holmes, Daniel R. Pérez, Aryamala Prasad & Zhoudan Xie. "Policy Transatlantic Agriculture & Regulation Working Paper Series, No. 3: Transatlantic Approaches to Agriculture Policy." The George Washington University Regulatory Studies Center. October 3, 2017. https://regulatorystudies.columbian.gwu.edu/transatlantic-approaches-agriculture-policy-transatlantic-agriculture-regulation-working-paper

[56] *Ibid*

EQIP is a key agricultural conservation program that complements EPA's efforts to control nonpoint source pollution from agriculture.[58] It provides financial and technical assistance to farmers who implement conservation practices that improve soil, water, plant, animal, air, and natural resources. The 2016 budget for EQIP is $1.35 billion.[59] There is no acreage cap established for EQIP, but the EQIP statute specifies a $450,000 payment limitation for individuals and legal entities.[60] In 2014, approximately 19.5 million acres of land in the U.S. were treated with one or more EQIP practices.[61] Of them, 8.3 million acres of land received EQIP practices related to water quality, 10.36% of which were for nutrient management.[62]

CSP is another working land conservation program that supports farmers who meet stewardship requirements on working agricultural and forest lands. Farmers can get annual payments for installing new conservation activities and maintaining existing practices, and supplemental payments for adopting a resource-conserving crop rotation.[63] The payment that farmers receive is determined by the actual environmental performance they achieve; the higher the performance, the higher the payment. The 2014 Farm Bill reauthorized CSP with an annual enrollment cap of 10 million acres.[64]

SWPP is a joint program with FSA and the nonprofit National Rural Water Association (NRWA) to promote clean source water primarily used for drinking water. NRWA implements the program with oversight and assistance by FSA, and provides education and technical assistance to local communities and farmers. There are 44 states participating in the program.

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[57] *Ibid*

[58] GAO. (2012). *Greater Oversight and Additional Data Needed for Key EPA Water Program.* Washington, DC: U.S. Government Accountability Office.

[59] USDA (2016)

[60] NRCS and CCC. (2016). Environmental Quality Incentives Program (EQIP). *Federal Register, 81*(92), 29471 - 29483.

[61] NRCS. (2015, July 15). *NRCS Conservation Programs: Environmental Quality Incentives Program (EQIP).* Retrieved from Natural Resources Conservation Service: http://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/fb08_cp_eqip.html

[62] *Ibid*

[63] NRCS. (2016). *Conservation Stewardship Program.* Retrieved from Natural Resources Conservation Service, USDA: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/#

[64] USDA (2016)

Table 7: Overview of U.S. Conservation Programs Related to Water Quality

	Conservation Reserve Program (CRP)	Conservation Reserve Enhancement Program (CREP)	Environmental Quality Incentives Program (EQIP)	Conservation Stewardship Program (CSP)	Source Water Protection Program (SWPP)
Initial Establishment	1985 Farm Bill	1996 Farm Bill	1996 Farm Bill	2008 Farm Bill	2002 Farm Bill
Administration Agency	FSA	FSA	NRCS	NRCS	FSA & NRWA
2016 Budget (million $)	$1,834		$1,350	$1,457	Not specified
2014 Enrollment Cap (million acres)	24		N/A	10	N/A

Source: USDA (2016)

Given the shared objective of controlling nonpoint source (NPS) pollution from agriculture, the CWA Section 319 NPS program and the Farm Bill conservation programs have a close linkage. In its national evaluation of the 319 program, EPA highlighted this linkage and the coordination between state NPS agencies and USDA agencies.[65] In 26 states, NPS program goals and priorities are supported by EQIP or other conservation program funding, although many states indicated that this support was not "broad-based" or "recurring."[66] Many states also fund NPS program/NRCS liaison positions to increase cross-program coordination and funding. Furthermore, in at least 16 states, the state may provide additional financial assistance to farmers for the cost of participating in a USDA conservation program.[67] This provides additional incentive for farmers to participate. The most recent NPS Program and Grants Guidelines for States and Territories further emphasized "coordination with USDA Farm Bill programs as a way to leverage water quality investments."[68]

[65] EPA. (2011). *A National Evaluation of the Clean Water Act Section 319 Program*. Washington, DC: U.S. Environmental Protection Agency.

[66] *Ibid*

[67] *Ibid*

[68] EPA. (2013b). *Nonpoint Source Program and Grants Guidelines for States and Territories*. Washington, DC: U.S. Environmental Protection Agency.

Comparison of EU & U.S. Policy Instruments

The EU and U.S. policy instruments for addressing water pollution from agriculture have several similarities but also present a great degree of variation. While both the EU and the U.S. have mandatory limits on point sources of effluent from animal operations, the U.S. NPDES covers a larger scope than the EU IED in terms of animal species and sizes of operations. When it comes to agricultural nonpoint sources, the EU's Nitrates Directive has established territory-wide requirements on nutrient pollution, whereas in the U.S., states have more authority to control nonpoint sources and there is more reliance on voluntary measures. Both the EU and the U.S. have programs that link agricultural subsidy payments to farmers' environmental practices, but the EU's programs create far more powerful incentives for compliance than do the suite of U.S. programs. Participation in U.S. agricultural subsidy programs are on a voluntary basis, with famers able to choose whether to opt-in to the programs. On the other hand, CAP payments comprise a large share of EU farm income, so making full payments contingent upon compliance with the Nitrates Directive creates a strong motivation to participate. Beyond CAP, however, the EU's voluntary agri-environmental program to promote environmentally friendly farming practices are similar to the suite of U.S. subsidy programs.

Policy Implementation

The ultimate impact of policies to protect water from agricultural nutrient pollution depends not only on the specific content of those policies but also on the practical realities of their on-the-ground implementation and the degree to which they are operationalized through ongoing enforcement and compliance.

Specific Implementation of Broad Policy

U.S. Implementation

The implementation of the national policy also varies across U.S. states. For example, CWA section 303(d) requires only the development of a TMDL but not its implementation, and states have demonstrated varied levels of progress toward implementation. A 2007 EPA survey suggests that only 37% of TMDLs submitted often or always have detailed implementation plans, while 46% never or seldom have them.[69]

When it comes to TMDL implementation, there is also variation in the choice of policy instrument. One example is the Chesapeake Bay nutrient trading programs, jointly developed by several states in the Bay watershed including Maryland, Pennsylvania, and Virginia in the early

[69] EPA. (2007b, January). *Developing Effective Nonpoint Source TMDLs: An Evaluation of the TMDL Development Process.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-09/documents/developing-effective-nonpoint-source-tmdls.pdf

2000s.[70] The Chesapeake Bay TMDL allocates needed reductions of nutrients (primarily nitrogen and phosphorus) to all the seven jurisdictions located in the Chesapeake Bay watershed.[71] Furthermore, the Chesapeake Bay TMDL includes a multistate trading platform, by which nutrient credits can be traded between participants from different states in the Chesapeake Bay watershed. Through this program, point sources may purchase nutrient credits from other point sources or agricultural nonpoint sources within the state to meet their annual load limits. Nutrient credits are generated from reductions of nutrient discharges to impaired water bodies. Compared to the conventional "command-and-control" instruments, nutrient trading is expected to achieve the TMDL load allocations in a more cost-effective way through the market mechanism inherent in the program.

In addition, states have demonstrated varied NPDES permit coverage status for CAFOs.[72] As of December 2014, five states (Maine, Pennsylvania, Wisconsin, Kansas, and Oregon) have accomplished 100% permit coverage, while most of the other states have lower coverage rates. Of the total 456 CAFOs in Delaware, for example, only one CAFO has been issued a NPDES permit. In North Carolina, 14 out of 1,222 CAFOs were reported to have NPDES permits.

The implementation of nonpoint source management programs presents even more variation than point source programs in the U.S, since the main efforts to control nonpoint source pollution are left to the states on a voluntary basis. For example, Section 319 grants have been used to address different categories of pollution, among which 40% have been targeted at agricultural nonpoint source pollution from fiscal year 2004 through 2010.[73] In these Section 319 projects, states have adopted different approaches to prevent water pollution from agriculture, including direct approaches such as agricultural conservation practices, as well as indirect approaches such as education and outreach.[74]

EU Implementation

When translating EU-wide requirements into specific national legislation, member states have considerable freedom to choose policies based on the characteristics of their agricultural sector and the condition of their natural environment. This has resulted in diverse approaches in

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[70] WRI. (2011). *Comparison Tables of State Nutrient Trading Programs in the Chesapeake Bay Watershed.* Washington, DC: World Resources Institute.

[71] Copeland, C. (2012). *Clean Water Act and Polluant Total Maximum Daily Loads (TMDLs).* Washington, DC: Congressional Research Service.

[72] EPA. (2014, December 31). *NPDES CAFO Permitting Status Report -- National Summary, Endyear 2014.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/npdes_cafo_permitting_status_report_-_national_summary_endyear_2014.pdf

[73] GAO (2012)

[74] GAO (2012)

implementation across the EU. Two prominent examples are the implementation of the Nitrates Directive and of the CAP Cross-Compliance Program.

EU countries have taken several approaches to the implementation of the Nitrates Directive. First, designation of NVZs reflects national management philosophies. Austria, Denmark, Finland, Germany, Ireland, Lithuania, Luxembourg, Malta, the Netherlands, Slovenia, the Region of Flanders and Northern Ireland have chosen to designate their entire territory as an NVZ, while other member states such as Bulgaria, Portugal, and Scotland have only designated waters that contain more than 50 mg/l of nitrates as NVZs.[75] On the other hand, some member states have not completed designation of NVZs for a number of waters exceeding the nitrate threshold (e.g. France, Greece, Poland, and Slovakia), although the Directive has been in force for over 20 years since 1991.[76]

Second, while the Nitrates Directive specifies minimum measures to be included in national Action Programmes, there is variation in the operational requirements established by member states to implement these measures. For example, with regard to limitation of fertilizer application, some member states set limits on total nitrogen (Netherlands, Ireland, Northern Ireland, and Flanders also have limitations on phosphorus) for all crops, while others have chosen to apply more complex systems.[77] For example, Denmark sets yearly farm-specific "nitrogen standard quotas," calculated by factoring in climatic conditions, soil types, crop composition and distribution, precipitation and irrigation.[78]

Further, EU member states have attempted to adopt different policy instruments to achieve particular objectives. For example, to control manure pollution, compulsory regulatory requirements for manure storage capacity and periodic bans on land application of manure as fertilizer are common in most EU countries. The Netherlands had to abandon its effort to apply a Mineral Accounting System (MINAS) that combined farm-level nutrient accounting with a tax on nutrient surplus, when the European Commission challenged the policy in the European Court of Justice on the grounds that it was in conflict with the maximum manure application rate specified in the Nitrates Directive.[79] More recently, a pilot project for voluntary nutrient trading was initiated in the Baltic Sea area in 2015, providing more cost-effective measures to achieve

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[75] EC (2013a)

[76] EC (2013a)

[77] EC (2013a)

[78] The Danish EPA. (2012, September 7). *Nitrate Action Programme 2008-2015.* Retrieved from Environmental Protection Agency, Ministry of Environment and Food of Denmark: http://eng.mst.dk/topics/agriculture/nitrates-directive/nitrate-action-programme-2008-2015/

[79] Schröder, J., & Neeteson, J. (2008). Nutrient management regulations in The Netherlands. *Geoderma, 144*, pp. 418-425.

nutrient reductions in the area.[80] The pilot project hoped to provide lessons for a national or inter-governmental nutrient trading system.[81]

Third, under certain conditions, member states are allowed to delay or relax some directive mandates if they can demonstrate that other measures can meet the directive's objectives (called "derogation" in the EU).[82] For example, Ireland was granted a derogation under the Nitrates Directive in 2014 that increases the manure application limit of 170 kg N/ha to 250 kg N/ha per year for farms with at least 80% grassland.[83] As of the end of 2012, seven member states (Denmark, Netherlands, Germany, United Kingdom, Ireland, Belgium, and Italy) had been granted derogations under the Nitrates Directive.[84]

With regard to the implementation of CAP Cross-Compliance Program, a series of SMRs and GAEC are required, but most are general in nature. Member states are responsible for developing specific operational obligations with which farmers must comply. Obligations for farmers in compliance with SMRs are mostly based on pre-existing national legislation, such as the national Action Programmes established respectively by member states. There is an even wider variation in the approach taken by member states to define farmers' obligations for GAECs.[85] For example, many member states (e.g. Austria, Cyprus, Finland, and France) have defined farmers' obligations for all three issues identified by the Commission, while some member states (e.g. Estonia, Denmark, Hungary, and Latvia) have developed obligations for only two or less issues.[86]

Enforcement and Compliance

The degree of enforcement and compliance activity can have a substantial influence on the degree to which various policy measures affect on-the-ground conditions. For both the EU and the U.S., data on enforcement and compliance are incomplete, and often less than fully transparent due to technical and administrative constraints.

In the EU, farmers are subject to sampling inspections for compliance with the SMRs and GAEC under the Cross-Compliance Program. In 2005, in the 23 member states that reported to the

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80 NutriTrade. (2016). *Background & Objectives*. Retrieved from NutriTrade: http://nutritradebaltic.eu/project-nutritrade/

81 *Ibid*

82 EC (2010b)

83 The European Commission. (2014, January 3). Commission Implementation Decision of 27 February 2014. *Official Journal of the European Union*, pp. 7-10.

84 EC (2013a)

85 Alliance Environment. (2007, July 26). *Evaluation of the Application of Cross Compliance as Forseen under Regulation 1782/2003.* Retrieved from European Commission: http://ec.europa.eu/agriculture/eval/reports/cross_compliance/index_en.htm

86 *Ibid*

Commission, inspections were carried out at about 5% of farms subject to the Program. Payment reductions were applied to 11.9% of inspected farmers, totaling about €9.8 million.[87] Some observers have, however, argued that compliance with the SMRs and GEACs is not always accurately recorded. First, the inspections were not always conducted as required. For instance, it was reported that more than 30 requirements from SMRs were not checked in Finland, including several standards pursuant to the Nitrates Directive.[88] In addition, regular inspections are undertaken only once for a sample of farms, and the timing of visit is not necessarily the best time in a year to verify a number of farming and environmental conditions.[89]

In the U.S., data on enforcement and compliance for the CWA are reported by states and integrated into EPA's Enforcement and Compliance History Online (ECHO) system. Of the 5,626 CAFOs regulated under the NPDES program recorded in ECHO, 362 facilities (6%) have a current violation, and 564 (10%) have had violations in the last three years. However, EPA also noted that many violations are not identified in public databases, because some states do not have the resources to record data for all permitted facilities, especially for small individually permitted ones.[90] NPDES compliance represents a small proportion of the U.S. efforts to control nonpoint source pollution, since most of the policy instruments are implemented on a voluntary basis, such as through Section 319 projects and conservation programs.

In the EU, payment reductions for noncompliance under cross-compliance are a function of the aid received and not of the cost of compliance, which can encourage noncompliance when the cost of meeting certain requirements is significantly higher than the expected payment reduction.[91] A sanction of 1% to 3% of total payments is usual. This is particularly prominent in the case of small farms: for example, a small farm in Slovenia that breached requirements from three regulations only received a 3% reduction, equivalent to €15.26.[92]

The U.S. CWA specifies higher penalties. Under the NPDES program, a person who discharges a pollutant from a point source into a water body without a permit or in violation of a permit would face penalties of 1-2 years in jail and/or $2,500 -$50,000 per day for negligent violations, and 3-6 years in jail and/or $5,000 - $100,000 per day for knowing violations.[93]

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87 *Ibid*

88 ECA. (2008). *Is Cross Compliance an Effective Policy?* Luxembourg: European Court of Auditors.

89 *Ibid*

90 EPA. (2015a). *A Summary of Reviews, Violations, and Enforcement Response at Individually-Permitted Nonmajor Dischargers under the National Pollution Discharge Elimination System (NPDES) Program.* Washington, DC: U.S. Environmental Protection Agency.

91 ECA (2008).

92 ECA (2008).

93 EPA. (2016c, March 16). *Criminal Provisions of the Clean Water Act*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/enforcement/criminal-provisions-clean-water-act#directdischarge

According to an internal evaluation undertaken by EPA, the primary reason for significant noncompliance with NPDES permits is inconsistent and ineffective oversight from EPA.[94] The report pointed out that EPA failed to provide clear guidance for taking suitable, timely, formal enforcement actions to major NPDES facilities, resulting in long-term significant noncompliance.[95] Such findings were echoed by a later GAO report, indicating that inconsistent oversight also caused considerable challenges faced by states' Section 319 nonpoint source management projects.[96]

Program Evaluation

Considerable limitations of data availability, with regard to both water quality and program implementation, have limited retrospective program evaluation for the regulations and programs implemented to control nutrient pollution from agriculture. Hence, the effectiveness of many of these policies in improving water quality has not been definitively established.

The European Commission has published four implementation reports for the Nitrates Directive since 1996. The most recent report assessed progress on implementation of the Directive by 27 member states for the period 2008-2011.[97] It summarized nitrate monitoring results in waters, as well as Action Programmes developed by member states. It found that water quality had improved since the previous 2004-2007 reporting period, with 42.1% of all freshwater monitoring stations showing a decreasing nitrates concentration trend.[98] However, it was unable to separate how much of that was attributable to implementation of the Nitrates Directive, since there are other EU Directives addressing nitrogen pollution such as the Urban Waste Water Directive.

The difficulty in attributing environmental improvements to a single Directive is also recognized in the 2012 Fitness Check of EU Freshwater Policy.[99] The Fitness Check was carried out to review EU freshwater policy, as a part of the Commission's approach to a new regulation agenda in the area of environment. Specifically, it analyzed relevance, effectiveness, efficiency, and coherence for eight Directives, including the WFD and the Nitrates Directive. It found that the Nitrates Directive had significantly reduced nitrogen and phosphorus inputs from agriculture to surface waters, but the progress is far slower than initially expected.[100]

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[94] EPA. (2007a). *Better Enforcement Oversight Needed for Major Facilities with Water Discharge Permits in Long-Term Significant Noncompliance.* Washington, DC: Office of Inspector General, U.S. Enironmental Protection Agency.

[95] *Ibid*

[96] *Ibid*

[97] EC (2013a)

[98] EC (2013a)

[99] EC. (2012). *The Fitness Check of EU Freshwater Policy.* Brussels: European Commission.

[100] *Ibid*

In the U.S., while the CWA requires states to develop TMDLs assessing water quality and defining water quality objectives, the implementation of TMDLs as well as their effectiveness on water quality improvement is unclear. In 2000, GAO found that EPA did not have complete and consistent data on water quality, particularly data for nonpoint sources, to implement and measure CWA programs.[101] In its 2002 report, GAO further pointed out that states used varied approaches to identify impaired waters, which lacked scientific basis and led to inconsistencies in the listing of impaired waters nationwide.[102] In response to these two reports, EPA published additional guidance on states' water monitoring and reporting since 2003.[103]

In 2007, EPA's Office of Inspector General conducted an internal assessment of TMDL implementation, recognizing that EPA did not have sufficient information on TMDL implementation activities and outcomes.[104] It recommended that EPA should improve data tracking on TMDL implementation and clarify TMDL performance measures. EPA officials responded that the CWA limited its ability to measure TMDL results.[105]

A 2013 GAO report showed that EPA still had limited information on the extent to which the TMDLs had achieved their policy objectives.[106] In its national database (i.e. ATTAINS), EPA tracks only development of TMDLs but not implementation activities. While information on discharge permits and program grants is recorded, albeit incompletely, in other databases, there are technical data constraints that limit EPA's ability to link that information to data on water quality.[107] State representatives surveyed by GAO stated that few impaired water bodies had attained water quality standards, primarily because a large proportion of TMDLs had not achieved their targets for nonpoint source pollution.[108] Another impediment to developing a more complete understanding of program effectiveness is that data on many USDA-funded conservation programs are not available to EPA because of the privacy provisions in the Farm Bill, according to GAO. While USDA has collected data for its projects, the data are highly aggregated so as to make assessments of project impacts impossible.[109]

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[101] GAO. (2000). *Key EPA and State Decisions Limited by Inconsistent and Incomplete Data.* Washington, DC: U.S. Government Accountability Office.

[102] GAO. (2002). *Inconsistent State Approaches Complicate Nation's Efforts to Identify Its Most Polluted Waters.* Washington, DC: U.S. Government Accountability Office.

[103] EPA. (2013a, September 12). *Monitoring, Assessment and Reporting Guidelines*. Retrieved from U.S. Environmental Protection Agency: https://archive.epa.gov/water/archive/web/html/repguid.html#int_rpt

[104] EPA. (2007c). *Total Maximum Daily Load Program Needs Better Data and Measures to Demonstrate Environmental Results.* Washington, DC: Office of Inspector General, U.S. Environmental Protection Agency.

[105] *Ibid*

[106] GAO. (2013). *Changes Needed If Key EPA Program Is to Help Fulfill the Nation's Water Quality Goals.* Washington, DC: U.S. Government Accountability Office.

[107] *Ibid*

[108] *Ibid*

[109] GAO (2012); GAO (2013)

Conclusion

Nutrient runoff from agricultural lands can contaminate surface and ground waters and pose particular challenges for governments seeking to protect environmental quality. One challenge is that, with the exception of large animal feeding operations, agricultural pollution comes largely from nonpoint sources, so traditional regulatory approaches that target effluent at the source are impractical. Another challenge for centralized governments is that environmental conditions vary regionally, so top-down policies may not be as effective as those based on local knowledge.

To address the nonpoint source nature of agricultural runoff, both jurisdictions use a combination of incentives and penalties to make farmers consider environmental externalities and apply sound environmental management practices. They do so, however, to different degrees. A large fraction of EU farm income (33%) comes from CAP subsidies. Since receipt of the full subsidy is contingent upon complying with the Nitrate Directive (among other requirements), farmers might be highly motivated to comply. However, research suggests that insufficient monitoring of compliance combined with rather limited penalties might reduce those incentives. In the U.S., farmers can voluntarily opt into programs that offer subsidies in exchange for certain practices, but the amount of payment tends to be much less than in Europe.

To address the localized nature of runoff, both the EU and the U.S. have approached the challenge of regulating agricultural nutrient pollution by establish general jurisdiction-wide guidelines, while largely leaving to states and member states the responsibility for developing specific numeric limits and ensuring compliance. This dispersed responsibility has advantages in that it allows jurisdictions closest to the problems to manage them. It also has drawbacks in that no comprehensive data are available to measure activities and outcomes in either jurisdiction.

Regulatory Studies Center
THE GEORGE WASHINGTON UNIVERSITY

Regulatory Impact on Corn Farming

Transatlantic Agriculture & Regulation Working Paper Series: No. 5

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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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2 This five-part working paper series was sponsored by a cooperative agreement with the United States Department of Agriculture. The authors are grateful to Linda Abbott for feedback and guidance on this project, along with Susan E. Dudley & Brian F. Mannix for their comments on this paper. This working paper reflects the views of the authors, and does not represent an official position of the GW Regulatory Studies Center, the George Washington University, or the United States Department of Agriculture. The Center's policy on research integrity is available at http://regulatorystudies.columbian.gwu.edu/policy-research-integrity.

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).

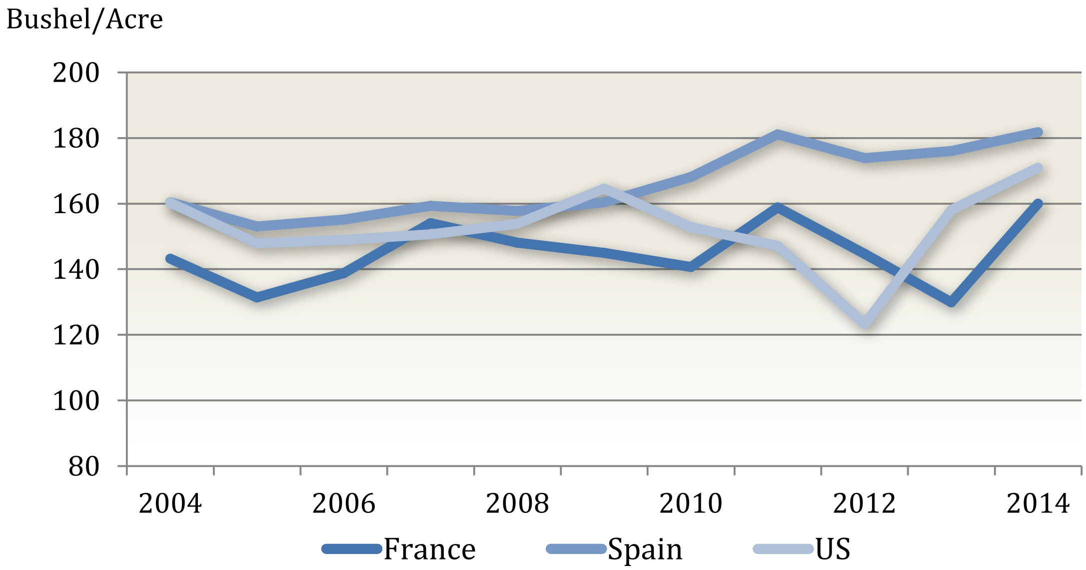
[5] *Ibid*

[6] *Ibid*

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

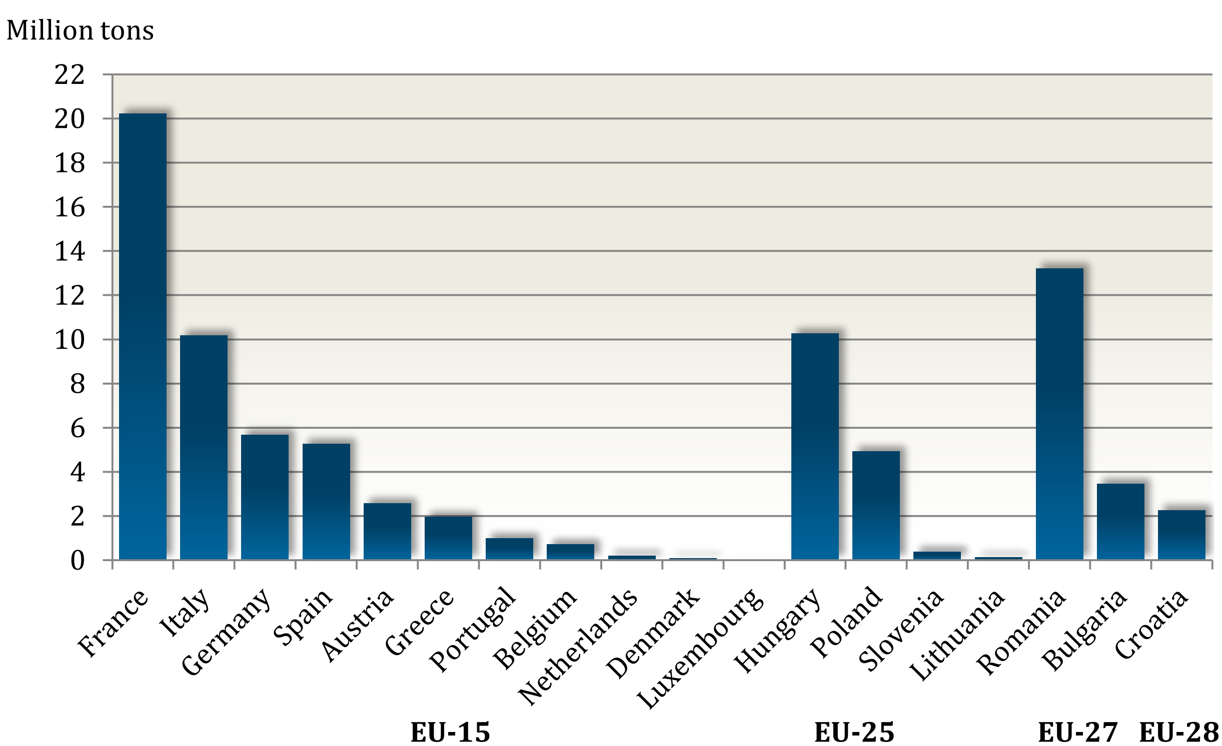
[8] USDA FAS. *EU-28 Grain and Feed Annual 2015.* GAIN Report, Washington, DC: USDA Foreign Agricultural Service, 2015.

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.

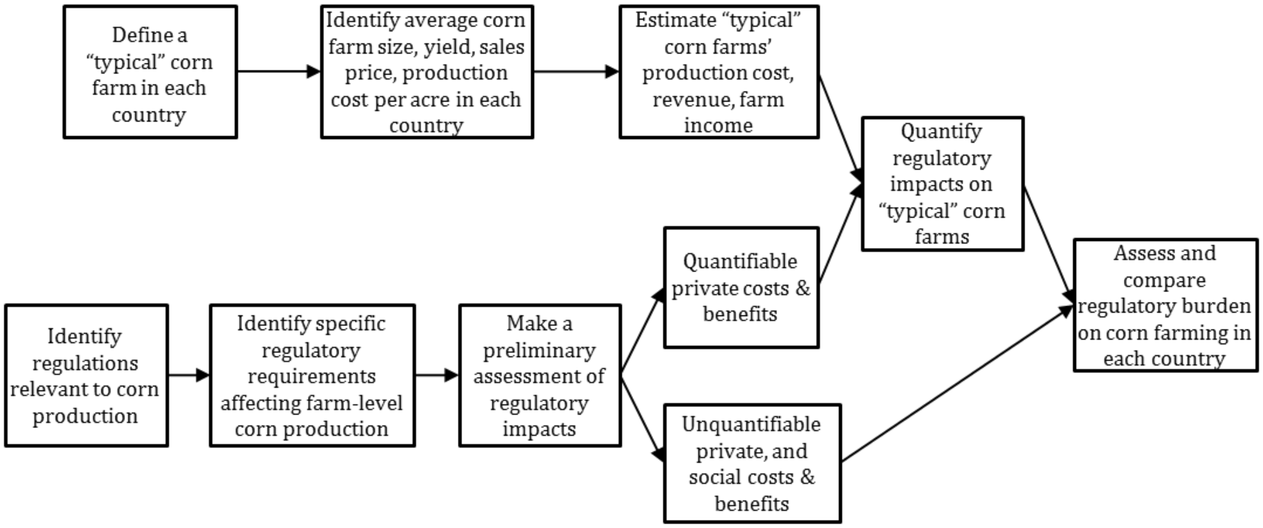
and programs that affect farmers' corn production are identified under each regulation. Those provisions and programs are then translated into operational requirements at the farm level, that is, specific measures that corn farmers need to take in order to fully comply with the corresponding regulatory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

[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.

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[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^{TM} 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

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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

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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

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[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

[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

[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%;

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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

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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.

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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]

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[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:

[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.
AGRI-ENVIRONMENTAL PRACTICES	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
AGRI-ENVIRONMENTAL PRACTICES	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.
	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.
	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.
	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.
	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		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									
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%	–	