How does European soy import affect the deforestation of the Amazon?

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How does European soy import affect the deforestation of the Amazon?

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Abstract

This thesis investigates how European soy import affects the deforestation of the Amazon through regression analyses and interpretation of previous studies and background information on the topic. The dataset that has been analysed was retrieved from Trase.earth and contained a comprehensive setup of the supply chain for soy produced and exported from municipalities in Brazil to European importing countries. The regression model was conducted by using territorial deforestation risk in hectare as the dependent variable and soy export equivalent tonnes as the independent variable. We use fixed effect estimator of year and municipality. Additionally, the standard errors are clustered on municipality level to consider correlation over time and solve potential problems related to heteroskedasticity and serial correlation.

Our analysis shows a statistically significant relationship between territorial deforestation risk in the Amazon and soy exported from municipalities in Brazil to Europe. It is also evident that the Soy Moratorium contributed to lower territorial deforestation risk rates through European soy import. Furthermore, we find the companies in the supply chain for soy export from municipalities in Brazil to Europe to reduce the deforestation risk rates of the Amazon after the implementation of the Soy Moratorium. We find a statistically significant result, where the impact of zero deforestation committed companies and companies who are not committed to zero deforestation had reduced the deforestation risk. Lastly, we find a decrease in the territorial deforestation risk in the neighbouring biome the Cerrado, where we originally expected to find a spillover effect. This is an indication that the Soy Moratorium had an indirect effect on the Cerrado.

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1 Introduction

Deforestation represents one of the biggest concerns of global climate, which is surprising when being presented with the fact that enough land has been cleared to sustain the levels of production we need. We do not need to clear more land, yet rainforests are still being cleared at an alarming rate. The biggest driver for deforestation worldwide is agriculture, typically cattle ranching and soy production. In order to reduce deforestation, regulatory pressure along with leadership from the private sector is needed. Incentives from the financial system to protect biodiversity and uphold sustainability is also needed (Trase, 2020). In 2009, the National Policy on Climate Change committed to having the deforestation rate in the Amazonia biome reduced by 80% (forest loss of maximum 392 500ha) by 2020. Instead of a decreasing trendline, the deforestation has increased with 47% to 753 600ha from 2018 to 2020. The forest loss in 2020 is thereby 182% higher than the goal set in 2009 at 1 108 800ha (Silva Junior, et al., 2020). Brazil was the country which cleared the largest area of forest between 1990 and 2005, with more than 42 million hectares gone (Earth Observatory, 2007).

The Amazon rainforest, or the Amazonia biome, covers approximately 6,7 million square kilometres across nine countries, where about 60% is located in Brazil (Greenpeace, n.d.). The rainforest is important not only for locals but also for the global climate, mainly through absorbing CO2 from the atmosphere through photosynthesis. Deforestation of the Amazon would directly lead to higher levels of CO2 in the atmosphere, increasing the greenhouse effect. In addition, scientists believe only a fraction of plant species have been studied for their medicinal potential (WWF, 2020). Since the demand for soybeans has increased dramatically worldwide the last decades and are expected to continue to increase, the rainforest is at imminent risk (Silva Junior, et al., 2020).

A common misconception is that the high soybean consumption comes from meat substitutes and other soy products. However, soybeans are processed into meal and oil, and are further used as animal feed. In fact, animal feed is responsible for the consumption of 98% of all processed soybean meal (IDH, 2020). Europe produces soy to a greater extent every year, but the largest share of soy is still imported. In recent times, the focus on responsible soy has increased drastically (IDH, 2020). The European Union (EU) imported approximately 13 million tonnes soy from Brazil in 2018 (Trase, 2021c). In 2019 the European Commission developed a strategy called the Green Deal, which will make Europe free from greenhouse gas emissions and the economy sustainable by 2050 (European Commission, n.d.). That same year, the European Commission took on protecting the world's forests. The goal is to increase sustainable biodiverse forests, and to better the health of already existing forests (European Commission, 2019).

In 2006, environmental Non-Governmental Organisations (NGOs) and soy producers came together to introduce the Soy Moratorium (SoyM) (WWF, 2016). SoyM is a global agreement of zero deforestation in the Amazon biome, keeping grain traders from purchasing soy that has been grown on land deforested after 2006 (Greenpeace, 2016). In 2008, the Brazilian government got involved by implementing new policies to reduce deforestation and started monitoring the area regulated by SoyM in order to oversee the implementation of the agreement (Gibbs, et al., 2015). Several companies have also made commitments towards reducing deforestation in their supply chain. These commitments are called "Zero Deforestation Commitments" (ZDC). There has also been established certification systems in order to verify that the soy produced is environmentally friendly and deforestation free. These are valuable because they help companies and countries make good decisions when it comes to import of soy and is widely used for import of soy to Europe (zu Ermgassen, et al., 2020).

The consequences of deforestation of the Amazon have received increased international attention, and there are several measures taken both nationally and internationally to reduce it. It is a joint responsibility to reduce deforestation, and for our master thesis we will therefore investigate Europe's role towards the deforestation of the Amazon rainforest through import of soy. Establishing how European countries contribute to the deforestation of one of the world's most important ecosystems is necessary for protecting the rainforest through policy reforms and commitments from corporations. This study is useful because we as consumers must expand our knowledge on how our consumption affects the environment, and how politics and incentives in importing countries can influence deforestation of the largest tropical forest on earth.

In addition to the rainforest, Brazil is also covered by the largest savannah region in South America, the Cerrado. It covers approximately 2 million km^2 and is one of the most over-exploited, yet unprotected, regions in Brazil. Soy production and cattle ranching is the main threats to the Cerrado, of which only 20% of its original vegetation remains intact (WWF, n.d.). Since soy is produced in both the Amazon and the Cerrado, the concern is that laws and regulation in one would affect the other. We will therefore also look at possible repercussions on the Cerrado, when studying the implementations of laws and regulations on the deforestation of the Amazon.

To answer our research question, we use previous research on how soy production can lead to deforestation of the Amazon and theory on tropical deforestation. In section 2 and 3 we present previous research and background information on SoyM, certification systems and the Cerrado biome, in addition to Norway and France as soy importers. Our analysis will consider these two countries in addition to Europe as a whole, as they have very different positions towards deforestation and will give us an indication of how incentives and politics in different countries can affect deforestation. Section 2 also provide an economic model that are presented in a demand and supply graph. Section 4 outlines the empirical strategy, presenting the underlying data retrieved from Trase.earth (Trase) and describing the regression models carried out in our analysis.

For our analysis in section 5, we will firstly establish a relationship between territorial deforestation risk and soy exported from municipalities in Brazil to Europe. We do this by conducting a regression analysis for territorial deforestation risk in hectare and soy equivalent tonnes and find a statistically significant relationship. After confirming this relationship, we want to see if there is a change in Europe's contribution to deforestation of the Amazon after the implementation of SoyM. We do this by using the previous regression analysis and adding the shock of SoyM. Here we find that SoyM do have an impact by decreasing the deforestation of the Amazon. When using a regression analysis to determine the effects of SoyM on the Cerrado biome, we find that there is a decrease in deforestation after the implementation. This is also evident when we test for a spillover effect, as we see that the Cerrado had a slight decrease in deforestation after SoyM. Lastly, we present limitations with our study in section 6 and section 7 conclude the thesis.

2 Literature Background

There has been done a lot of research on how soy production leads to deforestation of the Amazon. Different studies have used different methods and approaches towards the topic. However, the studies that have been done, largely focus on the relationship between soy production in general and how it is connected to deforestation. The relationship between European soy imports and the impact it has on the Amazon, has to the best of our knowledge not been studied to the same extent. In this thesis we will study this relationship and use previously published research to do so.

Jansen (2018) studied how land area used for different purposes in Brazilian municipalities, was affected by growth in Brazilian soy export. By using data from 2010 to 2015 from Trase on municipality trade flow on soy, he was able to find clear evidence that international soy demand causes an expansion in land use for exported soy. However, he is not able to find a causal link between demand for international soy and deforestation (Jansen, 2018). Tyukavina et.al (2017) used a sample-based approach to quantify deforestation of the Amazon. The research confirmed deforestation, documented by official maps. At the end of the research period the tree cover loss area was estimated to 53% and the gross aboveground carbon loss was estimated to 26 to 35% (Tyukavina, et al., 2017). This affirms the belief that the Amazon is at imminent risk, and that the environmental consequences from it are present. Others have focused their research on the drivers of deforestation and efforts to reduce it. Kastens et.al, (2017) studied the reduction of deforestation in Mato Grosso, Brazil after the implementation of SoyM in 2006 and concluded that the deforestation had taken an abrupt reduction. They produced land cover maps for the 2001-2014 crop years, to evaluate forest and agricultural intensification before and after SoyM. The conclusion of their research was that their hypothesis, which said that SoyM played a role in reducing both deforestation and subsequent use for soy production, was true. A finding supported by Gollnow, de Barros Viana Hissa, Rufin and Lakes (2018). Their research supports the statement that the SoyM has decreased direct and indirect deforestation from soybean expansion, even though the deforestation from soybean overall has increased (Gollnow, de Barros Viana Hissa, Rufin, & Lakes, 2018). A study done by Silva and Lima (2018) suggest that a significant driver for forest conversion in the Amazon is still soy. This was especially evident in the municipalities that are dependent on soy production. In their research, they found evidence that deforestation continues to increase. After cattle ranching, soy is the largest cause of deforestation in the Amazon (Silva & Lima, 2018).

When looking at deforestation in the Amazon the most relevant data come from the SoyM, and there has been done research to map the actual effects. Kastens, Brown, Coutinho, Bishop and Esquerdo (2017) used satellite maps to evaluate the changes in forestry and agriculture before and after SoyM. They found that deforestation was reduced by five times the frequency before SoyM, while the conversion from forest to soy production has doubled after SoyM (Kastens, Brown, Coutinho, Bishop, & Esquerdo, 2017). A report published by Abiove together with Agrosatelite in December 2018 stated that since the beginning of the SoyM, an area totalling 5 297 000 hectares has been deforested in the Amazon Biome. Looking at the 95 municipalities responsible for 97% of the soy production, only 4,6% of deforestation after SoyM can be blamed on the production of soy. For the entire Amazon biome, that number is 1,4%. Considering the massive expansion of land used for soy production, from 1,14 million hectares in 2006/07 to 4,66 million hectares in 2017/18, it is evident that the SoyM has served its purpose. Primarily, the soy production has expanded into pasture lands deforested before the implementation of SoyM (Nassar & Rudorff, 2018).

Previous research has also been interested in the effects of facilitating for foreign trade and commodity prices on deforestation. Schnepf, Dohlman and Bolling (2001) finds that some of the reforms undertaken by Brazil in the 1990s contributed to a greater market orientation and the stabilizing of macroeconomic conditions. Trade was liberalized and market signals was strengthened, leading to increased competitiveness and efficiency in foreign trade. This was followed by more export-oriented soy production (Schnepf, Dohlman, & Bolling, 2001). Additionally, Robalino and Herrera (2010) finds that the relationship between agricultural output prices and deforestation is positive. A positive correlation between agricultural output prices and deforestation was also found by Verburg et al. (2014), who found that soy and beef prices contribute largely to the deforestation of the Amazon. Harding, Herzberg and Kuralbayeva (2021) studied the effectiveness of three regulatory policies implemented by Brazil in reducing the pressure from commodity prices on tropical forest. By studying this, they also find that thousands of square kilometres of deforestation of the Amazon can be blamed on increased agricultural output prices. They observe that increased agricultural commodity prices are related to increased deforestation (Harding, Herzberg, & Kuralbayeva, 2021).

The Cerrado biome was excluded from the SoyM agreement, leaving the area without guarantee for protection from the ever-increasing agriculture expansion. A total of 54% of Brazil's soybean production is in the Cerrado (Magalhães, et al., 2020). Magalhães et al. (2020) concluded that the reason for the changes in agriculture was due to man-made disturbances. In addition to fires and deforestation, governance issues and policies could be related to land change in the Cerrado (Magalhães, et al., 2020). Overall, Trigueiro, Nabout and Tessarolo (2020) found a total loss of native vegetation of 46%. Furthermore, Parente et al. (2020) found from the total deforestation of the Cerrado in the period 2016-2018 that 33% was converted into agriculture and 45% into pastureland.

In addition to SoyM, ZDC are measures taken by companies to abolish deforestation in the supply chain. Zu Ermgassen et al. (2020) found ZDC to be lower in the Cerrado than in the Amazon, even though the Cerrado suffers a higher soy conversion. Furthermore, they state that 90% of soy export from the Amazon was handled by signatories of SoyM in 2017. In opposition to the Amazon, in the Cerrado only 46,5% of the soy is exported by companies with ZDC. They based their research on data collected from the Trase Database (zu Ermgassen, et al., 2020). Zu Ermgassen et al. (2020) found from ZDC companies in the Cerrado that there was no reduction in the deforestation risk due to soy agriculture. Their conclusion was that there was no evident decrease in deforestation risk inherent with soy, set aside SoyM (zu Ermgassen, et al., 2020).

When looking at deforestation from a purely economic perspective, it is profitable and can therefore be argued to be beneficial. However, when including environmental values, it should be less likely that deforestation could be considered beneficial. Most economic models don't take environmental values into account, and that represents a liability. We will therefore look at some models that has been developed from Hartwick's model (1992), which does take environmental considerations. It is easy for governments to look at tropical forests as capital assets, when clearing the forest for the benefit of agriculture can turn revenues quickly. Road building projects also open forested land, which provides sources of land for profitable agriculture and ranching as opposed to natural forest. Tropical deforestation could be argued to be a result of patterns of incentives. However, incentive structures can be changed and therefore alter behaviour leading to deforestation (Perman, Ma, Common, Maddison, & McGilvray, 2011, pp. 627-628).

There are several models that look at tropical deforestation. One of these models was developed by Hartwick (1992) and is repeated in Perman et at. (2011, pp. 627-628). This model suggests that the use of any piece of land will be determined by the net benefit of the land in forestry (MB^F) versus the net benefit of the land in agriculture (MB^A). As opposed to other models within forestry, this allows for environmental values to be included, as the net benefit of the land in forestry includes both timber and non-timber values. The socially efficient rate of conversion will be found when the benefits equalise at the margin: $MB^F = MB^A$. This model illustrates how the forest conversion may not necessarily slow down despite a decrease in tropical forest. Marginal benefits of agriculture can offset the effects on the forest conversion with increased population and higher incomes. When MB^A is higher than MB^F, deforestation will continue to happen. If removing the non-timber values from the MB^F, deforestation is even more likely (Perman, Ma, Common, Maddison, & McGilvray, 2011, pp. 627-628).

Additionally, Perman et at. (2011, pp. 627-628) repeated Barbier and Burgess (1997) optimising model, that is developed from Hartwick's model. They suggest that forestland conversion to agriculture can be shown in a demand and supply model, like in Figure 1. The vertical axis is price of forestland at time t and the horizontal axis is forestland converted to agriculture per period. The demand curve is a function of income (Y), price (P), level of population (POP) and agricultural yields (Q): D = D (P, Y, POP, Q). The model is optimised where S_t^* and D_t^* crosses in time t and benefits of timber and non-timber are considered. A growth in population will shift the demand curve rightwards, and therefore increase deforestation (Perman, Ma, Common, Maddison, & McGilvray, 2011, p. 628).

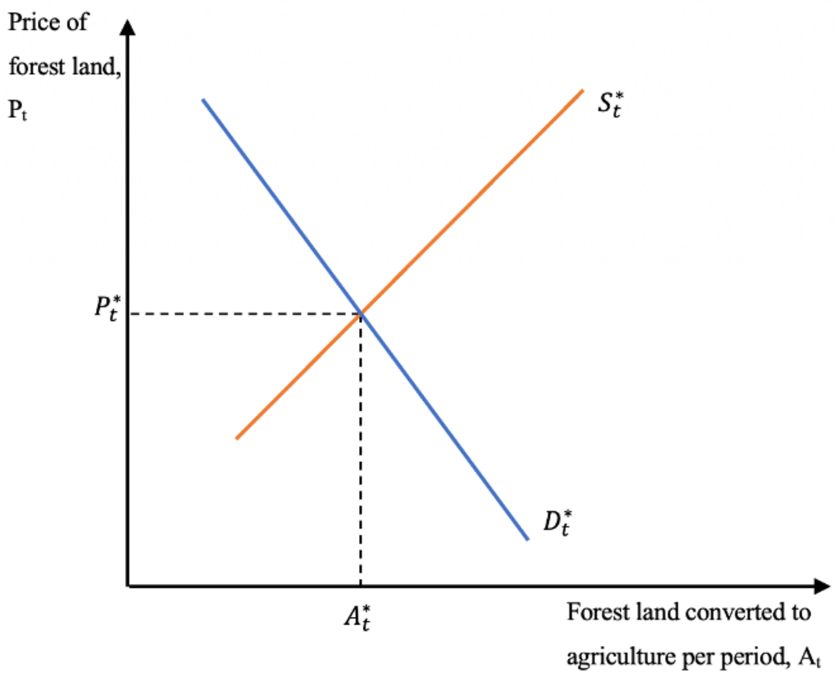

Figure 1 Optimal demand and supply for forestland conversion to agriculture at time t (Perman, Ma, Common, Maddison, & McGilvray, 2011, p. 628)

We can build further on this model by adding the shock of the implementation of SoyM. The shock will shift the supply curve to the left from S_t^* to S_t'. The supply would then have a higher price of forestland and a decreased demand for forestland converted to agriculture, at A_t^1. This would also be the effect of ZDC companies, as the price of forestland would already have increased due to the implementation of SoyM, there would be an increase in consumers demand for deforestation free agriculture. This would resolve in a decrease in the demand for forest land converted to agriculture. In Figure 2 this would represent the equilibrium (P_t^*,A_t'). When producing soy, one can choose to expand the land area by converting forest land into another area. In Brazil, SoyM has hit the brakes on the expansion in the Amazon and the alternative may then be to expand to the Cerrado. Due to the implementation of SoyM, the price of forest land in the Amazon is rising, and as a reaction to this, the Cerrado became a more interesting area. The price we look at in this sense is an expression of how interesting it is to engage in deforestation. The price is not integral in our analysis but is in the background. It is a way of thinking about how attractive it is to engage in deforestation. Intuitively, if the price of deforestation increases, deforestation will become less attractive.

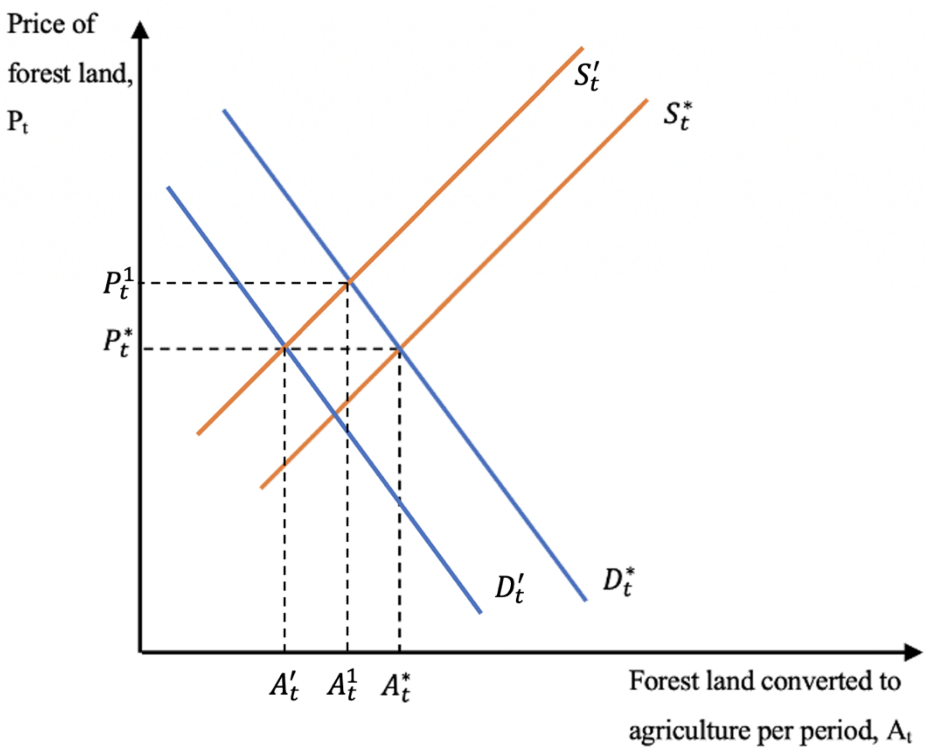

Figure 2 Demand and supply for forestland conversion to agriculture at time t when adding the shock of implementing SoyM

From looking at literature background, we have seen that there have been conducted various studies on deforestation of the Amazon. They are all somewhat conclusive when studying the effect of soy production on deforestation, and land use. A stabilisation of macroeconomic conditions, more efficient foreign trade and increasing commodity prices have been found to largely contribute to deforestation.

3 Institutional Background

Firstly, we will present an explanation of what SoyM is and how it works in practice. This is followed by a description of certification systems for companies to ensure deforestation-free soy to its consumers and collaborators. Furthermore, we will present SoyM and the certifications role for Norway and France. Next, we will present some theory about the Cerrado biome. Since soy is produced in both the Amazon and the Cerrado, the concern is that laws and regulation in one would affect the other, i.e., a spillover effect. Finally, we will discuss the role of genetically modified soy in the soy import industry relative to reduced deforestation of the Amazon.

3.1 The Soy Moratorium

Soy has been a major cause of deforestation of the Amazon, but recent studies has shown that soy plantation now plays a minor direct role in the recent deforestation. This effect has largely been attributed to the introduction of the SoyM, but also policies and incentives. SoyM monitors 76 municipalities responsible for 98% of the soy produced in the Amazon region (Greenpeace, 2016), and the latest monitoring report (released in 2018) states that in the last 11 years only 1,2% of soy was planted in deforested areas. However, since 2013 there has been a slight increase in soy plantation in deforested areas, from 0,6% in 2013 to 1,2% in 2018 (Rainforest Foundation Norway and Future in Our Hands, 2018). Overall, the deforestation has decreased since the implementation of SoyM in 2006, however the soybean production has been increased by 400%. This indicates that agricultural production can increase even if the rainforest is protected (FAIRR, 2021).

Even though SoyM was established in 2006, The Brazilian government didn’t become involved until 2008. The Brazilian Institute for Space research (INPE) received the responsibility of monitoring the SoyM agreement, together with the Soy Working Group (GTS). GTS came together in the making of the SoyM agreement by several environmental groups, in order to monitor and oversee the implementation of the agreement. INPE was brought in to lead the monitoring efforts using satellites and could then identify through images where soy was being grown after the cut-off date. The SoyM agreement has been renewed yearly since 2006, and in 2014 the SoyM renewal agreement changed the cut-off date from 2006 to 2008 (Gibbs, et al., 2015). Svahn and Brunner (2018) conducted a difference in difference analysis to investigate the impact of SoyM in the Amazon. They found SoyM to only have a significant impact towards reducing deforestation in the Amazon after the satellite monitoring enforced in 2008 (Svahn & Brunner, 2018). The fact that the Brazilian government got involved in 2008 and started monitoring the SoyM agreement, was an important step towards reducing deforestation. GTS estimates in 2017/18 that 95 municipalities responsible for 97% of the soybean production in the Brazilian Amazon is being monitored. Yet only 4,6% of the deforested area lays within the 95 monitored municipalities. In addition to the SoyM agreement, there was several new federal environmental policies that was introduced in the same period. These policies covered both the Brazilian Amazon Biome and other soy-producing regions (Nassar & Rudorff, 2018).

3.2 Certifications

The sustainable trade initiative (IDH) is an international organisation that helps large programs transitioning toward sustainability with their collaborators. In the 2020 European Soy Monitoring Report, IDH provides an overview of the transition to deforestation-free and responsible soy in Europe. The report shows that of all soy flour consumed in EU, Switzerland and Norway in 2018, 38% were in accordance with the European Compound Feed Manufacturers' Federation (FEFAC) and 19% were certified deforestation-free. The most frequently used certifications in Europe are Proterra and RTRS and will be presented in 3.2.2 and 3.2.3 (IDH, 2020).

The FEFAC Soy Sourcing Guidelines (SSG) has been valuable in defining baseline criteria when it comes to importing soy to the European market. By 2019 there was eighteen certifications that complies with FEFAC's SSG. These eighteen certifications were assessed in a research conducted by Kusumaningtyas & van Gelder (2019). They assessed the certifications against four crucial issues. Avoiding deforestation, conversion and degradation of HCV areas and other valuable natural areas, avoiding wetland conversion; and optimizing the standard's level of assurance. During their research, they found that only eight of the eighteen certificates had a clear prohibition of deforestation. These certificates are BFA, CRS, Donau Soja, Europe Soya, ISCC Plus, ProTerra, RTRS and SFAP Non-Conversion (Kusumaningtyas & van Gelder, 2019).

3.2.1 FEFAC

The members of FEFAC consists of the United Kingdom and 24 EU member states. In addition, Norway, Turkey, Switzerland, Russia and Serbia are associate members. FEFAC members are offered sustainable solutions according to the environmental, economic and social perspective of the animal nutrition, which is an important driving force for the European feed industry. In recent decades, the feed industry has made significant progress, but the challenge remaining is that farmers need support for tools to address the problems effectively (FEFAC, 2021).

FEFAC focuses on feed safety, feed quality, market access and innovation. In order to ensure sustainability, they have developed the FEFAC Roadmap on Responsible Soy. This includes the SSG, Verification Requirements and Benchmark tools. The SSG was presented in 2015 and set 59 baseline criteria. These were segmented into legal compliance, responsible working conditions, environmental responsibility, good agricultural practices, respect for land rights and maintaining good community relations. In 2019, the Responsible Soy Declaration was launched by FEFAC and the ITC and is a commitment to source according to the FEFAC SSGs. It was signed by 11 European compound feed companies in April 2019 and has since been signed by approximately 250 companies (FEFAC, 2021).

3.2.2 ProTerra Foundation

This non-profit organisation is passionate about full transparency throughout the supply chain and the possibility of traceability for businesses and consumers. Sustainable feed and food production and corporate social responsibility are in focus in their work. The ProTerra Foundation has also expressed concern about potential harmful impact of genetically modified crops on ecosystems, herbicide-resistance and biodiversity. This is an independent third-party certification that brings together stakeholders from the entire supply chain and ensures that high quality supply of crops, food and feed are available in the market. ProTerra certification also ensures that crops are non-GMO and produced with improved sustainability (ProTerra Foundation, n.d.).

3.2.3 RTRS

The non-profit organisation Round Table on Responsible Soy Association (RTRS) works towards sustainability throughout the value chain of soy production. RTRS focuses on the use of responsible soy through a global certification system (RTRS b., n.d.). With a RTRS certificate, one is ensured that the soy produced is deforestation- and conversion-free. (RTRS a., u.d.). The participating members of RTRS are organisations within the value chain of soy production or representatives for initiatives or projects that are soy related. Regulatory authorities, consulting and audit firms, academia, vital donors and governmental agencies among others also falls under the category of members (RTRS c., n.d.).

3.3 The Cerrado Biome

The Cerrado biome is the second largest biome in Brazil, and consist of savannah, grassland and a complex mosaic of forest (Parente, et al., 2020). Like the Amazon, the Cerrado stores greenhouse gases, approximately 13,7 billion tons carbon dioxide (WWF, 2017). Although, the Cerrado biome is not included in SoyM, there has been other initiatives to protect the biome from deforestation. In October 2017, 23 international food companies pledged to stop the deforestation of the Cerrado. They will do this through the distribution chain with a close collaboration with all actors included, with a main goal of protecting native vegetation (WWF, 2017).

3.4 Norway – importer

Norway uses soybeans in animal and fish feed, where salmon producers are the main consumers of soy for fish feed. Norway imports soybeans mainly from the Mato Grosso state in Brazil, who is covered by both the Amazonia and the Cerrado biome (Regnskogfondet, n.d.). The report from IDH states that the soy import from Brazil to Norway is 100% FEFAC and ProTerra certified as deforestation-free soy (IDH, 2020). Soy protein concentrate (SPC) from Brazil is a main ingredient in feed consumed by Norwegian farmed salmon. With 387 082 tonnes of SPC imported in 2015, Norwegian fish feed manufacturers are the largest importers of soy into Norway. 677 394 tonnes of soybeans are needed to produce this amount of SPC and 94% of it came from Brazil. In Brazil, one hectare produces three tonnes of soybeans. This means that Norwegian soy import in 2015 stood for an area totalling 2 258km^2 of arable land, which is the equivalent to approximately 316 246 football fields (Lundeberg & Grønlund, 2017).

3.5 France – importer

France is one of Europe's biggest importers of soy. In 2018, they imported a total of 3,7 million tonnes of soybeans, -meals and -oil, where most of it went to the livestock sector as animal feed. Most of which was imported from Brazil. There is an increasing focus on sustainable soy sourcing in France, and in 2018 French government adopted a strategy aiming to end all import of commodities linked to deforestation, either directly or indirectly, by 2030. This strategy is called "National strategy to Combat Imported Deforestation" (SNDI). In 2018, only 43% of total French soybean meal consumption was estimated to be FEFAC compliant. An estimated 20% of this was regarded by Eurofac to be deforestation-free (IDH, 2020).

3.6 Genetically modified soy

Genetically modified (GM) foods are a subject of controversy, especially in relation to human health and the environment (WHO, 2021b). In order to make crops more resistant to plant disease and increase their tolerance of herbicides, their DNA can be modified through technology often referred to as "modern biotechnology". Foods that are derived from organisms whose genetic material has been modified, are referred to as GM food. Use of modern biotechnology increase the supply of food and lower costs, which allow for reduction in food prices (WHO, 2021a). Soybeans are one of the crops that often is associated with GMO. Genetically modified soy is made by having resistance genes inserted. The soybeans get inserted genes where the goal is to give herbicide resistance or pest resistance, which would lead to the farmer using less insecticide and herbicide. This would theoretically be more environmentally friendly and cost-saving for the farmer (Willis, n.d.). However, Cassidy (2016) claims that farmers in the U.S. apply 16 times more herbicide to the crops than before the implementation of genetically modified organisms (GMO). This process is also bad for the farmers' health and the environment, hence certain insects, birds and wildlife (Cassidy, 2016).

There has also been done research that confirms positive environmental effects from the use of GMO. Graham Brookes and Peter Barefoot published a research article on environmental impacts of genetically modified (GM) crop use from 1996-2016. Through their research they found that since 1996 there has been a global reduction of 8,2% in the use of active ingredient in pesticide, relative to a reasonably expected amount if planting conventional crops. There has also been a significant reduction in carbon dioxide emissions through GM use in soybeans, as it has allowed for production systems with reduced soil cultivation. This accounts for 67% of total savings from 1996-2016 and has been greatest in South America (Brookes & Barfoot, 2018).

Nineteen out of 27 member countries of the European Union have partially or fully banned GMOs (Journey, 2021). Norway do not produce GMOs and has taken an active approach against the use of GMO. Norway is one of the most restrictive importers of GM products and has prohibited several EU-approved GMOs even though EU directives generally are implemented (Hofverberg, 2020). Unlike Norway, France allows some sales and production of some GMOs. The French regulations fall within the regulations in Europe, but France has other restrictions, such as labelling and concern for environmental damage (Boring, 2020). In 2020/2021 98% of Brazilian soy production was GM (ProTerra Foundation, 2021).

The production of non-GM soybeans has decreased rapidly over the last years in South America, for the benefit of GM soybeans. Most of the soy exported from Brazil to Europe is GM and are mostly used in the feed industry as most of Europe has strict policies towards the use of GM soy in human food. There is a lot of controversy surrounding the use of GM crops, and it has been argued that GM crops are more environmentally friendly than conventional crops. A vital argument for using GM crops is that it allows for less use of insecticides, herbicide and pesticide, as the soybeans are inserted with genes that makes them resistant towards herbicide and pest. This argument, however, is not fully supported by what has been revealed by research. The use of active ingredient in pesticide has decreased, which is beneficial for the environment, while the use of herbicides has increased. The increase in use of herbicides is unnecessary according to theory and could potentially be reduced by proper monitoring and training of farmers.

GM crops allows for more production with fewer resources, which is more cost effective than producing non-GM crops. When using GM soybeans, farmers are also able to grow more on the same land. This reduces the need for extra land and thereby deforestation, in the production of soy. As the world's population continues to increase, there is a need for increased production of food. GMO could be argued to be a solution to the problem, as the farmers need less land to produce the same amount of food. The assumed outcome of increased use of GMO would therefore be less deforestation. However, there has not been conducted enough research on the topic to determine whether less deforestation is the outcome of more use of GMO.

Other arguments against use of GM, is the uncertainty of repercussions. Although there hasn't been found conclusive negative effects of the use of GMO when it comes to allergenicity, transfer of genes from GM foods to human digestive tract and outcrossing, GMO is still a topic of high controversy. Since the focus of our thesis is deforestation, we only emphasise the environmental effects of GMO (WHO, 2021b).

The effect GMO have on deforestation is not something we will directly analyse in our study, but it is an interesting topic for further research. Several of the certifications for responsible soy exclude GM soy as it may lead to pollution of water, transfers of GM genes to surrounding organisms and the threat towards biodiversity. However, there are some strong arguments for using GM soy in order to reduce deforestation as well. The topic is therefore highly relevant, and further research is needed.

4 Empirical Strategy

The empirical strategy relies on a dataset retrieved from the database at Trase, developed through a partnership between Global Canope and the Stockholm Environment Institute (Trase, 2021a), which will be analysed by using a regression model. The dataset contains the entire supply chain for soy exported from municipalities in Brazil. Furthermore, the regression model will be developed to distinguish correlation between deforestation and soy in the Amazon, and to further be used in the analysis section. Additionally, we will present strengths and weaknesses with the methodology.

4.1 Data

For the empirical strategy, we will use a quantitative method with data, retrieved from Trase, on soy exported from municipalities in Brazil in the period 2004-2018. Trase is a recognized data-driven transparency initiative that shows how raw material exports are linked to deforestation in its production area. Through a combination of published data from companies with freight, customs, logistics, tax and other data to map details in the supply chains, as well as the trading companies' patterns of investment and ownership, Trase can point to social and environmental damage caused by raw material production (Trase, 2021b). They use publicly available data to map supply chain connections from production region to trading companies to countries of import, for a particular commodity. Their approach is about developing a logic-based map, and with the help of platform users and stakeholders they are able to make continuous improvements on their data. This is done by using a material flow analysis called Spatially Explicit Information on Production to Consumption Systems (SEI-PCS) (Trase, 2018). The data we will focus on in this thesis show the supply chain for Brazilian production and export of soybeans to importing countries and players in Europe (Trase, 2021b).

The dataset consists of data for all 136 countries that imports soy from Brazil and has a comprehensive set-up of the supply chain, from export country to import country, all the way down to the company level. We limited the dataset to only consist of the 34 countries in Europe who imports soy from municipalities in Brazil to customise the data to the research question. Furthermore, we excluded all biomes except the Amazonia and the Cerrado, so that we could carry out the regression analyses with each biome individually and both biomes together. Moreover, the data was collapsed into municipality level. This was done to make municipality-year the unit of observation. The variables that we will be focusing on in the data analysis are soy exported from Brazil in equivalent tonnes and territorial deforestation risk in hectare in the Amazon and the Cerrado biomes. As stated in the theory section, Norway scores 100% on using responsible soy, while France only scores 43%. We will also use an independent variable for the remaining countries in Europe, for comparison in the regression analyses. Thus, we will for each municipality split its exports into the exports to Norway, France and remaining countries.

4.2 Regression Model - Fixed effect estimator

The regression analyses will be carried out in the statistical tool Stata using the XTREG function with a fixed effect estimator. The fixed effect for this regression model is year and municipality. Furthermore, the standard errors are clustered on municipality level. When using clustering on municipalities, we consider correlation over time and solve potential problems related to heteroskedasticity and serial correlation. If we had not considered that it is the same municipality we observe over time, we would have underestimated the variation in the data, which would have given too small standard errors and erroneous conclusions of the results. Additionally, we created a dummy variable called Dpost which will divide the dataset into before and after the implementation of SoyM.

4.2.1 Regression model

Jansen (2018) has also used municipality-level data on the Brazilian soy industry from Trase for his thesis. We found inspiration in his econometric model for international soy demand for land use when developing our own regression model. In our thesis we will carry out five different regression analyses. Every regression analysis will use a logarithm of territorial deforestation risk in hectare as the dependent variable and soy exported from municipalities in Brazil in equivalent tonnes as independent variable. The model for deforestation and soy equivalent tonnes is:

$$logDF_{it} = \alpha + \beta logS_{it} + v_i + \epsilon_{it} \text{ (1)}$$

i is municipalities and *t* is year. However, for our analysis we expanded the first equation with the independent variables; soy equivalent tonnes in Norway, France and the remaining countries in Europe. Thereby, $S = SNor + SFr + Srest$. We also added a logarithm to the equation. The model for deforestation is now:

$$logDF_{it} = \alpha + \beta_1 logSrest_{it} + \beta_2 logSNor_{it} + \beta_3 logSFr_{it} + v_i + \epsilon_{it} \text{ (2)}$$

α is the constant and the βs are the estimated coefficient. v_i is the error term for each unit in the equation, and therefor varies in value. ϵ_{it} is the model's error term and is uncorrelated with the other terms in the equation (Stata, n.d.). We assume that soy export does not correlate with the residuals, which is a condition for ordinary least squares (OLS) and a violation of this assumption would produce biased results (Frost, 2021). If the residual is uncorrelated with soy export, the beta gives the causal effect of the independent variable on the dependent variable. However, there might be an omitted variable bias problem (OVB) that creates a correlation between the error term and our independent variables of interest. This will produce a biased estimate of beta. Therefore, we cannot rule out that our estimates pick up correlation rather than causality. We will more thoroughly address this in 4.2.3, strengths and weaknesses with the methodology.

4.2.2 Hypotheses

The first regression analysis will determine if there is a statistically significant relationship between territorial deforestation risk in the Amazon and the export of soy in equivalent tonnes. The following hypothesis will be tested by this regression analysis, for example:

H_0: There is no relationship between territorial deforestation risk and soy export.

H_A: There is a relationship between territorial deforestation risk and soy export.

For the remaining regression analysis, we will not state the hypotheses in the same manner as above. The hypothesis will be H_0: $\beta = 0$ and H_A: $\beta \neq 0$.

The results from the five regression analyses will be presented in the analysis section.

First, we want to investigate how European soy import affect the deforestation of the Amazon, because it will give us an indication of the impact Europe has on the deforestation of the Amazon. This will be done through a regression analysis, using data of the municipalities in Brazil who export soy to countries in Europe. This regression analysis will consist of a logarithm for territorial deforestation risk in hectare and soy equivalent tonnes in the Amazon, and will not divide the European countries, but look at Europe as a whole.

Secondly, we will investigate if there is a change in Europe's contribution to deforestation of the Amazon after the implementation of SoyM. We will build further on the first regression analysis by adding the introduction of the implementation of SoyM. Additionally, we will divide Europe into Norway, France and the remaining countries in Europe. By comparing two countries with such different positions towards deforestation, we will get an indication of how much incentives and politics in different countries can affect deforestation. It is interesting because it will show us the effect "good" policies have on deforestation compared to not so "good" policies and tells us whether incentives and politics actually help to reduce deforestation. Here we expect to find a decrease in the coefficient between the dependent variable and the independent variables after the implementation of SoyM.

Thirdly, we will look at the companies who export soy from Brazil to Europe and investigate if the measures taken by SoyM and ZDC companies to reduce deforestation of the Amazon have had an effect. This regression will be using a logarithm for territorial deforestation risk in hectare and soy equivalent tonnes in the Amazon, and will divide the independent variables into SoyM companies, ZDC companies and the remaining companies exporting from Brazil to Europe.

Fourthly, we will recreate the second regression analysis only with the Cerrado biome instead of the Amazonia. That is, we will look at the Cerrado biome in one regression analysis using a logarithm for territorial deforestation risk in hectare and soy equivalent tonnes, with the independent variables divided into Norway, France and the remaining countries in Europe. Here we expect the deforestation of the Cerrado to increase at a heavier rate after the implementation of SoyM in the Amazonia biome than before.

Finally, we will investigate if the decline in deforestation in the Amazon is a result of an equal increase in deforestation in the Cerrado, i.e., a spillover effect. This will be done through a regression analysis including both the Amazonia and the Cerrado biomes, using a logarithm for territorial deforestation risk in hectare and soy equivalent in tonnes in the Amazon and in the Cerrado.

Furthermore, all regression analyses will be conducted twice. Due to the monitoring that started in 2008, some of the effect of SoyM may not have become visible until 2008 (Svahn & Brunner, 2018). Therefore, we carried out the regression analyses with Dpost2006 and Dpost2008 and will thus mainly use Dpost2008 in the analysis. The regression analysis using Dpost2006 are located in the Appendix.

4.3 Strengths and weaknesses with the methodology

The dataset we chose is a strength for our analysis, as it presents details on the entire supply chain from export country to import country, all the way down to the company level. In the regression analyses we look at different aspects of the supply chain, which entails looking at exports at municipality level or company level. We also look at different aspects in the way of exports from biome and import countries. The many levels of actors in the supply chain (producing municipalities, exporting and importing companies, importing countries) required that we collapsed the dataset to the appropriate unit of observation.

A weakness with our empirical strategy is the possibility of endogeneity in the regression model, as we cannot rule out that our estimates pick up correlation rather than causality. For it to be an OVB problem, two conditions need to be fulfilled. The omitted variable must correlate with the dependent variable, and it must correlate with at least one independent variable that is in the regression model. An OVB problem can affect the results through positive or negative bias, and therefore needs to be addressed as a limitation in our study. If there is a negative bias, the model underestimates the effect of the independent variable that is correlated with the omitted bias. If that is the case, there is an even higher effect on deforestation from soy export. However, if there is a positive bias the model overestimates the strength of an effect, hence a weaker effect on deforestation from soy export (Frost, 2021). Since we cannot know if there is an OVB problem in our regressions, we cannot solve it. It is still worth taking into consideration that there may be such a problem and take that into account when reading our results. When using a regression model for this thesis, we thereby assume that soy exports are independent of residues. Possible future research could try to solve the potential OVB problem by looking for alternative empirical designs. There are several possible research themes one could investigate using data from Trase. It would be interesting to look for an instrument variable, such as demand shocks in the importing country, to affect soy export but not deforestation directly.

5 Analysis

For this part of the thesis, we will use the points presented in the literature and institutional background to interpret the results from the five different regression analysis in the empirical strategy section. The purpose of this is to fully look at and discuss the results in accordance with the arguments presented, so we can draw a conclusion to the research question we have presented in the introduction: how do European soy import affect the deforestation of the Amazon? Firstly, we will present visuals and descriptive statistics of the data, so that further analysis will be easier to understand. Furthermore, we will investigate if there is a statistically significant relationship between territorial deforestation risk in the Amazon and European soy import in equivalent tonnes. Next, we will investigate if there is a change in Europe's contribution to deforestation of the Amazon after the implementation of SoyM. Similarly, we will look at the companies who export soy from Brazil to Europe and investigate if the measures taken by SoyM and ZDC companies to reduce deforestation of the Amazon have had an effect. Moreover, we will look at how deforestation in the Cerrado has changed since the implementation of SoyM in the neighbouring biome Amazonia and investigate if the decline in deforestation in the Amazon is a result of an equal increase in deforestation in the Cerrado. In the analysis we will use 2008 as the year SoyM was implemented, because it gave the most statistically significant results. The regression analysis using 2006 is located in the Appendix.

5.1 Looking at the data

To get an overall picture of the data that will be used in this thesis, we will present some visuals and some descriptive statistics of the data in this section.

The territorial deforestation risk in the Amazon varies through time. Figure 3 shows the fluctuations in the curve of total territorial deforestation risk in hectare in the Amazon due to soy export to Europe over the period 2004-2018.

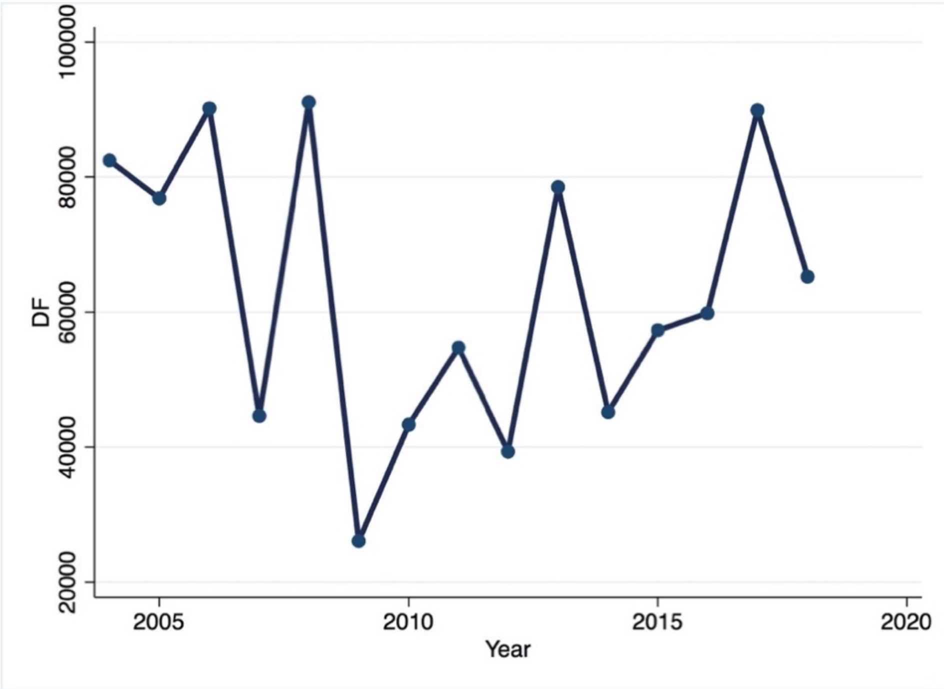

Figure 3 Territorial deforestation risk in hectare from 2004-2018 in the Amazon

Furthermore, we made a similar figure for soy equivalent in tonnes exported from the Amazon to Europe. Like the previous figure, Figure 4 shows the fluctuations in the curve of total soy equivalent in tonnes exported from the Amazon to Europe over the period 2004-2018. We can see that the soy export fell from approximately 22 to 14 million tonnes from 2004-2009, which is approximately a 30% decrease and a mean of 20 million tonnes. From 2010-2018 the mean value was approximately 15 million tonnes, which is a decrease of approximately 25% in export from the previous period estimate.

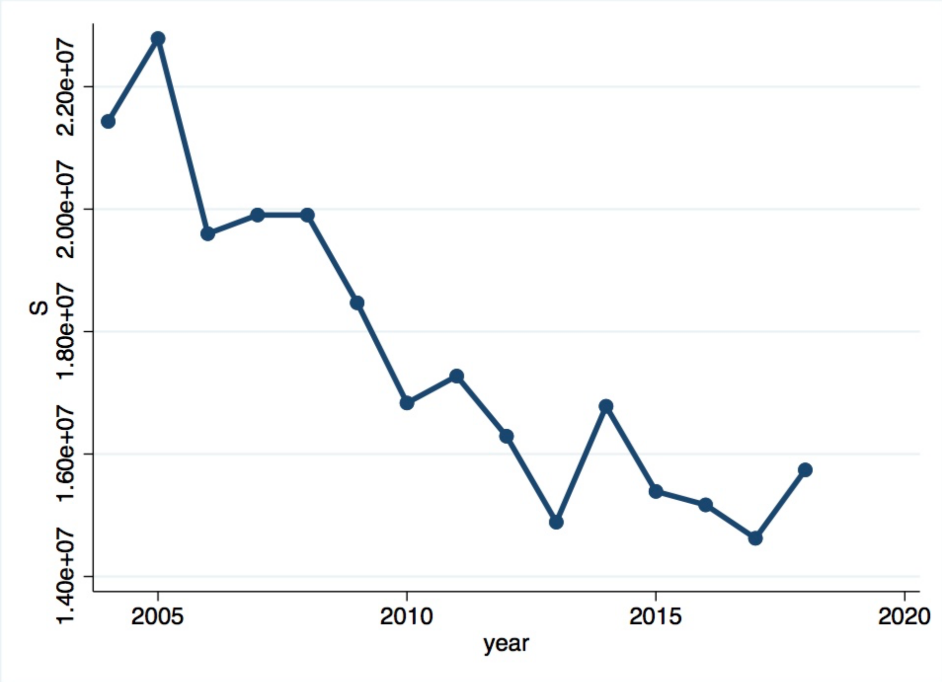

Figure 4 Soy equivalent in tonnes from 2004-2018 in the Amazon

Table 1 contains descriptive statistics of the variables we will use in the regression analyses for the situation in the Amazon. It is based on the dataset we retrieved from Trase, consisting of the supply chain for soy exported from Brazil to Europe. The mean for territorial deforestation risk is approximately 63 thousand hectares. Furthermore, the mean for soy equivalent in tonnes is calculated to approximately 1,8 million tonnes*.

Table 1 Descriptive statistics – the Amazon

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
DF	4,488	210.5	1,034	1.66e-07	35,072
S	4,520	6,074	13,191	1.75e-06	192,583
SNor	4,520	102.9	1,562	0	54,052
SFr	4,520	325.4	2,417	0	74,651
Srest	4,520	6,074	13,191	1.75e-06	192,583
SSoyM	4,520	4,511	10,641	0	157,396
SZDC	4,520	128.3	1,435	0	34,318
Srest1	4,520	6,074	13,191	1.75e-06	192,583
Number of m	816	816	816	816	816

Note: This table consists of a summary of descriptive statistics for the dataset containing soy exported from the Amazon to Europe in the period 2004-2018. *The calculated mean for territorial deforestation risk is (210,5*4488)/15years and for soy export (6074*4520)/15years.

This analysis will in addition to the Amazon look at deforestation risk in the Cerrado. Table 2 contains descriptive statistics of the variables we will use in the regression analyses for the situation in the Cerrado.

Table 2 Descriptive statistics – the Cerrado

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
DF	32,698	91.14	435.5	8.89e-07	14,461
S	34,276	3,860	13,515	5.67e-06	517,818
SNor	34,276	115.4	2,814	0	175,197
SFr	34,276	405.3	3,962	0	239,077
Srest	34,276	3,860	13,515	5.67e-06	517,818
Number of m	816	816	816	816	816

Note: This table consists of a summary of descriptive statistics for the dataset containing soy exported from the Cerrado to Europe in the period 2004-2018.

5.2 The relationship between deforestation and soy export in the Amazon

To investigate how European soy import affect the deforestation of the Amazon, there firstly needs to be established if there is a relationship between export of soy and territorial deforestation risk in the Amazon. This can give us an indication of how Europe contribute to the destruction of one of the world's most important ecosystems. Here we expect to find a positive correlation between the variables. The beta coefficient from the regression output in Table 3 tells us the difference in the effect, as for the logarithm of the variable soy equivalent in tonnes is valued to 0,71. This coefficient tells us that when the variable soy equivalent in tonnes is increased by 1%, the territorial deforestation risk is increased by 0,71. The model is statistically significant at a 99% level, and we can discard the null hypothesis and claim that there is a relationship between territorial deforestation risk in hectare and soy export equivalent in tonnes.

In section 5.1 we found the reduction in soy export to be approximately 25%. When multiplying this rate of decrease with the beta coefficient from the regression, we get an annual deforestation decrease of 18% caused by the reduction in soy export. If we multiply the mean of territorial deforestation risk of 63 thousand hectares with the annual deforestation decrease of 18%, we find an annual reduction in deforestation of 11,3 thousand hectares. This means that the decrease in soy export to Europe, decreases deforestation of the Amazon with 11,3 thousand hectares. Even though this is a rough estimation, it is interesting to see approximately how much soy import affects the deforestation.

Table 3 Territorial deforestation risk in hectare and soy equivalent in tonnes

	(1) DF
logS	0.710***
	(0.034)
Observations	590
municipality	105
R-sq	0.57

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazon. The independent variable is log soy equivalent in tonnes exported from municipalities in the Brazilian Amazon to Europe. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. The model is statistically significant at a 99% level, and we can discard the null hypothesis and claim that there is a relationship between territorial deforestation risk in hectare and soy equivalent tonnes. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.

In the regression model in Table 3, we established that there is a statistically significant relationship between territorial deforestation and soy equivalent tonnes exported. This finding is supported by theory, which was presented in the literature background. Tyukavina et.al (2017) confirmed massive deforestation in the Amazon through their research, while Silva and Lima (2018) found that the municipalities that are dependent on soy production are drivers for deforestation which continues to increase. Schnepf, Dohlman and Bolling (2001) found that trade was liberalised, and market signals were strengthened, leading to increased competitiveness and efficiency in foreign trade, due to the reforms undertaken by Brazil in the 1990s. Additionally, we looked at Barbier and Burgess optimising model which illustrated that factors such as a growth in population, will shift the demand curve rightwards and thus increase deforestation. With this as a basis we can conclude that there is a relationship between territorial deforestation risk in the Amazon and soy export to Europe.

5.3 The Soy Moratorium

Furthermore, we will investigate if there is a change in Europe's contribution to deforestation of the Amazon after the implementation of SoyM. This will be done by building on the previous regression analysis by adding the implementation of SoyM. We want to see if there is a reduction in territorial deforestation risk due to the implementation of SoyM on the export of soy to Norway, France and the remaining countries in Europe. That way we will see the effects of incentives and politics in the two countries, along with the effect soy export to Europe in general has on deforestation. The expectation for this regression is to find a decrease in the correlation coefficient between the dependent variable and the independent variables after the implementation of SoyM. This can be done by looking at deforestation and soy import after 2008 when the monitoring of SoyM started, towards the data we have from before 2008.

From the regression analysis in Table 4 we can see that for the remaining countries in Europe the beta coefficient before the implementation of SoyM was 0,776, thereby, if we increase the soy export with 1% the territorial deforestation risk will increase by 0,776%. This effect is statistically significant. After the implementation of SoyM, this coefficient has decreased to 0,632, meaning the territorial deforestation risk increases by 0,632% when soy export is increased by 1%. However, the change in the beta coefficient is not statistically significant, which means that there is no effect. For France the beta coefficient before SoyM was 0,066. Thereby, if we increase the soy export with 1% the territorial deforestation risk will increase by 0,066%. This result is statistically significant at a 90% level. After the implementation, this coefficient has decreased to 0,035, meaning the deforestation increases by 0,035% when soy export is increased by 1%. However, the change in the beta coefficient is not statistically significant, which means that there is no effect after the implementation of SoyM. On the other hand, Norway seems to be unaffected from the implementation of SoyM, as the beta coefficient changes from a negative 0,008 to a positive 0,013. Nor this variable has had a statistically significant effect.

Table 4 Territorial deforestation risk in hectare and soy equivalent in tonnes for Norway, France and the remaining countries in Europe

	(1) DF
logSrest	0.776***
	(0.081)
Dpost2008=1 # logSrest	-0.144*
	(0.085)
logSNor	-0.008
	(0.032)
Dpost2008=1 # logSNor	0.021
	(0.039)
logSFr	0.066*
	(0.035)
Dpost2008=1 # logSFr	-0.031
	(0.040)
Observations	590
municipality	105
R-sq	0.59

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazon. The independent variables are the logarithm of the variables logSNor, logSFr and logSrest. SNor is soy equivalent tonnes exported to Norway. SFr is soy equivalent tonnes exported to France. Srest is soy equivalent tonnes exported to the remaining countries in Europe. Additionally, we added the variables one more time, only consisting of data from after 2008 (depost2008). These depost dummy variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. To find the change in the coefficient Srest we sum 0,776 and –0,144, which gives the new coefficient 0,632 after 2008. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. The variable logSrest before and after SoyM and logFr were the independent variables who were statistically significant. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level. Due to the possibility of OVB, we interpret the results at a correlation driver, rather than at causality.

From a purely economic perspective, deforestation can be argued to be beneficial and thereby profitable. To interpret the relationship between soy export and deforestation we also must investigate the relationship between output price and deforestation. Robalino and Herrera (2010) and Verburg et.al (2014) both found a positive relationship between agricultural output prices and deforestation. Additionally, Verburg et.al (2014) also claims that prices contribute largely to the deforestation of the Amazon. Harding, Herzberg and Kuralbayeva (2020) supported this claim when finding that thousands of square kilometres of deforestation of the Amazon can be blamed on increased agricultural output prices. These findings are affirmative with our assertion that the introduction of implementing SoyM would lead to a higher pressure on the price of forest land and a decreased demand for forest land converted into agriculture. In the model for deforestation in section 2 where we added the introduction of implementing SoyM, we found that the introduction would lead to an immediate increase in price of forestland and a decrease in converted forest land. The price is not integral in our analysis but is in the background. It is a way of thinking about how attractive it is to engage in deforestation. Intuitively, when the price of deforestation increases, deforestation will become less attractive. Additionally, research conducted by Kastens et.al (2017) found that the reduction in deforestation in the Mato Grosso state after 2006 was an outcome of the implementation of SoyM. Furthermore, Gollnow, de Barros Viana Hissa, Rufin and Lakes (2018) stated that SoyM has had both direct and indirect effect on the reduced deforestation in the Amazon. On the other hand, Greenpeace's (2016) studies show that soy plantations play a minor direct role on deforestation of the Amazon. Rainforest Foundation Norway and Future in Our Hands (2018) states in their monitoring report that only 1,2% of soy was planted in deforested areas in the last 11 years. This indicates that SoyM has helped reduce the deforestation, even though it hasn't reduced the activity of the plantations. The SoyM renewal agreement changed the cut-off date from 2006 to 2008 (Gibbs, et al., 2015). Thus, INPE and GTS started the monitoring of the SoyM agreement. This is consistent with the idea that monitoring works, although we do not observe this effect. As we saw in Figure 3 and 4, the amount of territorial deforestation risk in hectare and soy equivalent tonnes has a negative trend line. In Table 8 in the Appendix, we conducted the same regression only using Dpost2006 instead of Dpost2008. Here we did not get a statistically significant effect, corresponding with Svahn and Brenner's (2018) findings that SoyM only had a significant impact towards reducing deforestation in the Amazon after the satellite monitoring enforced in 2008.

Moreover, from the regression analysis in Table 4, we concluded that SoyM did have an impact by decreasing the deforestation of the Amazon through European soy import, which supports the findings in the literature and theory above. For the remaining countries in Europe, we found a decrease in the beta coefficient, hence a decrease in deforestation as an effect of the implementation of SoyM. This is consistent with the expectation we had from before conducting the regression analysis.

5.4 The effect of certification systems

To act against deforestation of important biomes in the world, there has been created several certification systems. We will investigate the effect of some certifications on soy export to Europe and deforestation risk in the Amazon. Many companies are part of the SoyM agreement and are committed to refrain from buying or finance soybeans grown on deforested land after July 2008. Others have made own company commitments to buy deforestation-free soy, so-called ZDC companies. In the regression analysis in Table 5 we will look at companies in the supply chain for soy export from Brazil to Europe and investigate if the measures taken by SoyM and ZDC companies to reduce deforestation of the Amazon have had an effect compared to the companies who are not committed to zero deforestation. We will look at companies who exports soy from the Amazon and add the introduction of the implementation of SoyM, to investigate if there has been a change in the correlation between the dependent variable and the independent variables. We would like to see how SoyM committed and ZDC companies affect territorial deforestation risk as opposed to companies who are not committed. It is expected that SoyM reduces the deforestation rate for all companies who are committed to zero deforestation. This will be interpreted through the regression analysis in Table 5, where we will use the independent variables SoyM committed companies, ZDC companies and the remaining companies who are not committed to zero deforestation exporting from Brazil to Europe. We first conducted this regression using Dpost2006 as the year SoyM was implemented. However, several values were omitted due to collinearity in this regression. Therefore, we will be using Dpost2008 when interpreting the results. The regression using 2006 is located in the Appendix in Table 9.

Certifications for deforestation-free soy, has proven to be an important tool in order to reduce deforestation. Even though certifications alone won't stop deforestation, it helps towards achieving good governance and legal compliance. However, the certifications use different interpretations on how to avoid deforestation. Since this thesis looks at how European soy import affect the deforestation of the Amazon, it is beneficial to know what level of assurance the different certificates give against deforestation. FEFAC's SSG are valuable, but not impeccable as they rely solely on national legislation in the producing country as to how "deforestation-free" is defined. This definition varies significantly between producing countries, as well as the cut-off date they follow. Therefore, certificates can be FEFAC compliant, and still not be sufficiently deforestation-free. This represents a liability, as our data only distinguishes between SoyM committed companies, ZDC companies and not-deforestation companies. Because of the different definitions, SoyM committed companies and ZDC companies may not contribute to deforestation to the same extent. We will therefore not be able to determine the level of assurance with our data, although we can investigate if there is a statistically significant relationship.

In the regression analysis in Table 5 we can see that the companies who are committed to zero deforestation through SoyM went from a positive beta coefficient of 0,003 before SoyM to a negative beta coefficient of 0,004 afterwards. However, this result is not statistically significant, and we can therefore not claim this effect. Furthermore, the remaining companies who are not committed to zero deforestation experiences a slight decrease in the beta coefficient, from 0,828 to 0,647. This result is statistically significant in accordance with the regression analysis in Table 5. This means that after the implementation of SoyM, the companies who are not committed to zero deforestation would experience an increase of 0,647% in the territorial deforestation risk if soy export increases with 1%. This indicates that even though these companies are not obliged to actively reduce deforestation, they are indirectly affected by the initiatives around them. Consequently, the not-deforestation-free companies has also had an effect from SoyM and are indirectly affected by the initiatives to decrease the deforestation risk in the Amazon. This is in line with zu Ermgassen et al. (2020) who stated in their study in 2017 that 90% of soy export from the Amazon was handled by signatories of SoyM.

Table 5 Territorial deforestation risk in hectare and soy equivalent in tonnes for SoyM, ZDC and not-committed companies

	(1) DF
logSrest1	0.828***
	(0.073)
Dpost2008=1 # logSrest1	-0.181**
	(0.081)
logSSoyM	0.003
	(0.039)
Dpost2008=1 # logSSoyM	-0.007
	(0.046)
logSZDC	0.052*
	(0.027)
Observations	590
municipality	105
R-sq	0.59

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazon. The independent variables are log soy export equivalent tonnes divided into companies in the supply chain who are committed to SoyM, ZDC companies and the remaining companies who are not committed to zero-deforestation to Europe. Additionally, we added the variables one more time, using a dummy variable to only consist of data from after 2008 (depost2008). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. The variables for companies committed to SoyM before and after the implementation of SoyM were not statistically significant. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.

Furthermore, the variable for ZDC companies after 2008 got omitted in the regression analysis due to collinearity. With further investigation of the dataset, we saw that "company commitment" was an active measure after 2008 and is thereby the reason for the variable that got omitted. The beta coefficient for ZDC companies is 0,052 and is statistically significant. After a closer look at the dataset, we found that this could be because there were no municipalities that had registered company commitment before 2009. The coefficient for ZDC companies showed a lower impact on deforestation than the variable for not-deforestation-free companies. We interpret from this that this initiative has a positive effect by reducing the deforestation rate. This corresponds to our expectations for the analysis of this regression. We assume from this that the initiative of ZDC has had a positive effect by reducing the deforestation rate and conclude that this may be due to the monitoring of SoyM which started in 2008, in a way that it may have encouraged companies to engage in protecting the rainforest.

When studying the effect of certification systems, we can interpret that the ZDC companies have had a positive effect on reducing the deforestation risk in the Amazon. This effect may have been caused by the monitoring of SoyM even though this result is not evident in the regression analysis. Furthermore, we find a slight statistically significant decrease in the effect on territorial deforestation risk after the implementation of SoyM in accordance with companies who are not committed to zero deforestation. This can be an indication that these companies have been affected by the initiatives to decrease the deforestation risk in the Amazon indirectly.

5.5 The Cerrado biome

In this section of the analysis, we will first look at how European soy import from the Cerrado affects the territorial deforestation risk in the Cerrado. Furthermore, we will look at the possibility of a spillover effect in territorial deforestation risk from the Amazon to the Cerrado due to the implementation of SoyM in the Amazon.

5.5.1 Territorial deforestation risk due to soy export from the Cerrado to Europe

We will look at how territorial deforestation risk in the Cerrado has changed due to soy export to Europe, since the implementation of SoyM in the neighbouring biome Amazonia. SoyM only protects Amazonia biome and could make the areas outside the Amazon, such as the Cerrado, more prone to deforestation. When conducting this regression analysis, we found more significant results when using Dpost2008 as the year SoyM was implemented. The regression using Dpost2006 is located in Table 10 in the Appendix. The expectation from the regression analysis would be that the deforestation of the Cerrado would increase at a heavier rate after introducing the implementation of SoyM in 2008, than before.

Table 6 shows the results from the regression analysis. For the Cerrado we can see that the beta coefficient was 0,581 for the remaining countries of Europe. This means that if we increase the soy export with 1 % the territorial deforestation risk will increase by 0,581%. After 2008 this coefficient gets slightly lower, to 0,533, which means that the territorial deforestation risk then increases by a slightly smaller amount of 0,533% when soy export is increased by 1%. This decrease in the beta coefficient can be an indicator that the SoyM did influence the territorial deforestation risk of the Cerrado. For Norway, the beta coefficient before 2008 was statistically significant 0,044 which means that if we increase the soy export with 1% the territorial deforestation risk will increase by 0,044%. After SoyM, an increase of 1% in soy export leads to 0,07% increase in territorial deforestation risk. However, the result for Norway after 2008 was not statistically significant and we can thus not claim this effect. On the other hand, France's beta coefficient is statistically significant and decreases from 0,026 to -0,006, meaning, a 1% increase in soy export to France causes a 0,006% decrease in territorial deforestation risk after SoyM.

As we can see from interpretation of the regression analysis in Table 6, France and the remaining countries in Europe show that the Cerrado did experience a decrease in deforestation after the implementation of SoyM. This is contradictory to the expectation we had before we completed the regression analysis and is an indication of an indirect effect from SoyM.

Table 6 Territorial deforestation risk in hectare and soy equivalent in tonnes imported from Norway, France and the remaining countries in the Cerrado biome

	(1) DF
logSrest	0.581***
	(0.028)
Dpost2008=1	-0.781***
	(0.166)
Dpost2008=1 # logSrest	-0.048***
	(0.018)
logSNor	0.044*
	(0.024)
Dpost2008=1 # logSNor	0.026
	(0.028)
logSFr	0.026***
	(0.009)
Dpost2008=1 # logSFr	-0.032***
	(0.010)
Observations	4628
municipality	711
R-sq	0.66

Note: The dependent variable is log territorial deforestation risk in hectare in the Cerrado. The independent variables are log soy equivalent tonnes exported to Norway, France and the remaining countries in Europe. Additionally, we added the variables one more time, using a dummy variable to only consist of data from after 2008 (depost2008). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. This regression contains the fixed effects of year and municipality.

The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.

5.5.2 The Amazonia and the Cerrado biomes

It is reasonable to question if the decline in deforestation of the Amazon is a result of an equal increase in deforestation of the Cerrado, i.e., a spillover effect, caused by soy export to Europe. To further explore the effect of SoyM in the Cerrado, we conducted a regression analysis in Table 7 with both the Amazonia and Cerrado biomes and the impact of SoyM. Like the previous regression analysis, we also conducted this regression using Dpost2006 and Dpost2008. The one using Dpost2006 is located in Table 11 in the Appendix. We expect to find a decrease in deforestation of the Amazon and an increase in the Cerrado. Although, we found a decrease in territorial deforestation risk of the Cerrado due to European soy import in the regression analysis in Table 6, this result may change when we compare the Cerrado and the Amazon in the same regression analysis.

For the Amazonia biome we can see that the beta coefficient was 0,771, which means that if we increase the soy export in equivalent tonnes with 1 % the territorial deforestation risk will increase by 0,771%. After the implementation of SoyM the beta coefficient decreases to 0,661, which means that the territorial deforestation risk then increases by 0,661% when soy export is increased by 1%. This decrease is statistically significant and indicates that SoyM did influence the deforestation of the Amazon in the way that was expected. The Cerrado on the other hand, had a slightly lower decrease, also statistically significant, from 0,606 to 0,541, meaning, that after the implementation of SoyM, a 1% increase in soy export leads to 0,541% increase in the territorial deforestation risk of Cerrado. The correlations for the independent variables were slightly higher when we used 2006 (Table 11 in the Appendix), although the result remain the same.

Table 7 Territorial deforestation risk in hectare and soy equivalent in tonnes in the Amazonia and the Cerrado biomes before and after SoyM

	(1) DF
logSAmaz	0.771***
	(0.060)
Dpost2008=1	-0.787***
	(0.163)
Dpost2008=1 # logSAmaz	-0.110***
	(0.019)
logSCer	0.606***
	(0.027)
Dpost2008=1 # logSCer	-0.065***
	(0.017)
Observations	5218
municipality	816
R-sq	0.64

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazonia and the Cerrado biome. The independent variables are log soy equivalent tonnes exported from the Amazon and the Cerrado to Europe. Additionally, we added the variables one more time, only consisting of data from after 2008 (depost2008). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. T This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.

Other initiatives have been inserted to preserve the Cerrado, such as companies who commits to protect the area from deforestation. One can argue that these measures is a reaction to the pressure of the worldwide engagement in saving the world's forests. It can also be a reaction to SoyM. As we know from the dataset, some companies who exports soy from Brazil is committed to zero deforestation through own company-terms. This can be an indicator on why the deforestation decrease in the Cerrado biome are in line with the decrease of deforestation in Amazonia. On the other hand, zu Ermgassen et al. (2020) concluded that there was no reduction in the deforestation risk due to soy from ZDC actors in the Cerrado. There can thus be several reasons for the effect that has been observed in the Cerrado.

As stated in the literature background, Magalhães et al. (2020) concluded that the reason for the changes in agriculture was due to man-made disturbances, such as fires, deforestation and governance issues. Additionally, Trigueiro, Nabout and Tessarolo (2020) found a total loss of native vegetation of 46%. On the other hand, Parente et al. (2020) found that 33% of the deforestation in the Cerrado was converted into agriculture in the period 2016-2018. Since the Cerrado is not included in SoyM, there has been a concern that it would result in a spillover effect where the forest spared from deforestation in the Amazon would result in increased deforestation in the Cerrado. In the regression analysis above we looked further into if the decline in deforestation of the Amazon would result in an equal increase in deforestation of the Cerrado. The results showed that like the Amazon, the Cerrado had a decrease in deforestation after the implementation of SoyM. We can therefore not argue that there was a spillover effect because of the implementation of SoyM. On the contrary, the Cerrado has had a slight decrease in deforestation after SoyM, leaving the question if there was an indirect impact on the Cerrado.

6 Limitations

As mentioned in the empirical strategy section, the dataset was very advanced to work with. It is complex and contains the entire supply chain from export country to import country. Throughout the empirical strategy we looked at different aspects of the supply chain in the analysis. It took time to process and collapse the dataset, before we could begin to analyse the data in regression analysis. A potential pitfall with our regression models is the possibility of endogeneity. We built this thesis on the assumption that higher soy export causes higher deforestation and that soy exports are independent of residues. We discussed this in depth in section 4.2.3, where we raised the concern of an OVB problem. We cannot know for sure if there is an OVB problem in our regressions, and we thereby assume that soy exports are independent of residues in our regression models. This is a challenge we could not solve for this thesis, but we have considered and investigated it. For further research it would be interesting to try to solve the OVB problem by looking for alternative empirical designs.

7 Conclusion

The purpose of this thesis was to establish how European countries through import of soy, contribute to the deforestation of one of the world's most important ecosystems, the Amazon rainforest. From the regression analyses in section 5.2, we were able to establish a relationship between territorial deforestation risk and soy exported from municipalities in Brazil to European importing countries. This was supported by previous research and background information presented in section 2 and 3. It is also evident that SoyM contribute to lower territorial deforestation risk rates, as presented in the regression analysis in Table 4. By adding the introduction of SoyM to the regression, we observed that the independent variable, the remaining countries in Europe, had significantly contributed to a decrease in territorial deforestation risk of the Amazon as an effect of the implementation of SoyM. This is also consistent with the model for deforestation, which we presented in section 2. When adding the introduction of implementing SoyM we found an immediate increase in price of forestland and a decrease in forest land converted to agriculture. These findings are supported by previous research and background information presented in section 2 and 3.

During our analysis we also studied the effect that companies in the supply chain for soy export from municipalities in Brazil to Europe have on the deforestation of the Amazon. We distinguish between SoyM committed companies, ZDC companies and companies who are not committed to zero deforestation. Through our regression analysis in Table 5 in section 5.4 we wanted to see how the committed companies affected the territorial deforestation risk, as opposed to companies who are not committed. We found that companies who are not committed to zero deforestation had a slight, but statistically significant, decrease in the effect on territorial deforestation risk after the implementation of SoyM. This suggest that companies who are not committed to zero deforestation has had an indirect effect by the initiatives to decrease the deforestation risk in the Amazon. Furthermore, we interpret that the initiative of ZDC has had a positive effect by reducing the deforestation rate and conclude that this may be due to the monitoring of SoyM which started in 2008 even though this result is not evident in the regression analysis.

When studying European contribution to the deforestation of the Amazon, it is also natural to consider the neighbouring biome, the Cerrado. Since soy is produced in both the Amazon and the Cerrado, the concern is that laws and regulation in one would affect the other. In Table 6 we looked at how territorial deforestation risk in the Cerrado has changed in accordance with European soy import since the implementation of SoyM in the Amazon. The results showed that the Cerrado experienced a statistically significant decrease in deforestation after the implementation of SoyM towards soy export to France and the remaining countries in Europe. This was contradictory to the expectation we had for the regression analysis. To further investigate this result, we conducted a regression analysis with both the Amazonia and Cerrado biomes to look at the possibility of a spillover effect in territorial deforestation risk from the Amazon to the Cerrado due to the implementation of SoyM in the Amazon. The results in the regression analysis in Table 7 showed that like the Amazon, the Cerrado had a decrease in deforestation after the implementation of SoyM. With this as basis we cannot argue that there has been a spillover effect due to the implementation of SoyM. On the contrary, the Cerrado has had a slight decrease in deforestation after SoyM.

In the institutional background in section 3, we discussed the use of GMO in soy production. The topic is highly relevant to our research question, as the production of non-GM soybeans has decreased rapidly over the last years in South America, for the benefit of GM soybeans. We questioned whether GM crops could be part of the solution to reduce deforestation, as farmers need less land to produce the same amount of food. However, this is not something we have analysed in our study and further research is needed. Another interesting topic for further research would be the effect of monitoring and policies on reducing deforestation in the Amazon. Through our regression analyses we find evidence that suggest that monitoring is effective as some of the results were statistically significant when using 2008 and not when using 2006. Although we do not observe this effect, it is consistent with previous research. We can therefore propose that policy reforms, incentives and regulations are somewhat necessary to reduce deforestation. This would have to be researched further, but it would be quite interesting to observe the effects.

8 List of References

Boring, N. (2020, December 12). *Restrictions on Genetically Modified Organisms: France*. Retrieved from Library of Congress Law March 18th, 2021: https://www.loc.gov/law/help/restrictions-on-gmos/france.php

Brookes, G., & Barfoot, P. (2018, May 11). *Environmental impacts of genetically modified (GM) crop use 1996-2016: Impacts on pesticide use and carbon emissions.* Retrieved from Tandfonline April 3rd, 2021: https://www.tandfonline.com/doi/pdf/10.1080/21645698.2018.1476792?needAccess=true

Cassidy, E. (2016, March). *Are GMOs Bad for the Environment?* Retrieved from AgMag April 1st, 2021: https://www.ewg.org/agmag/2016/03/are-gmos-bad-environment

Earth Observatory. (2007, March 30). *Causes of Deforestation: Direct Causes*. Retrieved from Earth Observatory January 30th, 2021: https://earthobservatory.nasa.gov/features/Deforestation/deforestation_update3.php

European Commission. (n.d.). *A European Green Deal*. Retrieved from European Commission February 7th, 2021: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

European Commission. (2019, July 23). *EU Communication (2019) on stepping up EU action to protect and restore the world's forests*. Retrieved from European Commission February 7th, 2021: https://ec.europa.eu/info/publications/eu-communication-2019-stepping-eu-action-protect-and-restore-worlds-forests_en

FAIRR. (2021). *Amazon Soy Moratorium*. Retrieved from FAIRR April 2nd, 2021: https://www.fairr.org/engagements/amazon-soy-moratorium/

FEFAC. (2021, February). *FEFAC Soy Sourcing Guidelines 2021.* Retrieved from FEFAC March 15th, 2021: https://fefac.eu/wp-content/uploads/2021/02/FEFAC-Soy-Sourcing-Guidelines-2021.pdf

Frost, J. (2021). *Confounding Variables Can Bias Your Results*. Retrieved from Statistics By Jim May 5th, 2021: https://statisticsbyjim.com/regression/confounding-variables-bias/

Gibbs, H. K., Rausch, L., Munger, J., Schelly, I., Morton, D. C., Noojipady, P., . . . Walker, N. F. (2015, January). *Brazil's Soy Moratorium.* Retrieved from Research Gate: https://www.researchgate.net/publication/271213939_Brazil%27s_Soy_Moratorium

Gollnow, F., de Barros Viana Hissa, L., Rufin, P., & Lakes, T. (2018). Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil. *Land Use Policy 78*, pp. 377-385.

Greenpeace. (2016, May 22). *10 Years Ago the Amazon Was Being Bulldozed for Soy — Then Everything Changed*. Retrieved from Greenpeace January 15th 2021: https://www.greenpeace.org/usa/victories/amazon-rainforest-deforestation-soy-moratorium-success/

Greenpeace. (n.d.). *Brazil and the Amazon Forest*. Retrieved from Greenpeace January 16th, 2021: https://www.greenpeace.org/usa/issues/brazil-and-the-amazon-forest/

Harding, T., Herzberg, J., & Kuralbayeva, K. (2021, April 8). *Commodity prices and robust environmental regulation: Evidence from deforestation in Brazil. Journal of Environmental Economics and Management.* Retrieved from https://doi.org/10.1016/j.jeem.2021.102452

Hofverberg, E. (2020, December 30). *Restrictions on Genetically Modified Organisms: Norway*. Retrieved from Library of Congress March 18th, 2021: https://www.loc.gov/law/help/restrictions-on-gmos/norway.php

IDH. (2020, May). *European Soy Monitor.* Retrieved from IDH Sustainable Trade April 17th, 2021: https://www.idhsustainabletrade.com/uploaded/2020/05/IDH-European-Soy-Monitor-v2.pdf

Jansen, H. S. (2018, June). *A Brazilian Soy Story - How International Soy Demand Affects Deforestation and Agricultural Land Use [Master thesis]*. Retrieved from The Norwegian School of Economics: https://openaccess.nhh.no/nhh-xmlui/bitstream/handle/11250/2560748/masterthesis.PDF?sequence=1&isAllowed=y

Journey, E. (2021, February). *Where are GMO's banned?* Retrieved from GMO Watch April 18th, 2021: https://gmowatch.com/where-are-gmos-banned/

Kastens, J. H., Brown, J. C., Coutinho, A. C., Bishop, C. R., & Esquerdo, J. C. (2017). Soy Moratorium Impacts on Soybean and Deforestation Dynamics in Mato Grosso, Brazil. PloS one. *12 (4)*.

Kelly, B. (2020, June 23). *Investorer som Storebrand og KLP ut mot Brasils avskoging: – Vi er dypt bekymret. [Photograph]*. Retrieved from E24 May 10th, 2021: https://e24.no/internasjonal-oekonomi/i/g75W4k/investorer-som-storebrand-og-klp-ut-mot-brasils-avskoging-vi-er-dypt-bekymret

Kusumaningtyas, R., & van Gelder, J. (2019, June). *Setting the bar for deforestation-free soy in Europe A benchmark to assess the suitability of voluntary standard systems.*

Retrieved from Research Gate: https://www.researchgate.net/publication/333810941_Setting_the_bar_for_deforestation-free_soy_in_Europe_A_benchmark_to_assess_the_suitability_of_voluntary_standard_systems

Lundeberg, H., & Grønlund, A. L. (2017). *From Brazilian farms to Norwegian tables.* Retrieved from Rainforest Foundation Norway and Future in Our Hands: https://d5i6is0eze552.cloudfront.net/documents/Publikasjoner/Andre-rapporter/Rapport_Soya_eng.pdf?mtime=20180319134546

Magalhães, I. B., de Paula Pereira, A. S., Calijuri, M. L., do Carmo Alves, S., dos Santos, V. J., & Lorentz, J. F. (2020, September 3). Brazilian Cerrado and Soy moratorium: Effects on biome preservation and consequences on grain production. *Land Use Policy (99) 105030*.

Nassar, A., & Rudorff, B. (2018, December 18). *Soy Moratorium, Monitoring soy crops in the Amazon biome using satellite images.* Retrieved from ABIOVE Agrosatélite: https://abiove.org.br/wp-content/uploads/2019/01/Soy-Moratorium-Report-2018.pdf

Parente, L., Nogueira, S., Baumann, L., Almeida, C., Maurano, L., Affonso, A. G., & Ferreira, L. (2020, November 19). Quality assessment of the PRODES Cerrado deforestation data. *Remote Sensing Applications: Society and Environment (21) 100444*.

Perman, R., Ma, Y., Common, M., Maddison, D., & McGilvray, J. (2011). *Natural Resource and Environmental Economics. (Fourth edition).* Harlow, England: Pearson Education Limited.

ProTerra Foundation. (2021, February 16). *The non-GM production: how volatility is killing the supply chain in Brazil*. Retrieved from ProTerra Foundation March 14th, 2021: https://www.proterrafoundation.org/news/the-non-gm-production-how-volatility-is-killing-the-supply-chain-in-brazil/

ProTerra Foundation. (n.d.). *Our Approach*. Retrieved from ProTerra Foundation March 14th, 2021: https://www.proterrafoundation.org

Rainforest Foundation Norway and Future in Our Hands. (2018, October). *Salmon on soy beans - deforestation and land conflict in Brazil.* Retrieved from Rainforest Foundation Norway/Regnskogfondet and Future in Our Hands /Framtiden i våre hender. Research in collaboration with Reporter Brasil: https://www.framtiden.no/aktuelle-rapporter/849-salmon-on-soy-beans-deforestation-and-land-conflict-in-brazil/file.html

Regnskogfondet. (n.d.). *Problemet med soya*. Retrieved from Regnskogfondet: https://www.regnskog.no/no/om-regnskogfondet/dette-mener-regnskogfondet/problemet-med-soya

Robalino, J., & Herrera, L. D. (2010). *Trade and deforestation: A literature review. WTO Staff Working Paper, No. ERSD-2010-04.* Retrieved from Econstore: https://www.econstor.eu/bitstream/10419/57620/1/639992439.pdf?fbclid=IwAR1tgdyLHteGu_INo12rQLoCihEbOLFfwlcz3yNyQhb48JzOgyIHangJfhA

RTRS a. (n.d.). *Certification Scope*. Retrieved from RTRS March 15th 2021: https://responsiblesoy.org/certificacion?lang=en

RTRS b. (n.d.). *What is the Round Table on Responsible Soy Association?* Retrieved from RTRS March 15th, 2021: https://responsiblesoy.org/sobre-la-rtrs?lang=en

RTRS c. (n.d.). *Members*. Retrieved from RTRS March 15th, 2021: https://responsiblesoy.org/members?lang=en#nuestros-miembros

Schnepf, R. D., Dohlman, E., & Bolling, C. (2001). Agriculture in Brazil and Argentina: Developments and Prospects for Major Field Crops. *Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture, Agriculture and Trade Report. WRS-01-3*.

Silva Junior, C. H., Pessôa, A. C., Carvalho, N. S., Reis, J. B., Anderson, L. O., & Aragão, L. O. (2020, December 21). *The Brazilian Amazon deforestation rate in 2020 is the greatest of the decade.* Retrieved from Nature April 2nd, 2021: https://www.nature.com/articles/s41559-020-01368-x.pdf

Silva, C. J., & Lima, M. (2018). Soy Moratorium in Mato Grosso: Deforestation undermines the agreement. *Land Use Policy 71*, pp. 540-542.

Stata. (n.d.). *xtreg — Fixed-, between-, and random-effects and population-averaged linear models.* Retrieved from Stata April 10th, 2021: https://www.stata.com/manuals/xtxtreg.pdf

Svahn, J., & Brunner, D. (2018, Spring). *Did the Soy Moratorium Reduce Deforestation in the Brazilian Amazon? A Counterfactual Analysis of the Impact of the Soy Moratorium on Deforestation in the Amazon Biome [Master thesis].* Retrieved from Norwegian School of Economics: https://openaccess.nhh.no/nhh-xmlui/bitstream/handle/11250/2560493/masterthesis.PDF?sequence=1&isAllowed=y

Trase. (2018, December). *Supply chain mapping in Trase.* Retrieved from Trase.earth June 8th 2021: http://resources.trase.earth/documents/Trase_supply_chain_mapping_manual.pdf

Trase. (2020, September 14). *Trase data can help tackle global extinction crisis*. Retrieved from Trase Insights June 8th, 2021: https://insights.trase.earth/insights/insight-trase-data-can-help-tackle-global-extincti/

Trase. (2021a, June 11). *About: Partners*. Retrieved from Trase.earth June 11th, 2021: https://supplychains.trase.earth/about/partners

Trase. (2021b, June 9). *About: What is Trase*. Retrieved from Trase.earth June 9th, 2021: https://www.trase.earth/about/

Trase. (2021c, June 10). *Trase Supply Chains*. Retrieved from Trase.earth June 10th, 2021: https://supplychains.trase.earth/flows/data-view?toolLayout=1&countries=27&commodities=1&fbclid=IwAR2tKuZblshINHpfdDP_OBATDEmEESNdK5ahlIL3tlp5FrXL2gq6_owQ8DY&selectedColumnsIds=0_14-1_22-2_9-3_16&wdLOR=c147B0CEB-0D33-364A-84D0-BF75A101A2E0

Trigueiro, W. R., Nabout, J. C., & Tessarolo, G. (2020, August 22). Uncovering the spatial variability of recent deforestation drivers in the Brazilian Cerrado. *Journal of Environmental Management (275) 111234*.

Tyukavina, A., Hansen, M. C., Potapov, P. V., Stehman, S. V., Smith-Rodriguez, K., Okpa, C., & Aguilar, R. (2017). Types and Rates of Forest Disturbance in Brazilian Legal Amazon, 2000-2013. *Science Advances, 3 (4), e1601047*.

Verburg, R., Filho, S. R., Lindoso, D., Debortoli, N., Litre, G., & Bursztyn, M. (2014, March). The impact of commodity price and conservation policy scenarios on deforestation and agricultural land use in a frontier area within the Amazon. *Land Use Policy 37*, pp. 14-26.

WHO. (2021a). *Food, Genetically modified, Overview*. Retrieved from World Health Organization April 1st, 2021: https://www.who.int/health-topics/food-genetically-modified#tab=tab_1

WHO. (2021b). *Food, Genetically modified, Safety*. Retrieved from World Health Organization April 1st, 2021: https://www.who.int/health-topics/food-genetically-modified#tab=tab_2

Willis, H. (n.d.). *Are GMO soybeans the way to go?* Retrieved from Eco farming Daily March 18th, 2021: https://www.ecofarmingdaily.com/grow-crops/grow-soybeans/choosing-soybean-seeds/are-gmo-soybeans-the-way-to-go/

WWF. (2016, May 10). *Soybean Moratorium is extended for indefinite period*. Retrieved from WWF February 10th, 2021:

https://www.wwf.org.br/informacoes/english/?52122/Soybean-Moratorium-is-extended-for-indefinite-period

WWF. (2017, October 25). *International companies support "deforestation-free" meat and soy in the Cerrado*. Retrieved from WWF May 10th, 2021: https://www.wwf.org.br/informacoes/english/?61602/International-companies-support-zero-deforestation-in-the-Cerrado

WWF. (2020). *The vital links between the Amazon rainforest, global warming and you*. Retrieved from WWF February 7th, 2021: https://wwf.panda.org/discover/knowledge_hub/where_we_work/amazon/about_the_amazon/why_amazon_important/

WWF. (n.d.). *Species of the savanna*. Retrieved from WWF March 10th, 2021: https://wwf.panda.org/discover/knowledge_hub/where_we_work/cerrado/

zu Ermgassen, E. K., Ayre, B., Godar, J., Lima, M. G., Bauch, S., Garrett, R., . . . Gardn. (2020, February 18). *Using supply chain data to monitor zero deforestation commitments: an assessment of progress in the Brazilian soy sector.* Retrieved from Environmental Research Letters May 4th, 2021: https://iopscience.iop.org/article/10.1088/1748-9326/ab6497/pdf

9 Appendix

Here are the additional regression analyses located.

Table 8 Territorial deforestation risk in hectare and soy equivalent in tonnes for Norway, France and the remaining countries in Europe (Dpost2006)

	(1) DF
logSrest	0.758***
	(0.133)
Dpost2006=1 # logSrest	-0.091
	(0.134)
logSNor	-0.002
	(0.038)
Dpost2006=1 # logSNor	0.023
	(0.044)
logSFr	0.064
	(0.059)
Dpost2006=1 # logSFr	-0.023
	(0.059)
Observations	590
municipality	105
R-sq	0.58

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazon. The independent variables are the logarithm of the variables SNor, SFr and Srest. SNor is soy equivalent in tonnes exported to Norway. SFr is soy equivalent tonnes exported to France. Srest is soy equivalent tonnes exported to the remaining countries in Europe. Additionally, we added the variables one more time, using a dummy variable to only consist of data from after 2006 (depost2006). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. The variable logSrest was the only independent variable who were statistically significant. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level. Due to the possibility of OVB, we interpret the results at a correlation driver, rather than at causality.

Table 9 Territorial deforestation risk in hectare and soy equivalent in tonnes for SoyM, ZDC and not-committed companies (Dpost2006)

	(1) DF
logSrest1	0.809***
	(0.090)
Dpost2006=1 # logSrest1	-0.108
	(0.099)
logSSoyM	-0.011
	(0.023)
logSZDC	0.050*
	(0.026)
Observations	590
municipality	105
R-sq	0.58

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazon. The independent variables are log soy export equivalent tonnes divided into companies in the supply chain who are committed to SoyM, ZDC companies and the remaining companies who are not committed to zero-deforestation to Europe. Additionally, we added the variables one more time, only consisting of data from after 2006 (Dpost2006). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. The variables for companies committed to SoyM and ZDC companies after 2006 got omitted due to collinearity. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.

Table 10 Territorial deforestation risk in hectare and soy equivalent in tonnes imported from Norway, France and the remaining countries in the Cerrado biome (Dpost2006)

	(1) DF
logSrest	0.608***
	(0.028)
Dpost2006=1	-0.589***
	(0.163)
Dpost2006=1 # logSrest	-0.076***
	(0.017)
logSNor	0.042
	(0.026)
Dpost2006=1 # logSNor	0.028
	(0.028)
logSFr	0.022*
	(0.012)
Dpost2006=1 # logSFr	-0.023*
	(0.012)
Observations	4628
municipality	711
R-sq	0.66

Note: The dependent variable is log territorial deforestation risk in hectare in the Cerrado. The independent variables are log soy equivalent tonnes exported to Norway, France and the remaining countries in Europe. Additionally, we added the variables one more time, using a dummy variable to only consist of data from after 2006 (depost2006). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.

Table 11 Territorial deforestation risk in hectare and soy equivalent in tonnes in the Amazonia and the Cerrado biomes before and after SoyM (Dpost2006)

	(1) DF
logSAmaz	0.834***
	(0.063)
Dpost2006=1	-0.604***
	(0.161)
Dpost2006=1 # logSAmaz	-0.164***
	(0.023)
logSCer	0.628***
	(0.026)
Dpost2006=1 # logSCer	-0.087***
	(0.016)
Observations	5218
municipality	816
R-sq	0.64

Note: The dependent variable is log territorial deforestation risk in hectare in the Amazonia and the Cerrado biome. The independent variables are log soy equivalent tonnes exported from the Amazon and the Cerrado to Europe. Additionally, we added the variables one more time, using a dummy variable to only consist of data from after 2006 (Dpost2006). These Dpost variables is added to the original variables to show the change in the beta coefficient after the implementation of SoyM. * means statistically significant at 10% level, ** at 5% level and *** at 1% level. This regression contains the fixed effects of year and municipality. The error term is uncorrelated with the other terms in the equation. The value in the parenthesis is the standard errors, which are clustered on municipality level.