UCLouvain

UNIVERSITÉ DE NAMUR

Economics School of Louvain - ESL

Economics School of Namur - ESN

MACROECONOMIC EFFECTS ON DEFORESTATION OF THE EU-MERCOSUR TRADE DEAL

Estimation and Considerations for the Environment Debate

Author : Daniel Funari Fouto

Thesis Director : Joseph Flavian Gomes

Academic Year 2020-2021

Master in Economics – 60 credits

Université catholique de Louvain - Economics School of Louvain - Place Montesquieu 3, 1348 Louvain-La-Neuve
Université de Namur – Economics School of Namur – Rempart de la Vierge 8, 5000 Namur

TABLE OF CONTENTS

1. Acknowledgments 3
2. Abstract 4
3. Introduction 5
4. Background, Review and Debate 6
   Amazon Deforestation and Recent Turmoil 6
   EU-Mercosur 9
5. Methodology 11
   Robustness check 15
   Data 15
6. Results 18
   Model results 18
   Robustness check results 19
7. Discussion 20
   Challenges 23
8. Conclusion 24
9. Appendix 26
10. Bibliography 29

1. Acknowledgments

The biggest thanks I owe to the authorities of the State of São Paulo and of the University, to the employees and professors at the economics school and to all the Brazilian people, who gave me the opportunity to study. Following that, I also thank the UCLouvain for the continuity of my studies in economics, and my parents that afforded it.

As for the elaboration of this work, I thank professor Joseph Gomes, from UCLouvain's school of economics, for his assistance, responsible for major changes and improvements. And I thank professor Nuno Fouto, from USP's (University of São Paulo) business school, for corrections in the text and in the structure of the work.

Finally, I thank my wife Aurélie, professor Dante from the USP's school of economics, and everyone at the Bradesco Economic Research Department, who helped directly or indirectly in the elaboration of this work and during my academic trajectory.

2. Abstract

The major detractors of the EU-Mercosur agreement claim that as it may boost Brazil’s exports, it may also increase deforestation. This work estimates the possible macroeconomic effects of EU-Mercosur agreement on deforestation in Brazil's Amazon Forest. The estimation uses impulse response functions from local projections with annual panel data for all states of Legal Amazon region, covering the period from 1988 to 2020. It can be observed that no change in deforestation trajectory would come with an export increase, so, reinforcing the conclusions of previous studies. No major environment impact should come from the deal itself, but rather from the way institutions and companies will deal with environment protection by means of laws and cooperation.

3. Introduction

After two decades of negotiations, the European Union (EU) and the South American bloc (Mercosur) finally reached a trade deal. Soon after the deal, concerns emerged – at least, gained strength in the debate – regarding the impact it could have on the environment, mainly on the Amazon forest[1]. The deal is not yet signed, and it is unclear what its future should be, especially after these concerns were also shared by part of European heads of state and members of the European Parliament[2]. In response to those concerns, some studies have been produced trying to bring light to these concerns and help the institutions to make better decisions[3], yet no estimates have been made as to whether and what impact the increase in consummation (exports) will have over the Amazon deforestation. Answering this question also contributes to making decisions to overcome this issue. That is why it is was decided to address this subject in this work and try to answer this question by directly estimating what should be the impact on deforestation in the case of export increase.

Deforestation is a complex phenomenon where many drivers are in place and correlated with each other[4], working with microdata and separating each effect would be a difficult task. Therefore, it was chosen to use a macroeconomic approach, using state-level panel data analyses, ranging from 1988 to 2020, and using as observations all states that covered by the Amazon region. The variables chosen are the value of exports of each state, depending on the product and destination, and official numbers on deforestation, and besides this, other important indicators (gross domestic product, total population, and political interference) to control for important trends that also explains deforestation rate trajectory. The model used is an Impulse Response by Local Projection, a method developed by Òscar Jordà (2005), which allows estimating the effect of a shock over a variable of interest (deforestation) using simple techniques of regression, without the need for specification or estimation of an underlying model. Furceri et al. (2018) also use this technique, and their material available helped to construct and estimate the model. The sources of the data are from official public institutes from Brazil: INPE (National Institute for Space Research) for deforestation, and IPEA (Institute

[1] "EU-Mercosur trade deal: what it all means", Financial Times (2019).
[2] "Ireland: EU-Mercosur trade deal 'unlikely' during Portuguese presidency", Euractiv (2021).
[3] "Sustainability Impact Assessment in Support of the Association Agreement Negotiations between the European Union and Mercosur", European Commission (2020)
[4] Soares-Filho *et al.* (2005); Costa *et al.* (2021)

of Applied Economic Research) and IBGE (Brazilian Institute of Geography and Statistics) for the remaining data.

The most important result from the model estimation comes from the robustness check analyses, which predicts that the increase in exports to EU of soy, beef, wood, and palm goods and derivates would not significantly increase deforestation. This shows that exports to Europe and deforestation hold weak correlation with each other, while global trends and internal aspects of the country are much more impacting, which can relate to other findings and is in line with the debate about the subject.

The first section presents a review of important facts, research on subject of discussion and the recent environmental debate, and is subdivided in two subsections: one on the historical process of Amazon deforestation, in an environmental, economic and political point of view, and the second one on recent facts and studies about the EU-Mercosur trade deal. Then the sections Methodology, Data and Results, present the details about the construction of the empirical model and its results. The Discussion section will comment the recent environmental debate and ideas of how to conduct the EU-Mercosur trade deal using the empirical findings, previous findings, and recent facts; followed by Challenge's subsection that addresses some important considerations regarding this work.

4. Background, Review and Debate

Amazon Deforestation and Recent Turmoil

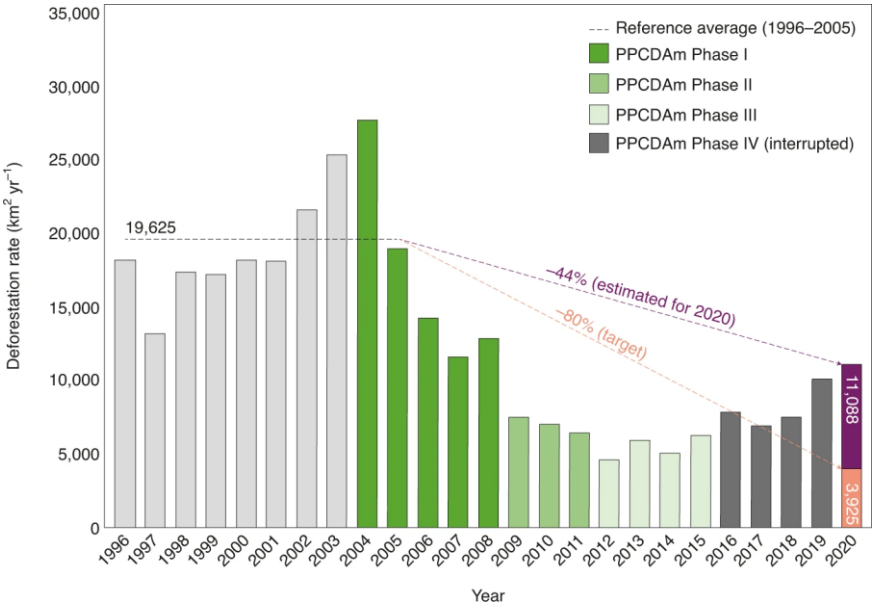
Many studies track the historical and present causes of deforestation in the Amazon forest. Among those studies, Soares-Filho *et al*. (2005) gather important publications about the subject to give a clear historical background and the current trends, and clearly defines the main drivers of deforestation, which are often correlated. The authors resume that, historically, deforestation began with tax incentives and colonization policies, which triggered a strong migration to the Amazon as an escape valve for the social problems of other regions (land conflicts usually motivated by land ownership and pressure for agrarian reform). Nepstad *et al*. (2001) also points that the economic scenario has favored past and present logging in the region. More recently, the global scenario has favored the expansion of cattle

ranching (beef meat industry) and the agribusiness boom in the region[5] (Soares-Filho *et al*. 2005), since a set of factors that contributed to the profitability of agricultural and livestock activity in the region came along with an increase in commodity prices (Costa *et al.* 2021). Finally, investments in infrastructure, especially road construction and pavement, play an indirect role, since they promote the economic viability of agriculture and logging deeper into the forest, with a consequent appreciation of the value of these areas[6]. These appreciation effects have so much influence on the increase in environmental damage, that transportation infrastructure could be the most important factor to locate and estimate the scale of deforestation, as in 2006 more than 75% of forest clearing in Brazilian Amazon occurred within 50 kilometers of a paved highway (Nepstad *et al*. 2001; Soares-Filho *et al*. 2006).

But changes in government policies, starting from 1996 with the establishment of new protected areas in the Brazilian Amazon - including indigenous reserves and sustainable use areas - after a deforestation spike in 1995, marks the beginning of the change in deforestation trend (Boucher *et al*. 2014). After deforestation spike again in 2004, partly because of poor governance and increasing international demand for agricultural commodities such as soy (Gregory 2017), the initial program was expanded and became part of a broader plan to combat Amazon destruction - the PPCDAm (Plan for the Prevention and Combating of Deforestation in the Amazon) (Boucher *et al*. 2014). In the years that followed, rates dropped consecutively, so that in 2012, Brazil achieved an unprecedented feat among tropical countries by reducing deforestation rates in Amazonia by 84% compared to the previous peak (2004). This achievement resulted from multiple government initiatives, particularly the PPCDAm and international pressure, such as the soy and beef moratoria (Silva Junior *et al*. 2020).

[5] Notably the expansion of soybean crops, which usually occurs over pasture areas (Soares-Filho *et al*. 2005)
[6] Carvalho *et al.* (2001); Laurance *et al.* (2001)

FIGURE 1: BRAZILIAN AMAZON DEFORESTATION RATES AND PPCDAM IN PLACE



Source: Silva Junior *et al*. (2020). Note from the authors: "Official deforestation rates for the Brazilian Amazon, taken from PRODES. The target 80% reduction from the 1996–2005 average is also shown. Bar colors represent phases of the Brazilian government's Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm).

Nepstad *et. al* (2014) elaborate a deep analysis of the mechanisms that cause this radical change, and discuss as well many hypotheses of how agents (farmers and politicians) acted and what were their motivations. Enforcement of laws, interventions in soy and beef supply chains (moratoria), restrictions on access to credit, and expansion of protected areas, not only contributed stopping further deforestation, but declined the demand for new deforestation. However, since 2013 rates have been on a significant upward trend, with a 34% increase of forest destruction in 2019, and 9.5% in 2020, reaching the highest rate of deforestation in the decade; resulting in the failure to fulfill the intentions to reduce deforestation as previously engaged (Silva Junior *et al*. 2020). The upward trend in deforestation, according to Silva Junior *et al*. (2020), started with controversial changes in the Brazilian Forest Code in 2012, was intensified by environmental setbacks, and recently have spiked because of Ministry of the Environment's weak enforcement of the law, disregard of climate change policies, and law bills that may regularize illegally grabbed lands. While Nepstad *et. al* (2014) stated, in the first year that deforestation started to climb (2014), that supply chain interventions were precariously dependent on corporate risk management; public policies, by then, relied excessively on punitive measures; and important systems to create positive incentives for farmers to forgo deforestation were not implemented, which was crucial to create cooperation with the law.

As a result, national and international pressure – from former environment ministers, environmentalists, business entities and non-governmental organizations, Organization for Economic Cooperation and Development (OECD), and the EU – has escalated demanding to Brazil to re-establish control of damaging illegal activities or expressing their concerns with the climbing of deforestation in the region (Silva Junior *et al*. 2020). Throughout this recent turmoil, besides the pressure being exerted, much has been produced bringing solutions. Rajão *et al*. (2020) analyze illegal deforestation in the Brazilian Amazon by tracking soy and beef that comes from these cleaned-up areas and are exported to the EU. The authors conclude that Brazil already has efficient programs to fight illegal deforestation and illegal products (that come from illegal damaging properties), so it is possible to "feed the world" while protecting the rich biodiversity of the region. To achieve this outcome the country and its international partners must assume their environmental responsibilities to seek common solutions. Yet the recent tensions and concerns have a special attention in this work because of its impact over the environment debate and international relations. An example, and subject of interest of this study, is the rising chances of compromising the EU-Mercosur deal.

EU-Mercosur

In June 2019, it was announced that the European Union (EU) and South American bloc (Mercosur) finally reached a free trade treaty, which has been discussed for the last 20 years[7]. Giving the market dimension, territorial size, total population of the two blocks, it is an important move in economic terms for the globe[8]. For each country, more than 90% of all goods will have no tariff on imports from the respective partner and all remaining products will have more favorable taxation. For the Mercosur, the deal will help mainly agricultural products to penetrate in the protected European farm sector; as for EU, it will especially help manufactured goods to enter the historically protectionist countries[9]. But, after the deal was announced, critics came up in the debate and the officialization of the still temporary agreement is now compromised.[10]

[7] "EU, Mercosur strike trade pact, defying protectionist wave", Reuters (2019).
[8] "Mercosul e UE fecham maior acordo entre blocos do mundo", Agência Brasil (2019).
[9] "EU-Mercosur trade deal: what it all means", Financial Times (2019); "EU and Mercosur reach agreement on trade", European Commission (2019).
[10] Rajão *et al.* (2020).

Besides the critics of an unfair business model for European producers[11], the spotlight of environmental issue in the EU-Mercosur deal has dwelled in the fact that it might increase the exports of products directly related to deforestation in the Amazon forest, mainly commodities and beef meat[12]. The concern has reached international relations scale, resulting in recent movements demanding to boycott Brazilian products and withhold ratification of the trade agreement[13]. It seems however that this concern does not lie in the impact assessment of the trade agreement itself, but it comes from the analysis of the recent upward trend in deforestation and illegal activities in Amazonia, which was catalyzed by a series of recent environmental setbacks (Silva Junior *et al.* 2020). These two analyses have to be separated, the first one demands an economic estimation, and the second one an investigation on the drivers of the recent trend, as it has been done by many studies (showed in the previous subsection).

This debate is recent and may lack in-depth studies assessing the impact of the trade deal on the environment. Much was written about the drivers of deforestation in Amazon forest, but no study estimated quantitatively what could be the impact of an export increase to the European Union after the trade deal, especially the exportation of beef meat and soy. An important study on this issue is the official report of assessment of the agreement conducted by the consulting team of the London School of Economics to the European Commission. Regarding the possible effects on the environment, especially in the Amazon region, the report conducts a deep risk analysis of the current productive agriculture structure. When it comes to Brazil in particular, the report recognizes that official environmental policies and laws are relatively satisfactory (compared to similar countries); regarding the adoption of climate change policies, the country outperform other Mercosur peers; and regarding rise in deforestation rates after 2014, the report points out it was triggered by a combination of worse economic conditions and deterioration of the commitments to environmental regulation and law enforcement. In conclusion, it considers, particularly in Brazil, moderate concerns about the impact of the agreement on deforestation, in the case where the

[11] "Ireland: EU-Mercosur trade deal 'unlikely' during Portuguese presidency", Euractiv (2021); "What is the new South American beef deal that will affect Ireland?", The Irish Times (2019); "EU-Mercosur trade deal: what it all means", Financial Times (2019).
[12] "Brazil exports to EU produced on illegally cleared land", Euractiv (2020); "Mercosur trade deal threatens to wreck EU's climate credibility", Euractiv (2021); "EU Commission 'failed' on assessing Mercosur trade deal", euobserver (2021); "EU-Mercosur trade deal: what it all means", Financial Times (2019).
[13] Rajão *et al.* (2020); Silva Junior *et al.* (2020)

environmental policy - that allowed past reductions in deforestation - is not maintained and any expansion of the agriculture and animal sectors are met by an increase in forest clearing instead of by increases in productivity and the conversion of existing low efficiency land. This conclusion shows that the study does not concern about export increase, but it points that presently the main determinants of deforestation are the evolution of the Brazil's productive structure and political commitment. However, this research outcome comes from analyzing many indicators, trends, and socioeconomic and political aspects, while there is no empirical estimation of the impact coming from more consumption of Brazilian products. Bringing an estimative of this impact would complement this research and bring more evidence to the recent environmental debate.

5. Methodology

The EU-Mercosur agreement is expected to increase exports of goods that are closely related to deforestation in the Amazon region, thus perhaps worsening this environmental issue. To verify that, an econometric model was constructed to estimate the impact on deforestation possibly caused by the deal. It consists in estimating, for each Brazilian state of the Legal Amazon region[14] (observations in the model), the effect of a positive export shock of these particular goods and compute the average dynamic response of deforestation to export increase. The measurement of the effect is done using an Impulse Response by Local Projection, method developed by Òscar Jordà (2005). Since it estimates a projection for each period of interest rather than creating forecasts from extrapolating a given model – as it is done with a VAR model – it does not require specifications or the estimation of a multivariate dynamic system. This computation brings many advantages[15], Òscar Jordà (2005) name four: (1) It can be estimated by simple econometric techniques, as a fixed effects estimation (which is used in this work). (2) They are more robust to misspecification than comparable time series techniques for impulse response functions. (3) Because coefficients are directly estimated, standard errors from traditional heteroskedasticity and autocorrelation estimation methods

[14] The Brazilian Legal Amazon is an administrative grouping that covers 61% of Brazil's territory. It includes the states of Amazonas, Roraima, Acre, Rondônia, Mato Grosso, Pará, Amapá and Tocantins, as well as part of the states of Mato Grosso and Maranhão (Gregory 2017)

[15] Brugnolini (2018) shows evidence that when dealing with a small sample size and the lags used in the model are misspecified, indeed local projection estimator is a good alternative. However, if the VAR model is well specified, the standard impulse function is a best option as estimator.

provide appropriate joint or point-wise inference, unlike using VAR models, in which inference would be difficult because the coefficients are wide nonlinear functions of estimated parameters. (4) It allows using non-linear and flexible specifications that may be impractical in multivariate time series.

Furceri *et al.* (2018) show that the Local Projection method has been advocated by important researchers and, using a country-level panel data, found robust results for macroeconomic effects of tariffs. In fact, it was used a model structure similar the one applied by Furceri *et al.* (2018), although the subject of research of this current work is different. The available script for Stata constructed by the authors to run the model was also used in order to help understanding how to compute local projections and how to code it on Stata. The response to the export shock is truncated up to 5 years after the first year of the shock, aiming a conservative attitude towards the results.

The regression model was estimated with Stata program "xtscc" using fixed effects with Driscoll and Kraay (1998) standard errors, applying a 90% confidence interval. The Driscoll-Kraay standard errors adapted to Stata are heteroscedasticity consistent, and robust to very general forms of cross-sectional and temporal dependence (Hoechle 2007). The program can compute many control variables and omit information that does not fit the model[16], a useful feature that allows different control variables being added to the regression and let the program consider it if they help explain the variable of interest or not.[17]

The regression used to estimate the effect is the following:

$$(1)\quad Y_{i,t+k} - Y_{i,t-1} = \alpha_i + \delta_t + \beta \Delta T_{i,t} + v \Delta X_{i,t} + PolicyDummy_i + \varepsilon_{i,t}$$

Where, for each state $\boldsymbol{i}$ and in period $\boldsymbol{t}$ or $\boldsymbol{t+k}$:

[16] That is actually what happened when running the model for this work, some control variables were omitted by the program. The script and data are available to replicate it.
[17] Typing "help xtscc" in the Stata command can show these features of the program.

- $\boldsymbol{Y_{i,t+k}}$ is equivalent to the variable of interest, being $ln(\text{annual deforestation})$. The expression $\boldsymbol{Y_{i,t+k} - Y_{i,t-1}}$ give the percentual change in deforestation between $\boldsymbol{t-1}$ (period with no export shock) and $\boldsymbol{t}$ (year of the shock) + $\boldsymbol{k}$ years after the shock.
- $\boldsymbol{\alpha_i}$ is equivalent to state fixed effects in order to control for unobserved cross-state heterogeneity.
- $\boldsymbol{\delta_t}$ equals period fixed effects in order to control for unobservable Amazon region or country shocks.
- $\boldsymbol{\beta}$ equals the coefficient of interest of the equation, showing the response of the variable of interest (deforestation) to a positive change in the exports. In fact, it is the elasticity of the deforestation with respect to selected exports to EU[18].
- $\Delta \boldsymbol{T_{i,t}}$ equals the change in the ln(selected exports to EU). This represents the export shock that the trade deal should cause.
- $\boldsymbol{v}$ equals the vector of the control coefficients.
- $\Delta \boldsymbol{X_{i,t}}$ equals the vector of the control variables. It is composed by two lags of the change in the following variables: the depended variable (ln[annual deforestation]), selected exports to EU ($ln\,[\boldsymbol{T_{i,t-1}}]$ and $ln\,[\boldsymbol{T_{i,t-2}}]$) and relevant variables (total exports, total population, and GDP[19] of the respective state – all in as $ln[.]$).
- $\boldsymbol{PolicyDummy_i}$ it a representation to simplify the following: 4 dummies and its coefficients. Each dummy is a PPCDAm Phase. For example, dummy PPCDAm Phase I has its values 1 for $t = 2005\text{-}2008$ and 0 for the rest, and so on, following each range represented in Figure 1[20]. Policies were implemented at federal level, so all $\boldsymbol{i}$ states have the same dummy.
- $\boldsymbol{\varepsilon_{i,t}}$ equals the residual of the regression.

The control variables are used to capture the most important trends in deforestation and then the model can correctly analyze the impact of an export shock of selected goods. They should, first, pick up the time trend of deforestation since it includes the variable's lagged values. Second, should pick up the impact in deforestation that selected products exported to EU have, controlling this effect in order to correctly capture the effect of a future shock. Total

[18] Exports of goods that are related to deforestation. Data subsection details them.
[19] Gross Domestic Product in real values (2010)
[20] For PPCDAm Phase I the year of 2004 was not included because the program was initiated in the middle of that year.

exports, GDP, and total population are representing the main drivers of deforestation when there is no public policy in place, as previous discussed in this work. These three should capture, respectively, the development of the agribusiness (most of the exports of these states come from this sector[21]); the local development, investments and also agribusiness (correlation of GDP with deforestation can be seen in Figure 7); and of settlement in the region. Still examining Figure 7, after 2004 GDP seems to be much less correlated with deforestation, that roughly shows the impact of public policy and private incentives to combat deforestation. To capture this last aspect, the dummies of the policies in action were inserted ($PolicyDummy$).

One point of concern is that whether the setting, a macro analysis of deforestation using past values to project one period ahead, is really feasible, that is whether deforestation rates follow or not a trend. To answers this concern, it can be used the work developed by Costa *et al.* (2021), in which the same series of deforestation is used, but aggregated (not by ste) and till 2018, to construct a time series model and estimate an impulse response function. Even though aware that deforestation is a complex phenomenon, the authors identify a clear trend in the deforestation rate during the last 30 years, with two evident interventions in the series, 1995 and 2004[22], and construct an intervention model using Box-Jenkins methodology. As a result, the estimates of the model were close to the observed values of deforestation and Mean Absolute Percentage Error was around 2.55%. The well fitted estimate made it possible to plausible forecast for 4 years ahead. If such autoregressive model was used and proved to be feasible, the doubt about the feasibility of the model of this current work is less concerning.

The model constructed for this study takes in account at least 2 lags of deforestation to predict future trend, but, different from Costa *et al.* (2021), uses 9 observations to compute the average and not only one aggregate value. Costa *et al*. (2021) identifies 2 interventions in the series of deforestation rates in the Amazon region, this work, by using period fixed effects ($\boldsymbol{\delta}_t$), should capture these interventions and other smaller shocks for each year of the series.

[21] Export data is available at the Supplementary Material. It shows for each state all products exported from 1989 to 2020. Agribusiness has always been an important sector. The exception is the Amazonas state, a poor state in exports, but with a very industrialized capital responsible for most of the exports.

[22] As shown before, the year 1995 was a record-high in deforestation rate, but one year later the rates fall back into a trend pattern, after a very strict forest code was implemented. The year of 2004 was also a record-high, followed by the implementation of the first PPCDAm, after which the rates also dropped.

Hopefully, with more observations and capture of different shocks, this work can also forecast with good accuracy.

Robustness check

A second concern about the model arises when analyzing the Figure 6 with the export values for each state. It can be noticed that total exports and total exports to EU does not always follow the same trend, as total exports to EU and selected exports to EU seems be more correlated. It is important, therefore, to insert the total exports to EU in the control setting in order to incorporate this unknow difference between trends. By doing this, it will give a more accurate estimation of the right impact from the increase of meat, soy, wood and palm exports to EU. The robustness check procedure consists in using the same setting of equation (1), except that in the vector of control variables ($\boldsymbol{X}_{i,t}$) the term ln(total exports to EU) will be incorporated. With this new variable, the regression will be run again, and the results will be important to understand the significancy of the exports to the EU of products related with deforestation.

Data[23]

If the European exports of products related with deforestation is a potential environmental issue within the EU-Mercosur deal, the best way to assess this is to analyze these products only, and not use total exports to EU. When talking about the recent trends of deforestation, Rajão *et al.* (2020) identify the main causers as cattle and soy illegal productions, calling it "rotten apples of Brazil's agribusiness". As showed before, much of the current environmental debate also points Brazilian production of cattle and soy as main concern. Gregory (2017) ranks the worst products in terms of deforestation as beef and leather, soy, and cotton, calling them "deforestation commodities". Therefore, to compose the variable "selected exports to EU" was chosen to add all products or direct derivatives of soy, cattle, wood, and palm.

Some remarks about the selected exports to EU: Although soy products already have preferred treatment in the EU, so exports are not expected to increase directly because of deal[24], three reasons led the decision of considering it. First, soy exports from Brazil to EU are

[23] All data and more information about the series are available at Supplementary Material

[24] "EU-Mercosur trade deal: what it all means", Financial Times (2019); "Don't allow doubts to stop the EU-Mercosur deal", El País (2021).

too big to be ignored - although China is currently the main destination of Brazil's soy exports - (Rajão *et al*. 2020). Second, the exports of soy products to EU are an object of deep concern among environmentalists [25]. Third, as the trade deal strengthens the commercial ties between the two blocks, soy export growth could come indirectly from it, working as conservative approach to not underestimate the impact of the treaty. Regarding the selection of wood and palm products, they can be directly appointed as deforestation causers, although exports are much lower (Gregory 2017), notably Palm production, of which recent growth has drawn attention[26]. In conclusion, wood and palm products may not influence much the results of the model, but it is worth including them. Finally, cotton exports were no considered among deforestation products to EU because they make less than 2% of the exports to the bloc, and there is no forecast that it should increase with the trade agreement (Gregory 2017).

Regarding the mining activity, Sonter *et al.* (2017) show it has a significant effect on deforestation when considering the indirect pathways that it creates. Although the attention and concern about this issue have increased in the last few years, especially after the valorization of gold prices during the Covid-19 crises (Calvimontes *et al*. 2020), there are 4 reasons why not considering the mining activity in the selected export no EU. (1) Mining is not among the main drivers of deforestation, at least not in the short run. When it comes about exports to the rest of the world or to EU, analysts are more concern about agriculture and livestock (Gregory 2017). (2) The impacts of this activity are complex, for their development are over long period of time and long distance from the mining place (Sonter *et al*. 2017). (3) There is no evidence that the minerals and metal goods should increase with the trade deal. (4) Much of the recent the increase of the mining activity is due to illegal logging (Siqueira-Gay and Sánchez 2021), which may not be well represented in the official export data. In any case, the total export of each state is a control variable, so if there is any forgotten impact of the mineral and mining export on deforestation, this is at least being controlled by the model.

All the export data comes from the Ministry of the Economy (more specifically from the Comex Stat website[27]). The range of the data used is 1989-2020. Many destination options and type of product exported are available. The destination used was exports to world (for

[25] "The Companies Behind the Burning of the Amazon", Mighty Earth (2019)
[26] "New palm oil frontier sparks scramble for land in the Brazilian Amazon", Mongabay (2021)
[27] Historical data are found at http://comexstat.mdic.gov.br/en/dado-historico and earlier at http://comexstat.mdic.gov.br/en/geral

the variable total exports) and exports to Europe (for the variable exports to EU[28]). The selection among all product options to create the variable "selected exports to EU" was made by analyzing the description for each product, which made it possible to distinguished soy, beef, wood and palm goods or derivatives [29]. To facilitate the analysis, all products that between 1989-2020 never sold at least in one year an amount greater than $50,000 were excluded. There are some missing values or no exports to EU in some states with smaller economic weight (Roraima and Tocantins), as Figure 6 shows.

All deforestation data comes from the PRODES database[30](more specifically, TerraBrasilis initiative) of the INPE (National Institute for Space Research), that has been monitoring Legal Amazon region by satellites since 1988 and producing annual deforestation rates for the region. The time span is 1988-2020 and the rates are at state level. Few observations are missing and are concentrated in states with smaller economic weight (Amapá and Tocantins) as Figure 6 shows.

GDP and total population data come from IPEA (Institute of Applied Economic Research) on Ipeadata website[31] and IBGE[32] (Brazilian Institute of Geography and Statistics), government official institutes for research and statistics, respectively. There are no missing values for all states, GDP data range is 1988-2018 and population data 1988-2020. Older data from the series can be found in IPEA (before 2010 in the case of GDP and before 2004 for total population) and earlier ones can be found in IBGE.

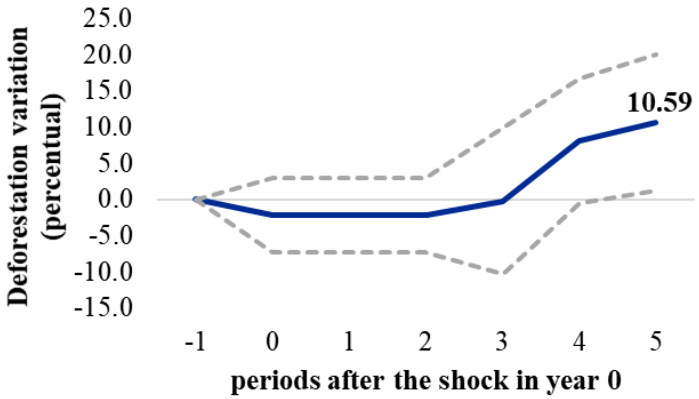
[28] It was chosen to use the export values to Europe as a whole and not only specifically to the EU because of two reasons: First, they do not differ much. Second, doing so will cover the hypotheses that the trade deal would have indirect consequences in Europe as whole, acting as a conservative approach in order not to underestimate the increase of trade and the impact on deforestation.
[29] List of all selected products can be found in the Supplementary Material.
[30] Available at http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/rates
[31] Available at http://www.ipeadata.gov.br/Default.aspx
[32] Available at https://www.ibge.gov.br/en/home-eng.html

6. Results

Model results

The following Figure 2 presents the dynamic response estimation of the variable of interest, deforestation rate, after a 1% increase in the export of the selected products (products related to deforestation):

Figure 2 - Deforestation (%)



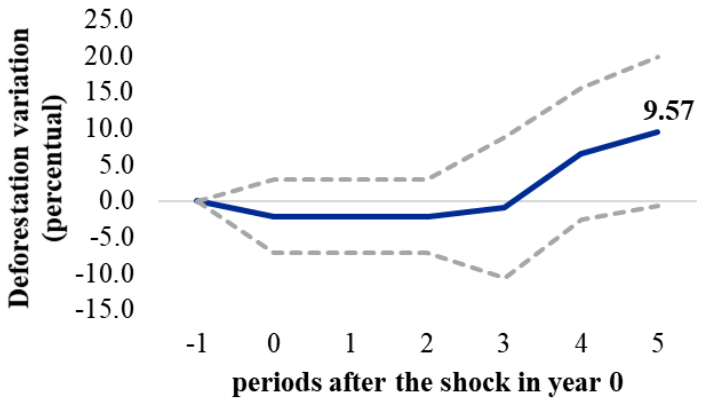
The Figure 2 indicates that following an 1% increase in total exports of soy, beef, wood, and palm products or derivatives, on average, deforestation rates in Brazilian states of the Amazon region will increase more than 10% after 5 years. The dotted lines show that the impact on deforestation becomes statistically significant 5 years after the shock, before this, there could have some impact already, but it is not significant. Yet, the most important analysis for this study will from using the robustness check results.

Figure 5 in the Appendix shows the details of the estimation. In the Figure 5, it is worth noting that periods 0, 1 and 2 have repeated values, this means that there will be an impact in the year of the shock (not significant) but in the following years the model omits the variable, which will only be impacting again from year 3 onwards. So, the model also captures that changes in exports impact deforestation rates de facto only in the medium to long term.

Robustness check results

The following Figure 3 presents the same estimation setting of Figure 2, but with total exports to EU incorporated as control variable:

Figure 3 - Deforestation (%)



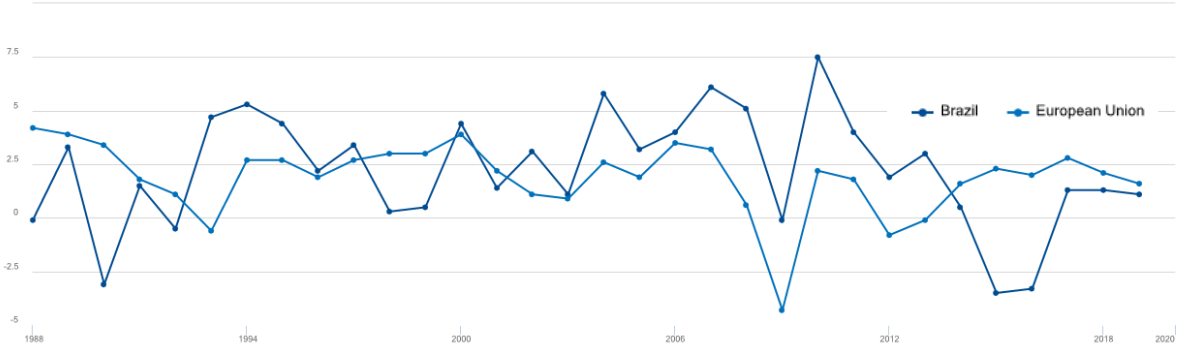
The Figure 3 indicates that following 1% increase in total exports of soy, beef, wood, and palm products or derivatives, on average, deforestation in each Brazilian state of the Amazon region could increase X% after 5 years, but no significant result can be stated. The dotted lines show that the impact on deforestation comes close of statistical significance, which means that there may be a tendency to a positive impact that could be observed in the next period, but, since analysis period is truncated up to 5 years, it is not significant.

Figure 5 in the Appendix also shows the details of the estimation. Just like for the previous results, periods 0, 1 and 2 have repeated values, which shows that there is almost no impact till the medium/long run.

Comparing both results shows that selected exports to EU, when significant at first look, is actually picking up some hidden effect existing at total exports to EU, just because is correlated with it. At second look, when total exports to EU is added (the correlation between them no longer interferes) and selected exports loose significance, it means that there is another trend that is correlated or might cause deforestation and is hidden in total exports to EU only. But what could be this hidden effect in total exports to EU that is correlated or causing deforestation, if the main products that could cause deforestation are separated in selected

exports to EU[33]? One plausible explanation comes from analyzing the correlation between GDP growth rate of Brazil and European Union, as the following Figure 4 shows:

FIGURE 4: GDP GROWTH (ANNUAL %) – BRAZIL AND EU – 1988-2020



Source: World Development indicators

Some correlation between the growth rates of the two economies can be picture in the graph, which means that trends in EU economy growth are also partly shared by Brazilian Economy[34]. When EU GDP shifts and exports from Brazil are affected by it, the variable total exports to EU might as well bring to the model hidden information about global shocks and trends. So, it could be that total exports to EU can partly be a proxy for EU shocks as well world shocks. Using this possible explanation, it can bring a light to why the increase in exports to EU of products related to deforestation is not a significant cause of higher deforestation: Because the increase is negligible when separating the effect of global shocks and tendencies that are acting and maybe interfering Brazil's deforestation rates.

7. Discussion

The model results give a clue that the impact on deforestation caused by exports of soy, beef, wood and palm cannot be ignored when thinking about the increase of commerce between EU and Brazil. But the loss of significance with the robustness check results is an evidence that these products exported are not the main drivers of deforestation. There is a deforestation trend in the course of time, as Costa *et al.* (2021) shows, and intense changes

[33] Change the shock variable to total exports or total exports to EU was tested, in the case they could have a significant impact deforestation rates, but no significance impact was found, showing that important analysis should remain in the selected exports to EU. Different shocks can be tried in the script available at the Supplementary Material, there is written how to do it.

[34] Indeed, the two economies are commercially strongly related: "EU and Mercosur reach agreement on trade", European Commission (2019); "Don't allow doubts to stop the EU-Mercosur deal" El País (2021)

or “interventions” (as the authors put), like a spike in illegal forest clearance or decrease of deforestation rates after government reaction or private cooperation, strongly affect this trend. But The result obtained in Figure 2, compared with the ones from the robustness check in Figure 3, shows that commodities exports to the EU cannot be listed as a significant “intervention”. The significant impact found in the first model might come from EU or international trade trends or even is capturing an internal trend, as there is an apparent correlation between EU and Brazil GDP growth.

Two other reasons can help to explain why exports to Europe do not change much deforestation rates. First, because the amount these goods exported to Europe are considerable, but there are other important importers around the world (Gregory 2017). For example, in 2010 EU was Brazil´s main trading partner, with a share of 27% of the country’s agricultural exports, but with China’s growing demand for agricultural products – mainly soybeans for livestock feed – the share of EU exports dropped to 17% in 2019, and China jumped from 14% to 32% in the same period (Rajão *et. al.* 2020). Second, as discussed before, many studies bring a deep analysis of direct and indirect drivers of deforestation, among which the agrobusiness expansion has a major role - besides hidden effects of mining activity and development of transportation infrastructure[35]. But the combat of this environmental issue has proven to be effective when influencing and changing the productive structure and institutions. Even the soy and beef moratorium, for example, initiatives that started in 2006 and 2009, respectively, that aimed at favoring legal products and punishing environmental violators, are estimated to have had limited effect in the historical deforestation rates drop of the past decade (Gregory 2017; Nepstad *et al*. 2014 and Ardila *et al.* 2021); while considering that, in that time, EU still had a large influence over Brazilian producers. As agricultural exports start to shift towards China, producers are confident that now the level of environmental requirements is lower, and retaliation is no longer a threat (Rajão *et al*. 2020).

Using these findings and known information, incentives and cooperation to change institutions and the productive system should be in the spotlight in the combat of deforestation, not boycott threats of Brazilian products. A negative shock in exports will have

[35] Rajão *et al*. (2020), Sonter *et al*. (2017) and Nepstad *et al*. (2014)

the same absolute results found by the model of this current work [36]. The action itself is not expected to significantly change deforestation through direct effects. It could do it indirectly, through political pressure, if the boycott causes public and private actors to change law enforcement and their behavior and bring internal structure changes.

In the same line, two analysts of the Earth Innovation Institution agree that, in the short to medium term, the chances of influencing Brazil will not come so much from the demand for commodities, because of strong demand from markets across Africa and Asia, including China[37]. The model results from this work, finding that an export shock is nearly omitted in the short-term, corroborates this statement. For the analysts, change should come through remaining engaged in negotiations, diplomacy, and dialogue. The EU-Mercosur trade deal would work in favor of it, as the London School of Economics report on the impact assessment shows, stating that the agreement brings an opportunity to engage and cooperate between both parties, as multilateral environmental agreements compliance can be enforced, such as the Paris Agreement. That is why Óscar Guinea, from European Centre for International Political Economy, argues that without the agreement Europe will lose the ability to forge a strategic alliance with Mercosur, which would reinforce Mercosur's commitment to fight against environmental issues[38]. Adding to this line of actions, stands the fact that Brazil has important and efficient monitoring systems of illegal trade activities. It would be possible to use these tools to fight illegal deforestation, with the country and international partners assuming their own responsibility in this process (Rajão *et. al*. 2020). Moreover, the EU-Mercosur deal could bring positive effects by increasing trade in environmental goods and services, stimulating cooperation for the development of green technology, and stimulating cooperation for the protection of natural resources[39].

With the EU-Mercosur agreement, not only environmental engagement could be achieved, but Brazil would be one of most favorable Mercosur countries in socioeconomic

[36] Since it uses changes in the logarithm of the variables, the negative effect of selected products exports to EU is simply the inverse of the results shown.
[37] "Soy Market Pressure To Save The Amazon Weakened In 2021", Earth Innovation of Institution (2021); "How The Eu Can Help Slow Deforestation In The Tropics: Q&A With Bjørn Thomsen", Earth Innovation of Institution (2020)
[38] "Don't allow doubts to stop the EU-Mercosur deal", El País (2021)
[39] "Sustainability Impact Assessment in Support of the Association Agreement Negotiations between the European Union and Mercosur", European Commission (2020)

terms[40]. Losing this alliance opportunity, added to possible losses that boycott movements or international pressure – consequences of current environmental crisis – may not change much deforestation in the short or medium run, but will certainly affect the country's economy, which is concerning for a country that has been deeply affected by the Covid-19 crisis [41]. In addition, deterioration of the socioeconomic situation in the country may intensify destructive activities and increase deforestation[42]. The EU-Mercosur trade deal could be beneficial in these two aspects, socioeconomic and environmental, and engaging in this solution should be the path to fight the two current Brazil's crisis, economic and environmental ones.

Challenges

A study that analyzes deforestation in the Brazilian Amazon handles with a process that has many origins and takes place in a large area, divided in several different states and municipalities. Soares-Filho *et al.* (2005) find it complex to analyze the drives of deforestation, therefore, it should not be easier to forecast it. It is important to show the limitations and challenges of this work, in order to help to understand better its actual application and help with insights for future studies.

First, there are many ways to build the model, and other future studies can contribute to it. Different lags, variables and the extension of the period observed can be applied. For example, no extensive work was done within the model to fix the lag-length at each horizon and maybe improve the performance of the local projection results. As Brugnolini (2018) raises options of doing so, a more accurate model could be found using his insights. In addition, Time Series methodology could be an alternative to the one employed in this work, but it should be well specified.

Second, when analyzing the data from figure 6 and 7, it is possible to see large disparities between states, regarding the values of goods exported and pattern of deforestation rate. Also, micro data available at the Supplementary Material shows that the type of good exported varies between states. For example, much of soy and beef exports comes from the Mato Grosso state alone, while Amazonas state hardly contributes with it. Rajão *et al.* (2020)

[40] "Sustainability Impact Assessment in Support of the Association Agreement Negotiations between the European Union and Mercosur", European Commission (2020)
[41] "Rising inflation complicates Brazil's Covid-19 crisis", Financial Times (2021)
[42] "Brazil's environment minister Ricardo Salles tackles the 'Amazon paradox'", Financial Times (2021)

shows that much of the "contaminated" exports (goods that were produced in recent cleaned up area) to Europe comes from the Mato Grosso. Therefore, since a macro analysis was used in this work, with no differentiation between states, some important particularities about deforestation might not have been captured, which could be fixed with a future approach that focus on each state. Besides that, the country analysis is important to answer the question annunciated in the introduction of this work, but a state focus analysis, instead, may be more important to environmental policy implementation.

Finally, regarding the data, some considerations are worth making. First, Sonter L. J. et al. (2017) arguments that most of the deforestation caused by mining activity comes from the infrastructure established (roads, hydropower plants etc.), urban growth to support mining workforce and the development of mining supply chain – especially when using charcoal. These effects, that are often neglected, were estimated for the Amazon forest by the authors, and they find impacting results: up to 9% of all Brazilian Amazon deforestation between 2005 and 2015 was caused by mining as a whole (12 times more deforestation than analyzing mining sites alone). Yet, metal and mining good exports were not taken into account when estimating the export shock in the model of this work, and the reasons were previously mentioned. It could be an important contribution if a future study provides solutions or an alternative test designed to include this effect. Second, the data used to observe deforestation does not take into account forest cover change. Forest cover loss is much higher than deforestation only, the difference between them is that the first one takes into account the cover loss for fires (natural or criminal origins) and effects of droughts [43]. This work does not consider these aspects, for their complexity and hoping that they do not affect the analyze addressed. Nevertheless, working with forest cover data could bring new analysis and findings.

8. Conclusion

In Brazil, policies implemented over the last decades were very efficient in controlling deforestation. To this extend, the major risk lies in abandoning them, and incentive low

[43] "Scientists measure Amazon drought and deforestation feedback loop: Study" Mongabay (2020).

productivity and ecologically damaging agricultural and animal sector activities[44]. As for the existent concerns that the EU-Mercosur deal could increase exports of products typically connected with deforestation, evidence using macroeconomic data shows that there is no significant sign that this will cause more deforestation in the future. This is the most important empirical finding of this work; it shows that environment concern should lie in Brazil's institutional and productivity structure and global trend of commerce rather than blocking commercial links between the EU-Mercosur. In this scenario, negotiations, diplomacy, and dialogue appears to be more fruitful.

One key element to be used is that the EU-Mercosur agreement is not just a commercial one, but also political. Investing and engaging on it would facilitate bilateral contacts and reciprocity between both regions. Sealing this strategic alliance with Mercosur could reinforce its commitment in the Paris Agreement, increasing trade in environmental goods and services, and stimulating cooperation for the protection of natural resources and the development of green technology.

Therefore, EU should not stop negotiations with Brazil/Mercosur but enlarge them. Blocking the deal will mostly compromise regional development and close opportunities of integration and cooperation of farmers and companies for environmental matters. Also, regarding the role that the government have in protecting the Amazon, closer economic ties can improve public agents and politician's commitment to stick to the existing targets.

[44] "Sustainability Impact Assessment in Support of the Association Agreement Negotiations between the European Union and Mercosur", European Commission (2020)

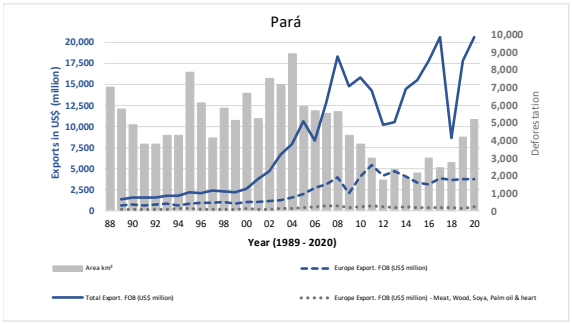
9. Appendix

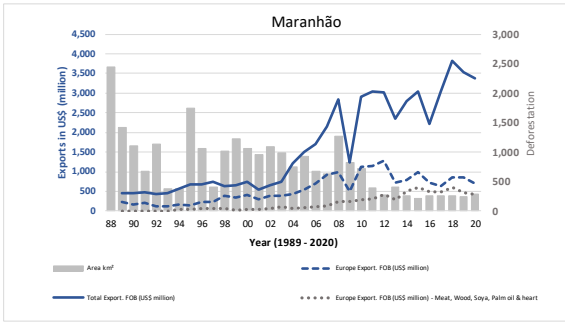
FIGURE 5: ESTIMATED IMPACT OF EXPORTS OVER DEFORESTATION

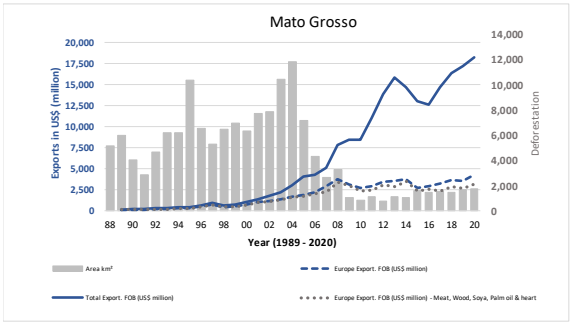
Model results		Robustness check	
Periods	**Deforestation (%)**	**Periods**	**Deforestation (%)**
t = 0	-2.138	t = 0	-2.134
	(3.106)		(3.077)
t = 1	-2.138	t = 1	-2.134
	(3.106)		(3.077)
t = 2	-2.138	t = 2	-2.134
	(3.106)		(3.077)
t = 3	-0.226	t = 3	-0.938
	(6.133)		(5.873)
t = 4	8.105	t = 4	6.560
	(5.234)		(5.511)
t = 5	10.592*	t = 5	9.573
	(5.712)		(6.208)
Average number of observations	200	Average number of observations	200
Number of States	9	Number of States	9

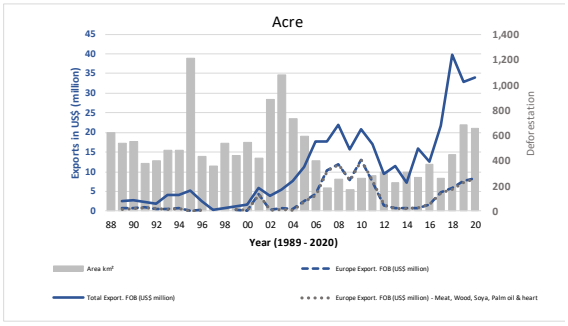
Note: The tables report the response of the variable of interest to the positive impulse of 1% increase of selected exports to EU (soy, beef, wood, palm products and derivatives), for each t years after the shock until t = 5, in which the conclusive result is observed. Standard errors are reported in parentheses, and * stand for 10% significancy. For example, it is observed in the Robustness check table that the 1% increase of the selected exports to EU results, in average, in more than 9% increase in deforestation after 5 years, but there no statistic significancy. Periods 0, 1 and 2 have repeated values, this means that there will be an impact in the year of the shock but in the following years the model omits the variable, which will only be impacting again from year 3 onwards.

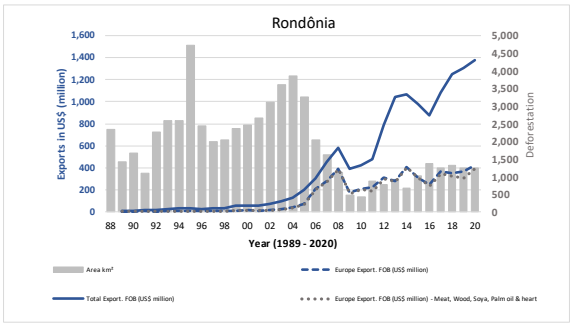
FIGURE 6: EXPORT AND DEFORESTATION RATE – DATABASE USED

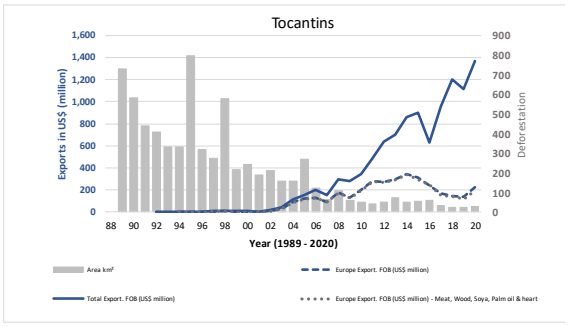


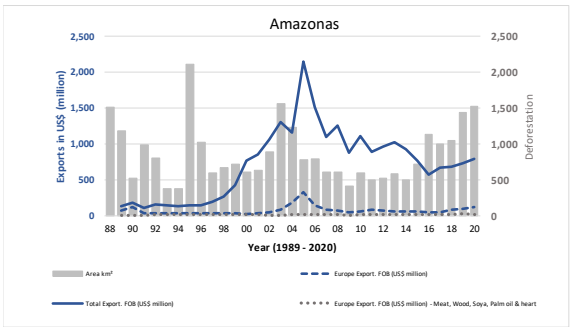


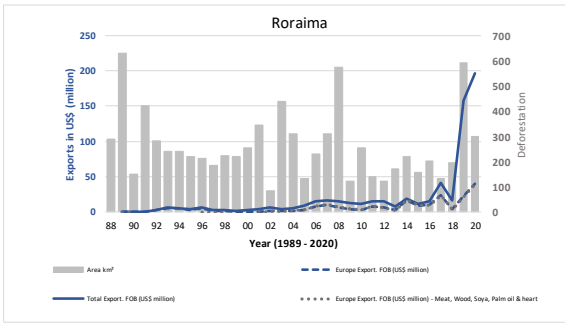












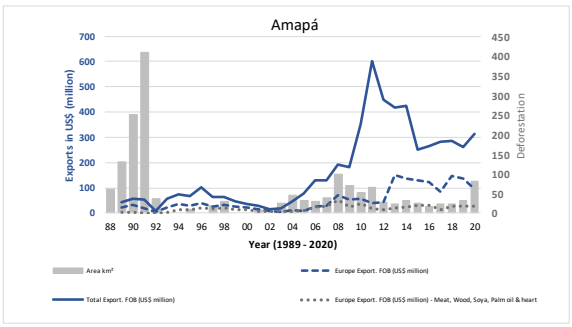
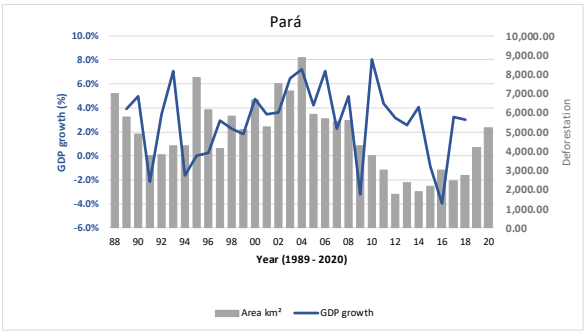
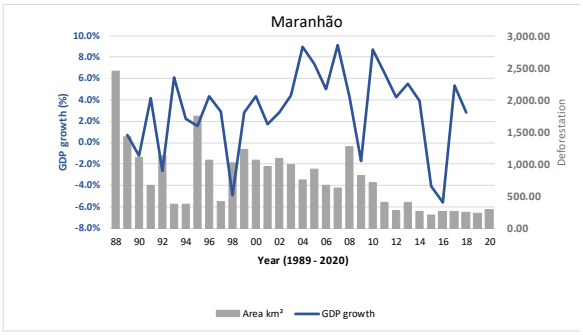
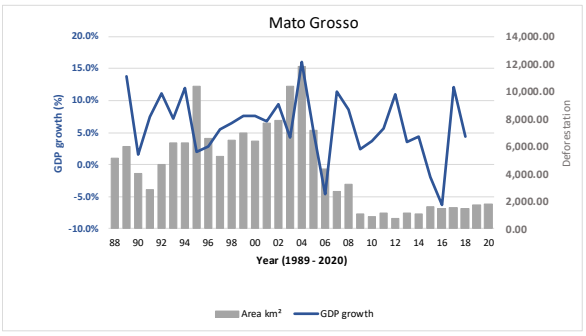
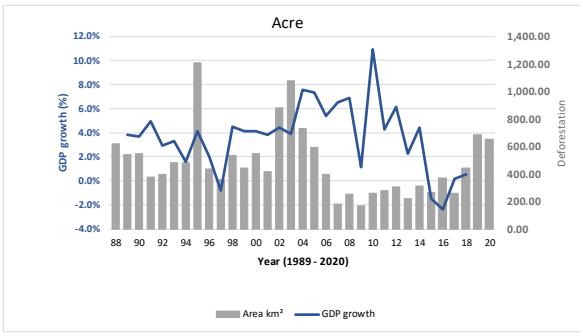


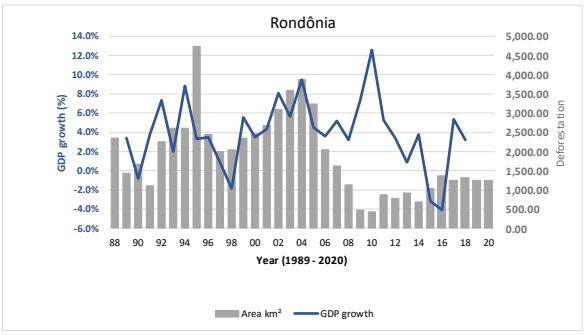
FIGURE 7: SHOWING CORRELATION OF GDP GROWTH AND DEFORESTATION RATE – DATABASE USED

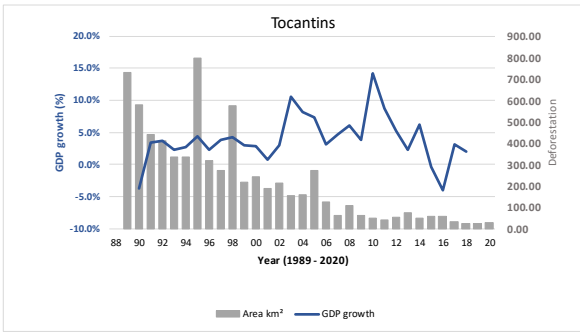


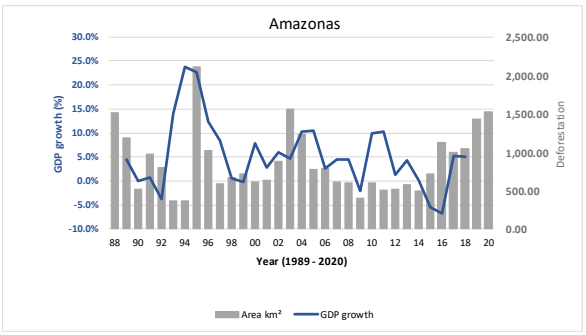


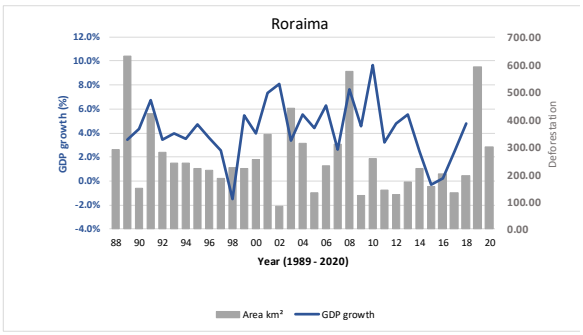


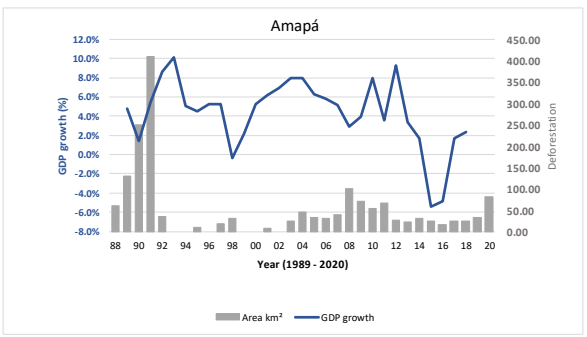












10. Bibliography

Ardila, J. *et al.* (2021). Latin American and Caribbean Forests in the 2020s: Trends, Challenges, and Opportunities. Inter-american Development Bank, Jan 2021. DOI: http://dx.doi.org/10.18235/0003019.

Boucher, D., Elias, P., Faires, J., & Smith, S. (2014). *Deforestation Success Stories: Tropical Nations Where Forest Protection and Reforestation Policies Have Worked* (pp. 7-13, Rep.). Union of Concerned Scientists. Retrieved May 27, 2021, from http://www.jstor.org/stable/resrep00076.7

"Brazil exports to EU produced on illegally cleared land". Euractiv. June 17, 2020. https://www.euractiv.com/section/energy-environment/news/brazil-exports-to-eu-produced-on-illegally-cleared-land-report/. View at: 28 May 2021.

"Brazil's environment minister Ricardo Salles tackles the 'Amazon paradox'". Financial Times. May 11, 2021. https://www.ft.com/content/97573b6b-8db9-4207-b869-9533ff4a1341. View at: 28 May 2021.

Brugnolini, l. 2018. "About Local Projection Impulse Response Function Reliability," CEIS Research Paper 440, Tor Vergata University, CEIS, revised 09 Jun 2018.

Calvimontes, L. Massaro, C.H.X. Araujo, R.R. Moraes, J. Mello, L.C. Ferreira, M. de Theije. Small-scale gold mining and the COVID-19 pandemic: Conflict and cooperation in the Brazilian Amazon, The Extractive Industries and Society, Volume 7, Issue 4, (2020), Pages 1347-1350, ISSN 2214-790X, https://doi.org/10.1016/j.exis.2020.08.013

Carvalho, G., Cristina Barros, A., Moutinho, P. et al. Sensitive development could protect Amazonia instead of destroying it. Nature 409, 131 (2001).

Costa, A. da S., Queiroz, J. C. B., Chermont, L. S., Lameira, O. A., Souza, E. B. de, Diniz, M. B., Moura, H. P., Costa, D. L. C. Deforestation forecasts in the Legal Amazon using intervention models. (2021). Research, Society and Development, 10(4), e8710413787. https://doi.org/10.33448/rsd-v10i4.13787

"Don't allow doubts to stop the EU-Mercosur deal". El País. April 19, 2021. https://english.elpais.com/usa/2021-04-21/dont-allow-doubts-to-stop-the-eu-mercosur-deal.html. View at: 15 Apr. 2021.

Driscoll, J. C., and A. C. Kraay. 1998. Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. Review of Economics and Statistics 80: 549–560

"EU and Mercosur reach agreement on trade". European Commission. June 28, 2019. https://ec.europa.eu/commission/presscorner/detail/en/IP_19_3396. View at: 28 May. 2021.

"EU Commission 'failed' on assessing Mercosur trade deal". euobserver. Mar. 22, 2021. https://euobserver.com/climate/151302. View at: 28 May 2021.

"EU-Mercosur trade deal: what it all means". The Financial Times. June 30, 2019. https://www.ft.com/content/a564ca96-99e7-11e9-8cfb-30c211dcd229. View at: 15 Apr. 2021.

"EU, Mercosur strike trade pact, defying protectionist wave". Reuters. June 28, 2019. https://www.reuters.com/article/us-eu-trade-mercosur/eu-mercosur-strike-trade-pact-defying-protectionist-wave-idUSKCN1TT2KD. View at: 15 Apr. 2021.

Furceri, D., Ahmed Hannan, S., Ostry, J., & Rose, A. (2018*). Macroeconomic Consequences of Tariffs. NBER Working Papers, No. 25402.*

Gregory, J. Trade Measures to Support Legal and Sustainable Agriculture in Brazil. (2017). Forest Trends. https://www.forest-trends.org/wp-content/uploads/2018/04/doc_5731.pdf. View at: 28 Apr. 2021.

Hoechle, D. Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence. *The Stata Journal*. 2007; 7(3):281-312. doi:10.1177/1536867X0700700301

"How The Eu Can Help Slow Deforestation In The Tropics: Q&A With Bjørn Thomsen". Earth Innovation of Institution. Sep. 2020. https://earthinnovation.org/2020/09/how-the-eu-can-help-slow-deforestation-in-the-tropics-qa-with-bjorn-thomsen/. View at: 28 May 2021.

"Ireland: EU-Mercosur trade deal 'unlikely' during Portuguese presidency". Euractiv. Apr 9, 2021. https://www.euractiv.com/section/eu-council-presidency/news/ireland-eu-mercosur-trade-deal-unlikely-during-portuguese-presidency/. View at: 9 May 2021.

Jordà, O. (2005). Estimation and Inference of Impulse Responses by Local Projections. American Economic Review, 95(1):161–182

Laurance, W. F., Cochrane, M. A., Bergen, S., Fearnside, P. M., Delamônica, P., Barber, C., D'angelo, S., Fernandes, T. "The Future of The Brazilian Amazon". Science, n. 291, 2001, pp. 438-439.

"Mercosul e UE fecham maior acordo entre blocos do mundo". Agência Brasil. June 29, 2019. https://agenciabrasil.ebc.com.br/politica/noticia/2019-06/mercosul-e-ue-fecham-maior-acordo-entre-blocos-do-mundo. View at: 28 May 2021.

"Mercosur trade deal threatens to wreck EU's climate credibility". Euractiv. Apr. 2, 2021. https://www.euractiv.com/section/energy-environment/opinion/eu-mercosur-trade-deal-threatens-to-wreck-the-blocs-climate-credibility/. View at: 28 May 2021.

Nepstad, D., Carvalho, G., Barros, A. C., Alencar, A., Capobianco, J. P., Bishop, J., Moutinho, P., Lefebvre, P., Lopes Silva, U., Prins, E. (2001) Road paving, fire regime feedbacks, and the future of Amazon forests. Forest Ecology and Management, Volume 154, Issue 3, 2001, Pages 395-407, ISSN 0378-1127, https://doi.org/10.1016/S0378-1127(01)00511-4.

Nepstad, D. *et al.* (2014) Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. Science. Vol. 344, Issue 6188, pp. 1118-1123 DOI: 10.1126/science.1248525

"New palm oil frontier sparks scramble for land in the Brazilian Amazon". Mongabay. Apr. 12, 2021. https://news.mongabay.com/2021/04/new-palm-oil-frontier-sparks-scramble-for-land-in-the-brazilian-amazon/. View at: 28 May 2021.

Rajão, R. *et al*. (2020). The rotten apples of Brazil's agribusiness. Science. 369. 246. 10.1126/science.aba6646.

"Rising inflation complicates Brazil's Covid-19 crisis". Financial Times. Apr. 11, 2021. https://www.ft.com/content/5dbcc5b2-2d9e-46b7-b9d5-1b612aa20cf3. View at: 28 May 2021.

"Scientists measure Amazon drought and deforestation feedback loop: Study" Mongabay. 21 July 2020. https://news.mongabay.com/2020/07/scientists-measure-amazon-drought-and-deforestation-feedback-loop-study/. View at: 28 May 2021

Siqueira-Gay, J., Sánchez, L. E. The outbreak of illegal gold mining in the Brazilian Amazon boosts deforestation. Regional Environmental Change 21, 28 (2021). https://doi.org/10.1007/s10113-021-01761-7

Silva Junior, C.H.L., Pessôa, A.C.M., Carvalho, N.S. *et al.* The Brazilian Amazon deforestation rate in 2020 is the greatest of the decade. *Nat Ecol Evol* 5, 144–145 (2021). https://doi.org/10.1038/s41559-020-01368-x

Soares-Filho, B. et al. Cenários de desmatamento para a Amazônia. Estudos Avançados. 2005, v. 19, n. 54 pp. 137-152. https://doi.org/10.1590/S0103-40142005000200008.

Soares-Filho, B., D. Nepstad, L. Curran et al. 2006. Modelling Conservation in the Amazon Basin. Nature 440(7083): 520-523.

Sonter, L. J., Herrera, D., Barrett, D. J., Galford, G. L., Moran, C. J., & Soares-Filho, B. S. (2017). Mining drives extensive deforestation in the Brazilian Amazon. *Nature communications*, *8*(1), 1013. https://doi.org/10.1038/s41467-017-00557-w

"Soy Market Pressure to Save the Amazon Weakened in 2021". Earth Innovation of Institution. Mar. 2021. https://earthinnovation.org/2021/03/soy-market-pressure-to-save-the-amazon-weakened-in-2021/. View at: 28 May 2021.

"Sustainability Impact Assessment in Support of the Association Agreement Negotiations between the European Union and Mercosur" (2020). London School of Economics and Political Science. Final Report. Publications Office of the European Union, ISBN: 978-92-76-26958-8, DOI: 10.2781/54752, Catalogue number: NG-03-20-817-EN-N

"The Companies Behind the Burning of the Amazon". Might Yearth. August 2019 https://stories.mightyearth.org/amazonfires/index.html. View at: 28 May 2021.

"What is the new South American beef deal that will affect Ireland?". The Irish Times. July 1, 2019. https://www.irishtimes.com/news/politics/what-is-the-new-south-american-beef-deal-that-will-affect-ireland-1.3942932. View at: 28 May 2021.