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Impacts of the 2014 EU-Senegal SFPA on Anemia Prevalence in Senegalese Children

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Abstract

On November 20 in 2014, Senegal signed a new agreement with the EU allowing for 45 French and Spanish vessels to fish Senegalese waters in exchange for a yearly monetary compensation during the following five years. Being the fish the first source of protein in the country, we argue that this agreement negatively affected the health situation of the local population, being the children one of the most vulnerable targets. Using the DHS individual-level survey data, we analyze the short and medium-term effects of this agreement on anemia prevalence in children under five years old. After conducting a quasi-experimental difference-in-difference approach together with a multinomial logit model, we found that children located in the more directly impacted coastal areas were found to display more negative consequences as compared to their non-coastal counterparts in response to the policy. Concretely, meanwhile after the agreement in 2015 the probability of children in the whole country to have worse levels of anemia was decreasing, when we isolate the effect for the coastal area we found an opposite trend. Overall, we follow the previous literature work on the negative effects of fish agreements in the absence of the proper public policies to support socioeconomically the inhabitants.

Keywords: Senegal, Anemia, Children, Fish, SFPA, Difference-in-Difference, Multinomial Logit

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1 Introduction

Located within the Canary Current Large Marine Ecosystem (CCLME), Senegal is home to a bountiful and diverse aquasphere, which provides both sustenance and income to the nation (DuBois & Zografos, 2012). A prominent sector, both culturally and economically, the Senegalese fishing industry is estimated to employ approximately 17% of the national workforce, creating over 600,000 jobs for both men and women (WorldBank, 2016). With its convenient location on the Gulf of Guinea, ample resources, and historical relationship with France, Senegal has been a prominent target of the European Union for resource harvesting agreements.

Designed to create a legally backed easement for EU member states to fish oceanic resource surpluses located within the exclusive economic zones of foreign nations, Sustainable Fisheries Partnership Agreements (SFPA) are intended to promote equal rules, scientific management, social empowerment, local growth, and shared accountability, delivered in a manner touted as being both environmentally sustainable and transparent. Presently the EU holds thirteen SFPA's with predominantly African nations, allowing for both mixed resource fishing, and tuna exclusive fishing practices. Additionally, the EU holds seven dormant agreements; agreements that are still valid and in effect, but that exist without a formal implementing protocol. As such, fishing within the waters of nations party to dormant SFPA agreements is deemed illegal. (EU, 2014).

Tactfully renewable every five years, the EU-Senegal SFPA examined by this paper allows for a total of 45 vessels —tuna seiners, pole-and-line seiners, longliners, and trawlers— all sailing under French and Spanish flags to fish Senegalese waters for tuna and black hake. The agreement was valid for the period November 20, 2014, to November 11, 2019, and articulates permissible harvest amounts totaling 10,000 tons per year (14,000 tons in the final year of the agreement), and 1,750 tons per year, respectively. In exchange for permission to harvest Senegalese resources, the EU agreed to pay an estimated €13.93 million to Senegal. These funds were intended to act as both financial compensations for access privileges and to support the implementation of the Senegalese sectoral fisheries policy (EU, 2014). Our rough calculations based on an average market price of tuna estimate the value of the allowable EU harvest at €300 million. We argue that these arrangements are not uniformly and bilaterally just, and so may result in negative economic impacts via various channels; not limited to unsteady dietary intakes and job losses (Nagel & Gray, 2012).

Given the limited number of systematic studies on the differential impact of fishing agreements and their connections to children's health, we seek contribute to the academic community our analysis of 2014 EU-Senegalese fishing agreement and its link to the welfare of the Senegalese population and its children. We contribute to the available literature as one of the first papers studying the effects of such agreements on a microeconomic and individual level. Studies on anemia among children has been studied over an unspecified or random period while our paper concentrates on the direct effect of the agreement on this health variable. Using a difference-in-difference approach we examine the short and medium-term effects of this SFPA on the prevalence and severity of anemia in children five years and younger. For it use the Demographic and Health Surveys to identify regional and yearly samples of children and heads of households and study differences between coastal and non-coastal areas. We argue that coastal regions were more impacted by the agreement than inland regions over the period starting in 2012 and ending in 2017. In doing so, we seek to answer two interrelated questions. First, do there exist persistent negative effects on anemia levels in children five years and younger after exposure to this exogenous shock? Second, can we observe differential effects between subgroups?

The remainder of the paper is organized as follows: Section 2 provides a literature review of previous studies examining the impact of such agreements on macro and micro levels. Section 3 introduces the DHS data used to convey our analysis and outlines relevant summary statistics as well as introduces our treatment specification. Section 4 presents our empirical strategy, which is followed by an overview of our results in Section 5. Here we additionally review data limitations and provide robustness checks.

Our conclusion is drawn in Section 6 where we also suggest potential policy improvements and academic extensions to our study. Our appendix attaches as Section 7.

2 Literature Review

2.1 General Overview

The wider literature primarily focused on macroeconomic variables such as trade in Africa (Béné, Lawton, & Allison, 2010) and the causality between poverty and trade (Winters, 2006) has failed to find any trend regarding the effects of fishing agreements on African trade. While studies directly targeting the case of Senegal in this matter are scarce and limited, as raised by (Binet, Failler, & Thorpe, 2012) Senegalese and Ghanian fishermen are the demographic groups most affected by these policy arrangements. To study this more deeply, hadj Bara Dème and Failler (2022) suggest that a greater importance and consideration should be given to the manner in which public policy may interfere with artisanal fishing within Senegal. Additionally, as active participants in the fishing industry, women both contribute to the household wealth classification, and via biological connections may impact the level of anemia amongst children, as an anemic mother will give birth to an anemic child. Harper, Grubb, Stiles, and Sumaila (2017) study the female contribution to the fishing industry in countries with strong links between livelihoods and marine capture fisheries, Senegal being one of the five countries analyzed. Findings show that this contribution was indeed substantial. Studies have also been conducted highlighting key determinants of anemia prevalance in children in Senegal neighboring countries such as Malawi and Angola (Khulu & Ramroop, 2020). Diouf, Sylla, Diop, Diallo, and Sarr (2013) demonstrate that improving a mother's level of literacy and animal protein consumption (meat, fish and eggs) will reduce their children's chances of contracting anemia.

2.2 The Fish Trade

The ideas and quantifications of beneficial impacts from trade as enjoyed by a developing country continue to be discussed with diverse and lively debate. While past researchers have conjectured as to how beneficial and influential an impact trade has on the economic growth of developing nations, current literature challenges the status quo and condemns perceived patterns of exploitation by first world nations onto their developing counterparts. No trend or specific causality between the fish trade and either pro-development, or worsening economic indicators in exporting African countries was found by Béné et al. (2010), though when observed from a macro level they do suggest that the redistribution mechanism from trade gains is not working effectively. We dedicate the remainder of this section to the exploration of both sides of the pro/anti-trade debates within the existing literature and their connections to the economic growth of developing nations.

Those of the inclination that the overall beneficial effects of trade on a nation's development argue that the liberalization of trade promotes developing nations' access to international markets, which in turn may attract new sources of revenue inflows. Stopler-Samuelson's theory concludes that this liberalization will reduce poverty across growing nations as they begin to utilize their comparative advantages to promote international trade (Bhagwati & Srinivasan, 2002). As such, nations with large aquatic resource endowments would be expected to observe economic gains from the harvest and trade of such assets. This theory is especially attractive as in recent years fisheries have become increasingly capital-intensive worldwide (Asche, Bellemare, Roheim, Smith, & Tveteras, 2015). Nevertheless, to simultaneously maximize welfare gains and avoid harming local industry fish exporters must be mindful with their promotion of the following policies: 1) Satisfying Pareto optimality conditions, by 're-injecting' gains from fishery exports into local economies at a volume and pace satisfactory in compensating local inhabitants for the reduction of dietary proteins lost as a result of increased trade (Béné, 2008), 2) Promoting the inclusion of local fishery management into decision-making processes, and 3) Harvesting at a level not beyond the threshold of resource sustainability (Schmidt, 2003). In accordance with trickle-down effects, the profitability of the fish trade should in theory benefit the overall economy of exporting nations (Béné et al., 2010).

The opposing argument contests that natural resource exploitation in developing nations —in this case, fish— may result in negative 'anti-poor' externalities, especially in the case when trade agreements culminate in the displacement of local small-scale fishermen. Introducing large industrial trade patterns to the local economies of developing nations increases the risk for both the potential marginalization of in-country supply chains and the exclusion of households from the labor force. The resulting effects of such policies and practices which are in essence more extractive than bilateral may lead to the overall devolution of an exporting nation's well-being (Maertens & Swinnen, 2009). In 2010 developing countries accounted for 50% of the value of global seafood exports, but only 23% of the value of global seafood imports (Asche et al., 2015), and while the world's overall seafood consumption is increasing (Zhou, Smith, & Knudsen, 2015), this pattern of 'Seafood Trade Deficit' is prominent throughout Africa where levels of fish consumption are below average (Chan et al., 2019). It may in fact be the case that Africa is supplying the first world with its seafood to their own detriment. Notably, in recent years Sub-Saharan Africa, where export volumes of fish have increased, is the only region in the world where fish supply per person has decreased (Béné, 2008). This trend is prominent in Senegal, where we also observe a scarcity of fish in local markets (hadj Bara Dème & Failler, 2022).

Supported by local narratives, Senegalese citizens have noticed both a decrease in availability and an increase in the price of fish in local markets in the time following the passage of the 2014 SFPA (Jönsson, 2019). This is reflected in Figure 1 below. Culturally, gastronomically, even some traditional Senegalese seafood dishes have become less accessible to locals (Diedhiou & Yang, 2018). As evidenced by a decreasing local supply of seafood, in lieu of promoting industry-building practices by supporting artisanal fishermen, Senegal's present fishing policies have been export-focused and have resulted in decreased levels of food security for Senegalese citizens (hadj Bara Dème & Failler, 2022). In the time since the passage of the SFPA, it has become more difficult and demanding for local fishermen to participate in the business cycle as now fuel and time requirements, and navigation efforts required for similar pre-agreement yields have increased (Diedhiou & Yang, 2018).

2.3 Dietary Contributions From Fish

Especially for coastal nations, fish is a staple to the African diet. Chan et al. (2019) reports that fish account for 19% of the diet of Africa's 995.4 million inhabitants. West Africa, the region with the largest percentage of fish consumption as a percentage of diet, attributes 34% of all sustenance as coming from fish. It has been found that in Senegal the most commonly reported daily source of protein/meat is sourced from fish Anderson et al. (2010), however, this trend is broken when analyzing rural versus urban areas. Hathie, Seydi, Samaké, and Sakho-Jimbira (2017) shows that urban areas tend to consume more fish than rural areas in Senegal, and while still the primary source of animal protein, when considering rural areas, after rice, peanuts are the second most consumed food; in urban areas, rice and fish are the primary sources of calories (Marivoet et al., 2021).

With income received from fishing and associated downstream business practices, small-scale fisheries generate access to food for many rural African households (Hartje, Bühler, & Grote, 2018). In West Africa specifically Belhabib, Sumaila, and Pauly (2015a) estimates that each dollar produced by a small-scale fishery injects 4.30 USD into the local economy, and as the artesian fishing industry is populated by local labor, communities are able to directly benefit from its participation in the economy. Conversely, due to the size and diversity of global supply chains, larger-scaled industrial fishing industries create challenges for measuring participatory impacts on local communities (Tsukamoto et al., 2008). As such we should be careful when drawing conclusions as to the impacts of industry on provincial areas.

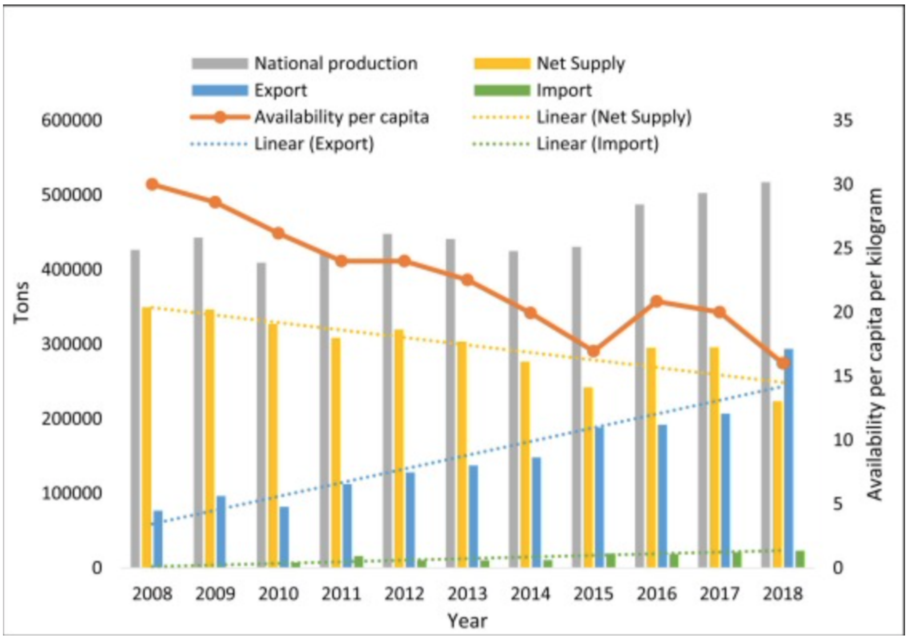

Figure 1: Senegalese Fish Trade
(hadj Bara Dème & Failler, 2022)

2.4 Size of the Atlantic Tuna Stock and Collection Capacity

We consider the possibility for bias in our study to be generated from strong and sudden fluctuations in the volume of the overall Atlantic tuna population and its availability to fishermen. This section addresses these concerns by referencing estimates from the most recent 2019 ICCAT assessment of Atlantic Tuna Fishery Indicators which provide insight as to the past, and present state of bigeye, skipjack, and yellowfin tuna fisheries.

From peak levels in 1990, overall Atlantic tuna catches have declined by over 45% as estimated for the year 2013 (193,584 tons to 106,288 tons); however these numbers have increased to an overall average of 140,143 between the years 2016-2018. These reports also express the growth of purse seiner capacities —returning to near peak 1990 levels— as the result of both the deployment of a new purse seiner fleet operating off the coast of Ghana, whose catches are likely underestimated, and increased piracy levels in the Indian Ocean causing a shift in fishing efforts towards the Atlantic (ICCAT, 2020). It is estimated that by the year 2010 the overall carrying capacity of the seiner fleet had increased to about the same level as in 1990, and that in the nine years since, had increased an additional 50% (ICCAT, 2020). Total numbers of purse seine vessels targeting east Atlantic tuna has increased by 18% from 2014 to 2019 (ICCAT, 2020). These estimates as provided by the ICCAT do not include all purse seiner vessels currently fishing Atlantic tuna.

Further, when considering the effects of fishing moratoriums on various nautical areas, the reports determine that such policies were largely ineffective, as any reduction in fishing was minimal. This is attributed to the redistribution of fishing efforts to locations adjacent to moratorium area boundaries (ICCAT, 2020).

Estimated tuna biomass as calculated in all ICCAT models displays a general decline over time, and suggests that while improvements appear present between the 2016 and 2019 models, in fact the recent calculations indicate a declining stock biomass between 2014 and 2018. Perceived improvements are likely

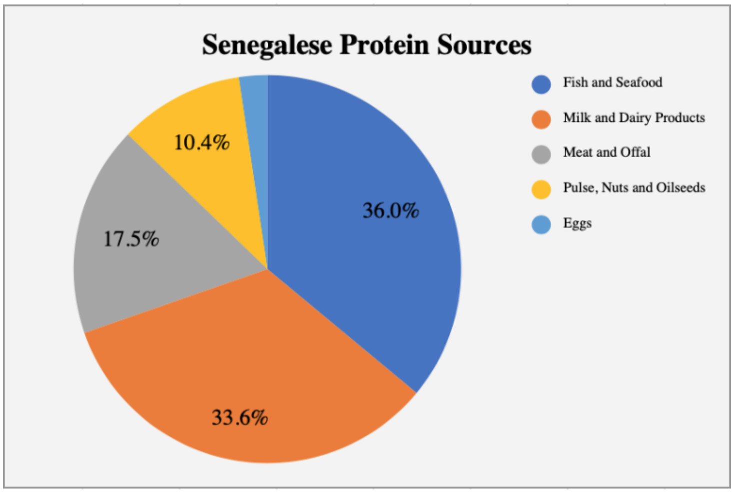

Figure 2: Senegalese Protein Sources. (FAO, 2010)

caused by changes in key data inputs (ICCAT, 2020). As such we disregard the hypothesis that abrupt shifts in the tuna population are impacting our analysis.

2.5 Anemia in Children

Anemia is a medical condition characterized by "reductions in hemoglobin concentration, red-cell count, or packed-cell volume, and the subsequent impairment insetting the oxygen demands of tissues" and is one of the leading causes of death in developing countries (Subramanian, Balarajan, Ramakrishnan, Özaltin, & Shankar, 2011). Women and children are more at risk than men, and over 2.5 million neonatal and maternal deaths in developing countries can be attributed to anemia complications (Stevens et al., 2013). It has been found that nutritional deficiencies in both iron and vitamin-B are direct causes of anemia development in Senegalese children (Diouf et al., 2013; Hirata, Kusakawa, Ohde, Yamanaka, & Yoda, 2017; Stevens et al., 2013; Subramanian et al., 2011). Iron deficiency is primarily caused by lack of access to animal protein (Diouf et al., 2013). In 2015, the prevalence of anemia in Senegalese children was 60% (ANSD/Sénégal & ICF, 2018). Long-term effects of anemia afliction during childhood development —an age for which we define as being less than 59 months— include stunted growth (Brar et al., 2020), immunocompromisation, and lasting cognitive impairment (Algarin et al., 2013; Ncogo et al., 2017). Given the demographic makeup of Africa, in which children account for the largest subgroup, unchecked and untreated anemia directly threatens the future development and security of the continent.

Studies have shown that in the past, structural changes in African countries' public administration, trade agreements, and other negative macroeconomic shocks have worsened children's nutritional condition, and thereby increased the youthful prevalence of anemia (Pongou, Salomon, & Ezzati, 2006; Tesema et al., 2021). It has also been shown that policies and technologies which have facilitated agricultural productivity and boosted the earnings of small-scale farmers have led to an improvement in the pervasiveness of anemia in African children (Pongou et al., 2006; Tesema et al., 2021). A heterogeneous exploration of anemia in children as conducted by (Chaparro, 2008; Tengco, Rayco-Solon, Solon, Solon, & Sarol, 2008) notes that female infants have a larger concentration of hemoglobin between 12 and 24 months of age as compared to males, and while the medical field continues to investigate the causality of these differences amongst infants, researchers have suggested that such disparities may be linked to physiological variability, metabolic differences, or varying levels of certain proteins between sexes. Interestingly, this presents a contrasting view between anemic vulnerability in adults where it is generally accepted that females are much more prone to the illness than their male counterparts. We, as many prior researchers have, utilize sex as a controlling variable. This is discussed in more detail in the following Data section.

Research has also recurrently highlighted the level of a mother's education as a relevant factor in determining the ubiquity of anemia in their children. (Adamu et al., 2017; Khulu & Ramroop, 2020) notes a negative relationship between maternal education level and severity of anemia in children; the higher a mother's level of schooling, the lower the probability of both her children contracting anemia, and chance that anemia cases being severe. This may perhaps be explained via income effects as more educated women may create increased levels of household income, and so increased access to nutritional diversity and security (Abuya, Ciera, & Kimani-Murage, 2012; Pierre-Louis, Nesheim, Bowman, & Mohammed, 2007). Choi et al. (2011) find that outside of Senegal, mothers with increased education levels have better knowledge of nutritional demands, and so place greater importance on the serving of nutrient dense foods to their children. However, as is the particular case in Senegal, research has observed that traditional, perhaps less nutrient-dense dishes are still regularly consumed by educated persons, suggesting that a Senegalese mother's educational level may respond more to wealth status. In this paper we assume that the income effect is the primary channel through which there exists a possible relationship between the existence of anemia in the young and maternal education levels. Assuming that educated women living in coastal areas are linked to local fishing industries, a disruptive SFPA may directly alter their income levels, resulting in a shift in their household's health status. Another exploratory topic in the medical field iron is the role of iron supplementation. The mother's level of iron during pregnancy is important not only for her well-being during pregnancy and postpartum, but also because most of the transfer of iron from mother to baby occurs after week 30 of gestation Lemoine and Tounian (2020). Some of the benefits that have been found is that mothers that have taking iron supplementation during their pregnancy have babies with less iron deficiency, therefore, are less likely to develop anemia (Chaparro, 2008; Niang et al., 2016). Whereas infants with high iron deficiency mothers are more vulnerable to develop anemia (Lemoine & Tounian, 2020).

3 Data

3.1 Data Source

Conducted regularly over the past 30 years, our primary data set originates from the Demographic and Health Surveys, pioneered by USAID. These cross-sectional data sets are "nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition". There are many waves of this household survey, also available in alternate forms –individual surveys and children surveys (0-59 months) alike– ranging from 1986 to 2019. In our analysis, we utilize information from the most recent, most consistent wave with collected data ranging from 2009 to 2019. We focus our study on a six-year range, 2012-2017, within the child database to better capture our variables of interest for the period surrounding the 2014 EU-Senegal SFPA. From this source, we observe one record for every child of interviewed women born in the five years preceding the survey. The survey contains information related to a mother's pregnancy, postnatal care, immunization, and other health factors. Data for the mother of each of these children is also included. This collection of data can be used to monitor various health indicators including, but not limited to immunization coverage, vitamin A supplementation, recent occurrences of diarrhea, fever, anemia, cough, and the treatment of disease.

Generally, DHS sample designs are consist of two-stage probability samples drawn from an existing sample frame, usually the most recent census frame. A probability sample is defined as one in which units are selected randomly with known and nonzero probabilities. A sampling frame is a complete list of all sampling units that entirely cover the target population. Stratification is the process by which the sampling frame is divided into subgroups or strata that are as homogeneous as possible using certain criteria. Within each stratum, the sample is designed and selected independently. Typically, DHS samples are stratified by geographic region and by urban/rural areas within each region.

In the following Table 1 we present general characteristics of our data set. These inferential statistics assist in the recognition of the collective properties of our dependent and independent variables and their comprising elements in years immediately before and after the SFPA enters into effect.

Table 1: Descriptive Statistics

			2014					2015		
VARIABLES	N	mean	sd	min	max	N	mean	sd	min	max
Dependent Variables										
Child Anemia Level	5,421	3.016	0.897	1	4	5,457	2.820	0.895	1	4
- severe	120					199				
- moderate	1,777					2,166				
- mild	1,421					1,509				
- not anemic	2,103					1,583				
Child Hemoglobin	5,421	104.720	23.179	12	980	5,457	100.395	15.040	38	151
Independent Variable										
Region	6,842			1	14	6,935			1	14
- Treatment	2,593			0	1	2,496			0	1
- Control	4,249			0	1	4,439			0	1
Control Variables										
Mother Educational Level	6,842	0.378	0.662	0	3	6,935	0.401	0.686	0	3
Gender Child	6,842	0.499	0.500	0	1	6,935	0.501	0.500	0	1
Pills in Pregnancy	4,484	0.934	0.248	0	1	4,679	0.938	0.242	0	1
Urban/Rural	6,842	0.697	0.460	0	1	6,935	0.727	0.446	0	1
Wealth Index Quintile	6,842	2.309	1.251	1	5	6,935	2.379	1.267	1	5

3.2 Dependent Variables

To measure health implications resulting from the passage of the SFPA, we choose to consider the variable designated to record anemia levels amongst children under the age of five. This variable was created by the DHS using the results of a test which identifies levels of hemoglobin in the blood. Samples were taken from all eligible children under the age of five whose parents volunteered them to be checked. Hemoglobin was measured using a portable HemoCue analyzer after blood samples were obtained. For children, anemia is classified as severe if the level of hemoglobin per deciliter of blood is lower than 7.0 g/dl; moderate if between 7.0 and 9.9 g/dl, and mild if between 10.0 and 10.9 g/dl.

3.3 Treatment and Control Groups

To assign our treatment and control groups, we divide Senegal into two areas designated as coastal and non-coastal regions. Coastal regions include Dakar, Saint-Louis, Ziguinchor, Thies, Louga and Fatick. Abutting the ocean, we assume these areas are most impacted by the SFPA. Our control group is comprised of the regions Kaolack, Kaffrine, MAtam, Diourbel, Tambacounda, Sédhiou, Kolda, and Kédougu. While fishing is not uncommon in the rivers and lakes of inland regions, these inhabitants will not be directly effected by an agreement permitting large vessels to enter and gather resources from national oceanic waters.

As the SFPA was signed at the end of 2014, we consider the years 2012, 2013 and 2014 as the time period before the agreement, our pre-shock designation. We then use 2015, 2016 and 2017 as a post-shock group used to analyze post agreement effects.

Figure 3: Political Map of Senegal

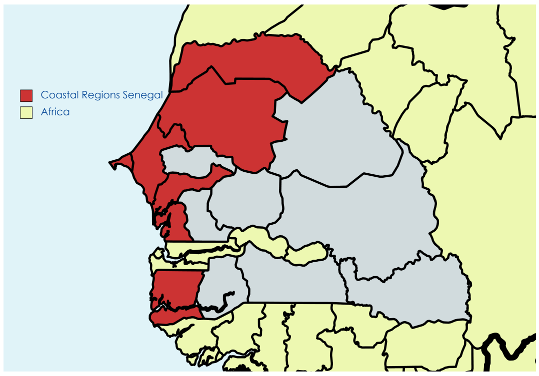

Figure 4: Treatment group definition

3.4 Control Variables

In order to capture individual-specific heterogeneity, we include a number of control variables, all from the same DHS survey. Every control variable is documented in previous literature review as potentially affecting the prevalence and severity of anemia in children under five years old. We review these control variables below.

- **Mother's Educational Level:** As discussed in the literature review we argue that women with higher educational attainment are more knowledgeable on the topic of general health and nutrition, and in actionable practices by which she may reduce both her and her children's risk of developing anemia through either a more satisfactory diet or the wherewithal to identify and seek appropriate medications and supplements necessary for sickness prevention (Abuya et al., 2012; Adamu et al., 2017; Choi et al., 2011; Khulu & Ramroop, 2020; Pierre-Louis et al., 2007)
- **Iron Pills:** Iron supplements may assist in the retardation of anemia development by compensating for iron typically consumed through fish intake, lost due to dietary constraints brought about by the SFPA (Chaparro, 2008; Lemoine & Tounian, 2020; Niang et al., 2016).
- **Urban and Rural:** According to the Property Appraiser Public Access (PAPA), urban regions consume more fish per year compared to rural areas (Marivoet et al., 2021).
- **Wealth Index Quintile:** This index is a combined measure of living standards. It is calculated by identifying various household characteristics and specific asset ownership, including material used in home construction, type of floor in home, ownership of livestock or arable land, water sources, sanitation facilities, etc… (Khulu & Ramroop, 2020)
- **Sex:** Medical research has found differences in iron deficiency and the amount of hemoglobin between female and male infants. Following previous studies, we decide to incorporate this control, and later explore possible heterogeneity. (Chaparro, 2008; Khulu & Ramroop, 2020; Tengco et al., 2008)

4 Methodology

4.1 Difference-in-Difference

4.1.1 Overview and Assumptions

Our identification strategy is a quasi-experimental design based on a difference-in-difference approach, where we aim to compare the impact of the SFPA on the prevalence and severity of anemia in children under five years old, between the coastal and non-coastal areas, and for pre and post-agreement time periods. Our variable of interest is the *Anemia Level* ordered category which groups the different results of the hemoglobin test by the DHS program in Senegal by severe, moderate, mild and non-anemic.

Regarding the DID assumptions that must be fulfilled in order to properly run our analysis we consider the following: interventions unrelated to outcome at baseline (allocation of the intervention was not determined by the outcome), treatment/intervention and control groups have parallel trends in the outcome, and the composition of the intervention and comparison groups is stable for repeated cross-sectional design (SUTVA) and without spillover effects. Parallel trend assumption is explained further in subsection 4.1.3.

Considering the independence of the treatment to the outcome variable, we define our treatment group as children located in coastal regions. In Figure 5, we note different levels of food insecurity in each region of Senegal for 2015 as calculated by the Standardized Monitoring and Assessment of Relief and Transition Hathie et al. (2017). Citizens living in food insecure citizens are assumed to have the highest levels of anemia. As the reader may perceive, food insecurity levels are varied and spread throughout the country. Definitively, we are not able to discern a pattern between coastal areas being more food secure as compared to non-coastal areas. Hence, the independence of our treatment group from the intervention assumption holds.

Finally, regarding SUTVA, due to the construction of the DHS baseline survey described in section 3.1 the composition of intervention and comparison groups is stable for every year of interview, ensuring that there is no selection bias. However even when clustered by household level we are unable to ensure the absence of spillover effects, as even when controlling for heterogeneity, omitted measurement errors may influence be influencing our analysis. We acknowledge that SUTVA is one of the most strict and difficult to hold assumptions in an empirical study.

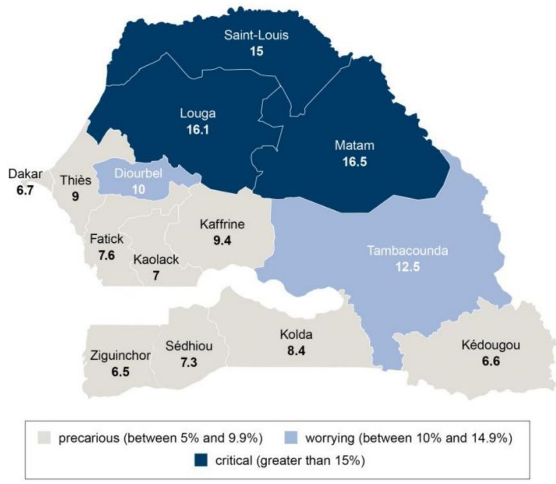

Figure 5: Prevalence of Acute Malnutrition in Senegal. Source: SMART 2015, through Hathie et al. (2017)

4.1.2 Regression Specification

Utilizing the DID regression framework specification, we apply a regional identification strategy and designate our main regression as the following:

$$AnemiaLevel_{irt} = \beta_0 + \beta_1 CoastalRegion_r + \beta_2 Post_t + \beta_3 (CoastalRegion_r \times Post_t) + \gamma X_{it} + \delta_r + \phi_t + \epsilon_{irt}$$

where $CostalRegion_r$ is a dummy equal to 1 if the region borders the Atlantic and 0 otherwise; $Post_t$ is a dummy equal to 0 for 2014 and 1 for 2015; $(CoastalRegion_r \times Post_t)$ represents the interaction term, our DID coefficient of interest, and will measure in which category of the *AnemiaLevel* variable children under five years of age in coastal regions post SFPA commencement are grouped into; X_{it} is a vector of individual specific characteristics including *Mother Educational Level*, *Gender of Child*, whether a mother was taking *Iron Pills During Pregnancy*, a dummy to denote if a child is living in an *Urban or Rural Area* and which *Wealth Index Quintile* the child belongs to; δ_r captures regional fixed effects; ϕ_t year fixed effects for unobserved time invariant heterogeneity across regions and time; ϵ_{irt} represents measurement error. Finally, we apply clustered standard errors at the household level, using a stable amount of households per cluster (approximately 25-30) within each of the 14 regions.

4.1.3 Parallel Trend Assumption

The parallel trend assumption is of the most critical assumptions to ensure internal validity of the DID model. It states that the difference between the 'treatment' and 'control' groups before the shock must be constant over time. Although there is no statistical test for this assumption, visual inspection is useful when considering many observations over many time points.

In Figure 6 we conduct this visual inspection. The trends between the treatment and control groups clearly demonstrate a parallel pattern when we considering levels of hemoglobin in children under five years of age. We choose to analyze hemoglobin levels as measured in grams per decilieter (g/dl) in this graphical analysis due to continuity characteristics, instead of choosing the anemia level ordered categorical variable. The intervention is considered to begin in 2015, as the SFPA was signed at the end of 2014. After this intervention, we clearly find a distortion in the distance between treatment and control groups, the former worse impacted by the agreement, as expected. Therefore, we note that treatment group begins to report lower levels of hemoglobin, suggesting a higher level of anemia in children in coastal areas after the SFPA is signed.

In conclusion, aligned with our hypothesis, Figure 6 shows that the parallel trend assumption holds in our study. Given the lack of the violation of the assumption, we can assume a non-biased estimation of our regressions.

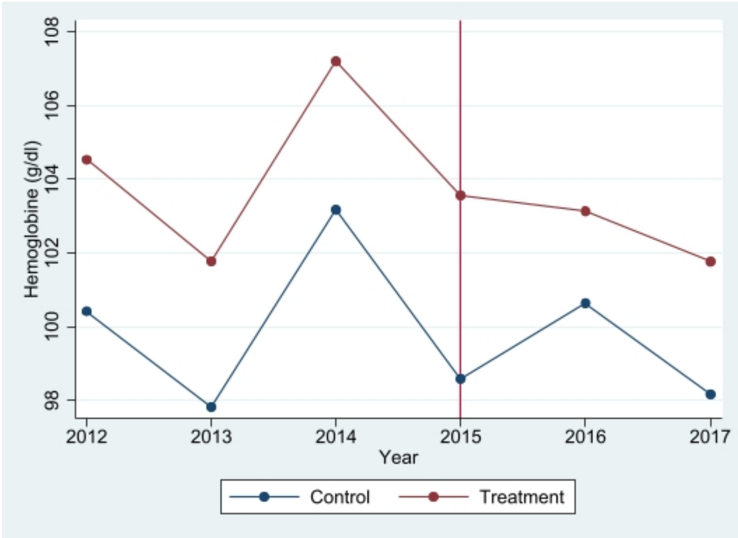

Figure 6: Parallel Trend Assumption by Hemoglobin Level (Data:USAID (2018))

4.2 Multinomial Logit Model

Given our main specification is a DID quasi-experimental approach, the nature of the outcome variable –an ordered categorical variable– compels us to run a Generalized Linear Model (GLM). The GLM is a flexible generalization of ordinary linear regression, allowing the linear model to relate to the response variable via a function and allowing the magnitude of the variance of each measurement to be a function of its predicted value.

Our GLM is a multinomial logit model. In the multinomial logit model we assume that the log-odds of each response follow a linear model represented as follows:

$$\eta_{ij} = log\frac{\pi_{ij}}{\pi_{iJ}} = \alpha_j + x_i^{'}\beta_j$$

where π_{ij} denotes the probability that the $i-th$ response falls in the $j-th$ category; α_j is a constant and β_j is a vector of regression coefficients, for $j = 1, 2, \ldots, J-1$. This model is analogous to a logistic regression model; the exceptions being that the probability distribution of the response is multinomial instead of binomial and that we have $J-1$ equations instead of one. The $J-1$ multinomial logit equations contrast each of categories $1, 2, ...J-1$ with category J whereas the single logistic regression equation is a contrast between successes and failures. If $J = 2$ the multinomial logit model reduces to the usual logistic regression model. Therefore, these types of models may be interpreted in two different manners, always by comparing an outcome base category with the rest ones. First, the output provides information regarding the sign of the coefficients, meaning, we are able to determine whether the probability that the $i-th$ response falls in the $j-th$ category is increasing or decreasing. Second, the marginal effects inform us as to the magnitude of the change of the dependent variable when a specific independent explanatory variable changes. Meanwhile other covariates are assumed to be held constant. The main results of our model are shown in the multinomial output format in subsection 5.1 and their marginal effects in subsection 5.2.

5 Results

5.1 Main Results

As explained in the subsection 4.2, the multinomial logit model reports the probability of an individual to transition from a base outcome category to any of the rest of the categories included in the dependent variable. As for us, we recall that our dependent variable Anemia Level has four different ordered categories: severe, moderate, mild, non-anemic, being our base outcome category **moderate**, due to the fact that it includes the biggest number of observations. Therefore, the output of the Multinomial logit model for the years 2014 and 2015 shown in Table 2 should be read as the probability of an individual (with and without controls) of moving from a moderate anemia level category to any of the another categories. In this section, only the output of the multinomial is going to be interpret by the sign of the coefficient, that means, if we face an increasing or decreasing probability to move to another category. The magnitude of the impact would be considered in section 5.2 when we will analyze the marginal effects.

Columns (1), (2) and (3) are reporting the results of the model without controls for the severe, mild and not anemic categories respectively. Even our Treatment variable doesn't report significance levels, we report that for the Post variable (2015 after the agreement), the levels of anemia were improving in the whole country, as the probability to move from moderate to severe decreases meanwhile moving to mild or not anemic categories the probability increase. However, our diff-in-diff coefficient ($Treament \times Post$) shows an opposite trend. The probability of moving from the moderate anemia category to the severe anemia category is increasing, even we don't report significance level. Otherwise, the probability to move to the better categories (mild and non-anemic) is decreasing with a 5% significance level. The previous results suggest that after the treatment in the coastal areas, children weren't improving their levels of anemia compared to the general trend, but we can't assume they worsen due to the lack of significance level of the severe category. In conclusion, meanwhile after the agreement the country reported better levels of anemia, for the coastal areas specifically they reported not worse but not improved levels.

On the other hand, columns (4), (5) and (6) report the same information but adding the controls. Our diff-in-diff coefficient and the post variables report similar directions than for the previous study without controls. For the Mother educational level, we can read that moving from the base category of "Mother educational level: no education", increasing the level of education of the mother is overall draws a decreasing trend of the probability to move from a worse category (severe). Due to the contradictions of the signs of the mild category we can't comment on them, but on the extreme best category not-anemic we can conclude that by increasing the educational level of the mother we increase the probability of moving from moderate anemia to not being anemic at all. Regarding the gender of the child, our model reports that being a female child benefits the levels of anemia as the probability to move from moderate to mild and not anemic report positive signs and significance level, aligned as well with our literature review. Unfortunately, we can't make many conclusions about the effect of mother taking iron pills during pregnancy or being a child located in rural areas, as they don't report significance levels.

Finally, for the Wealth Index Quintile, we are measuring the probability from a base outcome variable "Wealth index quintile: poorest" to the rest of the categories. As we only report significance levels for transitioning to better anemia categories (mild, not anemic) we are only making conclusion about their trends. Overall, we report that from the poorest level of wealth, moving to better income status increases the probability of their children to move from moderate anemia level to mild level or directly becoming not anemic. Those results are as well aligned by the previous researches done and documented in our literature review, in which better levels of income increases the access of resources to have a balance diet and possibly counteract a possible restriction of fish with other type of food.

5.2 Marginal Effects

As above-mention, the output of the multinomial logit model just gives us information about the sign of the coefficients, but not for the magnitude of them. Table 3 reports the marginal effects from Table 2 Multinomial logit output, but adding the controls. Aligned with the previous results, we don't report significance levels for the Treatment variables whereas we do for Post and our Diff-in-Diff coefficient of interest. Our Post variable outline an decreasing probability in -5.28pp to transition from moderate to severe anemia category, meanwhile to move to mild and not anemic the probability increases in 3.54pp and 6.73pp respectively. For our DID coefficient, we can't mention as well any conclusion about the probability to move to the severe anemia category due to the lack of the significance, but we show again an opposite trend for coastal areas in 2015: the probability of moving from moderate to mild and not anemic categories is decreased -3.29pp and -3.05pp respectively.

Regarding the controls, we focus our analysis only in the ones that reported significance levels: Mother educational level, Gender and Wealth Index Quintile. First, for educational level, even we can't make strong statements due to the inconsistency of the significance, we can overall perceive a beneficial trend. As an example, moving from the base category "Mother education: no education" to higher levels of schooling, shows a negative trend in the probability to fall in severe, being for the higher levels of education a decreasing probability of -96,2pp. Second, for the gender of the child, it shows that it affects positively in order to acquire better levels of anemia -mild and not anemic- in 15,4pp and 23,9pp respectively. Finally, for the Wealth Index Quintile, from a base category "Wealth index quintile: poorest", transitioning to better levels of wealth shows, like for the Mother education level, a positive increasing probability trend to have better levels of anemia. Taking the example of not anemic, we see that meanwhile from poorest quintile to poorer we report a 20,2pp increasing probability, from poorest to richest the probability reaches to 101,2pp.

5.3 Medium-Run Study

We decided to conduct a medium-run study in order to observe how the different variables and covariates behaves through time in order to attempt to draw a possible trend. For this reason, we incorporated the years 2012 and 2013 as a pre-treatment and years 2016 and 2017 as post-treatment. However, we faced an anomaly in the year 2017 where the number of observations dramatically increases as compared to other years in the sample. According to the 2017 DHS survey the rise in number of observations stems from the fact that Senegal received more resources to survey a larger sample of individuals during this time period (ANSD/Sénégal & ICF, 2018). Consequently, additional clusters were created in areas where they were not before present. Fortunately, this incorporation of additional clusters and individuals in newly observed locations, rather than the modification of previous clusters allowed us to drop the newly designated clusters (from ∼400 in the the year 2017 to the status quo ∼200 as in other years) from our analysis. We create a new variable denoted Cluster_2017 which balances the number of clusters to 200 for all periods. Results of our medium-run regression can be found in the Table 4 located in the appendix.

Briefly, we are going to just comment on the output of the multinomial, therefore to analyze the trends of the probabilities and compare them for the short-run approach in Table 2. Regarding the Diff-in-Diff coefficients, Treatment becomes now significant and reports that, for the coastal regions from 2012 to 2017, the levels of anemia were improving. However, we can't compare it with our interaction term $Treatment \times Post$, as the significance level disappears, surely because other covariates not included in our model would capture trends of the anemia level on the coast. On the other side, now the control variables "Taking iron pill during pregnancy" and "Rural" dummies acquires relevance in our study. Concretely, the pattern suggests that if the mother was supplementing herself with iron pills during the pregnancy of the child surveyed, the probability of that child of being not anemic increases, aligned with our literature review. Finally, if the child lives in a rural area, it increases the probability of having severe anemia, as well linked with previous studies on the field.

Table 2: Multinomial Logit Model of the Anemia Level in Children in Coastal Regions (2014-2015)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	severe	mild	not anemic	severe	mild	not anemic
Diff-in-Diff						
Treatment	-1.259**	0.448**	0.623**	-0.697	-0.411	-0.0464
	(0.577)	(0.220)	(0.244)	(0.827)	(0.297)	(0.379)
Post	-0.411**	0.247***	0.625***	-0.779***	0.442***	0.873***
	(0.181)	(0.0733)	(0.109)	(0.241)	(0.0991)	(0.161)
Treatment x Post	0.383	-0.288**	-0.345**	0.0953	-0.415***	-0.299
	(0.352)	(0.120)	(0.167)	(0.517)	(0.156)	(0.235)
Controls						
Mother education: primary				0.198	0.153	0.308***
				(0.269)	(0.114)	(0.115)
Mother education: secondary				-0.205	-0.109	0.235
				(0.410)	(0.152)	(0.159)
Mother education: higher				-12.19***	0.0585	0.707*
				(0.646)	(0.581)	(0.426)
Female child				-0.0323	0.274***	0.398***
				(0.185)	(0.0850)	(0.0850)
Taking iron pill during pregnancy				0.144	-0.0644	0.279
				(0.372)	(0.177)	(0.210)
Rural				0.185	-0.0458	0.0548
				(0.349)	(0.106)	(0.151)
Wealth index quintile: poorer				0.0711	0.218**	0.118
				(0.232)	(0.107)	(0.124)
Wealth index quintile: mild				-0.601	0.452***	0.340**
				(0.371)	(0.125)	(0.158)
Wealth index quintile: richer				-0.347	0.596***	0.800***
				(0.566)	(0.141)	(0.186)
Wealth index quintile: richest				-0.914	0.780***	1.013***
				(0.754)	(0.194)	(0.243)
Constant	-2.586***	-0.369***	-0.307*	-2.754***	-0.783***	-1.864***
	(0.280)	(0.128)	(0.168)	(0.689)	(0.290)	(0.350)
Observations	7,121	7,121	7,121	3,637	3,637	3,637

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Marginal effects for Anemia level in Coastal Regions (2014-2015)

VARIABLES	(1) severe	(2) moderate	(3) mild	(4) not anemic
Diff-in-Diff				
Treatment	-0.526		0.150	0.0252
	(0.698)		(0.251)	(0.268)
Post	-0.528**		0.354***	0.673***
	(0.221)		(0.0752)	(0.116)
Treatment x Post	0.173		-0.329***	-0.305*
	(0.392)		(0.124)	(0.175)
Controls				
(Mother education base category: no education)				
Mother education: primary	-0.146		0.0840	0.225***
	(0.209)		(0.0842)	(0.0718)
Mother education: secondary	-0.436		-0.0582	0.0179
	(0.346)		(0.104)	(0.116)
Mother education: higher	-0.962***		-0.213	0.334
	(0.419)		(0.423)	(0.324)
Female child	-0.127		0.154***	0.239***
	(0.138)		(0.0593)	(0.0568)
Taking iron pill during pregnancy	0.0246		0.136	0.327***
	(0.276)		(0.125)	(0.125)
Rural	0.213		-0.181**	-0.187
	(0.234)		(0.0850)	(0.114)
(Wealth quintile base category: poorest)				
Wealth index quintile: poorer	0.0280		0.217***	0.202**
	(0.152)		(0.0811)	(0.0948)
Wealth index quintile: mild	-0.708***		0.313***	0.494***
	(0.263)		(0.0960)	(0.121)
Wealth index quintile: richer	-0.432		0.527***	0.904***
	(0.421)		(0.115)	(0.152)
Wealth index quintile: richest	-1.127		0.519***	1.012***
	(0.685)		(0.160)	(0.178)
Constant	-2.483***		-0.740***	-1.246***
	(0.484)		(0.210)	(0.246)
Observations	7,121	7,121	7,121	7,121

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.4 Robustness Checks

As detailed in section 4.2 of the characteristics of the multinomial logit model, we shown that this model is considered a Generalized Linear Model (GLM), so therefore it is a ”flexible” generalization of ordinary linear regression. Hence, in order to contrast our results, we decided to run an OLS together with an ordered probit and ordered logit model so that we could cross-check if the information reported was aligned with our main findings. For the OLS regression, we changed our outcome variable from Kid Anemia Level to Kid Hemoglobin adjusted, as we precised from a continuous outcome variable to adequately make our estimatimations. On the other hand, ordered probit and ordered logit models would give us information about which is the probability to move from the top category (severe anemia) to the lowest category (not anemic), as an extreme-value comparison. Results are reported in Tables 5 and 6 in the Appendix for the short-run and the medium-run respectively. For each table, columns (1), (2) and (3) will report the results without controls, meanwhile columns (4), (5) and (6) will do for the results with controls. Only the diff-in-diff coefficients are reported for better understanding, as we only want to check the sign of the interaction term.

In conclusion, even not all of them report significance level, we can read that OLS regression on hemoglobin levels both with and without controls for the short and medium-run report a negative sign (except for column 1 in table 6, but as long as we consider the medium-run without controls we don't perceive it as a big concern). This results suggest that the hemoglobin levels for kids in the coast in the post year/s agreement were decreasing, aligned with our main results. Moreover, for the ologit and oprobit models we estimate as well negative coefficients, meaning that the probability of moving from severe category to not anemic category decreased. Therefore, the levels of anemia for children on the coastal regions were deteriorating. To sum up, running different models with strongest assumptions supports our main hypothesis of the effect of the fish agreement on the coastal region of Senegal.

Finally, in addition to the previous study, we decided to run as well the same multinomial logit model but avoiding the impact of the region and the capital of Dakar for our sample, as it could bias our study due to the fact that Dakar is the most populated and richest region of Senegal. Results can be found in Tables 7 and 8 in the appendix for the short and medium-run. Apparently, the results reported are not really different for the ones in our main estimation, nor for the significance lever or the sign of the coefficient. Hence, we can conclude that Dakar was not significantly affecting our estimations, so they should be assumed as robust.

5.5 Heterogeneity

Acknowledging the extend heterogeneity of our microdata, we wanted to explore the possible effects of our control variables on our outcome variable. For this reason, we decided to focus on the three control variables that reported significance level four our 2014-2015 study: Mother educational level, Gender of the child and Wealth index quintile. Nonetheless, many limitations were faced during this heterogeneity exercise that constrained our study in just subsampling by Wealth Index Quintile. First, we conclude that the covariate Mother educational level is a channel of Wealth Index Quintile. This means, the correlation between the highest levels of education for mothers with each Wealth Index Quintile category is really high. Therefore, exploring heterogeneity for both of them would be redundant for our study. Hence, we decided to just isolate the effect of the Wealth Index Quintile and assume that for the Mother educational level we would report similar results. Second, we tried to run a triple interaction term with the Gender and Wealth Index Quintile, but for the first case we didn't find any relevant and significant results and for the latter we faced multiple collinearity that difficult our estimations. Therefore, we just decided to subsample per Wealth Index Quintile as a possible alternative.

However, the results reported from Tables 9-13 didn't show us many important conclusions. As perceived in our regressions, the highest levels of Wealth reported better probabilities to acquire better levels of anemia. In conclusion, our heterogeneity study didn't enlighten new valuable information for our model. Therefore, this limitation should be consider as a possible extension of our paper.

6 Conclusion

In conclusion, through analysis of DHS survey data this study observes statistically significant and robust causal effects from the 2014 EU-Senegal SFPA on short-term anemia levels in children aged five and under. We find that these children from coastal regions experience an increased prevalence of anemia relative to their non-coastal residing counterparts during the time period immediately following the signing of the fishing agreement. These results are not significant for the long term. Further, we observe a negative influence on the wealth level of coastal citizens as compared to non-coastal citizens as caused by the 2014 SFPA. This effect is both robust and significant in the long term, and not robust nor significant in the short term. We consider the SFPA to be an ill-fated and rapacious policy and due to the potentiality for lack of enforcement, and the consequences that surround such excessive resource exploitation, 'legalized' or otherwise, believe that negative externalities associated with its passage will likely outweigh any positive benefits.

6.1 Limitations

Exceptional limitations of this paper stem primarily from the lack of relevant and available information and data originating from Senegal, and while the provisions set forth in the EU-Senegal SFPA both allow for and require the forwarding of some harvest data to be shared with various scientific institutions, they also express a requirement for the privacy and confidentiality of such information (EU, 2014). The opacity of Senegalese fishing industry data has undoubtedly made the enforcement of responsible fishing practices challenging and exacerbated environmental and economic health issues for citizens.

We as researchers believe that an understanding of the impacts of present day policies would benefit exceptionally with enhanced reporting practices, and as such would advocate for improved transparency and public availability of relevant data, considering that already 46% of Africa's catches are not reported (Belhabib, Sumaila, & Pauly, 2015b) as a means to combat illegal and exploitative fishing practices in Senegal, and to improve the policy decisions of governing officials.

From a purely speculative standpoint, we feel it is worth consideration as to why such impactful and useful information does not exist or is being restricted from public access. Does the lack of ability to easily and clearly demonstrate and understand adverse effects generated from bilateral policies make it easier for some nations to irresponsibly and unethically take advantage of others? It would seem such a strategy may at least mitigate repercussive consequences rightfully deserved of bullying nations.

6.2 Policy implications

As researchers, we recognize the benefits from trade, but also the limitations that can bring when trading policies are done poorly. To enrich Senegal's trading position and maximize gains from trade we propose:

- The developing of fish trade policies thought from and for the locals. The trade process needs to incorporate members from the communities, instead of displacing them.
- Prioritize regional fish trade to reinforce Africa's presence and sustainability. Instead of allowing foreign, European, vessels entering local waters, promote regional vessels to develop local economy and reducing illegal, unreported fishing.
- Include women in fisheries representation in fishing agreements, and policies. Displacing women in fishing industry can act as a channel to worsening children anemia levels and health overall.
- Promote transparency and accountability in the terms and implementations of the agreement. As researchers, we faced trouble accessing data such as: number of fish caught by EU in Senegal,

local people employed by the agreement, frequency of the ships in Senegalese waters, and detailed protocol of entering Senegal's port. This is a direct effect of the privacy and confidentiality clause in the SFPA, that does not allow information to be public.

6.3 Extensions

Future researchers may be motivated by potential migratory implications or gender disparity impacts of such policies in Senegal. Additionally, further analysis of the impact of EU SFPA's on other developing nations may brighten the awareness of potentially harmful and detrimental repercussions of biased resource exploitation agreements on the health and wealth-building opportunities for citizens of vulnerable nations.

We also encourage the development of complimentary studies incorporating a weighted regional distribution of the specific dietary consumption habits of Senegalese individuals as a means to more completely understand the dependency and importance of fish relative to other forms of sustenance within the country, and the utilization of climate change effects and the variation of types of geographic/climate zones within Senegal to better discover the heterogeneity of each in country region and such linkages to food insecurity levels.

7 Appendix

7.1 Medium-Run Main Regression table

Table 4: Multinomial Logit Model of the Anemia Level in Children on Coastal Regions (2012-2017)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	severe	mild	not anemic	severe	mild	not anemic
Diff-in-Diff						
Treatment	-0.880**	0.388***	0.685***	-0.394	-0.0788	0.349
	(0.367)	(0.124)	(0.150)	(0.660)	(0.162)	(0.238)
Post	0.366**	-0.0896	0.0893	0.545**	0.0908	0.147
	(0.176)	(0.0769)	(0.0962)	(0.224)	(0.117)	(0.161)
Treatment x Post	0.0873	-0.0723	-0.128	-0.0123	-0.182	-0.0214
	(0.196)	(0.0725)	(0.108)	(0.289)	(0.112)	(0.156)
Controls						
Mother primary education				0.149	0.182***	0.210***
				(0.172)	(0.0646)	(0.0774)
Mother secondary education				-0.134	0.0858	0.317***
				(0.262)	(0.0903)	(0.103)
Mother higher education				-12.57***	0.110	0.838***
				(0.372)	(0.292)	(0.254)
Female child				-0.0840	0.231***	0.459***
				(0.126)	(0.0506)	(0.0546)
Taking iron pill during pregnancy				-0.0672	0.0199	0.296**
				(0.213)	(0.117)	(0.148)
Rural				0.586***	-0.0693	-0.0654
				(0.199)	(0.0722)	(0.104)
Wealth: poorer				0.0564	0.0997	0.104
				(0.135)	(0.0722)	(0.0823)
Wealth: mild				-0.374*	0.304***	0.262**
				(0.214)	(0.0848)	(0.113)
Wealth: richer				-0.364	0.376***	0.547***
				(0.316)	(0.102)	(0.123)
Wealth: richest				-0.294	0.554***	0.885***
				(0.354)	(0.124)	(0.164)
Constant	-2.862***	-0.403***	-0.568***	-3.516***	-0.938***	-2.176***
	(0.193)	(0.0855)	(0.114)	(0.405)	(0.185)	(0.287)
Observations	26,466	26,466	26,466	8,995	8,995	8,995

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7.2 Robustness Checks Tables

Table 5: Robustness check Short-run (OLS, oprobit, ologit) (2014-2015)

VARIABLES	(1) OLS	(2) OLS controls	(3) oprobit	(4) oprobit controls	(5) ologit	(6) ologit controls
Treatment	7.230**	-1.779	0.326***	-0.0332	0.521***	-0.0774
	(3.212)	(1.955)	(0.108)	(0.167)	(0.180)	(0.285)
Post	4.723***	5.196***	0.309***	0.418***	0.518***	0.703***
	(0.772)	(0.815)	(0.0526)	(0.0626)	(0.0873)	(0.107)
Treatment x Post	-1.068	-1.192	-0.174**	-0.151	-0.290**	-0.265
	(1.478)	(1.248)	(0.0831)	(0.101)	(0.137)	(0.170)
Observations	10,878	3,637	10,878	3,637	10,878	3,637
R-squared	0.043	0.098				

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Robustness check Medium-run (OLS, oprobit, ologit) (2012-2017)

VARIABLES	(1) OLS	(2) OLS controls	(3) oprobit	(4) oprobit controls	(5) ologit	(6) ologit controls
Treatment	5.238***	1.137	0.333***	0.0932	0.541***	0.149
	(1.369)	(1.083)	(0.0632)	(0.0920)	(0.106)	(0.156)
Post	2.018*	0.492	-0.0157	-0.0109	-0.0149	-0.00389
	(1.167)	(1.530)	(0.0478)	(0.0667)	(0.0807)	(0.116)
Treatment x Post	0.197	-0.352	-0.0484	-0.0101	-0.0771	-0.0123
	(0.975)	(0.800)	(0.0529)	(0.0625)	(0.0881)	(0.109)
Observations	26,466	8,995	26,466	8,995	26,466	8,995
R-squared	0.024	0.057				

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Without Dakar - Short run (2014-2015)

VARIABLES	(1) severe	(2) mild	(3) not anemic	(4) severe	(5) mild	(6) not anemic
Treatment	-0.999	0.257	0.208	0.461	-0.658*	-0.754
	(0.783)	(0.280)	(0.355)	(1.079)	(0.384)	(0.459)
Post	-0.411**	0.247***	0.625***	-0.780***	0.440***	0.871***
	(0.181)	(0.0733)	(0.109)	(0.240)	(0.0990)	(0.161)
Treatment x Post	0.385	-0.250**	-0.256	0.0186	-0.362**	-0.134
	(0.356)	(0.125)	(0.175)	(0.533)	(0.164)	(0.244)
Constant	-2.586***	-0.369***	-0.307*	-2.770***	-0.784***	-1.818***
	(0.280)	(0.128)	(0.168)	(0.694)	(0.291)	(0.350)
Observations	10,599	10,599	10,599	3,565	3,565	3,565

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Without Dakar - Medium-run (2012-2017)

VARIABLES	(1) severe	(2) mild	(3) not anemic	(4) severe	(5) mild	(6) not anemic
Treatment	-0.967**	0.272**	0.440***	-0.440	0.0569	0.232
	(0.382)	(0.108)	(0.163)	(0.517)	(0.159)	(0.237)
Post	0.373**	-0.0947	0.107	0.531**	0.0790	0.127
	(0.177)	(0.0789)	(0.0951)	(0.223)	(0.118)	(0.165)
Treatment x Post	0.0685	-0.0444	-0.0502	-0.0869	-0.141	0.0572
	(0.196)	(0.0746)	(0.112)	(0.292)	(0.116)	(0.160)
Constant	-2.867***	-0.409***	-0.578***	-3.470***	-0.923***	-2.154***
	(0.193)	(0.0851)	(0.114)	(0.405)	(0.184)	(0.288)
Observations	25,065	25,065	25,065	8,562	8,562	8,562

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7.3 Heterogeneity Tables

Table 9: Subsampling - Wealth index quintile: poorest (2014-2015)

VARIABLES	(1) severe	(2) moderate	(3) mild	(4) not anemic
Diff-in-Diff				
Treatment	-12.87***		0.0790	0.918**
	(0.606)		(0.345)	(0.440)
Post	-0.395		0.332***	0.883***
	(0.279)		(0.124)	(0.207)
Treatment x Post	-0.351		-0.627**	-0.393
	(0.719)		(0.309)	(0.344)
Controls				
Mother primary education	0.286		0.208	0.538***
	(0.296)		(0.140)	(0.145)
Mother secondary education	-0.632		-0.100	0.586***
	(0.534)		(0.208)	(0.203)
Mother higher education	-12.82***		-0.218	0.716
	(0.607)		(0.820)	(0.505)
Female child	-0.0724		0.225**	0.392***
	(0.206)		(0.106)	(0.115)
Taking iron pill during pregnancy	0.141		-0.172	0.235
	(0.411)		(0.193)	(0.257)
Rural	0.428		-0.270**	-0.190
	(0.333)		(0.121)	(0.168)
Constant	-3.474***		-0.258	-1.500***
	(0.689)		(0.327)	(0.379)
Observations	2,438	2,438	2,438	2,438

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Subsampling - Wealth index quintile: poorer (2014-2015)

VARIABLES	(1) severe	(2) moderate	(3) mild	(4) not anemic
Diff-in-Diff				
Treatment	-13.02***		-0.0633	0.804*
	(0.554)		(0.349)	(0.444)
Post	-1.118***		0.448***	0.734***
	(0.433)		(0.151)	(0.217)
Treatment x Post	0.0360		-0.455*	-0.238
	(0.876)		(0.246)	(0.342)
Controls				
Mother primary education	0.0941		0.136	0.480***
	(0.315)		(0.136)	(0.135)
Mother secondary education	-0.469		-0.185	0.421*
	(0.523)		(0.192)	(0.219)
Mother higher education	-12.23***		-0.467	0.662
	(0.535)		(0.765)	(0.468)
Female child	-0.0375		0.227**	0.360***
	(0.197)		(0.103)	(0.109)
Taking iron pill during pregnancy	-0.0240		-0.102	0.381
	(0.434)		(0.205)	(0.316)
Rural	0.176		-0.401***	-0.304*
	(0.321)		(0.119)	(0.162)
Constant	-2.389***		-0.0715	-1.442***
	(0.712)		(0.336)	(0.433)
Observations	2,351	2,351	2,351	2,351

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Subsampling - Wealth index quintile: mild (2014-2015)

VARIABLES	(1) severe	(2) moderate	(3) mild	(4) not anemic
Diff-in-Diff				
Treatment	-13.50***		-0.243	0.782
	(0.617)		(0.365)	(0.489)
Post	-1.069		0.443**	0.777***
	(0.731)		(0.219)	(0.273)
Treatment x Post	0.973		-0.0985	-0.0164
	(1.000)		(0.292)	(0.372)
Controls				
Mother primary education	0.148		0.272*	0.460***
	(0.310)		(0.142)	(0.148)
Mother secondary education	-0.700		-0.0625	0.368*
	(0.507)		(0.186)	(0.201)
Mother higher education	-13.25***		-0.236	0.679
	(0.644)		(0.830)	(0.474)
Female child	-0.157		0.240**	0.408***
	(0.193)		(0.105)	(0.118)
Taking iron pill during pregnancy	0.0185		-0.207	0.219
	(0.463)		(0.201)	(0.327)
Rural	0.406		-0.259**	-0.195
	(0.334)		(0.122)	(0.160)
Constant	-3.018***		-0.0744	-1.439***
	(0.737)		(0.346)	(0.465)
Observations	2,184	2,184	2,184	2,184

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Subsampling - Wealth index quintile: richer (2014-2015)

VARIABLES	(1) severe	(2) moderate	(3) mild	(4) not anemic
Diff-in-Diff				
Treatment	-13.37***		-0.189	0.402
	(0.594)		(0.342)	(0.472)
Post	-13.51***		0.799***	1.142***
	(0.355)		(0.216)	(0.406)
Treatment x Post	0.416		-0.710**	-0.498
	(0.500)		(0.361)	(0.477)
Controls				
Mother primary education	0.157		0.194	0.458***
	(0.327)		(0.145)	(0.154)
Mother secondary education	-0.827		0.0197	0.565***
	(0.615)		(0.190)	(0.218)
Mother higher education	-13.02***		0.0868	0.757
	(0.660)		(0.773)	(0.501)
Female child	-0.121		0.194*	0.412***
	(0.208)		(0.113)	(0.125)
Taking iron pill during pregnancy	0.0208		-0.171	0.160
	(0.462)		(0.214)	(0.350)
Rural	0.367		-0.328***	-0.321*
	(0.346)		(0.121)	(0.167)
Constant	-3.007***		-0.0130	-1.234***
	(0.743)		(0.362)	(0.470)
Observations	2,042	2,042	2,042	2,042

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Subsampling - Wealth index quintile: richest (2014-2015)

VARIABLES	(1) severe	(2) moderate	(3) mild	(4) not anemic
Diff-in-Diff				
Treatment	-0.819		-0.250	0.334
	(0.770)		(0.343)	(0.430)
Post	-12.96***		0.0723	0.133
	(0.477)		(0.400)	(0.567)
Treatment x Post	13.10***		-0.282	0.573
	(1.050)		(0.464)	(0.694)
Controls				
Mother primary education	0.157		0.236	0.529***
	(0.326)		(0.153)	(0.153)
Mother secondary education	-0.954		-0.223	0.445**
	(0.620)		(0.203)	(0.213)
Mother higher education	-12.43***		0.203	0.943*
	(0.637)		(0.643)	(0.485)
Female child	-0.0796		0.227**	0.417***
	(0.207)		(0.116)	(0.130)
Taking iron pill during pregnancy	0.0349		-0.156	0.196
	(0.461)		(0.211)	(0.350)
Rural	0.432		-0.365***	-0.352**
	(0.360)		(0.128)	(0.165)
Constant	-3.077***		0.00470	-1.237***
	(0.748)		(0.368)	(0.470)
Observations	1,954	1,954	1,954	1,954

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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