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Abstract

Large oil reserves were discovered in northern Ecuadorian Amazon region in 1967. In 1972 the country became an oil exporter, and ever since crude petroleum has been the backbone of the national economy. According to different studies, the national effects of oil extractivism have been detrimental for socially inclusive and sustainable development. Economic growth has been unstable and low, achieved economic diversification is minimal, poverty still affects to about a third of the population, underemployment accounts for about half of the labor force, and the environmental effects of oil extraction (deforestation, pollution, biodiversity loss, oil spills) have been severe.

Most of the research about oil and development in Ecuador has been done from national or internationally comparative perspectives, and some studies were focused on local social conflict in extractive areas. This article complements former research, by focusing on local social effects of oil extraction, using census data and other geographical sources with a high level of spatial resolution.

An initial analysis was based on the 1990, 2001 and 2010 population censuses as the main social information source. A social development index (SDI) was elaborated, using principal components analysis, from 19 social indicators on education, health, housing and gender differences, broken down by parishes, the smallest administrative division in Ecuador. The Amazon consistently has been the most socially deprived region in Ecuador, both in the urban and rural areas. Moreover, differentiating between oil extracting zones and the rest of the Amazon, the social index remains lower in the oil extraction region, both in urban and rural areas. The most critical social indicators regard child mortality and access to health services, while differences in education are less severe.

A deeper analysis was done on explanatory factors leading to social distribution, breaking down the SDI at the census track level, and performing a spatial autoregressive multiple regression model with the SDI as the dependent variable, and selecting as independent variables oil extraction proximity, soil fertility, access to markets, proportion of deforested areas, a dummy for rural tracks, and 3 indicators of employment structure (proportions of agriculture, wage earners, and tourism in the labor force).

All independent variables reached statistically significant coefficients. The oil proximity indicator had a negative effect on social wellbeing, and deforestation, included in quadratic form, presents an initial small positive effect on social conditions, which vanishes as deforestation increases over 65% of the area. All the remaining regression coefficients had the expected signs.

The main regression findings are: a. After controlling for all relevant variables with available information, oil has a net negative effect on the local social development index. b. The social improvement linked to deforestation, other things being equal, is small, subject to decreasing returns, and disappear in advanced stages of the process. c. Economic diversification towards tourism has a high social redistribution effect.

As remaining oil reserves in Ecuador are low, and the environmental impact of deforestation is severe, a strategy towards alternative development paths in Ecuador's Amazon is a priority.

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Introduction

Comparative development studies point out structural hindrances facing extractive economies to reach equitable social distribution and sustained economic growth. Although national experiences are heterogeneous, extractivism often leads to weak an unstable economic performance, minimal sectoral diversification, insufficient employment generation and poor institutional development (Thorp 2013, Berry 2008, Karl 1997, Karl 1999, Sachs 1995, Gelb et a, Ross 2012). Bebbinton (2013) analyzes regional effects in extractivist areas, finding frequent social conflictivity, uneven social development and the prevalence of poverty and exclusion. However, Bebbington approach is mostly socio-political, and less attention has been paid to comparative social development analysis based on social and environmental indicators.

This article focuses on effects of extractive specialization on unequal regional development and the lack of social and environmental justice, taking Ecuador as a case study. The main objective is analyzing the long term social effects of oil extraction on the regional social conditions in the Ecuadorian Amazon, by comparing oil extraction areas with the rest of the Amazon and the country. The analysis is based on Census data from 1990, 2001 and 2010, broken down at highly detailed micro-regional level.

Theoretical framework

Most oil exporter developing countries share difficulties in reaching sustained and equitable growth, and several studies have found that oil exports have had negative impacts on development. Already in the 1950s, Prebisch and Singer pointed out the disadvantages of primary export specialization, as international commodity prices face short term instability and a declining long term trend. A comparative World Bank investigation concluded that most oil-exporting countries failed to efficiently channel oil revenues into development during the 1970s. In general, the economic results for national development were disappointing, as "Dutch Disease" and other shared problems reduced the possibilities of economic diversification and stability (Gelb et al, 1988).

The "Dutch Disease" theory refers to the negative effects of primary export booms on long term development prospects for industrialization and economic diversification. The term originated in Holland after the discovery of North Sea gas (Gelb, 1988). Booming export activities generate effects on the exchange rate and domestic demand that over-expand both the booming traded and shielded sectors, making other traded and import competing activities less competitive. Once the boom is over, the economy is affected by low diversification and deindustrialization.

Jeffrey Sachs, based on a sample of 97 developing countries between 1971 and 1989, found a negative and significant correlation between natural resource exports and economic growth (Sachs, 1995). Albert Berry, based on a comparative analysis of Indonesia, Venezuela, Chile, and Nigeria, found poor outcomes in job creation and income distribution in oil and mineral exporting countries (Berry, 2008). Terry Karl explains how oil exporting developing countries tend to rely excessively on oil revenues as fiscal resources, thereby weakening taxation systems and state institutions (Karl, 1997, 1999). Rosemary Thorp points out that mining and oil producer countries have generally serious long-term institutional development problems (Thorp et al, 2012) although, in some exceptional cases, such as Chile and Botswana, solid institutions prevented detrimental effects and permitted growth and diversification. Bebbington, based on a comparative

study of Peru, Bolivia and Ecuador, analyses the effects of extractive activities on local development in mining and oil extraction regions. Linkages of extractive industries with local economies are generally weak, as are the results of local development projects promoted by extractive corporations. Local redistribution of fiscal linkages may contribute to development but only in the infrequent context of efficient institutions, both national and local. Oil and mining regions are also severely affected by environmental degradation. The case studies show, most often, highly conflictive social scenarios with disappointing redistributive development results (Bebbington, 2013). In general, countries dependent on oil or mineral exports are vulnerable and fragile, and they share poor records in economic growth, diversification, institutional development, job creation, and equity (Larrea, 1993, Larrea and Warnars, 2009).

Background: Oil and development in Ecuador

Ecuador, a small South American country, ranks 89th among the 188 countries on the UN Human Development Index. Within Latin America, it is clearly a less developed country, with a per capita income below the regional average (UNDP, 2016)[2]. Ecuador's level of economic diversification remains low, and according to ECLAC, in 2013 primary products still represented 93% of exports, mostly composed of crude oil, bananas, shrimp, coffee, cacao, fish and flowers (ECLAC, 2015). Petroleum, the single most important product in the economy, accounted for 56% of total export revenue between 2010 and 2014, and oil revenues made up on average 32% of the government's revenues between 2009 and 2013 (Banco Central del Ecuador, 2018).

Ecuador has one of the most diverse natural and cultural endowments in the word, with the highest number of vertebrates per square kilometre on earth (Josse, 2001). Additionally, Ecuador ranks among the first ten most abundant countries in the absolute number of amphibians, birds, and butterflies. More specifically, Ecuador has the second highest number of orchid species in the planet, after Indonesia.[3] Ecuador also has a rich cultural diversity, with 14 indigenous nationalities and 13 spoken languages, although some of them may disappear soon[4].

In 1967 large oil reserves were discovered in the Amazon region, and from 1972 onwards Ecuador has been an oil exporter. Five decades later, it can be concluded that oil contributed little to equitable and sustainable development, in spite of some economic and social transformation. Economic growth remained evasive and unstable, with an average annual growth rate of 2.8% in per capita income between 1972 and 2014. This growth rate was only slightly higher than that of the pre-oil period (1950-1972), but the difference was not statistically significant. Despite important social achievements during the oil boom (1972-1982) and between 2006 and 2014, the social, ethnic, and regional disparities that have historically affected the country remained pervasive, as 30% of the population lived below the poverty line, underemployment affected 40% of the labour force in 2017 (Larrea, 2018), and social inequality barely declined, as the Gini coefficient remained at 0.52 in 2015 (ECLAC, 2015; Vallejo, Falconi, Larrea, and Burbano, 2015, Larrea, 2018).

Since oil extraction in Ecuador is located in a formerly undisturbed region in the Amazon basin,

[2] Ecuador's per capita GDP was 10,718 PPP Dollars, compared with the Latin American average of 14,041 dollars in 2015. PPP dollars are estimated at 2011 prices.

[3] Ecuador has 4,015 species of orchids, while Indonesia has about 5,000. World identified species number 27,934; the third country is Colombia, with 3,516 species. (Hassler & Rheinheimer, 2013).

[4] Some languages, such as the Zapara, are on the verge of extinction.

the environmental effects of oil activity have been severe, particularly regarding deforestation, loss of biodiversity, pollution, and human health hazards (Herbert, 2010; Amazon Defense Coalition, 2012).

Although during the recent neo-extractivist phase (2004-2014) a new development strategy was applied, strengthening state intervention in the economy and promoting more inclusive social policies, in an international context of high oil and commodity prices, the whole option collapsed when oil and raw material prices plummeted since 2014. Neo-extractivist strategies failed to diversify the economy, and under a heavy debt burden, in a context of limited oil reserves, the county is currently affected by a deep economic, social and political crisis (Larrea, 2019).

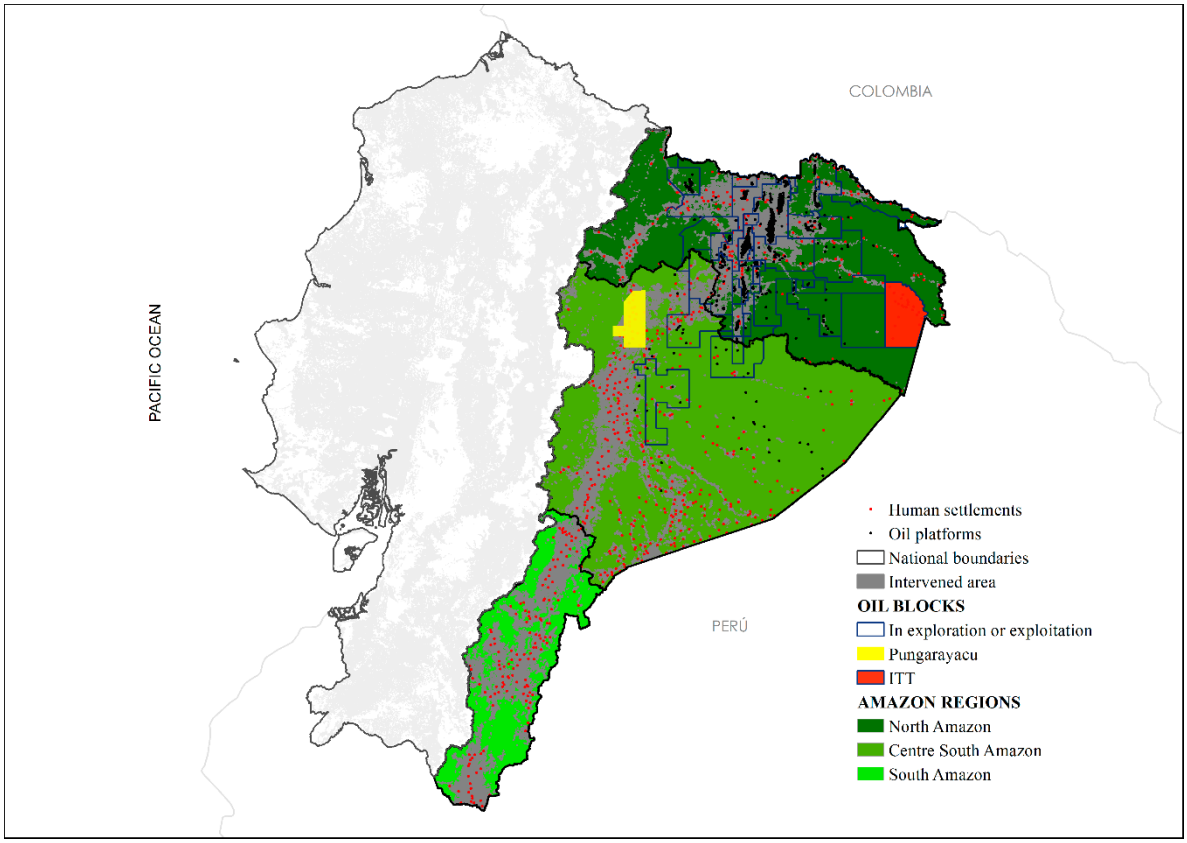
Oil and social development in the Amazon region

Although the Amazon provinces account for 47% of national territory, the region remained historically isolated from the rest of the country until 1967, when large oil reserves were discovered in the northern Amazon by Texaco. After the Spaniard conquest only two short periods of resource extraction deeply disrupted the indigenous cultures of the region. The first of them took place in the XVI century, linked with gold mines, and the second occurred in the late XIX and early XX centuries, related with rubber extraction (Taylor, 1994). Nevertheless, the Amazon population reached only 1.7% of the national total in the 1962 census.

Oil extraction brought about a rapid process of internal migration to the region, with expansion of agricultural frontier, deforestation in the northern Amazon and other severe environmental impacts. Between 1974 and 2010, The Ecuadorian Amazon population expanded more than fourfold, reaching 739,814 inhabitants in the latter year. In 2008, cumulative deforestation accounted for 17.8% of original ecosystems (Larrea, 2017). Map 1 illustrates oil activity, deforestation and population distribution in contemporary Amazon.

The national effects of oil dependence in Ecuador have been extensively analyzed elsewhere, differentiating economic, social and environmental dimensions (Larrea, 1993, Larrea 2017, Larrea 2018, Larrea, 2019). This article complements the mentioned studies by focusing on regional effects of oil extraction in the northern Amazon, with emphasis on human needs (education, health, housing, employment) and the fulfilment of SDGs. The analysis is done using high spatial disaggregation, including social and environmental information at detailed micro-regional level.

Map 1. Conservation, population and oil in Ecuadorian Amazon



Source: Unidad de Información Socio Ambiental, UASB.

Methodology

The main objective of this article is identifying and explaining the local effects of oil extraction on the social conditions of local population, with emphasis in basic needs satisfaction. A second objective is to explore the relationship between deforestation and changes in the living conditions of local population. Deforestation in Amazonian Ecuador has been mostly the result of expansion of agricultural frontier carried out for poor migrant peasants, who take the land open by roads built by oil companies.

The concentration on oil and agriculture is relevant because these activities have been the main support of the regional economy in Ecuadorian Amazon. Oil extraction accounted for 61% of regional GDP in 2017, but generated only 1% of employment, on the other hand, agriculture has been the main source of employment, with 52% of the rural labor force in 2010, equivalent to 36% of the total. However, the agricultural share in regional GDP was low (5% in 2017) as a result of poor land and labor productivity (INEC, 2010 Census, Banco Central del Ecuador, Cuentas Regionales, 2017).

The main data sources were the 1990, 2001 and 2010 national censuses, broken down with detailed spatial disaggregation. Additionally, high resolution digital maps on deforestation, soil fertility, location of agricultural markets and oil drills were used.

The social development index (SDI). To capture basic needs satisfaction at the local level we elaborated a social development index, estimating 19 indicators from the population censuses of 1990, 2011 and 2010, broken down by parishes in rural areas and by municipalities in urban areas. Six indicators deal with education, 2 with health, 3 with gender differences in education and employment, and 8 with housing. Parishes are the smallest administrative division in Ecuador, and the country was divided into 1024 local circumscriptions. The SDI was estimated as the first component using principal components analysis, maximizing its statistical representativity, and explained 50.5% of the total variance of its 19 components.

Education indicators were: 1. Average years of schooling for the population older than 23 years (ESCOL). 2. Proportion of literacy in the population older than 14 years (ALFAB). 3. Net assistance rate for primary education (TPRIM). 4. Net assistance rate for secondary education (TSECUN). 5. Net assistance rate for higher education (TSUP). 6. Proportion of population older than 23 years with access to higher education (TACSUP).

Health indicators were: 7. Weighted health personal for each 10,000 inhabitants (PERSAL). 8. Proportion of dead sons and daughters from mothers aged between 15 and 49 (PNINMUER).

Gender indicators were: 9. Difference between male and female literacy rates (DISEXAL). 10. Difference between male and female schooling (DISEXESCOL). 11. Female proportion in the economically active population (PFEMPEA).

Housing indicators were: 12. Proportion of dwellings with access to piped water inside the house (PAGUA). 13. Proportion of dwellings with sewerage (PALCAN). 14. Proportion of dwellings with collecting garbage service (PBASURA). 15. Proportion of dwellings with electricity (PELEC). 16. Proportion of dwellings with adequate walls (PPARED). 17. Proportion of dwellings with adequate floor (PPISO). 18. Proportion of households with less than 3 persons per room. 19. Proportion of dwellings with toilettes inside the house (PSSHH).

The SDI was rescaled to an interval between o and 100 points. Its formula is:

SDI = 0.904 * ESCOL24 + 0.707 * ALFAB15 + 0.604 * TPRIM + 0.859 * TSECUN + 0.822 * TSUP + 0.771 * TACSUP - 0.452 * DISEXAL + -0.299 * DISEXESCOL + 0.714 * PERSAL - 0.722 * PNINMUER+ 0.233 * PFEMPEA + 0.802 * PAGUA + 0.749 * PALCAN + 0.848 * PBASURA + 0.734 * PELECT + 0.693 * PPARED + 0.602 * PPISO + 0.716 * PPERCUA + 0.839 * PSSHH (Larrea and Camacho, 2013).

In the regression analysis, the SDI was used as dependent variable, breaking down the 2010 Census by census tracks (sectores). Ecuador was divided into 40,640 census tracks in 2010.

From the SDG perspective, the selected social indicators and the SDI are directly relevant for goals 1 (no poverty), 3 (health), 4 (education), 5 (gender equality), 6 (clean water) and 7 (energy). There are strong indirect links with goals 2 (zero hunger), 8 (decent work) and 10 (reduced inequalities).

The initial descriptive analysis brook down the SDI by area of residence (urban and rural) and natural region (Coast, Highlands, Amazon and Galapagos). The Amazon region was further divided into an oil extractive sub-region and the remaining part. The oil extractive subregion was integrated by the parishes or municipalities containing oil blocks in production in 2017.

For the regression analysis, the following independent variables were estimated at the census track level in the Amazon region.

Proximity to oil wells index. Defined as the sum of inverse distances between the centroid of each census track and the surrounding oil wells. The PRAS map (2013) was used to identify

wells.[5] A radius of 50 Km from the centroid was used to identify surrounding oil wells. The variable was included for identifying the effects of local oil extraction on social conditions.

Soil fertility index. Defined as the percent of area with at least medium soil fertility in each census track. The source is the map of soil agricultural aptitude from the MAGAP-SIGTIERRAS (2015) program of Ecuador´s Ministry of Agriculture, which identify 4 categories of fertility: very low, low, medium and high. The variable intends to evaluate effects of local soil quality on living conditions.

Proportion of intervened areas. Defined as the proportion of artificially modified areas on the total area of each census track, excluding natural water bodies. Modified areas include cropland, pastures, artificial water bodies, human settlements, infrastructure and no forested-covered areas. The source is the 2016 map of land use of the Ministry of Environment. This variable was included in the regression model in parabolic quadratic form. The variable intends measuring the effect of deforestation on local social conditions.

Travel time to the closest agricultural market. Defined as the number of hours required to travel from the centroid of each census track to the closest agricultural market. The variable is expected to evaluate the social contribution of market access.

Dummy rural. Dichotomous variable included to differentiate rural sectors from small towns, concentrated (blocked) settlements and cities.

Additionally, 3 local employment indicators were included in the regression model, to capture the potential effect of economic diversification and the expansion of capitalist relations in the labor force. Information was obtained from the 2010 population census.

Proportion of agriculture in economically active population (EAP). Included as an indicator of economic diversification from agriculture, the traditionally dominant sector.

Proportion of wage earners in EAP. Expected to capture the influence of capitalist social relations of production, as opposed to traditional family based or independent ways of production, which prevail among peasants and urban small producers.

Proportion of hotels, lodging, restaurants and food services in EAP. Expected to capture the extent of tourism in employment.

To differentiate between deforestation leading to expansion of agricultural frontier and deforestation leading to urban expansion, an interaction term **(Dummy rural)*(Proportion of intervened areas)** was also included.

Results and discussion

To explore the regional distribution of oil revenue in Ecuador, we began breaking down the SDI by region and area of residence for 1990, 2001 and 2010 (Table 1). The urban area includes all cities and towns with population higher than 10,000 inhabitants.

[5] PRAS (Programa de Reparación Ambiental y Social) is a public institution dependent of the Ministry of Environment in Ecuador.

Table 1

Social Development Index in Ecuador by region and Area: 1990-2010

Region and Area	1990	2001	2010
Rural Highlands	42.1	49.0	59.0
Urban Highlands	67.3	72.1	78.4
Rural Coast	42.4	47.7	55.3
Urban Coast	59.6	63.1	69.6
Rural Amazon	41.0	45.8	54.3
Urban Amazon	54.1	60.5	68.3
Rural Galápagos	62.1	65.9	69.6
Urban Galápagos	65.5	66.8	74.6
Total	55.2	60.4	68.1

Sources: UASB-UISA, based on: INEC, Censos de Población y Vivienda, 1990, 2001, 2010.

As the table shows, the Amazon region remains the poorest in the country, both in urban and rural areas. Oil revenues benefitted mostly the urban highlands where Quito -Ecuador´s capital - is located, and the gap between rural Amazon and the national average did not decline between 1990 and 2010.

To refine the analysis, the Amazon was divided into an oil extracting sub-region and the remaining part (Tables 2 and 3). Results illustrate that within the Amazon, oil extracting zones are consistently more affected from social deprivations than the corresponding non-oil zones, both in urban and rural areas. Table 2 illustrates also average schooling years, a representative education indicator, with lower differences, given the high proportion of immigrants in the population. As it is well known, immigrants usually have higher than average levels of education in their original regions. By contrast, in the case of health conditions, represented by the proportion of dead children, differences against oil extracting zones in the Amazon are deeper. As Table 3 shows, results for 1990 and 2001 are similar and inequalities remain consistent during the 20-year period.

Multiple regression analysis. As information shows, the Amazon barely benefited from the regional distribution of oil revenues. Not only the region consistently remained the most socially deprived in Ecuador, but also the oil extracting subregion kept lower social benefits than the non-oil part of the Amazon, both in urban and rural areas. The analysis suggests that oil extraction may have a negative or detrimental net effect on local social development, but the tables do not demonstrate this relationship, given that the improving in social conditions is the result of multiple factors, such as soil fertility, access to agricultural markets, opportunities of economic diversification, development of non-agricultural employment, and so on.

Table 2
Selected Social indicators in oil extracting and remaining Amazon regions: 2010

Subregion	Area	Years of Schooling	Child mortality proportion	Social Development Index
Amazon oil extracting region	Rural	6.7	0.057	48.7
	Urban	8.6	0.044	64.1
	Total	7.7	0.050	56.8
Amazon non-oil extracting region	Rural	7.1	0.047	50.8
	Urban	9.8	0.034	72.9
	Total	8.2	0.042	58.7
National Total	Rural	5.9	0.046	51.9
	Urban	9.5	0.032	73.1
	Total	8.7	0.035	68.1

Sources: UASB-UISA, based on: INEC, Censos de Población y Vivienda, 1990, 2001, 2010.

Table 3
Social Development Index by Subregion and Area: 1990-2010

Subregión	Zone	1990	2001	2010
Urban Amazon	Oil extracting	47.6	55.3	64.1
	Non oil extracting	58.3	64.8	72.5
Amazonia Rural	Oil extracting	40.4	44.9	53.0
	Intervened, Non-oil extracting	41.9	47.0	55.8
	Non intervened	31.1	35.6	42.3
Rural Highlands		42.1	49.0	59.0
Urban Highlands		67.3	72.1	78.4
Rural Coast		42.4	47.7	55.3
Urban Coast		59.6	63.1	69.6
Galápagos Islands		63.6	66.4	73.4
Total Nacional	Total	55.2	60.4	68.1

Sources: UASB-UISA, based on: INEC, Censos de Población y Vivienda, 1990, 2001, 2010.

To test in detail the net effect of local oil activity on social development, including the available information on other factors potentially influencing social development, a multiple regression model was elaborated, with information from 2,408 census tracks in the Amazon region with valid data (145 tracks were excluded due to missing values). The Amazon region was defined including all the six regional provinces, which incorporate not only the dominant lowlands but also the foothills of the Andean mountains, where many Amazon headwaters originate.

As information is spatially defined, OLS regression models may have a bias due to spatial autocorrelation, as a result of influences among neighboring or closer tracks. To control for spatial autocorrelation, a spatially autoregressive model was used, with a dependent variable lag and an inverse distance matrix among tracks. The model was run with Stata statistical software (version

15). The autoregressive regression results are presented in Table 3. Its main findings can be summarized as follows.

1. All independent variables have regression coefficients significant at least at the 5% level, and most of them are significant at 1% level. Only *dummy rural*, its interaction term and soil fertility have a 5% significance level.

2. The regression coefficient of local proximity of oil wells is negative and statistically significant at 1% level. The result is consistent with the negative effect of oil extraction on SDI presented in Table 2, and strongly suggests that, after controlling for other observable factors that may influence social conditions, such as soil fertility, access to markets, proportion of deforested land, and employment structure and diversification, the close proximity or local presence of oil extraction has a detrimental effect on basic needs satisfaction.

   As oil extraction is highly capital intensive, its local contribution to employment is low, and usually concentrated on skilled labor, coming from outside the Amazon region. Only during the brief construction phase oil extraction has an important local unskilled labor component. However, oil may have an important fiscal link with social development, as a result of the local investment of oil revenues in social development (schools, health facilities, housing infrastructure, productive credit, technical assistance, and so on). Social investment may come from the national government, local governments or oil companies. On the other hand, detrimental effects of oil extraction may come from pollution, disincentives to tourism, social conflict, prostitution and corruption. The negative coefficient suggests that in the Ecuadorian case, detrimental effects overcome social investment and other benefits from oil activity. Actually the environmental impact of oil in Ecuador's Amazon has been evaluated as severe, particularly during the intervention of Texaco (1967-1993), as most of residuals were systematically thrown to the environment without any treatment. Afterwards, the frequency of oil spills has remained high, averaging about once in a week (Herbert, 2010; Amazon Defense Coalition, 2012; Durango et al, 2018).

3. As mentioned, agriculture is the most important source of employment in the Amazon and has a modest contribution to regional GDP. Unfortunately, Amazon soils usually have low aptitude for cultivation, land productivity is low and decreases over time after deforestation, so that in a period of no more than 15 years, land become useless and crops or pastures are abandoned. Agricultural expansion mostly takes place through deforestation carried out by poor migrant peasants, who install themselves around new roads, usually open by oil companies.

   Deforestation obviously has a strong negative impact on biodiversity and is the most important source of CO_2 emissions in Ecuador, accounting for 66% of total (WRI, 2015). Moreover, deforestation rates in Ecuador are among the highest in South America, and there is no evidence of its reduction over time. Although there is not agreement on deforestation figures, according to FAO, Ecuador had a deforestation rate of 0.6% per year in the 1990-2015 period (FAO, 2015).

Table 3

Spatially Autoregressive model on factors influencing local social development in Ecuador's Amazon: 2010

Dependent variable: Index of Social Development (IDS)

Number of observations = 2408

Maximum likelihood estimates:

Wald chi2 (11) = 8894.03

Prob > chi2 <= 0.0001

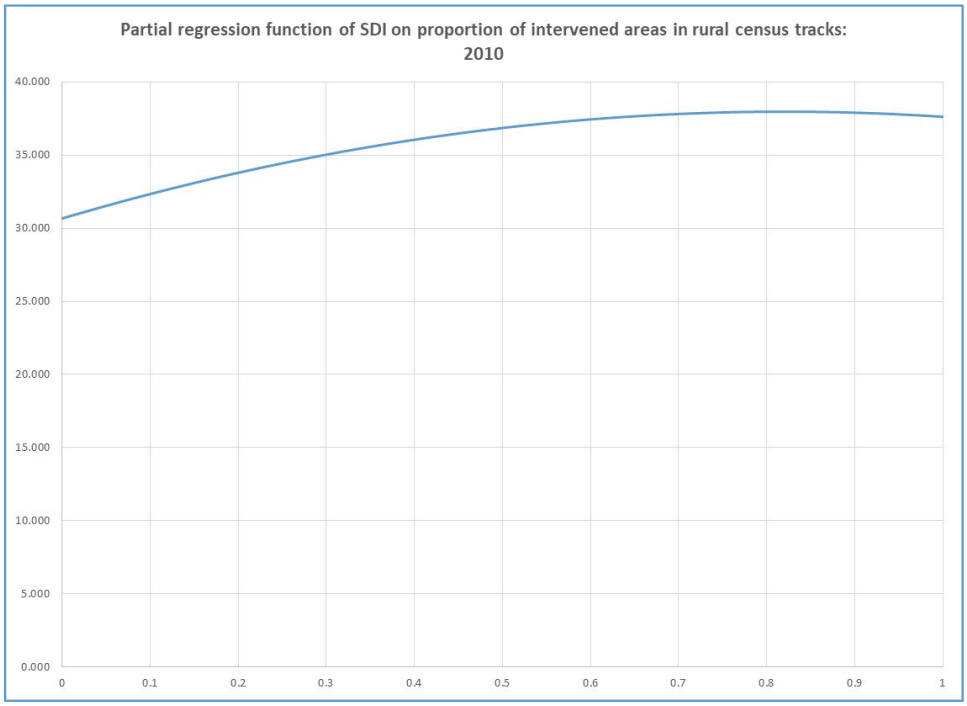
Log likelihood = - 7016.191

Pseudo R2 = 0.7842

InDesSoc100	Coefficient	Std. Error	z	P>|z|	[95% Conf. Interval]	
InDesSoc100					Minimum	Maximum
Proximity to oil wells index	-0.261	0.026312	-9.93	<0.001	-0.313	-0.210
Soil fertility index	0.854	0.4222169	2.02	0.043	0.026	1.681
Prop. of intervened areas	20.506	2.231269	9.19	<0.001	16.133	24.880
Prop. of intervened areas^2	-10.879	1.392222	-7.81	<0.001	-13.607	-8.150
Travel time to markets	-0.482	0.0688226	-7	<0.001	-0.616	-0.347
Prop. Agriculture in EAP	-5.042	0.6216075	-8.11	<0.001	-6.260	-3.823
Prop. wage earners in EAP	7.233	0.6529073	11.08	<0.001	5.953	8.512
Prop. logging in EAP	22.438	3.684288	6.09	<0.001	15.217	29.659
Dummy rural	-2.675	1.202942	-2.22	0.026	-5.033	-0.318
DRural*PropIntAreas	-2.666	1.328097	-2.01	0.045	-5.269	-0.063
Constant	35.197	1.363232	25.82	<0.001	32.525	37.869
Widist2 distance matrix						
InDesSoc100	0.077	0.009	9.05	<0.001	0.061	0.094
var(e.InDesSoc100)	19.876	0.573			18.784	21.031

The social effect of deforestation on local living conditions is one of the main topics to be explored in this article. The multiple regression model included the proportion of intervened areas in quadratic parabolic form. Chart 1 illustrates the partial regression function of SDI on the proportion of local intervened areas, keeping all the remaining variables at their mean value, selecting only rural census tracks.

Chart 1
Partial regression function of SDI on proportion of intervened area in rural census tracks: 2010



Note: 1,509 rural census tracks were included in the model.
Source: Table 3.

As Chart 1 shows, local living conditions improve at the initial stages of deforestation, but with decreasing returns, so that the function reaches a stable level with not further gains when deforestation is higher than 65%, with a small decline after 80% of deforestation. According to the model, the total social improvement between 0% and 100% of deforestation is 7 points (from 30 to 37), and there is not improvement at all from 65% to 100% of deforestation.

This weak and decreasing association between deforestation and living conditions may be explained due to low and decreasing land productivity in most of Amazon soils. During the first years of deforestation, soil fertility is still relatively high and family income may improve by selling wood. Later on, decreasing land productivity reduces agricultural revenue up to the point when land is abandoned ant the peasant family moves to deforest another plot of land.

These findings are broadly consistent with a research in Brazilian Amazon, which found that social benefits from deforestation appear only in the early stages of the process, and later social conditions stagnate and finally decline (Rodrigues, 2009).

The soil fertility index captures spatial differences in the land aptitude for agriculture, and has the expected positive regression coefficient at 5% significance level. Travel time for markets captures transportation costs of agricultural products, and has the expected

negative and significant association with SDI.

Dummy rural captures differences in living conditions between towns and the countryside, which are high in Ecuador. Its regression coefficient is negative and statistically significant.

All the remaining variables refer to employment structure. As a high proportion of agriculture in the labor force implies low productive diversification, their expected effect on SDI is negative. The proportion of wage earners, an indicator of expansion of capitalist relations, has an expected positive influence. In both cases the sign of the correlation coefficients is the expected and have significance.

Finally, the proportion of logging and food services, as an indicator of the expansion of tourism, has a strong positive coefficient with 1% significance, as expected. Its high value suggest an important socially distributive effect of tourism in Ecuador´s Amazon.

Conclusions and recommendations

This article focuses on the local effects of oil extraction on social development and satisfaction of basic needs in Ecuadorian Amazon. The Amazon remained as the most socially deprived region in Ecuador, at least between 1990 and 2010, both in the urban and rural areas. Among the most critical conditions are lack of appropriate health services, and high levels of child mortality. By contrast, differences in education were less severe.

A spatially autoregressive multiple regression model was built to explore the local effects of oil extraction, local deforestation, soil fertility, access to markets and employment structure on a multivariate index of social development. The model, disaggregated by census tracks from the 2010 census, found a negative and statistically significant effect of local oil extraction on social development, after controlling for all the remaining variables.

This finding strongly suggests that in the case of Ecuadorian Amazon, the detrimental effects of environmental degradation, pollution, loss of biodiversity, and social conflicts overcome the potential local benefits brought about for the employment generation and local social investment of oil revenues. The lack of a positive relationship between oil extraction and local social improvement extends, at the micro regional level, the conclusions of several studies, at national level, on the weak link between oil extraction and development in Ecuador. From an international perspective, the oil curse theory points out the detrimental economic, social and environmental effect of oil export specialization on developing countries.

In Ecuador, oil expansion has been an important indirect driver of deforestation in the northern Amazon. The regression model suggests that deforestation has a small and short-lived contribution to improving living conditions of local population. Only in the initial phases of the process of deforestation, some social gains are observed, but as local deforestation continues over 65% of the land, social benefits disappear.

As a result of oil expansion, Ecuador's Amazon population increased by tenfold between 1962 and 2010, and deforestation around roads open for oil exploitation affected approximately one sixth of original rainforest areas. This demographic, economic and social transformation, the largest in the regional history of Ecuadorian Amazon, has been based on two productive sectors,

oil extraction and agriculture.

The analysis shows that, unfortunately, not only the net local direct contribution of oil extraction to social development is minimal or even negative, but also that the local improvement brought about from deforestation-based agriculture and cattle raising is modest and short-lived. Considering the detrimental effects of deforestation on climate change and loss of biodiversity, the whole balance of benefits may turn negative.

The Amazon region, therefore, requires a deep structural process of social and economic transformation to find alternatives toward reaching sustainable and distributive social development. As the regression model suggests, the social distributive effects of diversification towards tourism are rewarding. Ecotourism is an example of a way of diversification able to improve living conditions, simultaneously preserving natural and cultural heritage.

As remaining oil reserves in Ecuador are low, lasting no more than 15 years at current extraction levels (BP, 2019), and detrimental effects of current agricultural practices overcome social gains, a structural transformation towards sustainable and distributive development strategies is required. Fortunately, a low emission development path, based on activities such as ecotourism, agroforestry and agroecology, seems feasible (Larrea 2017). Deforestation can be drastically reduced or eliminated, as the Brazilian experience between 2005 and 2015 demonstrates. Nevertheless, the required transformation in regional development strategies required further research, and available information only suggests some hypothetical transformative ways.

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