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Non-Timber Forest Products and the Cosmetic Industry: An Econometric Assessment of Contributions to Income in the Brazilian Amazon

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Abstract: This study explores Non-Timber Forest Products (NTFPs) production and company–community partnerships with the multinational cosmetic industry. The objectives are to critically assess: (1) how income generated from market-oriented NTFPs extraction impacts small farmers' livelihoods; and (2) whether membership in cooperatives linked to such partnerships is a factor in improved livelihood. Household-level data from 282 surveys conducted in remote communities in four municipalities in the Northeast region of the State of Pará provide empirical insight into NTFPs extraction and processing activities by smallholder farmers in the Brazilian Amazon. We employ a spatial econometric approach to assess if engagement in NTFPs extraction and membership in cooperatives result in statistically significant increases in the overall household income. A series of spatial regression models are used, including Ordinary Least Squares (OLS), Spatial Autoregressive Regression (SAR), Spatial Error Model (SEM), Spatial Durbin Model (SDM) and their corresponding alternative Bayesian models. Our study finds that NTFP extraction and membership in cooperatives tied to company–community partnerships are statistically significant and result in increases in total income at the household level. Findings also show that distance to transportation modes and markets are statistically significant with more distant households earning greater income. This finding presents challenges for the long-term sustainability of green alternatives to development that rely on remote, inaccessible environments for the commodities of interest. This is especially pronounced given the commitment of the Amazonian Nations, and the massive national and international investments, in the Initiative for the Integration of Regional Infrastructure in South America (IIRSA), which has as its goal the creation of a multimodal transportation hub to integrate the continent with global markets and make accessible far reaches of the Amazon.

Keywords: NTFPs; cosmetic industry; company–community partnership; smallholder extractivists and farmers; rural livelihoods and income

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1. Introduction

The Brazilian Amazon is a biodiverse region with vast carbon sequestration potential. Concerted development efforts over the last 50 years successfully integrated the region with the national economy and global markets, and today it hosts one of the world's most productive cattle and meat-packing industries and is a source of vast mineral wealth [1,2]. While the Amazon is resource-rich, its resident rural populations continue to suffer from perennial poverty given their limited access to livelihood opportunities [3,4]. All told, development came at a high environmental cost as the expanding agricultural frontier converted an estimated 800,000 km^2 of forest to fields and pasture [5]. To stem forest loss, Brazil and other Amazonian nations created vast conservation areas and established environmental policies that appeared effective, resulting in annual deforestation rates below historic averages at the turn of the new millennium. Unfortunately, deforestation

rates are once again edging up as global demand for minerals and agricultural products intensifies, and in 2019, deforestation was 34% higher than just one year prior [6].

A new wave of infrastructure projects in support of extractive development raises serious concerns that deforestation will push the forest past its tipping point and trigger severe negative consequences for the local and global environment [7,8]. As a result, scientists, environmental activists, international donors, and governmental agencies are all urgently seeking alternative approaches to the conundrum posed by the need for forest conservation on the one hand, and economic development on the other [9,10]. Policymakers and scholars alike agree that the solution resides in sustainable forest management that enhances the economic, social, and environmental value of forests for present and future generations [11]. An important strategy in this regard is the commodification of natural forest goods and ecosystem services, an approach that has been widely applied across tropical forest regions of the Global South [12]. Of particular interest are community-based forest management (CBFM) schemes, which are promoted as a viable solution to conserve forest biodiversity, mitigate climate change, and improve welfare of resident populations [13–16]. CBFM schemes vary by design, and include certified fair-trade agreements, agroforestry systems (SAFs), payment-for-ecosystem services (PES) such as carbon sequestration payment schemes, and, most relevant for the current study, market-oriented extraction of non-timber forest products (NTFPs).

Many early CBFM-NTFPs in the 1980s and 1990s tended to be top-down endeavors initiated by State development agencies in combination with agricultural extension technocrats and environmental NGOs. Despite concerted efforts, these initiatives failed to lift rural forest dwellers out of poverty, and consequently, were ineffective conservation strategies [17–19]. The reasons for failure are numerous, including bureaucratic inertia concomitant with State agencies, limited access to markets and credit opportunities, inadequate transportation infrastructure and high transport costs due to remoteness of NTFP extraction locations, and, most problematic, a lack of training in the management of forest enterprises [20,21].

A new approach to CBFM-NTFPs has emerged that aims to rectify the failings of earlier approaches with voluntary, bilateral company–community partnerships (CCPs) that reduce bureaucratic entanglements through direct engagement between multinational companies and smallholder communities [22–24]. Most of these CCPs involve national and international cosmetics companies (e.g., Natura, L'Oréal, Beraca, Aveda, The Body Shop, Weleda, O Boticário, L'occitane) that have progressively replaced man-made synthetic chemicals with natural and organic ingredients in the manufacturing of plant-based products to supply growing consumer demands [25,26]. The flagship design of these CCPs includes the establishment of local cooperatives, associations or collective microenterprises, and the provision of technical expertise supported by government agencies (e.g., Embrapa, Emater) and national and international research institutes and NGOs to provide management training as well as the resources and know-how to enable members to scale up their production and market-centered initiatives [4,27–30].

Through CCPs, advocates see a "win–win" approach for alleviating rural poverty and ensuring forest conservation, since NTFPs generate income that translates into livelihood improvements, while the collection of forest products maintains biodiversity with negligible impacts on ecosystem services [4,24,28–30]. In recent years, the Brazilian State and Federal governments have advanced ambitious public policies for the sustainable development of Amazonia that rely on the success of CBFM-NTFPs and CCPs strategies, such as the National Sociobiodiversity Plan and National Policy on Agroecology and Organic Production (PNAPO). To support these efforts national legislation and transnational agreements and regulations have been codified (e.g., the Convention on Biological Diversity; the Cartagena and Nagoya Protocols), and renewed government support and funding have been directed to NTFP endeavors [31,32].

Nevertheless, the jury is still out as to whether such strategies result in improved social welfare for the region's rural population, let alone the sustainable management of

its valuable biodiversity. Detractors maintain that NTFP-derived incomes are not sufficient to compete against other economically profitable activities (e.g., logging, agriculture, livestock), and there is overwhelming evidence from ethnographic studies conducted across the Amazon that peasant farmers and traditional extractivists, including the rubber tappers in Chico Mendes reserve, are shifting to pasture-based farming systems [33–35]. The present article attempts to shed light on the significance of CBFM-NTFP extraction and membership in CCP cooperatives to improved social welfare and livelihoods as indicated by increases in annual household income. To this end, it provides insight from household level data from field research conducted with peasant farmers living in remote communities of northeastern Pará State where NTFP extraction and CCPs tied to the cosmetic industry are prevalent. Household level surveys were employed to gather data on smallholder economic activities, including engagement in NTFP extraction and membership in cooperatives linked to CCPs. The objectives are two-fold: to critically assess: (1) if participation in market-oriented NTFPs extraction impacts farmers' livelihoods, measured in household income; and (2), whether membership in a cooperative is a factor in improved livelihood. Although the conservation benefits are important, this is beyond the scope of the research presented.

The article is organized as follows. In the section that follows we provide an overview of scholarship debating the merit of CBFM-NTFPs and CCPs as strategies to improve social welfare of peasant farmers resident in tropical forest regions. Following this, we consider our case study region, data, and methodology. Next, we present findings from a series of regression analyses to empirically gauge the significance of CBFM-NTFPs and membership in CCP cooperatives on social welfare improvements of peasant farmers, measured in terms of household income. Finally, we provide a discussion of the policy implications of our study, after which a brief conclusion ends the paper.

2. Background

2.1. NTFPs and CCPs for Improving Rural Livelihoods

Early critics argued that the production of NTFPs is insufficient to promote conservation, alleviate poverty and increase the income of small farmers [17,19,36,37]. In fact, research demonstrated that increasing demand for NTFPs tends to push extraction beyond sustainable thresholds, leading to boom-and-bust economic cycles that leave peasant farmers vulnerable to widely fluctuating prices and the forest environment to overexploitation [19]. The concern remains that the most valuable resources, such as rubber (*Hevea brasiliensis*) and Brazil nut (*Bertholletia excelsa*) are no longer relevant to the regional economy, and the opportunity costs presented by cattle ranching and wage labor is too great of an enticement for peasant farmers [38–41]. Possibly of greatest concern today is that both traditional extractivists and recent settlers perceive low value of NTFPs to their livelihoods, especially in comparison to specialized agriculture and livestock [42–44].

However, advocates maintain that CCPs provide the exceptional case where income derived from NTFPs is capable of providing a significant contribution to rural livelihoods, most notably because regional markets are no longer the target, and higher prices are paid to communities for niche commodities in the global market that together with other supplementary forest-based activities and farming provide genuine benefits [45–47]. In such cases, CCPs provide the conditions to improve NTFP-based income through the provision of training, technology and support to domesticate high-value species and integrate them into farming systems, and also establish market value chains for NTFP commodities [46,47]. In doing so, CCP arrangements improve household food security and total income [27,48]. While some studies acknowledge lower than ideal returns from NTFPs in comparison to total income, they argue the problem is that further investments are needed to support these activities, and the right mix of financial and technical input will result in sustainable forest management with benefits accruing to increased social welfare and environmental conservation [44].

Critics, however, view such assessments as "over-optimistic expectations," and argue that more often than not relations between companies and local communities are unilateral and exploitative, based in asymmetric power-relations and marked by contradictions between the companies' rhetoric and their business practices [49–51]. Although some processing steps in the market value chains take place locally, peasant farmers typically are the first actors in the production chain, and the profit captured by them is often limited, while the real profits accrue to the companies [52–54]. CCPs have divided expert opinion. For some, these market-based agreements cannot be considered a realistic alternative as a source of income for most forest people. In this regard, they maintain that extractivism works as a supplement rather than a substitute to ecologically destructive forms of income-generation. Based on this belief, they find such partnerships inadequate as an incentive to conserve forest ecosystems, since other harmful activities would continue anyway. Others advocate that CCPs are one of the few viable approaches to enhancing small farmers' remuneration and forest-based livelihoods, and thus reconcile social and economic development with the conservation of the Amazon [47], fostering ecosystem services and climate resilience [48]. For CCP advocates, this "nature-market solution" is the most promising alternative among those possible, and it is the only realistic path for saving the Amazon from other destructive land uses adopted by migrants, cattle ranchers, loggers and miners [28,55].

2.2. Estimating Income from NTFPs

Scholars contend that in the Brazilian Amazon, NTFPs contribute to the economic, social and cultural livelihoods of over 6 million households [31,32]. Despite the growing body of scholarship on the topic, a definitive answer as to the value of NTFPs as an income source remains elusive given the wide variability in estimates and methods employed in the studies, and the differences in biological and socioeconomic conditions across the Amazon [34,56,57]. One challenge for assessing the value of NTFPs is disaggregating the cash and non-cash uses of forests at the household and community levels [58]. Compounding the difficulty is that most of our understanding of the NTFPs economy in the Amazon comes from small sample case-specific studies, and this body of literature lacks a clear and definite consensus [59–63]. In this regard, studies suggest that NTFPs contribution ranges anywhere from 6% to 60% of total household income, depending on household characteristics and national, economic, political and cultural contexts, as well as degree of engagement and specialization of the activity [59–63]. According to a study that compared NTFP income reflected in global meta-assessments from the Program on Forests (PROFOR), an estimated US $6.50 per hectare per year is derived from NTFPs extraction in Brazil [64]. However, a study limited to the State of Acre suggests net revenues can reach as high as US $57 per hectare per year [31].

Another concern is that much of the data available on NTFP derived income come from studies conducted by a few organizations that promote forest-wise projects and are limited to participants interested in the development and continued funding of such initiatives. Consequently, the reports and other publications informed by these data are suspect since the data was collected, assembled and analyzed by organizations with a financial stake in the outcome [65]. In such cases, data collection can focus more on meeting the informational needs and agenda of the funding agency rather than on achieving a broader understanding of ecological outcomes or local economic realities and needs of peasant households. Furthermore, the data collection is limited to the sites and communities where these organizations have had success, thus the applicability and generalizability of findings are questionable.

To date few systematic studies have been done to gauge the effects of NTFP-derived income on improved livelihood outcomes for smallholder farmers. Far less attention has been given to the income impacts of CCPs and niche commodities in the Amazon destined for sophisticated, high-income global markets. The studies that have been done suggest that socioeconomic and environmental effects of such a market-based approach differ from

case to case and, sometimes, cases can be controversial [18,66–68]. Thus, scholars have called for additional theoretical and empirical research to address this market-based forest management approach as a part of a more extensive economic system [69].

3. Study Region

The research presented here partially fills this gap in the literature with a systematic study that examines the impact of NTFP extraction and CCP membership on smallholder incomes. The study region is comprised of extractive communities located in four municipalities in northeastern Pará State, including: Anajás, Breves, Igarape-Miri, and Tomé-Açu (Figure 1). Residents in these rural communities are mostly smallholder peasant farmers dependent on family labor. The communities rely on a mixture of subsistence activities including fishing, hunting, logging, collection or extraction of forest products and small-scale agriculture primarily for family consumption. They live in remote areas disconnected from market towns, with limited access to transportation, education, healthcare, energy, and sanitation. Given limited accessibility, only a minority of families are involved in market agriculture, producing black pepper, cupuaçu, passionfruit and cocoa. The very remoteness of some villages has helped preserve the valuable biodiversity-based commodities involved in NTFP activities. Most of the rural populations depend on the extraction of natural resources, which justifies their locations in isolated villages distant from the urban centers, normally situated at the junctures and meanders of rivers, flooded forests (igapós), and streams (igarapés), particularly for the case of Breves and Anajás in the Marajó archipelago.

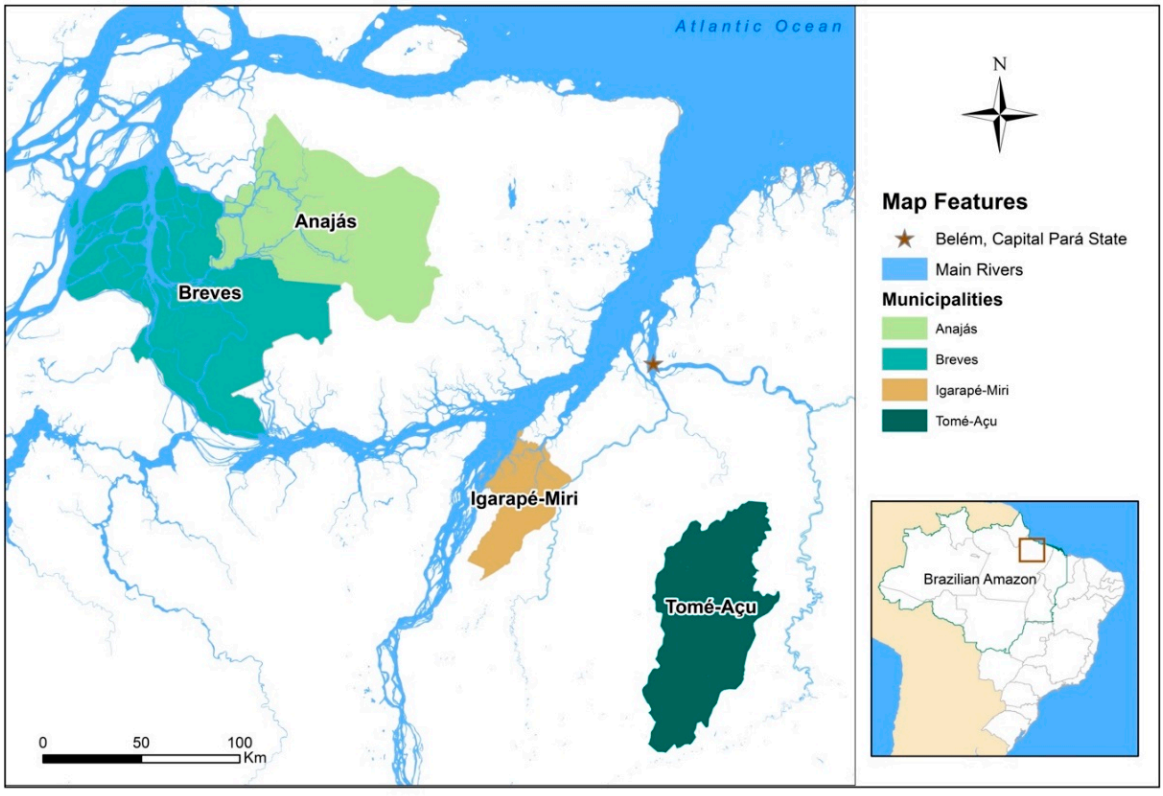


Figure 1. Study region in the northeastern Pará state, Brazilian Amazon.

All of the communities in this study have partnerships with the company Beraca Sabará Chemicals and Ingredients S.A, a multinational enterprise, and the leading global supplier of natural and organic ingredients from the Amazon rainforest for cosmetics, personal hygiene, pharmaceutical and food industries. In general, the company maintains partnerships with communities that extract the products of interest, which are mostly lo-

cated in proximity to extractive reserves (RESEX), sustainable development (RDS) reserves, as well as settlement projects (SPs) designed to support family farming that happen to be near public lands and forests. These partnerships allow communities to sell their goods through a local cooperative at a premium price with the company serving the role of broker. However, the company advocates for community involvement beyond the mere nuts and bolts of production and salesmanship to include community capacity-building and cooperativism (Deborah Goldemberg, manager Instituto Beraca, personal communication, 2017). In this vein they established the not-for profit Institute Beraca and created a social biodiversity program in 2000 to provide training in sustainable management techniques to more than 2500 families in 105 communities in 12 Brazilian states that benefits indigenous, quilombolas and riverine communities, as well as smallholder farmers. The Institute Beraca also works with communities to regularize land ownership, ensure environmental compliance and many other efforts tangentially related to the extraction of NTFPs.

4. Methodology

This study employs an explanatory mixed research design considered the best practice for research on forest-related collective actions [14,70–72]. The design process was highly integrated, including key informant interviews with public officials and company representatives to provide national, regional and local level contexts and specifics related to CCP activities, and household-level surveys with peasant farmers to gain empirical insight into NTFPs extraction activities, participation in CCPs, and income generating activities. Data derived from the surveys were analyzed using inferential statistics in a spatial econometric approach to assess the significance of NTFP extraction and membership in CCP cooperatives on social welfare measured in terms of household income. Based on the literature, two hypotheses are tested, namely that:

(1) Smallholders engaged in NTFP extraction have higher annual incomes than households that do not extract NTFPs.
(2) Smallholders who are members of CCP cooperatives will have higher annual incomes than households that are not members.

4.1. Sampling and Data Sources

The data used in this research came from 282 household surveys that were administered during two months of field work in January 2014 and June 2016, which was part of a collaborative effort involving an interdisciplinary group of scholars and graduate students from the School of International and Public Affairs (SIPA) at Columbia University (New York, NY, USA) and the Institute of International Relations (IRI) at the University of São Paulo (São Paulo, Brazil) that focused on the effects of NTFPs collection on smallholder farmer livelihoods. The fieldwork involved the administration of a two-page semi-structured survey that collected demographic and socioeconomic characteristics of households (e.g., family size, years of residence on property), detailed information on economic activities, including income sources and amount earned (e.g., NTFP extraction, agriculture, logging, fishing and non-farming activities), and whether the household was a member of a CCP cooperative. The difficulties of field data collection complicated formal efforts at geospatial sample design [73]. The sampling involved both systematic and random opportunistic approaches with the aim to survey a representative proportion of each of the four communities that make up the study region (Table 1). We adopted an approach that has become standard in similar studies conducted in the region, which entailed the systematic selection of every third house along the road; if the landowner was not present, the next house was visited and so on, until at least a 20 percent sample of households was reached [42,74,75]. In most cases our sample sizes were much greater. Such a sample possesses desirable statistical properties for regression analyses [73].

Table 1. Case Study Sample.

Municipality	Community Population	Sample Size	Percent
Tomé-Açu	159	36	22
Anajás	243	125	51
Igarape-Miri	198	48	24
Breves	90	73	81
Total	690	282	41

4.2. Analytical Approach

In accordance with the literature, we hypothesize that households who (1) participate in CBFM-NTFP extraction and (2) are members of CCP cooperatives, will have greater income in comparison to those households not involved in NTFP extraction and not members of cooperatives. To test these hypotheses, we employ a series of regression analyses and spatial statistics, including: ordinary least squares (OLS), spatial autoregressive (SAR), spatial error (SEM) and spatial Durbin (SDM) models, and their variants in the Bayesian approach [76,77]. The model may be stated as:

$$Y = X\beta + \varepsilon,$$

where Y is the dependent variable; X is a matrix of independent variables; β is the regression coefficient vector; and ε is a vector of random disturbances (error terms).

The dependent variable is total household income, used as an indicator of social welfare in accordance with the literature [60,63]. Total income is the sum of all income-generating activities that small producers reported, including income from: extraction of NTFPs (i.e., oilseeds and açai berries); annual and perennial agriculture products (i.e., black pepper, cocoa, cupuaçu and passionfruit); extractive activities (i.e., timber, palm heart, shrimp); sawmill; off-farm wage labor; and government transfer payments, which include: (1) bolsa-família (family allowance); (2) rural retirement; (3) defeso (fishing insurance); and (4) bolsa verde (environmental allowance). Bolsa-família is designed to reduce poverty, with payments tied to child vaccinations and school attendance. This monthly household stipend ranges from US $27 to $55 per person, and changes according to per person income, number of children and adolescents up to 17 years of age, and number of pregnant and lactating women in the family. Rural retirement benefits can be claimed by all rural workers who prove they have worked and contributed to social security for at least 180 months and have met the retirement age of 60 years for men and 55 years for women. The retirement income is always equivalent to one minimum wage, which at the time of data collection was US $287.50. Defeso, also equivalent to one minimum wage, is a temporary benefit granted to artisanal professional fishermen to compensate for revenue lost during the four month off-season period when fishing is prohibited in order to ensure species reproduction. Bolsa verde subsidizes quarterly income of US $92 to rural households in situations of extreme poverty who live in environmental protection priority areas with the aim to incentivize conservation.

The independent variables included two key explanatory variables of interest: (1) proportion of income derived from NTFPs, and (2) membership in a CCP cooperative, which is a dummy variable, coded 1 for member and 0 for non-member. We also incorporated a series of control variables, such as age and years of education of household head, family size, and length of residence on property, which all will likely have an impact on income. Finally, we included three distance variables: distance to rivers; distance to roads; and distance to the state capital, Belém, which is the main market center. Research has demonstrated that these distance measures significantly impact smallholder land use decisions and income generation [78–81].

To create these distance variables and prepare the data for spatial analyses we used Google Maps to identify the longitude and latitude point coordinates of the villages where households were located. We exported and converted the geographic coordinates from

KML format to Esri Layer (KML to Layer) using ArcMap, and then used ArcToolbox in Esri ModelBuilder to create geoprocessing workflows. We used the Proximity tool "Near" in the Toolbox to calculate distance and proximity information between the village center and major roads, rivers and the market in Belém.

4.3. Analytical Process

Before conducting statistical analyses, we inspected the data to ensure our model specifications were appropriate. We tested for multicollinearity in the variables using the variation inflation factor (VIF) function in R. Another concern, given the cross-sectional nature of our data formed by observations collected about points in space (e.g., households, villages), was potential bias from spatial autocorrelation [77,82]. Spatial autocorrelation in a regression framework typically manifests in two ways. Error terms can be correlated among themselves, which gives rise to so-called nuisance autocorrelation and coefficients that are not efficient, in the statistical sense [83]. Alternatively, the dependent variable can be autocorrelated, in which case the problem is referred to as substantive autocorrelation. When this form of the problem is present, OLS regression coefficients are biased. We followed the rationale suggested by Lesage and Pace [84] to test for spatial autocorrelation and identify the most suitable model for our data, as presented in Figure 2.

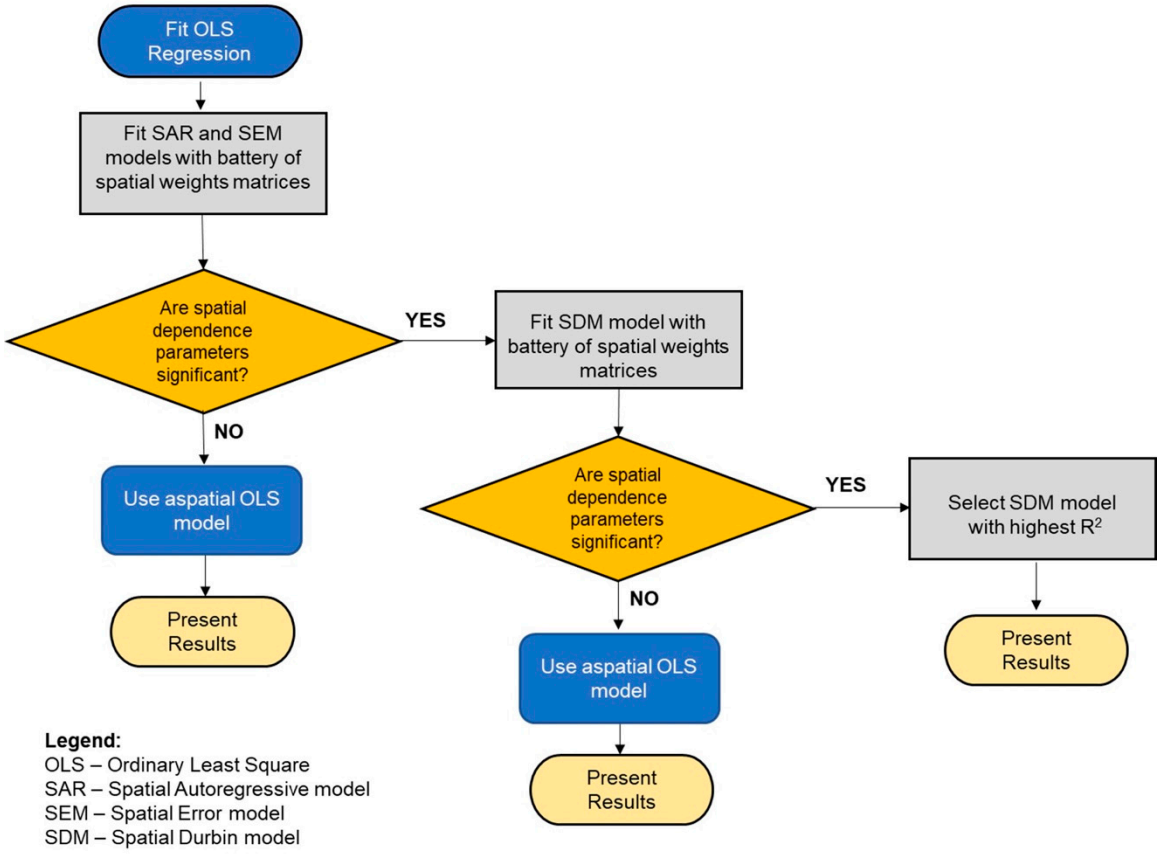


Figure 2. Analytical Approach.

All models were implemented using LeSage's Econometrics Toolbox (http://www.spatial-econometrics.com, last accessed on 28 May 2021), which contains an extensive library of Matlab functions to run various regression models. First, we estimated an aspatial conventional OLS model. Since we have no a priori reason to believe spatial autocorrelation will manifest under any particular distance, we employed the 'xy2cont' toolbox function to create a series of spatial contiguity weights matrices (W) using latitude and longitude coordinates of the households sampled. Subsequently, spatial autoregressive (SAR) and

spatial error (SEM) models were fit in order to verify whether spatial autocorrelation parameters were significant. If none of the spatial parameters indicate spatial effects in the data, one can assume that the best model is the aspatial standard OLS. If one of the spatial parameters (Rho or Lambda) are statistically significant ($p < 0.05$), the Spatial Durbin (SDM) model is specified. However, if the spatial parameters in the SDM are not statistically significant the assumption is that the OLS model provides the best estimations. To refine our results, we also ran a series of Bayesian alternative models (SAR_g, SEM_g, and SDM_g) using Gibbs sampling estimation, also known as Markov Chain Monte Carlo simulations. The benefit of such an approach is that it relaxes the assumption that model parameters are fixed, and instead takes them as random variables which is preferred given we have no a priori knowledge that the parameters are fixed [84].

5. Results

5.1. Household Characteristics and Economic Activities

Descriptive statistics for socioeconomic characteristics show that the mean age of household head is 43 years (see Table 2). On average, five people lived on each property, with a residence of 32 years on site. In terms of education, the average for the household head was five years of formal education. In general, the households live in remote regions that rely on river transportation with the nearest river 6 km away, whereas the nearest road is 86 km, and Belém, the primary market city, is 156 km from their residences. In terms of the characters of interest to this research, an estimated 237 households engage in NTFP activities (84% of sample) and 133 are members of a cooperative (47% of sample).

Table 2. General characteristics of the households (n = 282).

Variables	Mean (Std. Dev.)	Median	Min	Max
Age of the household head	43 (14)	42	18	81
Years of education	5 (4)	5	0	19
Years on property	32 (17)	33	1	80
Family size	5 (3)	5	1	17
Distance nearest river (km)	6 (14)	1	0	46
Distance nearest road (km)	86 (55)	113	318	141
Distance-Belém (km)	156 (50)	170	71	247
	# Households		%	
Engage in NTFP	237		84	
Membership in Cooperative	133		47	

Overall, the households depend on a variety of economic activities for income, as shown in Table 3. Across the sample, NTFP, including oilseeds and açai, was the primary income source providing 42% of the average annual household income, or US $3392, for 84% of the sample. The second most important source of income was government transfer payments at US $1591, or 20% of average annual income received by 79% of the sample. Government support included, in order of importance: (1) rural retirement at 10%; (2) bolsa-família at 7%; (3) defeso at 2%; and (4) bolsa verde at 1%. Although defeso was not an important income source across the entire sample, it compromised a substantial proportion of annual income for 34% of the sample who make up the poorest families living in environmentally sensitive areas. Agriculture was the third most important activity in terms of income generation at US $1365 or 17% of average annual income. However, only 13% of the sample reported income from agricultural activities, and the income was skewed as a result. For example, only 25 households specialize in black pepper production and from this activity alone they earn on average annually US $14,090, which is nearly twice as much as total average annual income for the entire sample at US $8076. Other important agricultural activities include cupuaçu, cocoa, and passionfruit, but income generation is nowhere near as great as black pepper. The fourth important income source

is extractive activities that include palmheart, timber, and shrimp in order of importance, representing 11% of average annual income, or US $870, for 46% of the sample. It is important to note that in the study region palmhearts are not derived from açai palms (*Euterpe oleracea*), which would kill the plant. Instead, they harvest an endogenous palm locally called pupunha (*Bactris gasipaes*), and in doing so they remove only the mother plant which allows the peripheral sprouts to flourish. Finally, off-farm labor ranks sixth in terms of income generation at US $745 for 24% of sample, followed by revenue from sawmilling at US $109 for 6% of households.

Table 3. Summary of annual income by source in US $, n = 282.

Income Source	Mean	SD	Min	Max	Count (%)	Mean	SD
NTFP (oilseeds, açaí)	3392	5107	0	27,344	237 (84)	4036	5098
Agriculture	1365	4903	0	28,625	38 (13)	10,125	4894
black pepper	1249	4582	0	27,666	25 (9)	14,090	4574
passionfruit	17	186	0	2656	4 (2)	1207	186
cupuaçu	51	287	0	2598	15 (5)	953	286
cocoa	45	260	0	3228	14 (5)	897	260
Extractive Activities	870	1733	0	14,140	129 (46)	1902	1730
palmheart	473	1305	0	10,329	65 (23)	2051	1303
timber	330	933	0	7082	61 (22)	1527	931
shrimp	67	292	0	3836	36 (13)	527	291
Off-farm Labor	745	1993	0	11,066	67 (24)	3137	1990
Sawmill	109	635	0	7097	18 (6)	1705	634
Government Transfers	1591	1742	0	7633	223 (79)	2012	1768
defeso	136	382	0	2671	36 (13)	1065	381
bolsa verde	62	142	0	738	47 (17)	375	141
bolsa família	547	543	0	2287	179 (63)	862	543
retirement	846	1772	0	7033	59 (21)	4043	1768
Total	8076	6276	1800	29,849	282 (100)		

Notes: Income converted from Brazilian R$1 to US $0.30740 based on 31 December 2016 exchange rates, which is the year data was collected.

5.2. Results from OLS Regression, Multicollinearity, and Spatial Statistics

The regression strategy was to apply ordinary least squares, test for multicollinearity, and then perform diagnostics for spatial autocorrelation. The results from tests on spatial autocorrelation using the Lesage and Pace [84] approach are presented in Table 4. Across the board, results indicate spatial autocorrelation in the SAR (rho = 0.15, p = 0.06) and SEM (lambda = 0.17, p = 0.05) models, as well as with the Bayesian SEM_g model (lambda = 0.17, p = 0.05). Subsequent SDM models also show significant spatial correlation. Specifically, the SDM_W4 (rho = −0.23, p = 0.01) and the Bayesian SDM_g W2 (rho = −0.50, p = 0.00) and SDM_g W4 (rho = −0.50, p = 0.00) presented with significant spatial correlation.

Table 4. Spatial Models Estimates.

Model	Rho/Lambda	R^2
SAR W matrix	0.15 (0.06) *	0.3534
SEM W matrix	0.17 (0.05) **	0.3641
SDM W matrix	0.14 (0.50)	0.3740
SDM W2 matrix	0.01 (0.90)	0.3991
SDM W4 matrix	−0.23 (0.01) ***	0.3943
SAR_g W matrix	0.08 (0.16)	0.3349
SEM_g W matrix	0.21 (0.03) **	0.3621
SDM_g W matrix	0.07 (0.23)	0.0535
SDM_g W2 matrix	0.50 (0.00) ***	0.1380
SDM_g W4 matrix	0.50 (0.00) ***	0.0332

Significance is designated at p = 0.01 ***, 0.05 **, and 0.10 *.

Results from the VIF function shown in Table 5 indicate there is no issue with multicollinearity in the variables since all factors are below 5, which is a rule of thumb point that indicates potential multicollinearity problems, and values 10 or over indicate very high correlations [85]. Results from the OLS and significant spatial regression models are also presented in Table 5 for comparison. The R^2 measures for most models are consistent with a range between 0.35 and 0.39, indicating relatively good explanatory power, especially for social science-based research which is notoriously difficult to measure. The Bayesian estimates for the SDM models, however, are quite low and likely reflect a poor model fit. Although the R^2 measures indicate that our models have satisfactory explanatory power, our real interest is not in finding the best model to predict annual income, but rather to determine the predictive power of the key variables, namely engagement in NTFP activities and membership in CCP cooperatives. In this regard, the findings are robust across all the models with %NTFP Income and Membership both statistically significant predictors of household income. Likewise, a number of control variables are significant, including years on property, years of education, distance to rivers, distance to roads and distance to the capital.

Table 5. VIF, OLS, and Spatial Regression Model Results.

Variables	VIF	OLS b(SE)	SEM_W b(SE)	SDM_W4 b(SE)	SEM_g W b(SE)	SDM_g W2 b(SE)	SDM_g W4 b(SE)
% NTFP Income	1.98	33(13) ***	32(12) ***	38(12) ***	33(11) ***	32(12) ***	31(11) ***
Membership	1.11	1321(647) ***	1389(665) ***	1916(826) ***	1244(711) ***	1090(794) *	1633(783) ***
Family size	1.21	52(129)	78(126)	−7(136)	101(120)	79(116)	68(115)
Years-Property	1.5	50(21) ***	48(21) ***	39(21) *	39(20) ***	21(21)	28(20) *
Years-Education	1.43	192(89) ***	201(86) ***	162(87) *	197(90) ***	182(86) ***	170(85) ***
Age	1.81	18(30)	15(29)	45(30)	27(29)	55(27) ***	40(26) *
Açai (y/n)	1.46	916(856)	839(839)	693(835)	741(865)	600(832)	728(794)
Distance-Rivers	2.15	111(31) ***	105(34) ***	−1565(705) ***	80(0.04) ***	−1374(0.89) **	−369(0.61)
Distance-Roads	3.25	−9(12)	−9(13)	−1171(598) ***	−12(0.01)	−639(0.84)	−215(0.51)
Distance-Belém	3.04	−34(10) ***	−34(11) ***	−267(343)	−34(0.01) ***	−163(0.42)	−68(0.30)
Constant		7340(2431) ***	7470(2441) ***	2383(5297)	7268(2547) ***	4260(3690)	280(5118)
R^2		0.353	0.364	0.390	0.362	0.138	0.033

Significance is designated at p = 0.01 ***, 0.05 **, and 0.10 *.

Overall, the SDM_W4 model provided the best fit to the data since it accounts for spatial autocorrelation and presents with the highest R^2 at 0.39. Of particular note are the robust findings for the two theoretical variables. Engagement in NTFP extraction, measured in terms of proportion of income from NTFP activities, is statistically and substantively significant such that every one-tenth increase in income derived from NTFP activities results in an increase of total annual income by US $377. More importantly, if a household is a member of a CCP cooperative their total income increases by US $1916, or more than 24% of the average annual income. In terms of control variables, both distance to rivers and roads were statistically and substantively significant, and in the direction expected such that every 1 km distant from rivers and roads results in a decrease of annual income of US $1565 and US $1171, respectively, or 15–20% decline for each 1 km. This clearly reflects the central role of hydrography in this region as it is the primary means of transportation and communication between the many remote villages and towns. Furthermore, many species of interest to the cosmetic industry are only found in várzea ecosystems (i.e., floodplain areas). Roads are likewise important given accessibility to markets. Finally, both years of education and years on property show suggestive significance (p = 0.06) with every additional one year of education or residency leading to annual income increases by US $162 and US $39, respectively.

6. Discussion

The research presented here provides three primary findings. First, it establishes that participation in NTFP extraction is both statistically and substantively significant with measurable improvements in livelihoods in terms of annual household income. Second,

membership in CCP cooperatives has a positive effect, with average annual incomes rising by ~25%. Finally, the regression models show that distance to markets affects annual income, although in an unconventional manner. Specifically, the relationship is positive, with increasing distance leading to greater household income. The households in our study engaged in the extraction of a diversity of NTFP commodities as well as other activities (e.g., agriculture), which scholars agree is the most beneficial approach [45–47]. A majority combined oilseed and açai berry collection, which was an explicit strategy in the CCP agreement. Açai has well-established regional and global markets [86], and therefore stable and strong prices. The result for participation in NFTP extraction could to some degree be dependent on the forest products involved. It is also important to note that our study was limited to income and did not account for the myriad of non-cash benefits from NTFP extraction that other studies have shown to be substantial [58].

Our study shows that CCP cooperatives improved annual incomes of members by training them and by providing support for the processing and marketing of forest products, and for diversifying production through more sustainable agricultural practices. The research presented involved households in partnership with one company, namely Beraca Sabará Chemicals and Ingredients S.A. Although we conducted key informant interviews with company representatives, we did not collect details on CCP specifics in each community and so are unable to determine which initiatives were successful. Thus, future research should consider CCP arrangements for a myriad of companies and their impacts on household livelihoods. This would provide valuable insight as well as a check on self-reporting by companies. For example, Natura, the leading Brazilian multinational cosmetic company with ~US $475 million invested in Amazonia (2010–2019) reports that its partnerships benefited 5136 families who have been incorporated into the biodiversity value chain with the 100% Ekos brand products [87].

As for the finding on market accessibility: this should not be a surprise given that the products of greatest value to global markets are typically found in remote forest or natural floodplain (i.e., varzea) environments. This presents a conundrum for development planners who wish to base income enhancement policies on NTFPs. Specifically, our results suggest that infrastructure (e.g., roads) by improving accessibility may very well incentivize traditional extractivists and smallholder farmers to abandon NTFPs for agricultural specialization and livestock [42–44]. This is potentially problematic for bioeconomy advocates since the Amazonian Nations are two decades into IIRSA's massive effort to integrate roads, rail, rivers into a multimodal transportation network connected to global markets [2]. For both Brazil and international investors, this will provide access to Amazonia's vast mineral wealth and open new lands for agroindustry, putting at risk indigenous and traditional peoples, as well as the region's biodiversity, essential to the proposed bioeconomy [1]. Presumably, the market accessibility enhancements will also provide Amazonia's rural populations with economic opportunities beyond that which can be derived from NTFPs, making engagement in bioeconomy-based programs less attractive to them [88].

7. Conclusions

The contemporary conservation discourse about sustainable development in Amazonia has begun to focus on supplanting the destructive agroindustrial growth model dependent on forest clearing with a new bioeconomy based on the renewable production of value-added, biology-based commodities demanded by markets for pharmaceuticals, cosmetics, and foodstuffs [55]. Advocates maintain that such a "nature-based" economy has the potential to enhance the social welfare of forest dwelling communities without threatening the forest and it ecosystems services [89]. This perspective has spurred a marked increase in CCP endeavors in Amazonia to supply NTFP commodities to the global cosmetic industry, and a new wave of initiatives has been announced by governments, social organizations, and private and public company coalitions (e.g., Amazônia 4.0; Amazônia Possível movement; Pro Green program) [23,55,90,91]. Although a bioeconomic

solution makes sense prima facie—and has certainly generated much interest—its efficacy has been questioned by some who call attention to lead times necessary for the innovation of new technologies, not to mention their widespread adoption. Further, it is legitimate to ask if the bioeconomy actually represents something new, given its similarity to the many sustainable development strategies that have come before.

Finding a pathway to sustainable development for the Amazon Basin has taken on renewed urgency given that deforestation rates have begun to climb again and climate change predictions are starting to materialize. Nor is there reason to believe that these worrisome trends are transitory, given the magnitude of the IIRSA program and the scale of the projects completed to date. Can the conservation imperative of the Amazonian bioeconomy manage to break the momentum of IIRSA and the socio-environmental transformation it would likely precipitate? The answer remains unclear at the moment, in which case we argue for swift and preemptive action to identify alternative futures for Amazonia before the damage becomes irreversible. Although the research presented here does not purport to address the viability of the bioeconomy carte blanche, the findings provide valuable information for policy makers, researchers and citizen stakeholders, since CBFM-NTFP and CCP initiatives play a central role in sustainable forest management efforts. Whether Amazonia's conservation–development conundrum can be resolved once and for all is anyone's guess. That said, we argue that NTFPs and CCPs provide at least part of the solution.

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