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An econometric model for non-timber forest products in the Brazilian Amazon

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Abstract

The objective of this study is to identify the determinants of Non-Timber Forest Products (NTFPs') supply and demand in the Amazon region. The method applied was an econometric model of supply and demand in a log-linear form. Based on consumer and firm theories as well as studies on the market for extractive products, we developed models of supply and demand for NTFPs. The models were estimated by Ordinary Least Squares (OLS) in the log-log functional form, allowing to obtain the elasticities of the variables that affect the NTFPs supply and demand. The results indicated that during the study period, the behavior of the NTFPs market was stable in terms of the price and the quantities produced. These products displayed low elasticity in relation to price, both on the supply and the demand sides. This indicates that the cultivation of NTFPs (producing species) is a better option than the expansion of extractive activity. We conclude that the modernization of extractive production, the development of the products, and government support for commercialization are essential for the development of sector and the local community.

Keywords: Non-Timber Forest Product; Amazon; Supply; Demand; Econometrics.
Abbreviations: NTFPs_Non-Timber Forest Products, OLS_Ordinary Least Squares, IBGE_Brazilian Institute of Geography and Statistics, IPA-DI_Wholesale Price Index, ANTT_National Land Transportation Agency, INPE_National Institute for Space Research, IPEA_Institute of Applied Economic Research, P_price, MV_road network of the Northern Region, DES_accumulated deforestation in the Amazon, TDES_deforestation rate in the Amazon, CMO_labor cost, T_trend, R_consumer income, POP_size of the Brazilian population, VIF_Variance Inflation Factor.

Introduction

According to World Bank reports, more than 1.6 billion people rely on forests for their livelihoods. Moreover, approximately 350 million live in or near dense forests (Chao, 2012; World Bank, 2012). One-third of the world's forests—about 2.1 billion hectares—have been used for the production of wood and non-timber forest products (NTFPs). NTFPs generated US$ 88 billion in 2011, that about 76 million tonnes of food from the forest were consumed on average in the same year (FAO, 2018). In Brazil, the value produced by the extractive industry in 2021 reached USD 1.2 billion, USD 440 million of which are related to NTFPs (IBGE, 2022). The list of these products currently monitored by the Brazilian Institute of Geography and Statistics (IBGE) consists of 32 products, classified into eight categories: 1) food, 2) aromatic, medicinal, toxic, and dyes; 3) rubbers; 4) waxes; 5) fibers; 6) non-elastic gums; 7) oleaginous, and 8) tannins.

Although extractivism is considered an important activity by the Brazilian government, it has resulted in the creation of several conservation units for sustainable use, such as Extractive Reserves, Sustainable Development Reserves, and National Forests. Extractive activity is known for being antiquated, economically unsustainable, and underdeveloped.

According to Nogueira et al. (2009), economic alternatives for environmental preservation should not be proposed without fundamental analysis of costs, benefits, profitability, supply, and demand. The study considers that socially and economically sustainable proposals should primarily consider research of demand and profitability. In that sense, market studies and business plans are powerful tools for identifying real opportunities.

Brazilian agricultural production has been studied and examined in detail by Pastore (1973), Barbosa and Waizbort (1979) and Giatti et al. (2021). Products whose supply responds to price, in addition to enjoying the natural balance between supply and demand, may have their markets stimulated by policies that influence prices when necessary. If this is not the case, these policies do not have the desired effects, and other mechanisms must be used.

Some aspects of the NTFPs market still require further study, such as the response of extractive supply to the market price of NTFPs. According to the law of supply, ceteris paribus, the quantity of goods produced increases when its price increases (Mankiw, 2020). This principle is of paramount importance in the dynamics of markets.

This paper's main objective is to analyze and discuss the supply and demand responses to changes in NTFPs' prices. We examine the evolution of prices and the commercialized quantities of NTFPs in the Brazilian Amazon.

Results

The evolution of NTFP's quantity and price indices is shown in Figure 1.

Figure 1 shows that after the implementation of the Real (R$) (the current currency of Brazil) in 1994, the market for NTFPs in the Amazon entered in a stabilization phase compared to the previous period, where the annual variations for the quantity and the price were high.

Estimation of elasticities affecting NPFS supply

The proposed model for NTFPs supply is presented in Equation 1.

lnQ = 6.70 – 0.10lnP + 0.39lnCMO - 0.00lnMV - 0.80lnDES [1]

Teste *t*: (5.75*) (-1.46^{ns}) (2.15*) (-0.46^{ns}) (-3.39*)

n = 36 R^2 = 0.35 F = 4.00 d = 2.08

^{ns} (not significant); * (significant at 5% probability)

With a coefficient of determination (R^2) of 0.35. The proposed model explains 35% of the supply of NTFPs in the Amazon. The F statistic proves that the estimated coefficients differ simultaneously from zero at the 1% level. The Durbin-Watson statistic (2.08) confirms the non-existence of serial correlation of the residues at the 5% level. White's test confirmed the absence of heteroscedasticity at the 5% level.

As seen in Table 1, none of the tolerance coefficients was less than 0.10, and none of the VIF values calculated was greater than 10. The presence of multicollinearity among the variables of the model was ruled out.

Little sensitivity of the supply to the price variable was already expected. The estimated coefficient of the price variable (P) presented an opposite sign to the prediction (-0.10). However, this was not statistically significant. Falesi et al. (2010) estimated the price elasticity of extractive fruit supply in Pará and found a value of 0.11, which characterizes a strong inelasticity with respect to prices. Negative coefficients for the price elasticity of supply indicate situations where prices are determined by the quantity supplied. Rigid supply, as examined by Homma (1983), where the extractive production has already reached or is close to its limit, having its elasticity of supply becoming inelastic to the price.

Accumulated deforestation in the Amazon (DES) showed a coefficient of -0.80, significant at the 5% level, indicating that a 10% increase in the total deforested area would reduce the supply of NTFPs by 8.0%.

The Amazonian road network (MV) presented a non-significant coefficient, indicating that the NTFPs aggregate supply was not influenced by the increase in the road network in Amazonia. This can be explained by the fact that much of the transport in the Amazon, mainly between the interior where NTFPs are produced, and the cities, are carried out by the river.

Labor cost (CMO) was also positively related to the supply of NTFPs, with a coefficient of 0.39 (significant at the 5% level). For a 10% increase in labor cost, production would increase by 3.9%. According to firm theory, increases in production costs shift the supply curve to the left, so this coefficient should be negative. Nogueira et al. (2011) estimated the impact of the cost of labor on the supply of açaí in Pará. They found a cost of supply elasticity of approximately -0.50 for the joint supply of extractivism and cultivation, using as a proxy of labor the cost of rural salary in the state.

One possibility for the interpretation of this contradictory principle is that the increase in production costs through cultivation, based on wage labor, leads to the retraction of production through cultivation. This, in turn, leads to an increase in the extractive supply, not salaried, and based on family work.

The estimated results for the NTFPs supply equation should be analyzed cautiously. The balance between supply and demand for rubber, açaí, and palm heart used in the composition of the indices under analysis is determined by the interaction between the demand and the joint supply of extractive products and the cultivated/imported products. Thus, the isolated analysis of the partial supply, without considering the supply of similar cultivated/imported products, can lead to erroneous conclusions.

Estimation of Elasticities Affecting NPFS Demand

The proposed model for NTFPs supply is presented in Equation 2.

lnQ = 0.26 – 0.11lnP + 1.20lnR + 0.13lnPOP – 0.04T [2]

Teste *t*: (0.13^{ns}) (-1.65^{ns}) (2.54*) (0.70^{ns}) (-5.09*)

n=36 R^2= 0.51 F = 7.76 d= 1.95

^{ns} (not significant); * (significant at 5% probability)

The coefficient of determination R^2 is 0.51, and the F statistic is numerically significant at the 1% level. The Durbin-Watson statistic (1.95) proves the non-existence of serial correlation among the residuals at the 5% probability level. White's test confirmed the absence of heteroscedasticity at the 5% level.

There was no evidence of multicollinearity (Table 2) among the explanatory variables in the model.

As none of the tolerance coefficients was less than 0.10, and none of the VIF values calculated was greater than 10, the presence of multicollinearity among the variables of the model was ruled out.

Demand was inelastic for price (P). The value of the coefficient is -0.11, but it is not significant. Similarly, the demand for açaí estimated by Nogueira et al. (2011) also presented an inelastic price, with a coefficient of -0.78.

The income variable (R) showed a high impact on demand, with a coefficient of 1.20, significant at the 5% level. This indicates that for a 10% increase in Brazilian per capita income, the consumption of NTFPs would increase by 12%. Nogueira et al. (2011) estimated the income elasticity of demand for açaí and found a value of 2.36. This result is quite interesting for the extractive sector given the expectation of increasing income of the Brazilian population.

The variable responsible for capturing the effect of market growth and size on non-timber product demand (POP) presented a coefficient of 0.13. However, this was not statistically significant as the growth of the Brazilian population is not a factor that affects this market. The use of data from specific segments of the population can bring significant results in future work.

This study provides important information about the response of NTFPs prices on the supply of these products in the Amazon as well as its determinants and elasticities.

The response to the price of NTFPs supply was low and, in some cases, even negative. Although some products in isolation may have a positive elastic response to market prices, in general this does not occur. Rigid supply indicates very low mobility from extractivist producers. Continued investments in regional infrastructure, organization of extractive communities, development, and transfer of appropriate technologies to the management, production, and processing of NTFPs in the Amazon as well as training

Table 1. Analysis of multicollinearity for the supply model variables.

Variable	Tolerance	VIF
lnP	0.403	2.484
lnCMO	0.566	1.767
lnMV	0.541	1.848
lnTDES	0.983	1.017

Source: Authors (2021); Note: ln_natural logarithm, P_price, CMO_labor cost, MV_road network of the Northern Region, TDES_deforestation rate in the Amazon

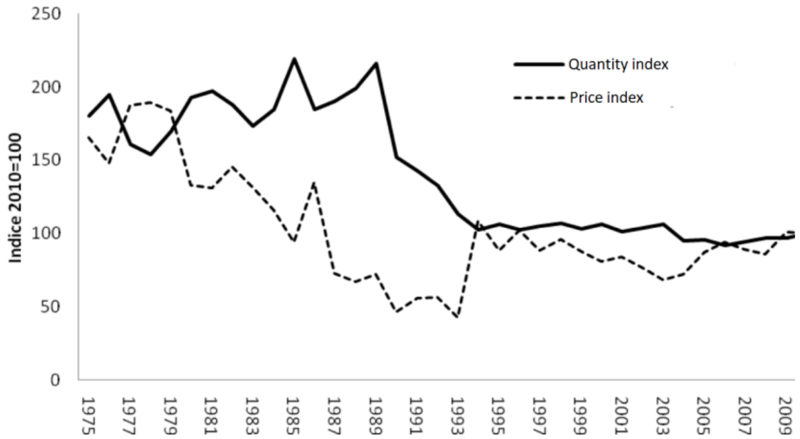

Fig 1. Evolution of the quantum and price indices of the NTFP market in the Brazilian Amazon from 1975 to 2010
Source: IBGE (2022)

Table 2. Multicollinearity analysis for the variables of the demand model.

Variable	Tolerance	VIF
lnP	0.553	1.809
lnR	0.180	5.551
lnPOP	0.721	1.387
T	0.144	6.951

Source: Authors (2021); Note: ln_natural logarithm, P_price, R_consumer income, POP_size of the Brazilian population, T_trend.

and assistance in the marketing and commercialization area, can change this framework.

Discussion

The inelastic price of supply found by this research translates into a market where supply and demand do not fit as predicted by perfect competition. Therefore, it is not a market in which price stabilizes at the point of equilibrium that satisfies both consumers and producers. Supply was heavily influenced by production in the previous period.

In this market, prices are determined by the excess or scarcity of the product, as well as by the productive capacity of the production areas, and the quantity demanded. Therefore, the demand determines the price, the scarcity, or the excess of the quantity offered in relation to the product.

Public policies aimed at the sector, such as the minimum price policy, should consider that the market price is not necessarily the equilibrium price for the extractive product. There is also no evidence that price increases lead to increased supply. Minimum price policies for extractive products are essential as a form of income for extractive families. The supply of cultivated species, in addition to the demanded capacity, may lead to a sudden drop in prices. The inelasticity of the extractive supply may indicate the extractivist's low ability to change activity against the low remuneration of its product.

If supply is inelastic to prices, vertical production in the community becomes essential for income generation in extractive regions. The assistance provided by governments to the formalization of cooperatives of extractive producers is one of the strategies that should be continued. Another public policy that might help is the provision of beneficiation units to the communities by the states, at subsidized cost or fund lost, as the state government of Acre has been doing. The government enters with investments in infrastructure and machinery, and the organized community starts to manage production and marketing with supervision and government assistance.

Policies of local production acquisition by governments are also important for the maintenance of activity and security of return and feasibility of investments, mainly in the early stages of the organization, production, and commercial capacity building of communities. The high-income elasticity of demand, as well as the high coefficient of the variable referring to the size of the Brazilian population, indicates a great potential for the growth of the NTFP market. To use this opportunity in the generation of income for the extractive populations in the Amazon, it is necessary that the products are oriented to the market and receive added value in the productive regions. The growing market for organic and natural products as well as for certified products, is a valuable option for these products. The development of

brands and the registration of Geographical Indication (GI) are other strategies with great potential.
Extractive products should gain an advantage from the market by exploring their origin, form of production, and benefits generated by environmental preservation.
Disputing the market with the cultivated product is not an option for the extractive NTFPs. Because production through cultivation tends to have lower production cost, closer location to the market, greater homogeneity, and safety as to the volume produced. This reduces the costs of the cultivated product, giving an advantage over the extractive industry in terms of price.
The extractive product necessarily needs to be seen in a differentiated way and with superior qualities over cultivated and synthetic products. Thus, it could dispute market slices with a greater willingness to pay.
In the long run, the idea of basing the development of regions or communities on the production and marketing of a single product such as rubber is unsafe as markets change over time, replacing one product with others continuously. Therefore, the economic and financial survival of extractivist communities would depend on a mix of NTFPs and derivatives.
Diversification, whether by the extraction of a greater variety of products or by the processing and transformation of a single product such as chestnut into various derivatives is an essential long-term strategy for minimizing the risks caused by community dependency on a single product and market, as was the case with rubber tappers.
The finite nature of the market for any NTFP is not an impediment to its development, but merely a proof of the need to diversify production, both in terms of the NTFPs and of the beneficiation and differentiation of its derivatives.
Each NTFP should be seen as a raw material that can be transformed into different products. In this way, although the market for the raw material may be in decline, its derivatives may last longer, provided that they target specific markets.
The main strategies suggested in this research for the commercialization of NTFPs are those that add value to the product in the community or producing region, diversify the products generated from each available non-timber resource, differentiate the product from the cultivated or synthetic competitor, and continuously strengthen, train, market, and commercialize the community, always with the help of various governmental and non-governmental spheres.
These results indicate the need for durable public policies to foster the production of NTFPs. They also highlight the need for policies that may lead to the organization and empowerment of communities that can benefit from NTFP production and the subsequent manufacturing of finished products.
Increased public investment in the areas of infrastructure, market access, and credit for production and marketing would have a positive effect on the Brazilian production of NTFPs, provided they have medium- and long-term policies.
Currently, the diversification of government production and support to commercialization are also indispensable. If these policies are not implemented, and ongoing initiatives are not maintained, NTFPs extractivism in the Amazon would likely continue to be a subsistence activity for poor families, stimulating rural exodus.
The minimum price policy for extractive NTFPs is also crucial for guaranteeing income for extractive families. Minimum price policies in isolation would not be effective in maintaining the activity, but would be useful in guaranteeing income for families and communities that do not have other forms of income.

Materials and methods

Data

This study used data on the production and commercialization of six predominantly Amazonian Brazilian NTFPs: açaí (*Euterpe oleracea*), babassu almonds (*Attalea ssp*), Brazilian nut (*Bertholletia excelsa*), palm heart (*Euterpe oleracea*), rubber (*Hevea brasiliensis*), and copaiba oil (*Copaifera langsdorffii*). Our analysis is carried out using observations from 1973 to 2011. This period was chosen because the data for recent years were not available. We used data from the Statistical Yearbooks of Brazil, published by the IBGE. From these statistics, we collected the quantities produced and the value of production of the NTFPs derived exclusively from extractive activities. The Statistical Yearbooks of Brazil include the values and quantities of NTFP produced. We calculate the average value and the average price of the products.
The IBGE data were used because it is an official institution responsible for the collection and maintenance of historical series concerning the most diverse sectors of the economy as well as census data. Although there are limitations in some data series, such as the annual rather than monthly periodicity for the data on the production of NTFPs in the Amazon, especially those of regional or national scope, the series provided by IBGE is the only source available.
We converted all monetary series into Dollar (USD), as demonstrated by Hoffmann (2006) and Castanheira (2008). To deflate the values, we used an inflation index, and we opted to use the Wholesale Price Index (IPA-DI) calculated by the Getúlio Vargas Foundation.

Econometrics

NTFP supply

Supply and demand models for NTFPs were developed from the consumer and firm theories (Mankiw, 2020) as well as numerous studies on the market of extractive products, such as Homma (1993, 2001, 2012), Almeida et al. (2009 a, b), Balzon et al. (2004), Santos and Guerra (2010), and Afonso and Angelo (2009), together with research describing the environment and form of production and commercialization of extractive NTFPs (Amazonas, 2005; Josa, 2008; Afonso, 2008; Almeida et al., 2010; Ruiz, 2010).
According to the Law of Supply, with all variables kept constant, the offered quantity of a good increases when its price increases (Mankiw, 2020). According to the author, other important variables that influence supply are the price of production inputs, technology, expectations, and the number of sellers.
Angelo (1998) considers that the expansion of the road network in the Amazon increases the availability of raw material for the timber industry, reducing the cost of forest exploitation and production. In our study, we also consider the road network as a cost variable. This variable is expected to be directly related to the supply of NTFPs by lowering the costs of production inputs as it expands. We used data from the paved road network in the Northern Region from National Land Transportation Agency (ANTT, 2012).
According to Almeida et al. (2009b), the main reasons for the decline in the NTFPs market were motivated by factors

related to supply, probably due to the increase in the extraction costs or the decrease in the quota of extractivists. The increase in costs is linked to deforestation, the advancement of agriculture, forest fires, and the unsustainable extraction of some products. In this research, we tested the hypothesis that deforestation affects the supply of NTFPs in the Amazon by including in the model two variables related to deforestation: the reduction of total area (accumulated deforestation) and the rate of annual deforestation. This data was extracted from the National Institute for Space Research (INPE, 2012).

Homma (2012) concludes that the extractive industry uses manpower intensively. This activity generates low income. In this way, extractivism activities would have a higher labor cost in relation to capital and other inputs. The hypothesis that labor cost affects the extractive supply is tested by the inclusion of the real minimum wage among the explanatory variables in the supply model. Again, we use data from the Institute of Applied Economic Research (IPEA, 2012).

According to Mankiw (2020), one of the factors affecting the supply is technology, and more specifically technologies related to production. It is expected that the continuous advancement of technology will lead to a decrease in production and marketing costs. According to Angelo (1998), this hypothesis is tested by including a trend variable in the model.

The theoretical model adopted considers that the aggregate supply of NTFPs is a function of price (P), the road network of the Northern Region (MV), accumulated deforestation in the Amazon (DES), the deforestation rate in the Amazon (TDES), labor cost (CMO), and trend (T). The econometric model of supply, in log-log form, read as follows (Equation 3):

$$lnQ_t^s = \beta_0 + \beta_1 lnP_t + \beta_2 lnMV_t + \beta_3 lnTDES_t + \beta_4 lnCMO_t + \beta_5 lnT_t + \varepsilon_1 \quad [3]$$

Where:

Q_t^s = supplied quantity of NTFPs in the year t; P_t = price of NTFPs in the year t; MV_t = increment of the road network in the North Region in the year t; $TDES_t$ = accumulated deforestation in the Brazilian Amazon in the year t; CMO_t = cost of labor in the year t; T = trend; ε_1 = stochastic term.

According to microeconomic theory, the rise in prices stimulates supply. In this case, a positive coefficient is expected for the price.

The expansion of the road network in the Amazon can have two opposite effects on the supply of NTFPs. A positive effect would be to facilitate the flow of production and to reduce the production costs. However, the increase in the road network can also lead to a reduction in NTFP-producing areas due to the conversion of native forest areas to other land uses. Its coefficient does not have a certain signal a priori, as it depends on which of the effects, positive or negative, has a greater influence on the supply of NTFPs.

It is expected that deforestation in the Brazilian Amazon will have a negative effect on the production of NTFPs in the region. Therefore, the predicted coefficient is negative.

An important input into the production of NTFPs is labor. The cost of labor is one of the determinants of the cost of production. A negative coefficient is expected for this variable since an increase in the production cost leads to the retraction of the quantities supplied.

One of the advantages of the logarithmic specification is that the elasticities are given directly by the values of the coefficients.

NTFP Demand

According to the Law of Demand, with other variables kept constant, the demanded quantity of a good decreases when the price of that good increases (Mankiw, 2020), and vice versa. Mankiw mentions other important variables that affect demand, such as consumer income, price of related goods, consumer tastes and preferences, expectations, and the number of buyers.

The proposed model of the demand for Amazon NTFPs considers the national demand for the products. In addition to the variable price, the per capita gross domestic product (IPEA, 2012) was used as a proxy for consumer income. In addition, we include the population in the country and a trend to capture changes in consumer tastes and preferences.

Demand for NTFPs (QD) is a function of price (P), consumer income (R), size of the Brazilian population (POP), and trend (T). The demand econometric model, in log-log form, is described as follows (Equation 4):

$$\ln Q_t^D = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln R_t + \beta_3 \ln POP + \beta_4 \ln T_t + \varepsilon_2 \quad [4]$$

Q_t^D = demanded quantity of NTFPs in the year t; P_t = price of NTFPs in the year t; R_t = income of consumers in the year t; POP_t = Brazilian population in the year t; T = trend; ε_2 = stochastic term.

In this model, demand depends negatively on the price (P) and positively on the income of consumers (R) and the Brazilian population (POP). The sign of the coefficient of the trend variable (T) is not known at first.

As a proxy for consumer income, we use the per capita gross domestic product, also deployed by Soares et al. (2008 and 2009). In his research, NTFPs are considered normal products where the higher income of their consumers is proportional to greater consumption. À priori, the expected signal for the coefficient of this variable is positive.

The Brazilian population is a proxy for the size of the market since it is considered that NTFPs are widely used in the domestic market. For its coefficient, the expected signal is positive. Thus, with increasing population, the consumption of NTFPs also rises.

Evaluation of models

Simultaneity and specifications

The equations were estimated by Ordinary Least Squares (OLS). For models 3 and 4, the hypothesis of simultaneity was tested using the Hausman test (Gujarati, 2000), which did not consider the presence of simultaneity between the price and quantity variables.

The tolerance values and the Variance Inflation Factor (VIF) assessed the presence of multicollinearity. According to Gujarati (2000), although there are no rigid limits for this analysis, if the values calculated for tolerance are not below 0.1, and the VIF does not exceed 10.00, it is considered that the model does not present a problem of multicollinearity among its explanatory variables.

The presence of heteroscedasticity in models from equations 3 and 4 was tested using the White test, as described by Gujarati (2000). The Durbin-Watson test was used to evaluate the presence of serial autocorrelation of the residuals of the non-autoregressive models.

The adjustment of the models to the data was made by the analysis of the "R^2". We also compute the "F" statistics to access the global significance of the regression and the "t-values" for the significance of each coefficient. The level of significance adopted in this study for statistical inferences was 10%.

Conclusions

During the study period, from 1973 to 2011, each NTFP presented its own behavior and the NTFP market was stable in terms of prices and quantities following the implementation of the Real Plan. The proposed supply model for NTFPs in the Amazon presented satisfactory statistical results. However, it did not demonstrate consistency with economic theory. The supply model presented high explanatory power (0.92) and significant coefficients, but the price coefficient showed the opposite sign of the expected. Deforestation in the Amazon showed a positive coefficient, which was also inverse to what was expected. The labor cost also presented a positive coefficient, contrary to the paradigm microeconomic theory. Only the road network in the North region showed positive coefficient as expected. The determinants of the supply of NTFPs in the Amazon remain open for future studies.

The NTFPs were inelastic to prices on both the supply and the demand sides. The low price elasticity of supply favors the cultivation of NTFP-producing species rather than the expansion of extractive activity. The low price elasticity of demand is indicative of consumer preferences for these products. Each of the NTFPs analyzed in this work presented its own dynamics, both in terms of price and quantity. This indicates the need for public policies that consider the specificities of each product, the market, and the producing region. Public investment in the areas of infrastructure, market access, and credit for the production and commercialization of extractive NTFPs will have a positive effect on the Brazilian production of NTFPs, provided that these policies aim at medium- and long-term results.

References

Afonso SR, Angelo H (2009). Mercado dos produtos florestais não-madeireiros do cerrado brasileiro. Ciência Florestal. 19(3): 315-326.

Afonso SR (2008). Análise Sócio-Econômica da Produção de Não-Madeireiros no Cerrado Brasileiro e o Caso da Cooperativa de Pequi em Japonvar, MG. 2008. Dissertação (Mestrado em Ciências Florestais) - Departamento de Engenharia Florestal, Universidade de Brasília, Brasília, DF.

Almeida AN, Angelo H, Silva JCGL, Hoeflich VA (2010). Mercado de madeiras tropicais: substituição na demanda de exportação. Acta Amazonica. 40(1): 119-126.

Almeida AN, Santos AJ, Silva JCGL, Bittencourt AM (2009a). Análise do mercado dos principais produtos não madeiráveis do estado do Paraná. Floresta. 39(4): 753-763.

Almeida AN, Bittencourt AM, Santos AJ, Eisfeld CL, Souza VS (2009b). Evolução da produção e preço dos principais produtos florestais não madeireiros extrativos do Brasil. Cerne. 15(3): 282-287.

Amazonas (2005). Cadeia produtiva do açaí no estado do Amazonas. Série Técnica Meio Ambiente e Desenvolvimento Sustentável, 1, Manaus.

Angelo H (1998). As exportações brasileiras de madeiras tropicais. Tese (Doutorado em Engenharia Florestal) - Universidade Federal do Paraná – UFPR. Curitiba – PR, 129 p.

ANTT (2012). Agência Nacional de Transportes Terrestres. Anuário Estatístico dos Transportes Terrestres (diversos números). http:www.antt.gov.br. Accessed November 12, 2021.

Balzon DR, Silva JCGL, Santos AJ (2004). Aspectos mercadológicos de produtos florestais não madeireiros - Análise retrospectiva. Floresta. 34(3): 363-371.

Barbosa F de H, Waizbort E (1979) Expectativas versus ajustamento, no modelo de Nerlove de produtos agrícolas: alguns resultados para o Brasil. Revista de Economia Rural. 17(4): 163-81.

Castanheira NP (2008). Métodos quantitativos. Curitiba: Ibpex, 183p.

Chao S (2012). Forest peoples: Numbers across the word. Forest People Programme, United Kingdom.

FAO (2018). Non-wood forest products in international statistical systems. Non-wood Forest

Products Series no. 22. Rome, FAO.

Falesi LA, Santana AC, Homma AKO, Gomes SC (2010). Evolução e interação entre a produção e o preço das frutas no Estado do Pará. Rev. Ci. Agra. 53(1): 69-77.

Giatti OF, Mariosa PH, Alfaia SS, Silva SCP, Pereira HS. (2021). Potencial socioeconômico de produtos florestais não madeireiros na reserva de desenvolvimento sustentável do Uatumã, Amazonas. Revista de Economia e Sociologia Rural, 59(3): e229510.

Gujarati DN (2000). Econometria básica. 3 ed. São Paulo, Makron Books.

Hoffmann R (2006). Estatística para economistas. 4 ed. São Paulo: Pioneira Thomson Learning, 432p.

Homma AKO (1983). Esgotamento de recursos finitos – o caso do extrativismo vegetal na Amazônia. Boletim da Fundação Brasileira Para a Conservação da Natureza. 18: 44-48.

Homma AKO (1993). Extrativismo vegetal na Amazônia: limites e oportunidades. Empresa Brasileira de Pesquisa Agropecuária, Centro De Pesquisa Agroflorestal Da Amazônia Oriental. Brasília, 201 p.

Homma AKO (2001). O desenvolvimento da agroindústria no Estado do Pará. Saber. Ciências Exatas e Tecnologia. 3 (ed. Especial): 47-76.

Homma AKO (2012). Extrativismo vegetal ou plantio: qual a opção para a Amazônia? Estudos Avançados. 74: 167-186.

IBGE (2022). Instituto Brasileiro de Geografia e Estatística. Sistema IBGE de recuperação automática – SIDRA. Produção da extração vegetal e da silvicultura. http://www.sidra.ibge.gov.br. Accessed November 04, 2022.

INPE (2012). Instituto Nacional de Pesquisas Espaciais. Taxas anuais de desmatamento na Amazônia Legal. Disponível em: <www.inpe.br>. Acesso em: 08 de ago. 2021.

IPEA (2012). Instituto de Pesquisa Econômica Aplicada. Disponível em: <www.ipeadata.gov.br>. Acesso em: 12 de ago. 2021.

Josa IO (2008). Piaçabeiros e piaçaba no médio rio Negro (Amazonas – Brasil), socioeconomia da atividade extrativista e ecologia da Leopoldiniapiassaba Wallace, 2008, 107f. Dissertação (Mestrado). INPA/UFAM, Manaus.

Mankiw NG (2020). Introdução a Economia. São Paulo: Cengage, 720 p.

Nogueira JM, Nascimento Junior A, Bastos L (2009). Empreendimentos extrativistas como alternativas para geração de renda: do sonho ambientalista à realidade do estudo de mercado. Rev. Ciênc. Admin. 15(1): 85-104.

Nogueira JM, Santana AC (2011). valor econômico de bens e serviços ambientais: uma aplicação para o extrativismo no Cerrado. Anais. 48º Congresso da Sociedade Brasileira de Economia Administração e Sociologia Rural. Campo Grande.

Pastore AC (1973). A resposta da produção agrícola aos preços no Brasil. Editora APEC, São Paulo, 170p.

Ruiz JDS (2010). Benefícios econômicos e sociais a partir da participação em esquemas associativos: o caso das quebradeiras de coco babaçu no povoado de Ludovico, município do Lago do Junco – Maranhão. Dissertação (Mestrado) – Curso de Agroecologia, Universidade Estadual do Maranhão, São Luiz.

Santos AJ, Guerra FGPQ (2010). Aspectos econômicos da cadeia produtiva dos óleos de andiroba (*Carapa guianensis* Aubl.) e copaíba (*Copaifera multijuga* Hayne) na Floresta Nacional do Tapajós – Pará. Floresta. 40(1): 23-28.

Soares NS, Silva ML, Valverde SR, Alves RR, Santos FL (2008). Análise econométrica da demanda brasileira de importação de borracha natural, de 1964 a 2005. R. Árvore. 32(6): 1133-1142.

Soares NS, Silva ML, Valverde SR, Lima JE, Souza UR (2009). Análise do mercado brasileiro de celulose, 1969 – 2005. R. Árvore. 33(3): 563-573.

World Bank (2012). Rio + 20: A Framework for action for sustainable development. http://siteresources.worldbank.org/EXTSDNET/Resources/RIO-BRIEF-Forests.pdf. Accessed June 25, 2021.