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The Bee Honey Market in the State of Pará, Brazilian Amazon: An Econometric Model

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Abstract

This study evaluates the effects of socioeconomic, environmental, and institutional variables on the bee honey market in the state of Pará, from 1990 to 2019. The generalized method of moments was used to create the econometric model for estimation. The results show that the supply of honey is price-inelastic and that the rate of forest deforestation strongly impacts honey production. The creation of the Federação das Associações de Apicultores do Estado do Pará was denoted an important institutional landmark for the beekeeping production chain; however, the effects of incentive policies such as rural credit are limited and do not meet the needs of beekeepers. Institutional market policies are ineffective and rarely accessed by beekeepers; however, they represent an opportunity to diversify marketing channels. Honey is a product of biodiversity that is economically classified as a superior good and its demand is price-inelastic. Honey and its derivatives lack marketing strategies to enable their competitive insertion in new markets and government programs; these would enable access to broader markets in cities and lead to the acquisition of more consumers in the future.

Keywords: beekeeping, demand; supply, public policy

1. Introduction

The Amazon has great potential for beekeeping and meliponiculture development because of the diversity of its flora, territorial extent, and climate. The activities combines the fundamental requirements of sustainable development: in addition to generating products for the market, it provides important environmental services by facilitating pollination processes (Balbino et al., 2015). It is also aligned with the social and productive context of family farming and can be developed on small properties in consonance with other rural productive activities, allowing family labor to be used more intensively throughout the year.

The production of natural honey in Brazil in 2019 was approximately 26 000 tons, corresponding to a production value of R$ 636 million. In the same year, the northern region was responsible for 1 023 tons, corresponding to 2.22% of total national production and 3.37% of the value of production, ranking fifth among the country's large bee honey producing regions (IBGE, 2020a).

In the North, the state of Pará is the largest producer of honey, accounting for 65.52% of the regional total, and a production value of R$ 9.4 million in 2019. The 2017 Agricultural Census data show that Pará has 19 308 bee hives. In general, beekeeping is an activity complementary to other cultures in production systems with diversified land use. Compared to other agricultural activities, it has significant advantages for producers as it requires relatively low capital investment and provides continuous cash flow to agricultural production units, thereby generating income in a short period of time (Karadas & Birinci, 2018).

In the last 30 years, beekeeping in the state of Pará has undergone several institutional and political transformations, such as the structuring of associations through the creation of the Federation of Beekeepers Associations of the State of Pará (Federação das Associações dos Apicultores do Estado do Pará – FAPIC), the operation of the Constitutional Fund for Financing Norte (Fundo Constitucional de Financiamento do Norte – FNO) and the National School Feeding Program (Programa Nacional de Alimentação Escolar – PNAE).

In addition, there are other factors that determine beekeeping market dynamics, such as the price of honey, income and consumer preferences, technological advances made in beekeeping in recent years, price of possible substitute products, agricultural expansion, and the advance of deforestation. These variables can affect the demand and supply of honey.

This study aims to evaluate the influence of socioeconomic, environmental, and institutional variables on the demand and supply of honey in the state of Pará by estimating an econometric model for the period 1990–2019. The results allow us to understand the economic relations among the agents that operate in the market and evaluate the effects of public policies directed to the honey market in the state of Pará.

2. Methodology

2.1 Area of Study and Data Collection

The study area is the state of Pará in the northern region of Brazil, which covers a territorial extent of 1.24 million km², and is geographically divided into six mesoregions, 22 microregions, and 144 municipalities, with an estimated population of 8.89 million inhabitants, in 2020 (Figure 1). According to the 2017 Agricultural Census, the state has 281 000 agricultural establishments, including 889 beekeeping establishments (IBGE, 2020a).

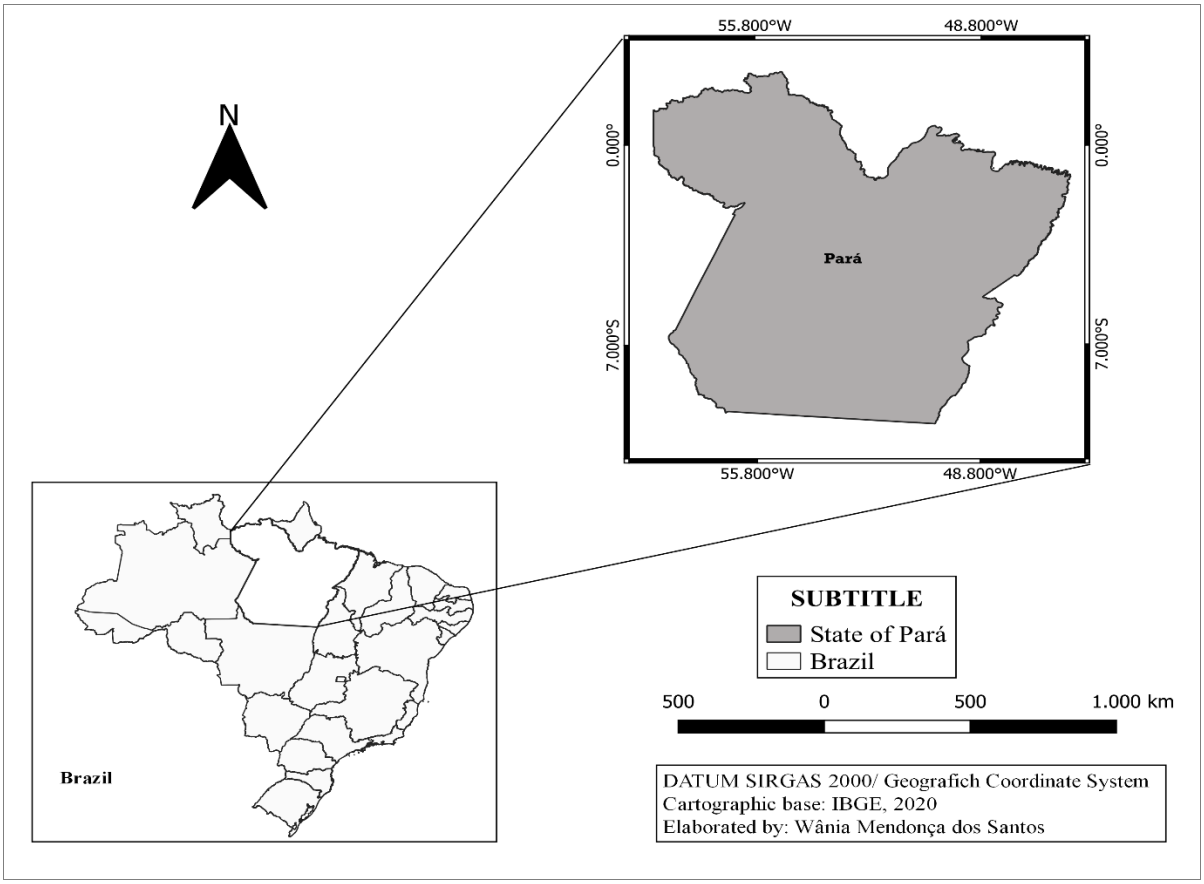

Figure 1. Location of the state of Pará in Brazil

A time series from 1990 to 2019 was used. The quantity produced and gross value of honey production were collected from the Municipal Livestock Research of the Instituto Brasileiro de Geografia e Estatística (IBGE, 2020b); these data were also used to calculate the price of honey in the state. The total area occupied by permanent and temporary crops in the state of Pará was obtained from the Municipal Agricultural Survey of the Brazilian Institute of Geography and Statistics (IBGE, 2021). The deforestation rate was obtained from the National Institute for Space Research's Deforestation Monitoring System in the Legal Amazon (Instituto Nacional de Pesquisas Espaciais – INPE, 2021). The values of rural credit applications for beekeeping was obtained from the Statistical Yearbook of Rural Credit of the Central Bank of Brazil (Anuário Estatístico do Crédito Rural do Banco Central do Brasil – BACEN, 2020). The figures for per capita income, rural salary, and the price of sugarcane were obtained from the Institute of Applied Economic Research (Instituto de Pesquisa Econômica Aplicada – IPEADATA, 2021). Monetary variables were corrected for December 2020 based on the General Price Index – Internal Availability of Fundação Getúlio Vargas (FGV, 2020).

2.2 Theoretical Model

Honey market dynamics are determined by the relationship between demand and supply for price formation. In the honey production model, demand is mainly generated by the domestic

market, and supply by producers. The quantity of honey supplied tends to evolve in the same direction as the prices received by producers; that is, price rises induce an increase in supply, as beekeepers project profit expectations, ceteris paribus.

On the demand side, quantity demanded is inversely related to the price of honey; that is, the consumer tends to purchase larger quantities of the product at lower prices, ceteris paribus. Other factors that affect the demand for honey are the income of consumers, other related products (substitutes and complements), and the number and preferences of consumers in the market.

In the state of Pará, beekeeping activities are characterized by family labor. Production in 2019 was 670.84 kg (IBGE, 2021), with emphasis on the northeast region of Pará, which represented 77.69% of the total. From the farms, produce then passes through associated entities like honey warehouses and middlemen or intermediaries. Thereafter, the honey produce may be destined for purchase by the government through institutions looking to encourage commercialization, by industries (food, cosmetics, and pharmaceuticals), and for table consumption (Almeida & Carvalho, 2009).

Regarding policy advances, Law No. 11.947, of June 16, 2009 (BRASIL, 2021), enables the provision of school meals through PNAE. This aims to encourage the purchase of healthy foods for students enrolled in public elementary schools, and could boost the demand for honey.

The expansion of rural credit is also an advancement in the field of development policies. The creation of the National Program for the Strengthening of Family Agriculture (Programa Nacional de Fortalecimento da Agricultura Familiar – PRONAF), in 1996, uses the resources of FNO to guarantee a stable supply of financing for agricultural activities in the northern region, which, consequently, favors the bee industry.

The development of beekeeping in the state began in the 1990s, with the strengthening of associativism through the holding of the first beekeepers' meetings and the formation of the first municipal beekeeping associations, such as the Association of Beekeepers of the State of Pará (Associação dos Apicultores do Pará – APIC); the Association of Organic Bee Breeders of São João de Pirabas (APISAL); the Viseu Association of Beekeepers (Associação Viseuense de Apicultores – AVAPIS); the Association of Beekeepers of the Municipality of Capitão-Poço (Associação de Apicultores do Município de Capitão Poço – AMEL), and the Beekeepers Association of the Municipality of Pimavera (Associação de Apicultores de Primavera – AAPRI).

Except AVAPIS, these associations combined to create FAPIC in 2002. FAPIC intends to represent, organize, and train the beekeeping segment of Pará in partnership with governmental and non-governmental institutions (Costa, 2009).

The rate of deforestation is expected to have an inverse correlation with beekeeping and honey production. According to Yamamoto and Barbosa (2010) and Imperatriz-Fonseca et al. (2012), deforestation of natural areas reduces the availability of substrates for nesting by bees and causes scarcity in the resources bees use for subsistence and procreation. Thus, habitat losses cause a reduction in gene flow and the supply of environmental services.

2.3 Econometric Model

The econometric model of the bee honey market in the state of Pará was structured using supply and demand equations and an identity equation. The variable used to measure demand and supply was the total production of honey from 1990 to 2019. The equations are as follows:

$$QOH_t = a_0 + a_1 PH_{t-1} + a_2 RC_{t-1} + a_3 DR_t + a_4 DV_{1t} + a_5 T + e_{1t} \quad (1)$$

$$QDH_t = b_0 + b_1 PH_t + b_2 R_t + b_3 DV_{2t} + e_{2t} \quad (2)$$

$$QDH_t = QSH_t = QH_t \quad (3)$$

The endogenous variables are:

QDH_t and QSH_t = bee honey quantities demanded and supplied in the state of Pará, in kg, in period t from 1990 to 2019.

PH_t= real price of bee honey in the state of Pará, in R$/kg, from 1990 to 2019.

The exogenous and instrumental variables are:

R_t = real per capita GDP, used as a proxy for consumer income in the state of Pará, in R$/inhabitant from 1990 to 2019.

PH_{t-1} = real price of bee honey in the state of Pará, lagged by one period, in R$/kg, from 1990 to 2019.

RC_{t-1} = real value of rural credit applications for beekeeping in the state of Pará, lagged by one period in R$, from 1990 to 2019.

DR_t = deforestation rate, in percentage, from 1990 to 2019.

DV_{1t} = dummy variable included in the model to capture the effect of the creation of FAPIC, which takes a value of 0 in the period 1990–2001, and a value of 1 in the period 2002–2019.

DV_{2t} = dummy variable included in the model to capture the effect of Law No. 11.947, of June 16, 2009, on the demand for bee honey, which assumes a value of 0 in the period 1990–2008, and a value of 1 in the period 2009–2019.

T = trend variable included in the model to capture technological advances in beekeeping from 1990 to 2019.

RS_t = rural salary (daily worker), in R$/day, included in the model as an instrumental variable to capture the effect of labor cost on beekeeping from 1990 to 2019.

PSC_t = real price of sugarcane, in R$/ton, from 1990 to 2019, used as an instrumental variable to capture the effect of the sugar market on demand for bee honey.

$AGRIC_t$ = total area occupied with permanent and temporary crops in the state of Pará, in hectares, from 1990 to 2019, used as an instrumental variable to capture the effect of agricultural expansion on beekeeping.

The random error terms: e_{1t} and e_{2t} = random errors associated with the supply and demand equations, respectively.

2.4 Hypotheses to Be Tested

According to economic theory, the expected signs for the coefficients of the variables are as follows: a_1, a_2, a_4, a_5, b_2 and $b_3 > 0$, a_3 and $b_1 < 0$.

The supply equation can be estimated independently; however, owing to the market equilibrium condition, it configures a recursive system with the demand equation. Thus, the generalized method of moments (GMM) was used to estimate the parameters of the structural equations, as it covers the main methods of generalized estimation of the parameters of linear and nonlinear econometric models. It also helps to overcome the basic problems of violation of the classical hypotheses of autocorrelation and heteroscedasticity (Greene, 2003). In the Amazon, this method has already been widely applied in the market analysis of agricultural products such as cowpeas, tropical fruits, wood, açaí, and beef cattle (Santana & Santos, 2000; Falesi et al., 2010; Santana et al., 2011; Nogueira et al., 2013; Santos et al., 2018).

Data were stored in Libre Office spreadsheets and later analyzed using GNU regression, econometrics, and time-series library (Gretl) software from the Free Software Foundation (FSF, 2021).

The demand and supply equations were estimated from the original variables and the elasticity coefficients were calculated as specified by Norwood and Lusk (2008).

3. Results and Discussion

The system of supply and demand equations for honey in the state of Pará was specified correctly. The exogenous and instrumental variables explained 97.02% and 92.31% of the variations in the quantities supplied and demanded, respectively. The error terms did not show autocorrelation problems as measured by the Ljung-Box test (Table 1).

Table 1. Results of the adjustment of the supply and demand equations of honey from bees in the state of Pará, 1990–2019

Variable	Coefficient	Standard err	T test	Elasticity
Supply equation				
Intercept	−72 570.10*	51 729.50	−1.4029	–
PH_{t-1}	2 072.62*	996.64	2.0796	0.1943
CR_{t-1}	0.0015^{ns}	0.01	0.15	–
DR_t	−16.8076*	4.1405	−4.0593	− 0.3135
DV_{1t}	68 483.50*	27 236.40	2.5144	0.2743
Trend (T)	20 163.60*	1 818.47	11.0882	0.0808
R^2	0.9702			
R^2 Adjusted	0.9638			
Q de Ljung-Box	0.8852			
Demand equation				
Intercept	−375 738.00*	122 082.00	−3.0778	–
PH_t	−4 978.29*	1 526.02	−3.2622	-0.42
R_t	29 271.20*	5 036.33	5.812	2.8944
DV_{2t}	12 521.90^{ns}	56 148.70	0.223	–
R^2	0.9231			

R^2 Adjusted	0.9139
Q de Ljung-Box	1.9442

Source: Research Data.

Note. (*) and (ns) indicate significance at the 1% probability level and non-significance, respectively.

The supply price elasticity coefficient expresses the effect of prices received by producers on honey supply. The value shows that for every 10% increase in price, with a lag of one year, the supply of honey increases by 1.943%, *ceteris paribus*, indicating price inelasticity of supply. Similar results have been reported by Kizilaslan and Kizilaslan (2007) and Chemwok et al. (2019). Price is an important economic variable affecting the decision to offer a product in the market, as it increases the income of the producers and motivates them to increase production capacity. Consequently, there is an increase in supply due to expectation of profit, making the slope of the supply curve positive.

The deforestation rate was inversely proportional to the supply of honey. A cross-elasticity coefficient of -0.3135 indicates that each 10% increase in deforestation implies a 3.135% reduction in honey supply. This is because the practice of deforestation and burning is associated with reduced bee species in the Amazon (Brown & Oliveira, 2014), because, like wild bees, managed bees also need inputs from native vegetation for honey production.

The *dummy* variable introduced to capture the effect of the creation of FAPIC in 2002 was significant in the model. In partnership with public and private institutions, FAPIC trained beekeepers in Pará through a series of courses on the beekeeping production chain. In the following years, the state of Pará experienced a change in the scenario of honey production in the North, when it gained the position of the largest producer in the region, previously occupied by the state of Rondônia.

Training for beekeepers can fill the knowledge gap and, thus, increase production and productivity. Toma et al. (2017) and Tarekegn et al. (2018) point out that honey producers' participation in training and qualification for beekeeping, contributes to increasing the production and supply of honey. Chemwok et al. (2019) show that honey production can increase by 7.5 times when access to rural extensions and producer associations increases. This reinforces the importance of technical training to leverage the production and supply of bee honey in the agricultural sector, along with the adoption of technologies and management practices that contribute to increasing yield and honey quality (Mujuni et al., 2012).

The trend variable that captures technological advances in beekeeping in Pará is positive and significant for the model. This indicates that technological increments in production processes generate increases in productivity and, thus, in the supply of honey in the market. Allied to this, beekeeping in Pará has been aligning itself with the national competitive market, which, in addition to other factors, seeks sustainable production. According to Kizilaslan and Kizilaslan (2007), beekeeping depends more on nature than other animal production activities; therefore, it is considered an agricultural activity that requires greater sustainability practices to preserve its existence. It must also be considered that beekeeping in

Pará is supported by cooperatives and associations to help improve the efficiency of the honey production chain and enter new markets.

The results of the demand equation show that the variables of honey price and per capita income were significant at the 1% probability of error; the variable used to capture the effect of Law No. 11.947, was not statistically significant.

The demand for honey is price inelastic because for every 10% increase in honey prices, there was a 4.2% reduction in demand; indicating a relatively smaller percentage change in the quantity demanded. The importance of honey for people's health may explain this result because basic necessities have relatively inelastic demand.

In the case of honey, studies have shown that products such as sugar and artificial sweeteners, despite being affordable, are not considered significant substitutes because of the unique characteristics of honey, such as color, flavor, viscosity, moisture retention capacity, and marketing appeal. In addition, it is a functional and valuable food with beneficial effects that contribute to the prevention and treatment of diseases (Macedo et al., 2008).

From an economic perspective, honey differentiation makes the demand curve more inelastic, thus reducing the number of substitute products. In this study, the price of sugar was inserted as an instrumental variable to estimate the effect of a substitute for honey, but did not show relevance to the econometric model. Similar results were reported by Willet and French (1991) in their econometric model of the US bee industry.

In relation to *per capita* income, the elasticity coefficient shows a positive value of 2.894, revealing that the model is consistent with consumer theory. A positive coefficient greater than 1 shifts the demand curve to the right, indicating that honey consumption increases as income increases. Ismaiel et al. (2014) demonstrated that the *per capita* consumption of honey increased significantly with an increase in household income in Saudi Arabia. Therefore, honey can be defined as a superior good; that is, an increase in income generates a more than proportional increase in demand.

The *dummy* variable included in the demand equation to capture the effect of Law No. 11 947 was not significant for the model. The law states that at least 30% of the amount transferred to states, municipalities, and the Federal District by the National Education Development Fund for the National School Feeding Program must be used to purchase local food products directly from family farming and rural family entrepreneurs or their organizations.

In addition to contributing to the inclusion of healthy food and encouraging family farming by offering an opportunity for marketing honey (Staron et al., 2015), the PNAE is an important opportunity to conquer future consumers by including honey into the eating habits of school-age children.

4. Conclusion

Honey supply in the state of Pará is price inelastic. The deforestation rate was inversely proportional to the supply of honey, indicating the importance of controlling forest fires for the prevalence or proliferation of bees and, therefore, for honey production. The demand for

honey is price inelastic and the *per capita* income coefficient is significant and positive, showing that the model is consistent with consumer theory. The variables used to capture the effect of the creation of the FAPIC and the technology variable were significant and positive, demonstrating the degree of importance of technological development and associativism as instruments of modernization and training in the production of honey in the state of Pará.

Several aspects deserve particular attention regarding the development of the honey production chain in the state of Pará. There must be progress in terms of technology, organization, and management of production units, since many of the producers are beginners in this activity, have a low level of education, are not engaged in associations and/or cooperatives, and do not have capital for investment. Thus, they require support from institutions and public policies to incorporate knowledge, management, and advanced processing techniques into the production process, with the aim of increasing quality and productivity to meet consumer market requirements.

Rural credit plays an important role in enhancing technological innovation in beekeeping. However, our study results show that the effect is not significant, suggesting that the level of access to rural credit by beekeepers in Pará is still low. Therefore, the challenge is to reduce the asymmetry of information between financial agents and producers so that knowledge about the socioeconomic characteristics and profitability of the business is shared, allowing the inclusion of the activity in the portfolio of investment opportunities in the region, opening the way for the expansion of financing with public resources for funding, investment, and commercialization.

Initiatives to promote honey and beekeeping products within society, actions that allow their inclusion in the school lunch diet and in family farming product acquisition programs, are crucial to win over current consumers and, mainly, future consumers who are still in school. This is a slow process, but it must be started as soon as possible, as it allows the expansion of the market.

The results of this study provide an opening for other studies to deepen knowledge of the structural and socioeconomic characteristics of beekeeping in Pará. New studies must be conducted to establish the analysis at the municipal level, evaluate growth patterns in the main municipalities, and correlate them with indicators of financing, provision of technical assistance services and rural extension, technological levels, diversification of production, and market access, among others. Analyses of this nature represent an important contribution to the elaboration and operationalization of agricultural policies to support beekeeping in the state of Pará.

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