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Spatial Econometrics Applied to Study the Influencing Factors of Honey Prices in Brazil

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Abstract

Recently, empirical econometric research has started to take into account the potential bias and loss of efficiency when spatial effects are ignored in the estimation process. The spatial econometrics methods deals with this kind of problem, by incorporating the spatial dependence into model specification. The application of this methodology has wide use, including rural economy, as apiculture. Currently, brazilian beekeeping is undergoing an expressive growth, projecting the country through the honey production and other bee products as well. Although, beekeeping sector has faced some important problems to reduce the deficits that strongly influence the beekeeping chain. Important issues are related to market, especially to understand the factors that influence the honey prices. This study aims to identify socio-economic, technological, management and geographic factors that have influenced the honey prices in Brazil. The analyses were based on classical linear and spatial econometrics regression models. In order to measure spatial dependence the Moran's Index was applied and the stepAIC and Nagelkerke Pseudo-R^2 approaches to select the most appropriate model. The best model identified factors linked to improper agricultural practices, access to fund, honey production level, market competition and educational level as target variables that influence the honey prices in Brazil.

Keywords: *Econometrics, Spatial analysis, Beekeeping, Honey market, Price.*

Introduction

Recently, empirical econometric research has started to take into account the potential bias and loss of efficiency that can result when spatial effects are ignored in the estimation process, so then, the spatial econometrics area has gained significantly ground in economics's literature (Bivand, 2002; Anselin, 1998). This fact has occurred because the evidence of interdependence effects in different regions (Figueiredo, 2002).

The spatial econometrics considers two spatial effects in their estimation: the spatial dependence or spatial autocorrelation and the spatial heterogeneity; commonly these effects are often ignored in traditional econometrics models (Anselin, 1988). When do not take into account spatial effects it possible generates biased estimates in the statistical models. This methodology might be applied more in research for

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the Brazilian agribusiness to enhance productivity through innovation generation or information diffusion (Krugman, 1991).

Brazil stands out as a leader in the agriculture global market; in 2005, 28.0% of the total incomes of the Brazilian Economy were derived from agribusiness, which accounts for important part of Gross Domestic Production (GDP) (Guilhoto and Sesso Filho, 2005). It is most interesting studies that cover the economic situation regarding this issue and together use data for querying and information.

One particular aspect of Brazilian agribusiness is its origin from family farming. Around 80% of its agrarian production depends on this segment, covering a population of 13.8 million people, who is responsible for the production of most consumed food in the country (IBGE, 2006). Livestock and crop production are important sources of livelihood involving economics, ecological and socio-cultural benefits (Guelber and Kerr, 2005).

Beekeeping is one of small-scale family-based operation, especially used by people with no opportunity to earn income, with remarkable success in terms of profitability. This rural activity can offers different kind of bee products, as honey, propolis, royal jelly, pollen, beewax, etc., especially from unfavorable regions for crops and livestock, besides less expensive than any other income activity. As sustainable activity, beekeeping can manipulate factors of production such as land, labor and capital resources into meaningful and productive uses. The expansion and development of Brazilian beekeeping is undeniable and its potentiality is vast in favor of the rural economy of Brazil, providing major employment and reducing of poverty. As a result, this rural sector accelerates the development of national economy (SEBRAE, 2006).

Around the world, Brazilian beekeeping is famous by the africanization of European honeybees. There have been important advances such as in those publicized in Bee Health and Genetics, whose researches recognized the poly-hybrid Africanized honeybee for its remarkable resistance and improved production capacity in tropical climates as compared to European bees (Guerra *et al.,* 2000; De Jong and Gonçalves, 1998). However, beekeepers are currently facing important constraints, probably due to insufficient technology and improper management. Therefore, the introduction of modern beekeeping techniques has been become imperative.

Since 2000, Brazilian honey market is increasing the exports and experienced better honey prices: the national honey production is three times greater in the last years, reaching around 40,000 t in 2009 and currently ranks as the 11th largest honey producer (IBGE, 2010; FAO, 2008). Nowadays, Brazilian beekeeping supply chain involves more than 350,000 producers, generates 450,000 occupations and 16,000 direct jobs in the industrial sector. In this last decade the honey market reached the highest level of production, with the hope of providing better conditions for structuring the activity.

For the effective structuring the level of awareness towards beekeeping as a viable/profitability source of income and the constraints factors have to be evaluated. This study is therefore, a step towards this direction, especially about the potential factors that influence the honey prices to improve the beekeeping supply chain in its logistics, production and trade. Using econometrics methods, this study aims to identify socio-economic, technological, management and geographic factors that influence the honey prices in Brazil.

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Research Methodology

Study Area and Dataset

Brazil belongs to South America and is formed by 26 states and the Federal District. The country has 5,565 counties, 191,480,630 inhabitants and 8,514,876.599 km^2, equivalent of 47% of South American territory. It is the fifth highest world population and fifth largest area, its economy is considered the fifth largest and represents the first in the Latin America (IBGE, 2000).

Despite the high population, Brazil has low population density; most of the population is concentrated along the coast, while the country is marked by huge demographic gaps (IBGE, 2000).

The database of this study, Brazilian honey prices and other variables were obtained in Agricultural Survey (IBGE, 2006), using aggregated data from 137 mesoregions.

Econometric Models

Initially, economic theory did not have many concerns with the empirical part, but with the construction of a theoretical framework, sought to take propositions that would explain the behavior of economic agents, without the empirical part. But the theorists were challenged to quantify numerically the parameters of the generated models by the propositions of economic theory, without testing them in the reality. Econometrics comes to solve these two important related (Wooldridge, 2002).

Among many concepts about econometrics (Gujarati, 2003; Kmenta, 1988; Theil, 1971; Frisch, 1936), this science can be defined as the quantitative analysis of concrete economics phenomena based on the simultaneous development of theory and observation, related by appropriate methods of inference. Thus econometrics is the application of mathematical and statistical procedures in economics problems.

Econometrics regression models are statistical tools that use the relationship between two or more variables. According to Greene (2003), regression analysis is concerned with the study of dependence of one variable (Dependent or Exogenous Variable, Y_i), in relation to one or more co-variables (Explanatory or Endogenous Variables, $X_1, X_2, X_3, \ldots X_n$).

Typically, in fitting a regression analysis, the objective is to find a good fit between the predicted values by the model and the observed values of the exogenous variable. In addition, were intended to find out which of the endogenous variables contribute significantly for a linear relationship. The standard hypothesis points out that the observations are not correlated and the residuals (ε_i) of the model are independent, non correlated with the dependent variable and are normal distributed with zero mean and constant variance ($\varepsilon_i = N(0, \sigma^2)$. The linear regression equation can be represented as follows:

$$Y_i = \beta_0 + \sum_{j+1}^{K} \beta_j X_{ij} + \varepsilon_i \qquad (1)$$

$$i = 1, 2, \ldots, n \text{ and } j = 1, 2, \ldots, k$$

where Y_i is the exogenous variable; β_0 the intercept, X_{ij} the endogenous variables and β_j their coefficients and ε_i is the random term.

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When the data are spatial referenced in geographic space, may occur the spatial dependence between events (spatial autocorrelation), so it must be taken into account the spatial structure of these data. The non use of this condition, may affect the significance of the parameters becoming then underestimated, and the existence of large-scale geographic variations may even induce the presence of spurious associations (Druck *et al.*, 2004).

Another aspect is the characterization of spatial dependence, which shows how the values are correlated in space. To measure the spatial autocorrelation, the Global Moran's Index was applied; it value ranges from –1 to 1, and indicate how much each area examined is similar to its immediate neighborhood (Anselin, 2002). The Global Moran's Index can be defined as:

$$I = \frac{\sum_{i=1}^{n}\sum_{s=1}^{S} w_{is}(Z_i - \overline{Z})(Z_s - \overline{Z})}{\sum_{i=1}^{n}(Z_i - \overline{Z})^2} \quad (2)$$

$i = 1, 2, \ldots, n$ and $s = 1, 2, \ldots, S$

Being Z_i the attribute inherent in each area, $\overline{Z}$ is the average value of the attribute in the study region and W_{is} the elements that compounds the array of neighborhood, with $W_{is} = 1$ whether a state *i* shares a common border with another mesoregion, otherwise $W_{is} = 0$. The Moran Map (INPE, 2009) was also used to verify the geography of spatial dependence. To account the spatial dependence phenomenon, it is plausible to use the spatial regression models (Anselin, 2002). For this study, was fitted a pure simultaneous autoregressive (SAR) model (Anselin, 2003). The SAR model can be defined as:

$$Y_i = \beta_0 + \sum_{j=1}^{K} \beta_j X_{ij} + p w_{is} + \varepsilon_i \quad (3)$$

$i = 1, 2, \ldots, n, j = 1, 2, \ldots, k$ and $s = 1, 2, \ldots, S$

Being Y_i is the exogenous variable, β_0 the intercept, X_{ij} the endogenous and β_j their coefficients, ε_i is the random term, ρ the spatial autoregressive term representing the spatial dependence and W_{is} the elements that compounds the array of neighborhood.

Variables Selection

The method for variables selection is based on stepAIC (Venables and Ripley, 2002); this method makes the combination of all possible variables in order to determine which are most relevant to fit the most parsimonious model. For comparison of the models, the Akaike Information Criterion (AIC) (Akaike, 1974) was used, which is expressed by:

$$AIC = -2\ LogLike + 2k \quad (4)$$

The variable *k* is the number of the model regression parameters and *LogLike* is the logarithm of maximum likelihood; Residual Sum Square (RSS) was also used to choose the most appropriated model. According to these criterions, the best model is

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the one with the lowest value of AIC and RSS. To measure the degree of adjustment and accuracy of the spatial models was applied Nagelkerke Pseudo-R^2 (Nagelkerke, 1991), it generalizes coefficients of determination using deviance information.

Softwares Used

For plot the Brazil map and estimate the Global Moran's Index, the geographic information system TerraView (INPE, 2009) was applied. The statistical package R (R Development Core Team, 2010) was used for exploratory analysis and modeling of data.

Modeling Strategy

The influencing factors of honey prices in Brazil were identified using Agricultural Survey of 2006 database, carried out by IBGE, aggregated in to 137 mesoregions and, then analyzed 47 variables about socio-economic, technological, management factors.

The modeling strategy was based on a construction of the best fitted model for the studied phenomenon. A classical linear econometric model (OLS) was fitted and, after the detection of spatial autocorrelation with the Moran's Index, was also fitted a spatial econometric model (SAR). Then, with support of stepAIC procedure to select the most relevant variables and others measures of goodness of fit, as Residual Sum Square (RSS) and Nagelkerke Pseudo-R^2, the best model was chosen, in order to identify the influencing factors of honey prices.

Results

The honey yield is important information that influences the honey prices: if we have a larger production the prices may fell, otherwise the prices may arise. The average honey yield per apiary was 476.50 kg [356.88; 596.11; 95% CI] and a variation coefficient of 198.41%. The average honey yield per bee colony was 16.31 kg [11.88; 20.84; 95% CI], with a variation coefficient of 213.65%. The total of honey yield in 2007 was 34,747.12 t, 2008 37,791.91 t, 2009 36,026.40 t and 2010 was 37,213.78, showing an average production growth rate of 3.03% per year. However, despite that regular rate from 1990 to 2006, the average production growth rate was 10.21% per year, demonstrating a decline process of honey production in Brazil.

An important cause to explain the decline of honey production can be the evasion of beekeepers. Like any agribusiness activity, beekeeping aims profitability and sustain of its producers, supporting by the honey prices. Thus, the uptrend of prices increases the production and the ingress of new beekeepers.

From 1994 to 2006, the average honey price was US$ 1.67 kg, and during 2006 to 2009 the average honey price was US$ 2.40 kg, in these last years the beekeepers probably did not show up profitability problems. Therefore, the shortage in the production could have been caused by: colony losses, depletion of natural resources, management and technological deficits and other factors.

In the Brazilian territory, the honey prices show high heterogeneity according to its spatial distribution. In the thematic map (Figure 1a), the North region of Brazil

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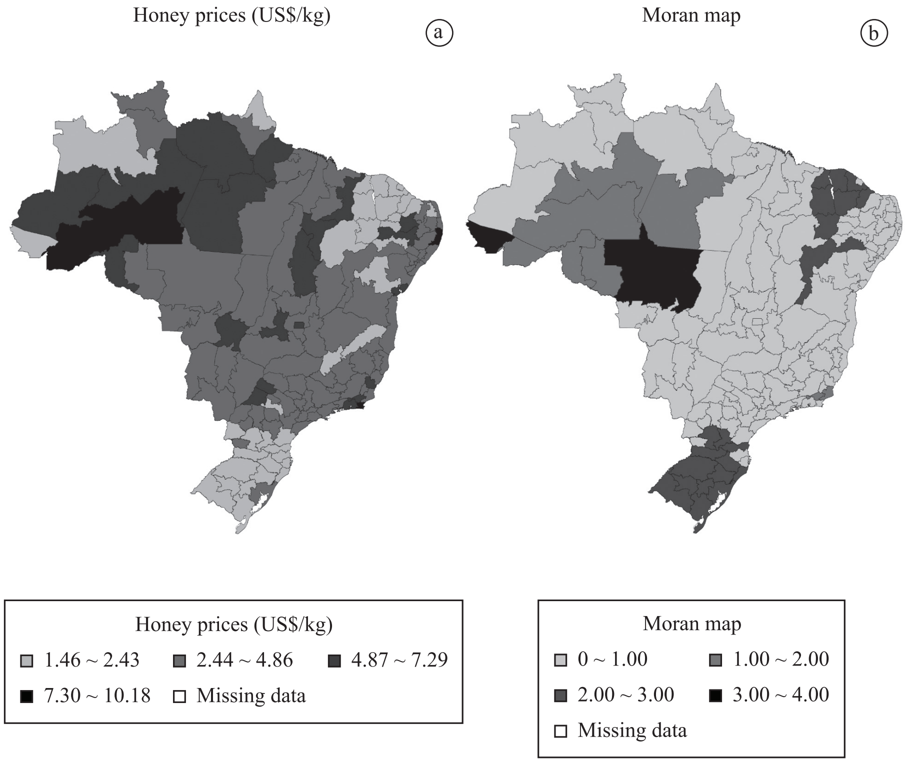

Figure 1. Thematic map of observed honey prices in Brazil (US$ per kg) and Moran Map.

had prices ranging from US$ 4.87 to US$ 10.18 per kg, adversely, in the South region the prices are more affordable, varying from US$ 1.46 to US$ 2.43 per kg. The low prices practiced in Southern region held for years, although it position as Brazilian largest honey producer and the proximity of Argentina, a global largest producer, encouraging the competition among these regions. The Moran's map (Figure 1b) also finds similarities of any natures: Middle-West, Southeast and Northeast are the regions where the prices are homogeneous, staying from US$ 2.44 to US$ 4.86 per kg. An exception ought to be made into this homogeneous zone, where Rio de Janeiro, Salvador and other close localities are tourists cities and had prices similar as those practiced in North region.

The average honey prices in Brazil determinate for 2006, based on the surveyed establishments was US$ 3.96 [US$ 3.79, US$ 4.13; CI = 95%] per kg, with a minimum US$ 1.46 and maximum US$ 10.18, and a variation coefficient of 38.63%. In the same year, Argentina, as a global competitor in the honey market, shows average prices around US$ 1.47 per kg, 63% lower than Brazilian average. Brazilian honey is known by its quality, free of chemicals residuals and more appreciate due to origin from wild flora. These important conditions fit the International market trend to demand organic products, and thus, promote the Brazil honey price valuation.

In the regression analysis of the honey prices, there was a downsizing of the variables, implied by the use of stepAIC methodology, which selected the variables that

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were less significant and increased the disturbances in the model, which are neglected. From 46 endogenous variables analyzed in the beginning, 15 variables were selected to fit the most parsimonious model, see Table 1.

Checking the Global Moran's Index (*I = 0.338, p-value < 0.001*) for diagnose the existence of spatial autocorrelation, a spatial econometrics model was fitted, using the geographical structures as an input for explanation the factors influencing the honey prices in Brazil. The application of SAR model (Simultaneous Auto Regressive) is compared with the linear model in Table 1.

Table 1. Estimated Parameters from the Agricultural Survey and the Confident Intervals (CI = 95%) of the regression models.

Model variables	Linear model	SAR model
	Parameters [CI = 95%]	Parameters [CI = 95%]
Intercept	–2.15500 [–10.19100 , 5.88100]	–1.01130 [–8.34974 , 6.32714]
Farms that make control of pastures	1.87200 [0.48883 , 3.25517]*	2.01090 [0.75519 , 3.26661]*
Average honey yield per farmer (kg)	–0.00029 [–0.00057 , –0.00001]*	–0.00028 [–0.00055 , –0.00001]*
Proportion of farms related to beekeeping	–33.94000 [–52.64624, –15.23376]*	–34.71700 [–51.51734, –17.91666]*
Illiterate farmers	–8.21400 [–11.23828, –5.18972]*	–8.14470 [–10.77874 , –5.51066]*
Farms using pesticides	–0.33120 [–3.21436 , 2.55196]	0.59857 [–2.04567 , 3.24281]
Farms using sprays and atomizers	0.11340 [0.06166 , 0.16514]*	0.10951 [0.06111 , 0.15791]*
Farms using fertilizer machine	1.57300 [–0.72216 , 3.86816]	1.21940 [–2.37524 , 4.81404]
Use of gasoline per farm	–1.03700 [–1.71849 , –0.35551]*	–1.05030 [–1.79726 , –0.30334]*
Use of diesel per farm	0.28780 [0.19539 , 0.38021]*	0.31338 [0.22772 , 0.39904]*
Use of LPG per farm	12.65000 [9.19060 , 16.10940]*	13.75100 [10.56972 , 16.93228]*
Amount of debt per farm	9.36800 [1.84552 , 16.89048]*	8.36990 [1.44953 , 15.29027]*
Amount of loan received from friends per farm	–0.05129 [–0.08924 , –0.01334]*	–0.05537 [–0.09182 , –0.01892]*
Farms obtained funding for costs and investments	0.00005 [0.00001 , 0.00009]*	0.00004 [0.00001 , 0.00007]*
Value of goods by farm	–0.00230 [–0.00417 , –0.00043]*	–0.00242 [–0.00411 , –0.00073]*
Value of ornamental flower production per farm	–0.00336 [–0.00730 , 0.00059]	–0.00299 [–0.00673 , 0.00074]
AIC	987.85	986.74
RSS	863.63	846.51
F-Test (p-value)	<0.001	<0.001
Nagelkerke Pseudo-R²	70.63%	64.79%

* Significant at 5%.

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The significant improvement of the SAR model, for the AIC and the RSS support a model for better explanation and greater parsimony. Despite the Nagelkerke Pseudo-R^2 of SAR Model, which is lower than the Linear Model, this was due to the attachment of the spatial regressive parameter, bringing more perturbation, than the Linear Model. Since our model is applied to explain the factors associated with the variability of the honey prices in Brazil and not exactly to discuss prediction, this inference can eventually becomes irrelevant.

Comparing the fitted values of the Linear and the SAR models with the values observed in the honey prices in Brazil (Figure 2), the box plot of the SAR Model shows the fitted honey price quartiles values more compressed than the Linear model, thus the SAR Model can behave better the observed values and reduce the fit variability. This result enhances SAR, as the model that best describes the data. Analyzing the map of honey prices (Figure 1) and the box plot of the fitted values of the SAR Model (Figure 2), there are a high concentration of the prices in the region between the quartiles of the model (US$ 3.21 to US$ 4.38). A significant correlation was found among the fitted values of SAR model with observed values of the price of honey ($\rho = 0.749$, p-value < 0.001).

According to the fitted spatial econometric model parameters, SAR (Table 1), the factors associated with increase in honey prices are due to the lack of support for funding and investment, leading beekeepers to use their own funds as initial and

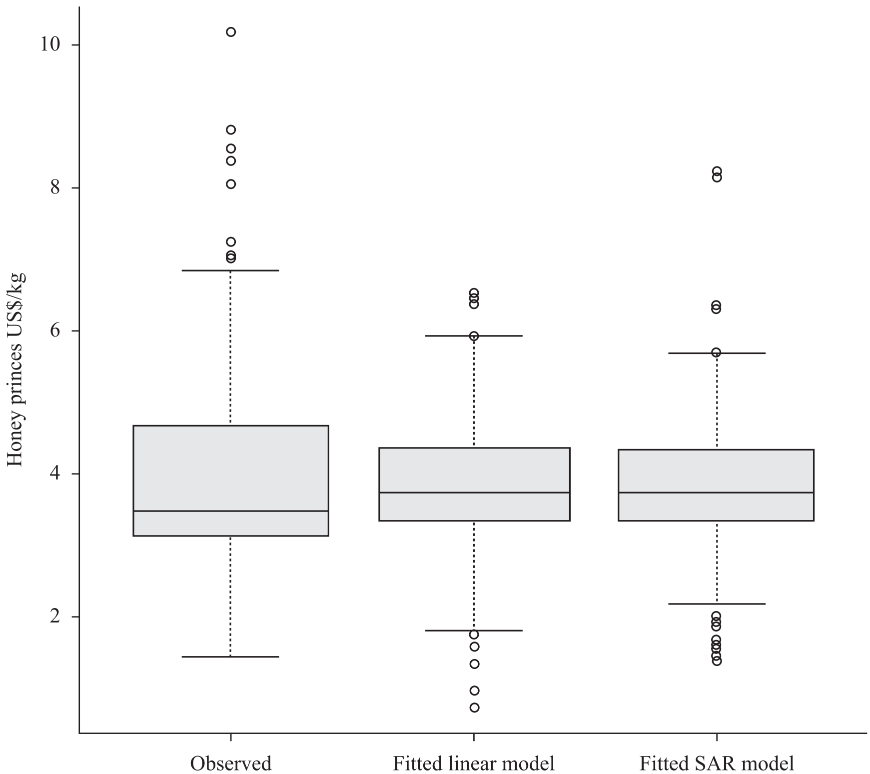

Figure 2. Box plot of observed honey price, Linear and SAR fitted honey price values.

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working capital. In a second moment, to recover their invested funds, the beekeepers raise the prices, attributing the increase of financial costs. It is noteworthy that this factor may also affect the entire supply chain, in a cascading effect, affecting negatively the profitability of beekeeping as agribusiness as well.

Another bias of price increase is the adoption of agrarian practices such as, pasture control and fertilization of land, currently used by farmers. These agrarian practices may strongly affect native hives and their natural resources, declining food and population in these locations (Macfarlane *et al*., 1983; Williams 1982). The shortage of food and the weakness of bee hives reduce the honey production, which promotes rising prices of bee products.

Exposure to pesticides also can affect the performance and ability of bee workers to perform the field tasks, impacting immediately in the bee colony performance (Weick and Thorn, 2002). As a consequence, bee colonies do not allow enough honey yield to beekeepers, decreasing the honey production and generating a local deficit in honey market, so that the prices arise. Besides, beekeeping explored near areas that use pesticides, such as fruits fields, represent an important danger for the quality of honey, due to chemical contamination; the performance of bee colonies; and breaching health standards regulated by several oversight agencies (e.g. Food and Agricultural Organization, World Trade Organization) (Brazil, 2006).

The model also identified factors that acted to reduce honey prices. Some are related to the increase in supplied honey, and this effect in the short-run, implies an excess supply in the honey market, forcing prices to fall. The ingress of new beekeepers in activity represents a strong weight of explanation in the honey prices. This factor is worth, as this studying honey has no value aggregated, this imply in no product differentiation among beekeepers, which leads to competition among brands, leading the offered price at a level close to the marginal cost of production.

The illiteracy was identified by the model as a reason associated with lower prices. The low educational level is usually related to lower income (Barros *et al.*, 1997). Therefore, these producers become economically vulnerable in the business favoring the entrance of crossovers. In this case, there is an offer of low prices, and the producer easily sells to ensure the fragile income. Furthermore, besides the impossibility to offer honey with a high value, given the low-income consumer market present in these regions, honey is view as a good of second need and these low-income regions prefer to demand basic consumption items.

Increase in loans received by friends or relatives may be seen as a proxy of credit at low or zero interest rate in order to decline honey prices. This type of loan promotes the investment and relives the costs of production. Finally, the greater availability of land provides bee flora and affects positively on honey production and causing an increase in market supply, leading to lower the price charged.

It is noteworthy that the presented factors associated with the honey price suffer influences from other determinants that are not listed in this survey.

Conclusion

This study provided an opportunity to build a econometric model, in order to analyze the variability of honey prices in Brazil. To attend this purpose we use spatial

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analysis to measure and include the geographic heterogeneity and autocorrelation through Brazilian territory in the spatial econometric model (SAR). The results highlight the inclusion of spatial dependence affected and improved all the parameters and inferences about them, suggesting that SAR model is more parsimonious than the classical linear model.

The results provided by the SAR model enabled to infer hypotheses about the behavior of the honey prices when they are related to socioeconomic factors, such as number of producers, funding, value of goods and educational level; technology use, like machinery, fertilizer, sprayers and atomizers; management related to the level of production and pesticides uses; geographical proposals and others factors.

In this context we emphasized a diagnosis of price and production of honey over years and especially the factors associated with them. The Nagelkerke Pseudo-R^2 value (64.79%) demonstrates that the statistical models can be enhanced, imputing others variables (like exportations or population income), and fitting others types of spatial models like the Conditional Auto Regressive (CAR), Simultaneous Moving Average (SMA), Generalized Additive Model (GAM), etc.

New researches should be performed in spatial modeling area, for comprehension of the behavior of honey prices at regional and local level. This is an important effort that can be used by technicians and producers to control the production and influencing the market, bringing up strategies for improvement the Brazilian beekeeping chain.

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References

Akaike, H. (1974) Fitting autoregressive models for prediction. Annals of the Institute of Statistical Mathematics, Vol. 21, No. 1, pp. 243-247. http://dx.doi.org/10.1007/BF02532251

Anselin, L. (1988) Spatial econometrics: Methods and models. Boston: Kluwer Academic Publishers.

Anselin, L. (1998) Exploratory spatial data analysis in a geocomputational environment, in: Longley, P.; Brooks, S.; McDonnell, R. and Macmillan, B.Geocomputation, a primer. New York: John Wiley & Sons.

Anselin, L. (2002) Under the hood: issues in the specification and interpretation of spatial regression models (forthcoming: Agricultural Economics). Available: http://agec221.agecon.uiuc.edu/users/anselin/papers/hood.pdf. Access: 3th June, 2009.

Anselin, L. (2003) GeoDa 0.9 User's Guide. Urbana-Champaign: Spatial Analysis Laboratory, University of Illinos.

Barros, R.P.; Machado, A.F. and Mendonça, R.S.P. (1997) Inequality of Poverty: Strategies and occupational differences by gender. Rio de Janeiro: IPEA, 36 p. (in Portuguese)

Bivand, R.S. (2002) Spatial econometrics functions in R: classes and methods. Journal of Geographical Systems, Vol. 4, pp. 405-421. http://dx.doi.org/10.1007/s101090300096

Brazilian Journal of Operations & Production Management
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Brazil. Ministry of Agriculture, Livestock and Supply (2006) Ordinance No. 137 of June 5, 2006. Technical Regulation of the National Health Bee - PNSAp. Official Gazette of the Federative Republic of Brazil, No .109, pp.1-6, 8 jun. (in Portuguese)

De Jong, D. and Gonçalves, L.S. (1998) The africanized bees of Brazil have become tolerant to varroa. Apiacta, Vol. 33, pp. 65-70.

Druck, S.; Carvalho, M.S.; Câmara, G. and Monteiro, A.V.M. (2004) Spatial Analysis of Geographic Data. Brasília: EMBRAPA. (in Portuguese)

Food and Agriculture Organization - FAO (2008) Faostat Database. Avaiable: <http://www.faostat.fao.org>. Access: 4th February 2010.

Figueiredo, A.M.R. (2002) Response of agricultural prices in the Midwest: a spatial econometric analysis for the period 1975/1995-1996. Tese. Federal University of Viçosa, Viçosa. (in Portuguese)

Frisch, R. (1936) Note on the term "econometrics". Econometrica, Vol. 21, No.1, pp. 31-40.

Greene, W.H. (2003) Econometrics Analysis. New Jersey: Pearson Education.

Guelber, V.M.O. and Kerr, W.E. (2005) Influence of the exchange of queens from colonies of Africanized bees in the pollen production. Bioscience Journal, Vol. 22, pp. 107-118. (in Portuguese)

Guerra, J.C.V.; Gonçalves, L.S. and De Jong, D. (2000) Africanized honey bees (Apis mellifera L.) are more effecient at removing worker brood artificially infested with the parasitic mite Varroa jacobsoni than are Italian bees or Italian/Africanized hybrids. Genetics and Molecular Biology, Vol. 23, No. 1, pp. 89-92. http://dx.doi.org/10.1590/S1415-47572000000100016

Guilhoto, J.J.M. and Sesso Filho, U.A. (2005) Estimation of input-output matrix from preliminary data from national accounts. Applied Economy, Vol. 9, No. 2, pp. 279-299. (in Portuguese)

Gujarati, D.N. (2003) Basic Econometrics. New York: McGraw-Hill, Inc.

Instituto Brasileiro de Geografia e Estatística - IBGE (2000) Censo Demográfico do Brasil. Available: http://www.ibge.gov.br/censos. Access: 5th May, 2009. (in Portuguese)

Instituto Brasileiro de Geografia e Estatística - IBGE (2006) Censo Agropecuário do Brasil.. Available: http://www.ibge.gov.br/censos. Access: 2nd April, 2009. (in Portuguese)

Instituto Brasileiro de Geografia e Estatística - IBGE (2010) PPM - Produção da Pecuária Municipal, vários anos. Available: http://www.ibge.gov.br/censos. Access: 3rd May, 2010. (in Portuguese)

Instituto Nacional de Pesquisas Espaciais - INPE. Divisão de Processamento de Imagens - DPI (2009) TerraView versão 3.3.1. Available: http://www.dpi.inpe.br/terraview/index.php. Access: 27th March, 2010. (in Portuguese)

Kmenta, J. (1988) Elements of econometrics. New York: MacMillan.

Krugman, P. (1991) Increasing returns and economic geography. Journal of Political Economy, Vol. 99, No. 3, pp. 483-499. http://dx.doi.org/10.1086/261763

Macfarlane, R.P.; Griffin, R.P. and Read, P.E.C. (1983) Bumble Bee Management Options to improve 'Graslands Pawera' Red Clover Seed Yield. Proceedings of the New Zealand Grassland Associations, Vol. 44, pp. 47-53.

Nagelkerke, N.J.D. (1991) A note on the general definition of the coefficient of determination. Biometrika, Vol. 78, pp. 691-692. http://dx.doi.org/10.1093/biomet/78.3.691

R Development Core Team (2010) R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing. Available: http://www.R-project.org. Access: 20th June, 2010.

Brazilian Journal of Operations & Production Management
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SEBRAE (2006) Challenges of the Brazilian Apiculture. Review SEBRAE Agribusiness, No. 324. (in Portuguese)

Theil, H. (1971) Principles of econometrics. New York, John Wiley & Sons.

Venables, W.N. and Ripley, B.D. (2002) Modern Applied Statistics with S. New York: Springer.

Weick, J. and Thorn, R.S. (2002) Effects of acute sublethal exposure to coumaphos or diazinon on acquisition and discrimination of odor stimuli in the honey bee (hymenoptera:Apidae). Journal of Economic Entomology, Vol. 95, No. 2, pp. 227-236. PMid:12019994. http://dx.doi.org/10.1603/0022-0493-95.2.227

Williams, P.H. (1982) The Distribution and Decline of British Bumble Bees (Bombus Latr.). Journal of Apicultural Research, Vol. 21, No. 4, pp. 236-245.

Wooldridge, J.M. (2002) Econometric Analysis of Cross-Section and Panel Data. Cambridge: MIT Press.

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