Brazilian Chicken Meat Production Chain: a 10-year Overview

ABSTRACT

Brazil is the world's largest broiler meat exporter. Health control, knowledge and technology, as well as the natural aspects of the country are pointed out as the keys for the success of that product in the market. Brazilian broiler production grew significantly in the last decade; it creates jobs and has a significant social role in Brazilian economy. This study aimed at evaluating the Brazilian broiler meat supply chain from 2000 to 2010 using the social network analysis (SNA). Data from governmental and private sources were organized and analyzed. The focus of this study was the broiler production supply chain segment involving the hatchery, the broiler farm, the feed mill, the processing plant, and the government. The inputs considered were one-day-old chicks, pullet, feedstuff, and the infrastructure; and the outputs were broiler meat and taxes paid. The software UCINET was applied for calculating the structural attributes and indicators of the network. Results showed a relatively disorganized network in 2000 with the strongest tie between the farmer and the processing plant. The structural organization of the network improved until 2010. The density of the ties in the broiler meat production network increased steadily from 2000 to 2010 within a vertical cohesive supply chain structure. The success of Brazilian broiler meat production is attributed to the abundance of land, fertile soil, favorable climate, and the effort and investments in research and development by innovative companies in the last few years. The results of the present study showed that Brazilian broiler production evolved positively in the last ten years, and it was weakly influenced by international challenges.

INTRODUCTION

Broiler meat is one of the most important meat in the global market, and today is the world's second most consumed meat (FAO, 2007). This is due to a few critical factors, such as its low price relative to other meats; excellent image by the consumers, who considered it a light meat; acceptance by most cultures and religions; and whole sales present a wide range of products based on broiler enabling the product market (IPARDES, 2002; Girotto & Mieli, 2004; Amorim, 2011; Vieira et al., 2012). Brazilian chicken meat is sold both in the domestic and international markets as whole carcass and/or parts with added value. The most important importers are the Arab countries, Asia and Africa (MDIC, 2010; UBABEF, 2012, 2013). During the last twenty years Brazilian broiler farming became important for the country’s economy. The broiler industry has significantly evolved in Brazil, and its dynamism is linked to constant productivity gains, particularly through the improvement of feed conversion ratios, nutrition technology, genetic research, increased automation of broiler facilities, and better production management (Sousa & Osaki, 2005; Patricio et al., 2012).
The broiler production chain includes farmers, suppliers, and partners. Using a rather unsophisticated housing facilities, the main inputs of the chicken meat production chain are one-day-old chicks and the feed supplied by the integration companies, while the final output is meat (Patricio et al., 2012). The unique nature of the broiler-meat supply chain derives from the complexity and scale of managing the flow of goods and information between various units involved in the network (Cooper et al., 1997; Furstenau, 2007; Araújo et al., 2008). Keeping an adequate balance between partners is a major challenge, and, in order to promote the effective management, the supply chain can be assessed by checking all the activities undertaken within the organization (Hanneman & Riddle, 2005; Borgatti & Li, 2009). Other important challenge is related to government regulations and the need to comply with a multitude of rules and regulations related to food safety in the domestic and exports markets (Allen et al., 2000; Pereira et al., 2007; Rubin et al., 2009).

Initially developed to describe social structures, the social network analysis (SNA) originated from studies on patterns of communication, influence, and interactions within social groups (Cross & Cummings, 2004; Richardson, 2009). Furthermore, a method of drawing on graph theory was developed for capturing and analyzing the relationships among members of a group with specific links and interactions (Carpenter & Westphal, 2001). The network perspective views any system as a set of interrelated actors or nodes. The actors can represent entities at various levels of collectivity, such as persons, companies, or countries (Cross & Cummings, 2004). The ties among actors can be of many different types, such as alliance or competition, and be considered along multiple dimensions, such as duration and frequency. SNA may be used as a strategic tool to an add value to organizations (Carpenter & Westphal, 2001). The analysis may also issue the invisible pattern of information and collaboration flow, which involves strategic players (Cooper et al., 1997).

This study aimed at analyzing the Brazilian chicken meat production chain between 2000 and 2010 by applying the social network analysis.

**METHODOLOGY**

This study was carried out in two parts. First, the complexity of chicken-meat supply chain was described from the hatchery to the domestic and exports markets. In this simplified supply chain, we defined the actors and their roles and functions. Data on product volume and financial movement were retrieved from published material (FAO, 2007, 2010, 2013; IBGE, 2013; MAPA, 2010; MDIC, 2010; USDA, 2010; USDA, 2012; CONAB, 2013; UBABEF, 2013), and market data (UBABEF, 2010, 2012, 2013). The data were organized, and the supply chain was studied considering two segments: (1) inputs to produce chicken meat (products and capital), and (2) the output of chicken meat production for domestic and exports markets (product and capital). The main selected chain actors were the hatchery, the feed mill, the farmer, the processing plant, and the market (Figure 1). The products involved were one-day-old chicks, feeds, and chicken meat. The capital was the financial inflow and outflow among actors within the chain until the meat reaches the market.

Second, some assumptions were made relative to commercial broiler production. Average market weight was assumed to be 2.2 kg (Araújo et al., 2008). The mean feed consumed during the grow out period was assumed as 1.80 kg of feed for each kg of weight gain, and we assumed an average tax of 8% applied on all products. Data on products and financial flow were collected from 2000 to 2010.

The actors in the meat supply chain were identified as suggested by Martins (2005) and Buainain & Batalha (2007). The information flow starts from the broiler farmer at the beginning of the chain and flows towards the market at the end of the chain, and the bi-directional relationships are described (Table 1). The actors were grouped based on their objectives and interfaces in order to define a unified and embedded protocol (Borgatti, 2005). From input data information on the chain, the output was developed.
Table 1 – Bi-directional relationships and product exchange among the network actors in the Brazilian broiler supply chain.

| From            | To               | Product/payment       |
|-----------------|------------------|-----------------------|
| Hatchery        | Farmer           | day-old chick(ton)    |
| Government      | Hatchery         | Payment (US$)         |
| Farmer          | Feed mill        | Payment (US$)         |
| Feed mill       | Government       | Tax (US$)             |
| Government      | Feed mill        | Tax (US$)             |
| Processing plant| Farmer           | Payment (US$)         |
| Government      | Processing plant | Tax (US$)             |
| Export Market   | Processing plant | Payment (US$)         |
| Domestic Market | Processing plant | Payment (US$)         |
| Government      | Farmer           | Tax (US$)             |
| Government      | Hatchery         | Infrastructure        |
| Processing plant| Government       | Health Certificate    |
| Feed mill       | Hatchery         | Infrastructure        |

A communication protocol was built with the aim of allowing data to flow efficiently among the chain elements/actors, as suggested by Hanneman & Riddle (2005) (Table 2).

Table 2 – Actors and the flow of product and/or payment within the Brazilian broiler meat supply chain from 2000 to 2010.

| Actor and flow of product and/or payment within the relationship | Unit | Year          |
|---------------------------------------------------------------|------|---------------|
|                                                               |      | 2000  | 2001  | 2002  | 2003  | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  |
| Export market to Processing plant                             | million US$ | 829.00 | 1320.00 | 1890.00 | 1980.00 | 2500.00 | 2590.00 | 3200.00 | 4600.00 | 6900.00 | 5800.00 | 5560.00 |
| Domestic market to Processing plant                           | million US$ | 3.35  | 3.09  | 3.05  | 3.57  | 3.88  | 4.59  | 4.85  | 7.27  | 8.87  | 8.62  | 11.05  |
| Processing plant to Domestic market                           | 10^3 ton   | 4.96  | 5.48  | 5.89  | 5.88  | 6.02  | 6.10  | 6.62  | 7.02  | 7.29  | 7.35  | 8.43  |
| Processing plant to Export market                             | 10^3 ton   | 0.94  | 1.26  | 1.63  | 1.96  | 2.47  | 2.85  | 2.72  | 3.29  | 3.65  | 3.66  | 3.80  |
| Hatchery to Farmer                                            | 10^3 ton   | 0.14  | 0.15  | 0.16  | 0.16  | 0.18  | 0.18  | 0.20  | 0.19  | 0.22  | 0.23  | 0.23  |
| Farmer to Hatchery                                           | million US$ | 493.83 | 623.42 | 566.88 | 614.02 | 875.96 | 715.97 | 1011.80 | 1858.17 | 1987.50 | 1576.34 | 2441.64 |
| Government to Farmer                                         | million US$ | 0.02  | 0.02  | 0.02  | 0.02  | 0.02  | 0.02  | 0.03  | 0.04  | 0.05  | 0.05  | 0.06  |
| Farmer to Government                                         | million US$ | 0.60  | 0.56  | 0.55  | 0.64  | 0.70  | 0.83  | 0.87  | 1.31  | 1.60  | 1.55  | 1.99  |
| Farmer to Feed mill                                          | million US$ | 1053.70 | 1135.46 | 1509.02 | 1517.22 | 1553.34 | 1432.16 | 1775.82 | 2337.66 | 2551.50 | 2431.97 | 2849.34 |
| Feed mill to Farmer                                          | 10^3 ton   | 9.32  | 10.14 | 10.78 | 10.76 | 11.02 | 11.10 | 12.25 | 12.99 | 12.76 | 12.94 | 14.25 |
| Farmer to Processing plant                                   | 10^3 ton   | 5.56  | 6.22  | 7.09  | 7.56  | 8.63  | 9.62  | 9.32  | 10.80 | 11.58 | 11.67 | 12.45 |
| Processing plant to Farmer                                   | million US$ | 4263.34 | 3912.09 | 3640.04 | 3800.64 | 4428.48 | 5837.79 | 5596.69 | 9054.64 | 11489.06 | 11380.34 | 14919.92 |
| Processing plant to Government                               | million US$ | 149.82 | 238.16 | 340.75 | 357.04 | 450.70 | 467.03 | 576.87 | 829.31 | 1243.60 | 1045.55 | 1002.79 |
| Government to Processing plant                                | million US$ | 4.49  | 7.14  | 10.22 | 10.71 | 13.52 | 14.01 | 17.31 | 24.88 | 37.31 | 31.37 | 30.08 |
| Government to Feed mill                                      | million US$ | 5.69  | 6.13  | 8.15  | 8.19  | 8.39  | 7.73  | 9.59  | 12.62 | 13.78 | 13.13 | 15.39 |
| Feed mill to Government                                      | million US$ | 189.67 | 204.38 | 271.62 | 273.10 | 279.60 | 257.79 | 319.65 | 420.78 | 459.27 | 437.75 | 512.88 |
| Hatchery to Government                                       | million US$ | 88.89 | 112.22 | 102.04 | 110.52 | 154.75 | 208.07 | 182.12 | 334.47 | 357.75 | 283.74 | 439.50 |
| Government to Hatchery                                       | million US$ | 2.67  | 3.37  | 3.06  | 3.32  | 4.64  | 6.24  | 5.46  | 10.03 | 10.73 | 8.51  | 13.18 |

Data were processed, and the relationships were studied using UCINET® 6 for Windows® (Borgatti, 2002). Values that explain the network interactions were obtained for cohesion (density, the cluster coefficient, mean distance between actors, compactness, and distance weighted-fragmentation), grouping (cliques), and centrality measurement (in-degree, out-degree, closeness, and centralization index). Geodesic distance was evaluated by the distance between actors in the graphic network (Haythornthwaite, 2001). The graph theory used is a descriptive method based on the vision of the network as a set of nodes connected by links (Carpenter & Westphal, 2001). In the present study, the structural measurements of centrality and the analysis of roles were done using the theory of graphs applied into the UCINET® software.

RESULTS AND DISCUSSION

Results from the SNA showed a relatively disorganized network in 2000 (Figure 2), with the strongest tie (shown in the larger line linking two actors) established between the farmer and the processing plant. The network becomes more organized in 2003 and continued until 2005 (Figure 3), although the country was seriously affected by
avian influenza, which also affected Canada and Indonesia in 2004. At that time, Brazilian producers presented a well-structured and competitive business, reaching the world’s leadership in exports of this meat. Araújo et al. (2008) also described that a better relationship within the broiler supply chain (farmers and processing plants) started to be established between 2001 and 2006, when the market faced a large variation in prices. A partnership in food and agribusiness can be defined as a set of interdependent players working closely together to manage the flow of product and services along the supply chain, in order to assure customer value at minimal costs (Ziggers & Trienekens, 1999).

Starting in 2008, after the international financial downturn, the 2010 supply chain shows a more compact array (Figure 4). The SNA geodesic distances (distance between nodes/actors) are shorter than in other years, indicating more cohesion within the network. A key concept in SNA is the notion of node centrality, which may be defined as the importance of a node due to its structural position in the network as a whole. Three sub-groups were identified, in which products and money flows and probably the decisions were made (Carpenter & Westphal, 2001).

Table 3 summarizes the structural characteristics of the network from 2000 to 2010. While some properties of cohesion (mean distance between actors, compactness, and distance-weighted fragmentation) remained the same during the studied period, the density and the cluster coefficient consistently increased over the years, indicating the strategic organization of the supply chain (Vieira et al., 2012). On the other hand, a small variation in structural centrality results (in-degree and out-degree) shows that this supply chain tends to be vertical. Vertical integration may cause the players to require less information, leading to cost reduction. This potential cost advantage should be balanced against the disadvantage possibly missing advantageous external opportunities. Vertical integration also allows the introduction of more focused procedures and organizational structures to improve production (Vallet-Bellmunt et al., 2011).

From 2006 (Table 3), there is a clear increase in the network cohesion properties (density and cluster coefficient) which allowed identifying a large impact on the chain. In January of 2006, the avian virus H5N1 was detected in the Miyazaki region, Japan, and the disease affected chicken meat prices and increased international restrictions on its trade. Despite the virus outbreak, the density of the network remained...
high, indicating cohesion between actors (Windahl & Lakemond, 2006). The reduction of the international financial flow from 2008 increased the density of the ties in nearly 60% from 2005 to 2010. Although the effect of the international down turn in 2008 led to a reduction (-8.1%) in the growth percentage of the network density (Figure 5), there was a fast recovery up to 2010. In vertical integration, the central management holds the control, and the different stages have no separate controls. This allows the actors to focus on their core business and to outsource other functions (Vallet-Bellmunt et al., 2011).

Broiler farming became vital to the Brazilian agribusiness in the last twenty years, and its relationship with the processing industry has greatly increased (Souza & Zylbersztajn, 2011). The industrial-scale broiler farming replaced the previous commercial broiler production when greater investments in research started to be made and agencies related to multiple aspects related to broiler production were established (Patricio et al., 2012). Brazil has also achieved considerable productivity results with development of more stringent health inspections, gaining the confidence of new markets, as it has adapted to the demands of the globalized world.

The increase in Brazilian broiler production in the last 10 years was mainly driven by worldwide increase in chicken meat consumption. In 2010 Brazil became worlds’ largest exporter of chicken meat, with a total of 3.8 million tons exported to over 150 countries, followed by the United States (UBABEF, 2012; USDA, 2012). Factors such as the use of advanced technology, proper health control, compliance with international standards, and favorable exchange rate for exports, helped Brazil achieve those marks. Results from the present study show that Brazilian broiler production positively evolved in the last ten years, and it was weakly influenced from international virus outbreaks, as none of the viruses that affect broiler production in other countries was found in the country. Although product trade was stable until 2006, from that time on there was a significant increase both in financial trade and in producers’ profit. According to that trend, consumers’ income will continue to increase rapidly in the next years, unless some unexpected event in the international scenario emerges in the future (Figure 6).

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Table 3 – Results of the structural properties of Brazilian chicken meat production chain from 2000 to 2010, from SNA data processing.

| Year | Index | Cohesion | Sub-Group | Centrality measurement (%) |
|------|-------|----------|-----------|-----------------------------|
|      | Density | Cluster Coefficient | Mean Distance between Actors | Compactness | Distance-Weighted Fragmentation | Cliques | In-degree | Out-degree | Closeness | Centralization Index |
| 2000 | 169.19  | 104.92   | 1.76      | 0.68 | 0.32 | 3.00 | 15.52 | 14.85 | 39.49 | 52.22 |
| 2001 | 180.69  | 104.71   | 1.76      | 0.68 | 0.32 | 3.00 | 15.27 | 14.10 | 39.49 | 52.22 |
| 2002 | 199.30  | 108.28   | 1.76      | 0.68 | 0.32 | 3.00 | 14.91 | 13.11 | 39.49 | 52.22 |
| 2003 | 207.26  | 112.35   | 1.76      | 0.68 | 0.32 | 3.00 | 14.94 | 13.13 | 39.49 | 52.22 |
| 2004 | 244.90  | 130.01   | 1.76      | 0.68 | 0.32 | 3.00 | 15.00 | 13.02 | 39.49 | 52.22 |
| 2005 | 286.00  | 157.25   | 1.76      | 0.68 | 0.32 | 3.00 | 15.31 | 13.76 | 39.49 | 52.22 |
| 2006 | 303.14  | 159.06   | 1.76      | 0.68 | 0.32 | 3.00 | 15.12 | 13.16 | 39.49 | 52.22 |
| 2007 | 464.89  | 248.90   | 1.76      | 0.68 | 0.32 | 3.00 | 15.25 | 13.48 | 39.49 | 52.22 |
| 2008 | 597.53  | 303.62   | 1.76      | 0.68 | 0.32 | 3.00 | 15.50 | 13.39 | 39.49 | 52.22 |
| 2009 | 548.92  | 287.90   | 1.76      | 0.68 | 0.32 | 3.00 | 15.62 | 13.84 | 39.49 | 52.22 |
| 2010 | 662.78  | 371.52   | 1.76      | 0.68 | 0.32 | 3.00 | 15.58 | 14.28 | 39.49 | 52.22 |

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Figure 5 – Percentage fluctuation of the density of the Brazilian chicken meat production network from 2000 to 2010.

Figure 6 – ...
However, updated strategic actions are needed to ensure quality, appropriate disease control, product standardization, and compliance with international standards (Furstenau, 2007). Brazilian chicken meat consumption per capita increased from 10 kg in 1996 to 35 kg in 2004 (Girotto & Mieli, 2004), reaching nearly 90 kg in 2010 (UBABEF, 2011). Much of this achievement is due to the economic stability after “Plano Real”, which is considered the most successful Brazilian economic plan to date. Launched to fight chronic inflation in 1994, it fixed prices and strengthened the purchase power of workers, and stabilized the economy. After “Plano Real”, the broiler supply chain strengthened the ties amongst the actors, despite maintaining its vertical structure (Allen et al., 2008).

Considering the broiler production chain and its influence on Brazilian economy, other actors and the roles they played affected the productivity and cash flow during the evaluated period. Broiler farmers’ profit consistently increased from 2000 to 2010. There was a slight decrease from 2000 to 2004. However, from 2004 to 2010, it steadily increased (Figure 6). The governmental structure inside broiler supply chain strengthened the ties amongst the actors, despite maintaining its vertical structure (Allen et al., 2008).

Veirea et al. (2012) mention that the main producers of chicken meat are located in the South and Southeast regions of Brazil today, where there is a predominance of small farms, which is compatible with broiler production integration. The Southeast benefits from the proximity to ports and to main consumer markets. However, the evolution and trends of the overall broiler production supply chain still needs to be further understood.

**CONCLUSIONS**

Several factors have raised Brazil to a privileged position in the chicken meat production and exports markets. Such factors include the abundance of land, fertile soil to produce feedstuff, favorable climate, and innovativeness of the companies in overcoming challenges. Results from the present study showed that the Brazilian broiler industry has positively evolved in the last ten years, and was not affected by international virus outbreaks. Although trade was steady up to the year 2005, from that time on there was a significant increase in both financial exchange and farmers’ profit. According to the trend, broiler farmers’ profit is likely to increase in coming years, unless some unexpected event emerges in the future in the international scenario.

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