Brazilian Chicken Meat Production Chain: a 10-year Overview

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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' 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). This 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.
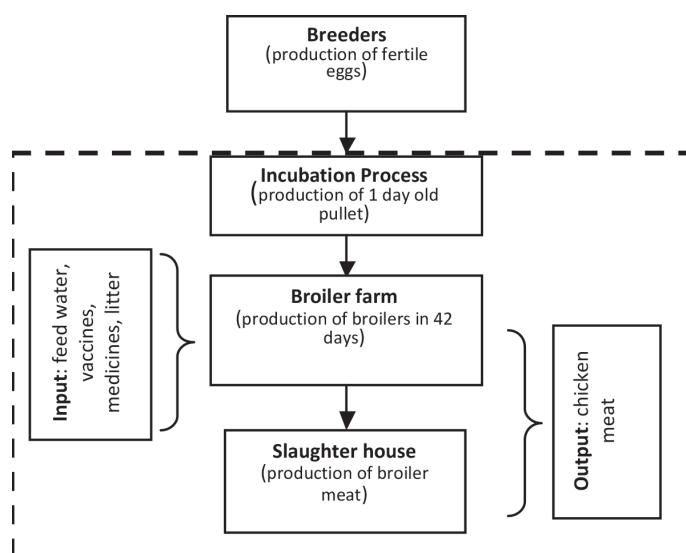

Figure 1 – Simplified scheme of the broiler meat supply chain showing the input and output.

Second, some assumptions were made relative to commercial broiler production. Average market weight was assumed to be 2.2 kg (Araujo *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.

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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	Tax (US$)
Farmer	Hatchery	Payment (US$)
	Feed mill	Payment (US$)
Feed mill	Farmer	Feed (ton)
	Government	Tax (US$)
Processing plant	Farmer	Payment (US$)
	Government	Tax (US$)
	Export Market	Chicken meat (ton)
	Domestic market	Chicken meat (ton)
Export Market	Processing plant	Payment (US$)
	Government	Tax (US$)
Domestic Market	Processing plant	Payment (US$)
	Government	Tax (US$)
Government	Farmer	Infrastructure
	Processing plant	Health Certificate Infrastructure
	Feed mill	Infrastructure
	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).

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

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 toProcessing 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	0.20	0.19	0.22	0.23	0.23	0.25
Farmer to Hatchery	million US$	493.83	623.42	566.88	614.02	859.75	1155.97	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

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).
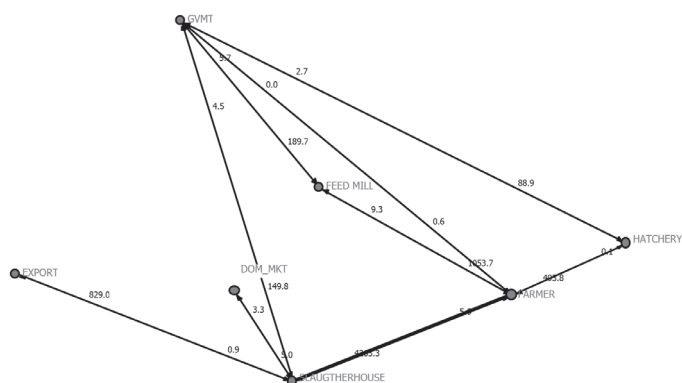
(GVMT=Government; Producer=Broiler farmer; Fodder Producer=Feedstuff mill; Export+ Int_Mkt=Market)

Figure 2 – SNA output describing the actors and ties in the broiler meat production chain in 2000.
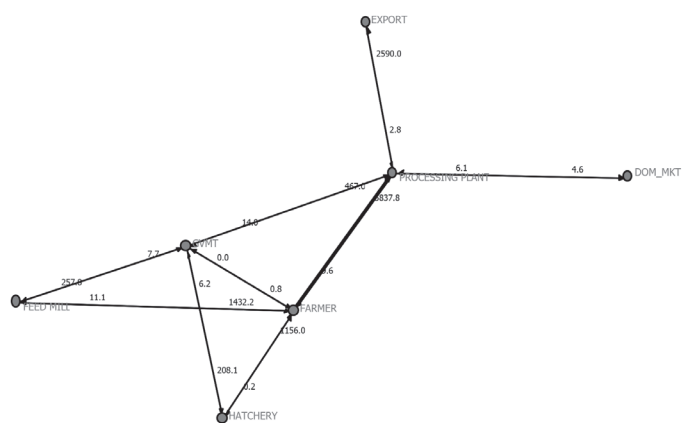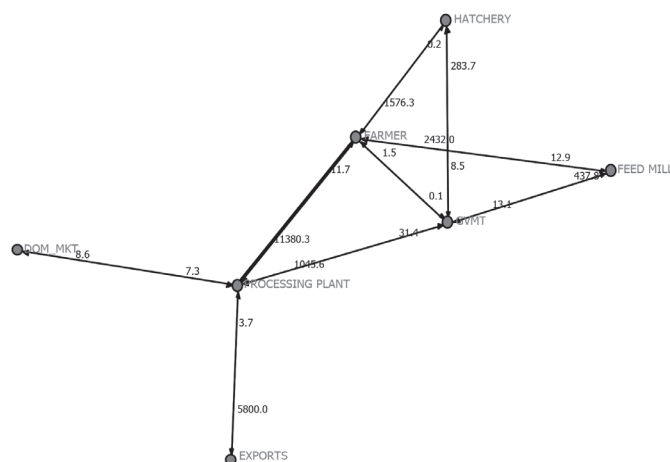

(GVMT=Government; Producer=Broiler farmer; Fodder Producer=Feedstuff mill; Export+ Int_Mkt=Market)

Figure 3 – SNA output describing the actors and ties in the broiler meat production chain in 2005.

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).

(GVMT=Government; Farmer=Broiler farmer; Export+ Dom_Mkt=Market)

Figure 4 – SNA output describing the actors and ties in the broiler meat production chain in 2010.

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 H_5N_1 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

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

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
Year	DATA									
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

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)
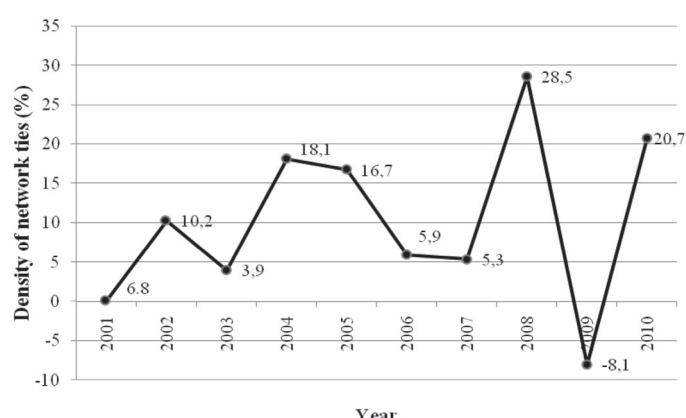

Figure 5 – Percentage fluctuation of the density of the Brazilian chicken meat production network from 2000 to 2010.

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).
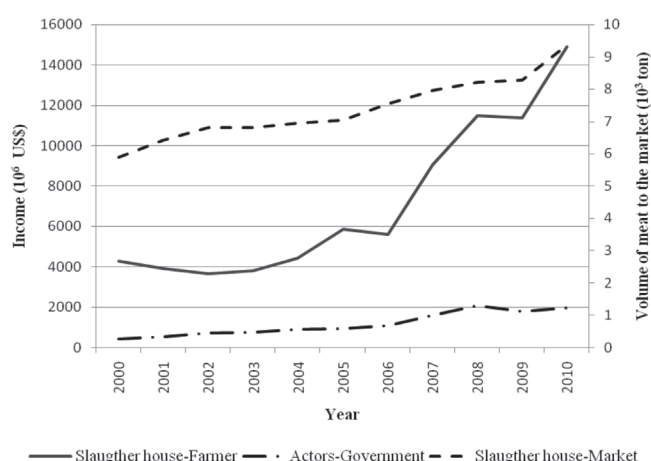
Figure 6 – Evolution of the supply chain actors' income flow in Brazilian chicken meat production from 2000 to 2010.

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 is relatively ineffective to apply measures to coordinate controls and establish standards. This system is inefficient to share the income flow, emphasizing and enhancing the need of an institutional legal framework to prevent anti-competitive actions in the chain (Souza & Zylbersztajn, 2011).

Vieira *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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