SUSTAINABILITY ANALYSIS OF ETHANOL LARGE SCALE PRODUCTION NETWORK IN BRAZIL

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ABSTRACT

With growing interest worldwide in the use of liquid biofuels in the transport sector, ethanol is considered as one of the best alternatives. Rising oil prices, environmental concerns and interests in energy security have driven Brazilian researchers to look to biofuels production as a potential solution. Other driving forces are the need to stabilize commodity prices and cut down on agricultural subsidies. This paper describes the analysis of Brazilian large-scale network of ethanol production and lead to answer issues related to the sustainable development indicators by studying the structural characteristics of the production chain through social network analysis (SNA). The result showed two structural indicators that monitor the growth of the production chain and also indicates sustainability, based on the fact that no major change occurred in the area planted with sugarcane. The increasing power of distributors is noticed by the increase of the degree of centrality and the strengthening of the chain which is visible through the density evolution.

Keywords: Social Network Analysis, Biofuels Production, Structural Indicators.

RESUMO: Com o crescente interesse mundial pelo uso de biocombustíveis líquidos no setor dos transportes, o etanol é considerado uma das melhores alternativas. A alta do petróleo, as preocupações ambientais e os interesses da segurança energética levaram os pesquisadores brasileiros a olhar para a produção de biocombustíveis como uma solução potencial. Outras forças são a necessidade de estabilizar os preços das *commodities* e reduzir os subsídios agrícolas. Este artigo descreve a análise de rede em grande escala de produção brasileira de etanol e leva a responder a questões relacionadas com os indicadores de desenvolvimento sustentável por meio do estudo das características estruturais da cadeia produtiva através da análise de redes sociais

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(ARS). O resultado mostrou dois indicadores estruturais, que permitem acompanhar o crescimento da cadeia produtiva e também apontam para a sustentabilidade, baseada no fato de que nenhuma grande mudança ocorreu na área plantada com cana. O crescente poder dos distribuidores é percebido pelo aumento do grau de centralidade e do fortalecimento da cadeia que é visível através da evolução da densidade.

Palavras-Chaves: Análise de Redes Sociais, Produção de Biocombustíveis, indicadores estruturais.

INTRODUCTION

According to WALTER (2007) and NASS et al. (2007), Brazil is a developing country in the tropics that have comparative advantages for producing biofuels thanks to land availability, adequate weather conditions, and a sufficient workforce. Biofuels production offers a high potential to create jobs, especially in rural areas. Biofuels production would induce economic growth and would certainly create jobs.

PAULILO (2010) points out that alcohol used in chemical industry, production of beverages, and as fuel (the focus of this work is in this function) is the main bioenergy use in the world. The author observed that the period between 2000 and 2004, where the alcohol global production grew 46.8%, it reached 41 billion liters of which almost 73% were used as fuel. The largest ethanol producers are also the biggest consumers. Together, Brazil and the United States accounted for almost 70% of world' production and consumption in 2004, followed by China (8.9%), EU (5.3%) and India (4%), using ethanol blended with gasoline at different percentages (LICHT, 2005).

With a domestic demand of 13 billion gallons of ethanol the U.S. market was the fastest growing in recent years, due to the replacement of MTBE (methyl butyl ether Tertius) for bioethanol as a gasoline oxygenator in several states. The growth in U.S. demand has been backed by the growth of maize supply in the country and the expansion of productive capacity. Brazil, a leader in the production and consumption of alcohol in 2006/07 was a record production of 17.7 billion liters, of which 80% were intended for domestic market and 20% external. The current growth rests, especially in sales of flexible fuel vehicles (biofuels). From the environmental perspective, blending gasoline with ethanol offers the benefits of phasing out lead, because ethanol has higher octane grade than gasoline (PAULILO, 2010).

The chain structural analysis involves several linked actions between production, distribution and consumers segments, which can be considered similar to a social network, and it can be studied using the principles of Social Network Analysis (SNA). Initially developed to describe social structures SNA has its origins in studies of patterns of communication, influence and interactions within social groups (HARARY, 1972; WASSERMAN & FAUST, 1994; SCOTT, 2000;

RICHARDSON, 2009). Further on 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; WESTPHAL et al., 2001).

The objective of this research was to select the indicators that could be applied to Brazilian ethanol production, aiming to identify the chain sustainable development and growth considering the fact that no major change occurred in the area planted with sugarcane from 2003 to 2009.

MATERIAL AND METHODS

Network analysis was applied to this study in order to organize the production and payment flow in the ethanol chain, and further on to select which was the indicators to show the sustainability and growth of the chain, starting on the production farms (sugar cane production), until the product (ethanol) reaches the final costumer. Seven subsequent years were studied (2003 to 2009) in a chain scenario of selected and condensed group of actors (all of them condensed in a single triad), and also considering their bi-directional relationships.

The construction of the network began with the identification of the Brazilian ethanol supply chain main actors to insert them into the structure of triad (MIRANDA & MOTTA, 2001) Information flow starting from the producer (in the beginning of the chain) towards the consumer, in the final of the chain (Figure 1).

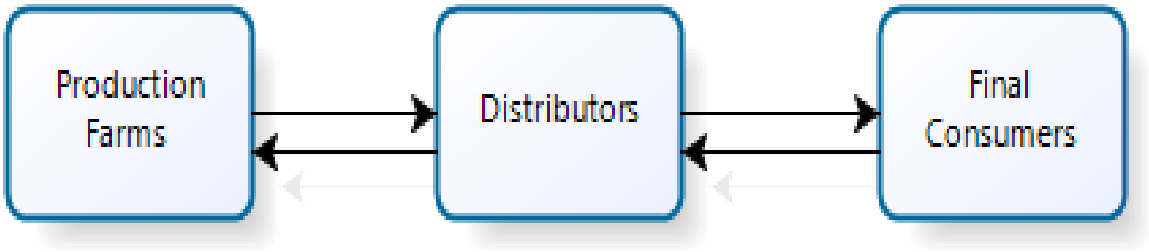

Figure1 - Condensed ethanol chain main identified players.

The ethanol chain is complex and it is composed by elements interacting in similar way (MIRANDA et al., 2005). The relations between actors, allowed to determine the weights to relationships, and they are based in the sugarcane production (in ton), the payment from the distributors to the production farms (in U.S. dollar), the volume (in liter) send to final consumers and the value received from them to the distributors (in U.S. dollar).

All relations data are gathered from Sugarcane Industries Union (UNICA, 2010). Specific weights were given to the relations, and the analysis was processed using the software tool based on SNA - social network analysis - (Ucinet® 6 for Windows®; Borgatti, 2002) developed in the Analytic Technologies Laboratories of Greenwich University.

The goal was to survey the interactions, identifying the actors and their graphical structure and understanding how the chain develops.

Data analysis was done from the identification of the adjacent matrix obtained from the relationships.

The graph theory is a descriptive method based on the vision of the network as a set of nodes connected by links. MIZRUCHI (1996) included early examples of diagrams, referred to as ‘‘sociograms” which attempted to capture the network effects. In these diagrams participants were represented as points or ‘‘nodes” and the relationship between them was represented by a line or ‘‘edge”. Subsequent research has developed quantitative measures to reflect the key aspects of the network structure, and the position of individual points within the network (CARPENTER & WESTPHAL, 2001; WESTPHAL et al., 2001).

In this research the structural measurements of centrality, and the density analysis were established using the theory of graphs in the software Ucinet® integrated module NetDraw®, which also enabled visualizing the social network graph data. The values of the following network structural properties where compared year by year: Density (ratio of all ties that are actually present to the number of possible ties), and the Degree Centrality (refers to the amount of immediate ties the actor has within the network).

RESULTS AND DISCUSSION

The ethanol network graph was found for each year (Figure 2 shows the net obtained for 2009) by inputting the identified relationships (Table 1) in the Netdraw® software (BORGATTI, 2002). The actors’ properties were adjusted and organized according to their geodesic framework and the links using their strengths.

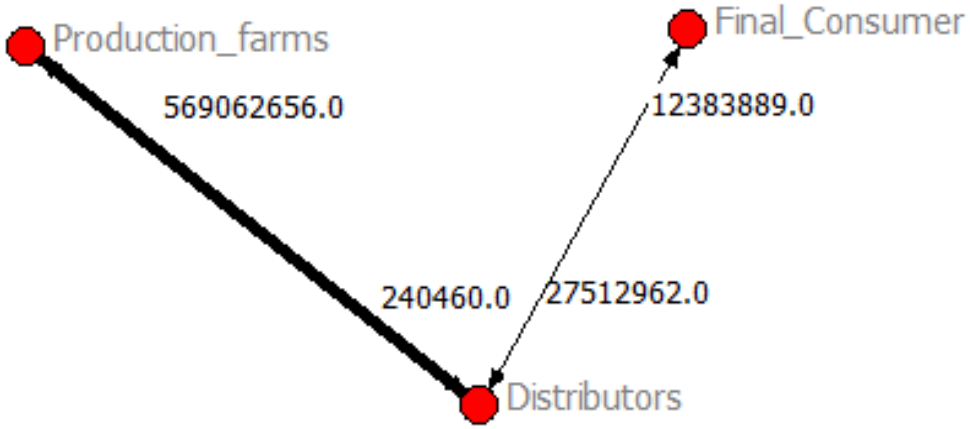

Figure 2 - Network obtained using the software UCINET® and the module Netdraw®.

The structural properties of the network with their weights obtained from the relations between the network actors were processed using the Ucinet® software environment,

and the structural network values obtained were applied to find the initial parameters to describe the complete network. Values that explain the network interactions were obtained for Density and Degree Centrality (Table 1).

By using the data obtained by the tools, and with the construction of Table 1, it was possible to plot the graphs of Figures 3 and 4, which show trends of the results of the seven years studied.

Table 1 - Interactions between actors within the network that describes the ethanol proposed chain.

	Relations Between Actors				Structural Data		
Year	a->b (Tons)	b->a (US$)	b->c (K liters)	c->b (US$)	Degree Centrality (%)	Density (Avg.)	Density growing (%)
2003	320650076	119050,25	12623225	4324155,85	51,97	56878512	-
2004	359315559	115779,46	14808705	6249273,51	52,06	64263560	12,98
2005	386090117	158554,34	15416668	6561505,20	52,00	68933816	7,27
2006	387441876	194086,86	15946994	9142943,23	52,12	70032592	1,59
2007	425535761	168039,34	17719209	6643718,97	52,08	75919360	8,41
2008	495723279	198068,99	22526824	11063173,56	52,27	89753384	18,22
2009	569062629	240460,58	27512962	12383889,90	52,42	103216576	15,00

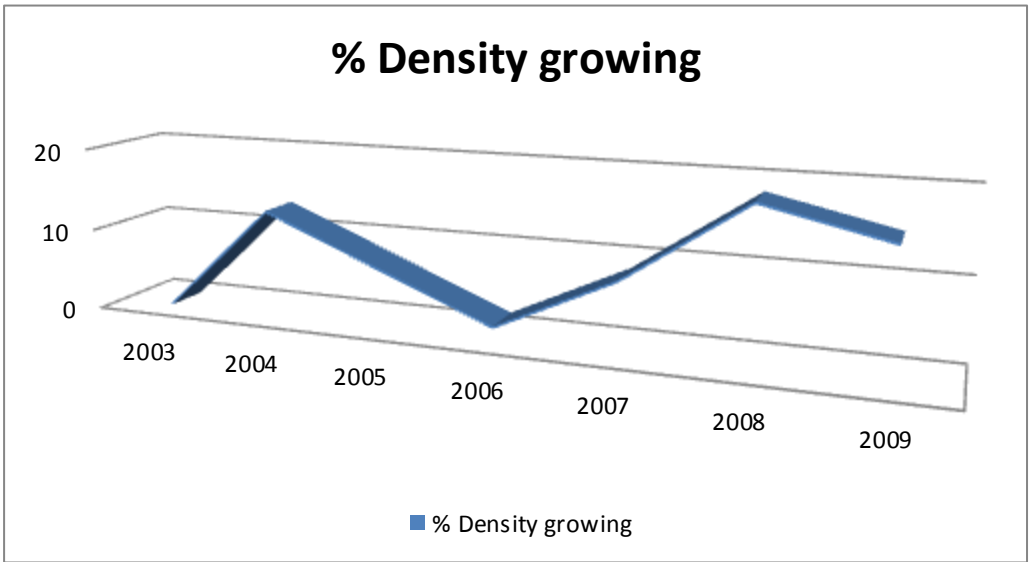

Figure 3 - Density data plotted to show the trends from 2003 to 2009.

The outcome point to a consistent growth, which goes against the results achieved by the authors WALTER (2007) and NASS et al. (2007), due to the land availability, adequate weather conditions, and an adequate workforce. And according to LAPOLA et al. (2010), the ethanol use really brings greater environmental advantages as can be seen with the growth of consumer fleet represented by the last actor of the triad.

The chain structural analysis also revealed the importance of the relationships established between the production chain actors's, exactly as proposed by the authors HARARY, (1972); WASSERMAN & FAUST, (1994); SCOTT (2000) and RICHARDSON (2009).

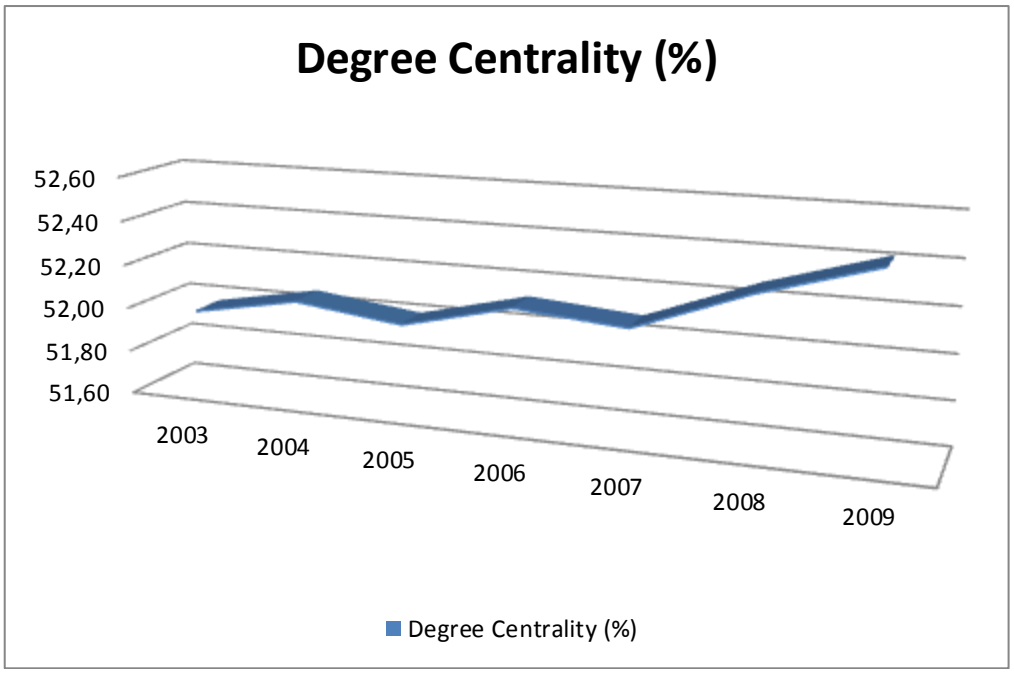

Figure 4 - Degree Centrality data plotted to show the trends from 2003 to 2009.

The automotive use of ethanol also reduces emissions of particulate matter, carbon monoxide, and toxics, and causes less ozone formation. Consequently, ethanol use contributes to improving air quality in Brazilian large cities, like São Paulo. These advantages are even more relevant when the existing fleet is relatively old. Introducing more efficient emission control systems in vehicles (electronic management injection, catalytic converters and canisters) could generate roughly the same overall reduction in exhaust emissions, no matter which fuel is used. But when these control systems do not exist, or do not operate well, ethanol would bring greater environmental advantages (LAPOLA et al., 2010).

Large-scale use of biofuels is one of the main strategies for reducing greenhouse gas (GHG) emissions. The development of a biofuels system requires a reliable set of suppliers of goods and services. In the planning process, the necessities of the whole production chain have to be identified upstream and should define the best indicators of growth. The sugarcane industry in Brazil was already well established when large-scale production of ethanol started. Biofuels production and use must be sustainable and the use of these indicators must help the whole chain to reach sustainability, according to NASS et al. (2007).

Applying the principles of Social Network Analysis (SNA) it was possible to draw, capture and analyze the relationships among members of this group detailing the specific links and interactions as recommended by CARPENTER & WESTPHAL, (2001) and WESTPHAL et al. (2001). The triad was built based in the indications of MIZRUCHI (1996) and the software tool developed by BORGATTI (2002) allowed determine the values of structural measurements (centrality and density) to build a quantitative analyze of the chain trends. The results show the increasing power of distributors and this increase is related and noticed by the growth of the degree of centrality and the strengthening of the chain which is visible density evolution that represents most participative actors in the Brazilian ethanol market.

CONCLUSÕES

Applying the concepts of social network analysis (SNA), it was found that the proposed methodology can be used by Brazilian ethanol producers to establish indicators, and it showed in this research that with the use of two structural indicators, we obtained that the development of the Brazilian biofuels is sustainable and is growing, based on the fact that no major change occurred in the area planted with sugarcane. The highest density of the network indicated the closest approach between the actors in the production chain and a higher degree of centrality points to the set of actors in the middle of the triad (Distributors), which allowed viewing your strength over time.

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