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The impact of Chinese imports of soybean on port infrastructure in Brazil: A study based on the concept of the “Bullwhip Effect”

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ABSTRACT

Brazil is a continental country and the major soybean production areas are located far from the ports. Thus, the storage, transport and port infrastructure represent an important factor in the export of the product. China is the largest importer of Brazilian soybean, with monthly and yearly volumes variability. This study aims to identify the impact of the variation in export volumes of soybean to China on the Brazilian port infrastructure, exploiting the concept of the ‘bullwhip’ effect (BE). Data on the export volumes of the five largest soybean-producing States is used to calculate the extent of the bullwhip effect caused by the demands for port services from these producer States on the main exporting ports. Beyond the variability of Chinese demand, climatic conditions contributed to produce bullwhip effect up to 2.0 in 2011, causing pressure on the ports of Santos and Paranagua. The research results suggest that to reduce the bullwhip effects provoked by the Midwest Producers-States, it will be necessary to design informational and coordination mechanisms to integrate the logistical agents involved in the export process and to invest on infrastructure (storage capacity).

1. Introduction

The production and consumption of food are topics of global importance. Concerns about the capacity to produce food for the world population on a global scale have generated discussion among both governments and academics. Progress has been made in relation to food production, with the introduction of new technologies that enable crops to be grown in places previously considered unproductive. However, inefficient food distribution systems still plague some countries that, while they are self-sufficient in terms of production, are unable to export their excess produce efficiently to countries that need to import it. This leads to imbalance, in which some countries have to pay high prices for a product that in another country is surplus or wasted. Thus, the efficient distribution of food is highly relevant in ensuring that agricultural products reach the locations where they are in demand and do so

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at fair prices so that the maximum number of people can access them.

Within the context of the global supply and demand for food, soybean stands out as a highly nutritious grain that provides a range of by-products for human consumption. In addition, soybean has an important role in the production of animal protein (chicken, pork and beef). Due to climate and soil requirements, the main soybean producing countries are located in North and South America, while, due to issues related to the distribution of the people on the planet, the main soybean consumers are located in Asia. Thus, issues related to the transport and shipping of soybean are of great relevance for the feeding of the world's population.

The soybean chain is of great importance in the Brazilian agribusiness scene. In 2016/2017 Brazil produced 114.0 million tons of soybean in a planted area of 59.2 million hectares (CONAB, 2017; USDA, 2017). In 2015 Brazil exported approximately 57 million tons of soybean (An and Ouyang, 2016).

China currently holds a leading position within the world consumer market for soybean (Song et al., 2009) and, in the last ten years, has become the largest importer of *in natura* soybean from Brazil. In 2015, China imported approximately 40 million tons of soybean from Brazil (Canal Rural, 2016), representing approximately 75% of the Brazilian export of soybean. Thus, today China and Brazil are major players in the soybean market (Liu, J., et al., 2015).

Soybean production is subject to the uncertainties inherent to agricultural activities in general. Some aspects, such as difficulty in predicting production volumes due to climatic factors, as well as pests and diseases and seasonal production, may have negative effects on the infrastructure available for the transport and storage of this grain. Large variations in price and demand volume may also make managing the production and distribution of soybean a complex activity, in which positioning and strategy can determine performance within the globalized context involving this crop (Davison and Crowder, 1991).

The problem of supply, demand and price variability in agricultural products has received particular attention from economists and policy makers who seek to balance supply and demand and reduce price volatility in the agricultural sector (Hueth, 2000). Among the different approaches adopted when addressing this problem, the Cobweb theorem, proposed by Kaldor (1934) and improved by Ezekiel (1938), has been widely used as a tool to support the formulation of agricultural policies aimed at minimizing the productive and economic effects of such variability (Anokye and Oduro, 2013, Declerk and Cloutier, 2006, Glöser and Hartwing, 2015; Haile et al., 2015, Mitra and Boussard, 2008, Stigler, 2011, Westerhoff and Wieland, 2010). The Cobweb model explores elements of farmers' expectations about future prices. Considering the existence of intervals between the decisions regarding planting, harvesting and selling the crop, the Cobweb theorem assumes farmers base their predictions on past prices. If, for example, there is a crop failure due to climatic problems, the supply of the agricultural product will be reduced and consequently its price will rise. If farmers create expectations that prices will be high in the next year, they will increase production and, as a consequence, there will be excess supply of the product and a fall in its price. According to the same logic, the following year the farmer will expect crop prices in the next year will be lower and thus will reduce production, which will lead again to an increase in the price. As this process is repeated over the years there may be a series of adjustments, with convergence towards price and quantity equilibrium or divergence in the magnitude of price and quantity fluctuations (Ezikiel, 1938).

The problem of demand and supply variability has also been studied and explored from a managerial perspective (Forrester, 1961; Sterman, 1989). Demand and supply variability can cause systemic effects that extend the length of a supply chain. Demand information may become distorted along a supply chain, generating errors that may be amplified and propagated and causing various problems including low service levels and increased costs at different stages of the supply chain. One such effect is the so-called 'bullwhip effect' (Bayraktar et al., 2008; Bray and Mendelson, 2012; Disney and Towill, 2003; Geary et al., 2006; Lee et al., 1997a, 1997b, 2004; Mackelprand and Malhotha, 2015; Metters, 1997; Sucky, 2009; Towill et al., 2007). Lee et al. (1997a, 1997b) identified the causes of bullwhip effect: demand signal processing, non-zero lead times, the rationing game, order batching, and price variations (a detailed characterization of these causes will be presented in Section 2). The presence of these elements in the relations between agents in a supply chain can trigger the bullwhip effect (Isaksson and Seifert, 2016; Lee et al., 1997a, 1997b; Miragliotta, 2006; Shan et al., 2014). A small variation or seasonal fluctuation in consumer demand can provoke a bullwhip effect on the suppliers causing them to alternate between overproduction and idleness (An and Ouyang, 2016; Geary et al., 2006; Metters, 1997).

In the production and export of agricultural commodities, demand variability associated with the seasonal nature of production and price volatility can provoke the bullwhip effect, as defined by Lee et al. (1997a, 1997b), and generate problems such as deficient transport of the produce to the ports, queues at ports, delayed shipments and failure to meet deadlines, thus generating higher operating costs and loss of market share (Carter et al., 2016; Davison and Crowder, 1991; Geary et al., 2006; Haile et al., 2015; Harrison and Fichtinger, 2013; Mackelprand and Malhotha, 2015; Machado and Margarido, 2001; Margarido et al., 2007; Menezes and Piketty, 2011; Mitra and Boussard, 2008; Roberts and Schlenker, 2010; Song et al., 2009; Towill et al., 2007).

Considering the fact that Chinese imports of Brazilian soybean have grown and fluctuated over recent years, together with the geographical distribution of soybean production, the location of the export ports in Brazil and the international price variability, it is expected that the variability of Chinese imports will produce bullwhip effects on the Brazilian ports. Since this study does not deal with the problem of agricultural policies in Brazil related to soybean production due to the expansion of Chinese imports of this agricultural commodity, but rather attempts to identify and analyze the effects provoked by variability in the Chinese soybean imports on Brazilian port infrastructure, the management approach towards the Bullwhip Effect seems to be better suited than the agricultural policy approach proposed by the Cobweb Theorem.

The bullwhip effect has been widely investigated in the relationship between the manufacturing and retail sectors. The academic literature includes a number of studies that seek to identify the bullwhip effect and indicate how to reduce its impact of on relations/transactions between retailers and manufacturers (Bray and Mendelson, 2012; Chen et al., 2000; Wang and Disney, 2016; Warburton, 2004). The present study, however, differs from previous studies by exploring the concept of the bullwhip effect in a highly relevant and little explored sector, which is the global supply chains in agricultural commodities. In contrast to the traditional