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The Brazilian Soybean Complex

Peter Goldsmith and Rodolfo Hirsch

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Introduction

The rise of the Brazilian soybean complex simultaneously tells two important stories. The first story is the classic rise of an industry due to natural resource abundance (the Cerrado) and strategic investments in agricultural technology (low-latitude soybeans). Brazil is now the second leading producer of the fastest growing broad-acre crop in the world, has unparalleled arable land reserves, and has the technology to efficiently employ those reserves.

The second story is about the different challenges facing developing countries in the post-modern world. Norms and standards for land use are not the same as when the United States, Canada, and Europe were being settled. Technology and scale economies have redefined a "family farm on the frontier." Environmental and social stakeholders are now actively involved in land use and policy decisions affecting agriculture. And, the Media now plays an important institutional role in development settings communicating the activities of firms and governments to the public.

Whereas agricultural productivity and growth historically were the central objective for economic advancement, policy makers and industry leaders are increasingly cognizant of new and important environmental and social expectations. This heightened social consciousness and very effective communications environment require Brazil's agriculture to develop very differently than its forbearers in North America and Europe.

To explore these themes, this article presents the soybean complex from three perspectives: as an agro-industrial complex; as an ecosystem; and as the nexus between infrastructure, institutions, and development.

Background

The story of the Brazilian soybean industry begins within the broader context of the rise of soybeans as a key protein source for livestock and a key oil source for the food industry. Few soybeans were grown world-wide before WWII. The original genetics come from China and were adapted to the United States as a feedstuff for a fast industrializing poultry industry. For example, in 1960 world soybean production was only 12% of today's production and the United States represented 70% of that total (Figure 1). The success of soybeans in the United States, combined with the rise of the poultry sector in the Southern U.S., created research interest in Brazil for developing a soybean that could be grown at lower latitudes. Researchers quickly developed varieties adapted to the longer growing season and warmer climates by focusing on the role of the night-time photo-period in soybeans' growth and development.

These new varieties became the opening for the Brazilians. Researchers took the low-latitude technology and developed germplasm that could be deployed in the Southern three states of Brazil, Rio Grande do Sul, Santa Catarina, and Parana, a growing climate similar to the Southern U.S. (Schnepf, Dohlman, & Bolling, 2001). Brazil's soybean industry began in the South of the country in the late 1960s, supporting both soybean processing and poultry production.

By the 1980s, the federal agricultural research institute (Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)) had advanced the photo period line of research even further. EMBRAPA successfully adapted soybeans to grow in the tropics at even lower latitudes. Developing this technology opened up the West and North regions of the country that lies between 15 degrees south latitude and 5 degrees north latitude to soybean production. Of greatest potential was the Cerrado region encompassing over 200 million hectares[1] of low brush-like forest that was easy to clear and had predictable rainfall . The development of the lowest-latitude varieties begins

the real story of the Brazilian soybean complex.

Compared to the Southern region of Brazil, Cerrado farming could take advantage of huge economies of scale. U.S. agricultural development and land privatization began before the age of mechanization. The U.S. Midwest was settled using the concept of a section, where 80 acres was sufficient to support a homesteading family. Brazil's Cerrado region has none of that social, political, or normative legacy as to what is an appropriate unit of production. The rapid expansion of soybean production in the 1980s arose because of the availability of large tracts of arable land, soybean technology that produced yields equal to the United States, mechanization that allowed operational efficiency and the lowest operating costs per hectare in the world (Figure 2). Cerrado farming also has great challenges. The infrastructure is underdeveloped, markets are distant, soils are relatively poor, and environmental concerns exist.

The Soybean Complex as an Agro-industrial Complex

Latin America has wrestled for many years with effective policies to create growth and economic prosperity. Initial attempts by Brazil in the 1970s and 1980s employed policies of import substitution and government market intervention to foment agricultural development. As a result of government incentives, there was significant investment in soybean processing. Then in the 1990s the pendulum of government policy shifted to market-based tools, aggressive

1. *This is equal to the combined land areas of the 12 Midwestern states stretching from Ohio to North Dakota.*

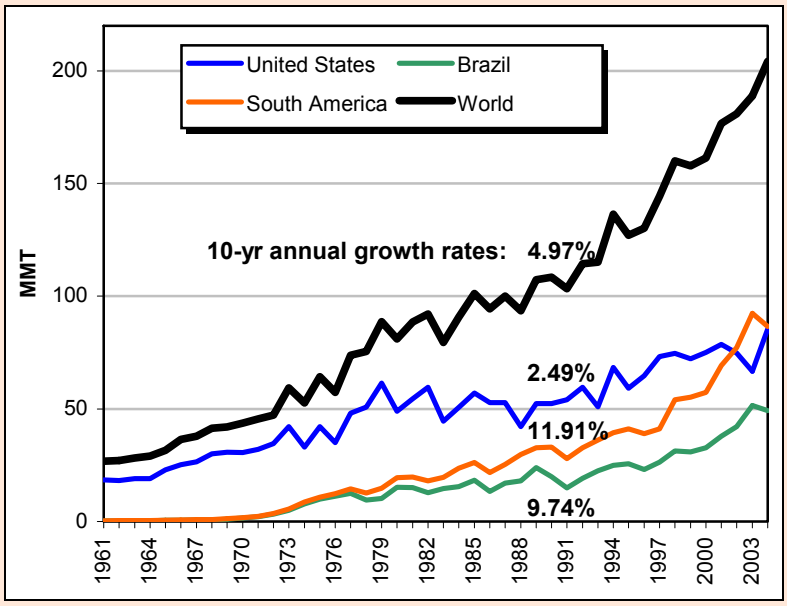

Figure 1. World soybean production.
Source: FAO and Authors' calculations.

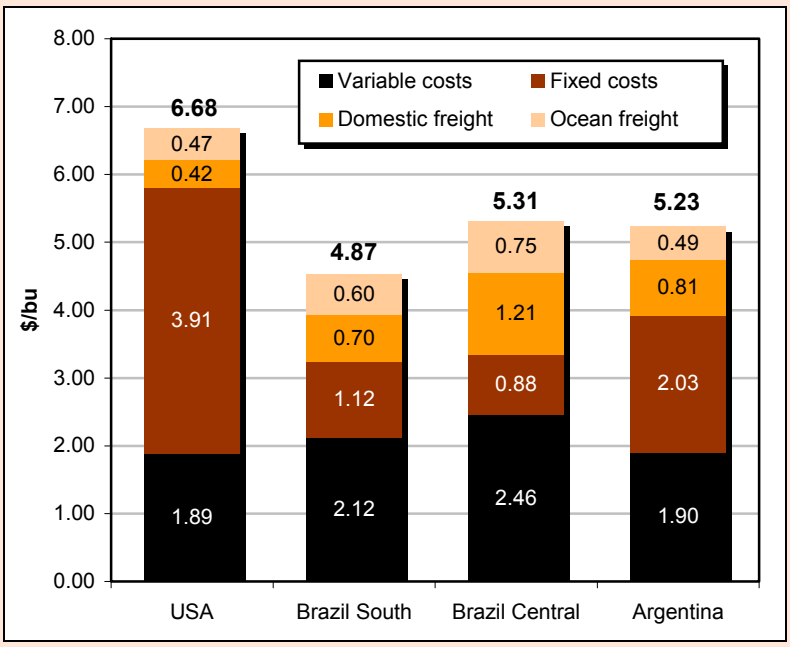

Figure 2. Average cost[a] of soybean production.

[a] Average across six studies that looked at one or more aspects of the cost of soybean production in Brazil, Argentina and the United States.

[b] OF = ocean freight; DF= domestic freight; FC= fixed costs; VC=variable costs.

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inflation fighting, and export development (Schnepf, Dohlman, & Bolling, 2001). Brazil was no longer a preferred location in which to process soybeans. Soybean processing capital was now better placed in Asia and Argentina (Goldsmith et al., 2004). While Brazil has a tremendous capacity to produce some of the least expensive soybeans in the world, it still lacks the transportation infrastructure and domestic industrial cluster to make inland processors globally competitive.

Brazil is second only to the United States in producing soybeans, and Brazilian production is growing twice the global rate. Brazil is the third leading soybean processor[2] behind the United States and China, with a 7% annual growth rate from1992-2002. Though, over that same period, other major countries were increasing crush capacity at much faster rates: China 41% per year; Argentina 15%; and India 14%. Brazil's story as a leader in soybean production has been more as an exporter of soybeans, not an exporter of processed products (i.e., Argentina, or a domestic user, like the United States). Since the 1980s, there has been a steady reduction in the ratio of soybean meal: soybean exports. For example, in the last 15 years the ratio has fallen from 4:1 to 1:1.

Expansion of soybean production to the West Central and North regions pushed the grain supply far from traditional crushing and consumption regions and the well-developed transportation infrastructure of the East. Crushers were challenged to invest in the center of the continent far from livestock and export markets.

Brazil has a crush capacity of 113,000 tons per day (2002) (Goldsmith et al., 2004), second only to the United States. Fifty-five different companies own facilities and the largest five firms produce 45% of the nation's output. The biggest processors are Bunge (18%), Cargill (11%), ADM (7%), and Coinbra (a Brazilian subsidiary of Louis Dreyfus) (6%). Cooperatives own 9% of the crushing capacity and 4% of the soybean oil refining capacity, and are responsible for 29.4% of the Brazilian soybean trade.

Brazil's industry, due to the legacy of government intervention in the 1970s-1980s, is comprised of much smaller processing plants, than the United States or Argentina. Argentina has the largest plant[3] in the world and the capacity to process 12,000 tons of soybeans per day, while the largest plant in Brazil can process only 3,800 tons per day (Hinrichsen, 2000; Oleofar, 2002; Soya & Oilseed Bluebook, 2003).

Most of the national soybean crush (51.62%) is still located in the Southern region out of position as southern agriculture switches away from soybeans and the West Central and North regions rapidly expands (IBGE.a, 2003; Olefar, 2002). Mato Grosso, the largest soybean producing state in Brazil produced 13.4 mmt in 2003 but only had crushing capacity to process 38% of the crop. Alternatively, the southern state of Parana is 16% over capacity (Oleofar, 2002; IBGEa, 2003).

The strategic implication for crushers is that current crushing infrastructure is old, small, and out of position. Making inland investments close to production is difficult because the agro-industrial cluster, especially in livestock and meat production, is small and transportation infrastructure is poor. As a result, there are relatively few marketing opportunities for processors and the cost of transport to markets is high.

Soybeans are an intermediary (industrial) input and have numerous food, feed, industrial, energy, and textile uses. They are also easy to transport, store, and process. Their widespread use and favorable logistics characteristics make soybeans very conducive to trade. As a result, the geographic location and the associated economic impact of the industrial cluster into which raw soybeans flow may be distant. For example, China has shifted its policies towards raw soybean importation rather than domestic production.[4] It now imports 125% of domestic production and absorbs 38% of world exports.

This issue of the location of the industrial cluster and geography is important in the case of Brazil's soybean complex. Of importance for continued development is how to create and capture greater value through the production and exportation of higher valued goods and services rather than simply exporting raw soybeans. Most government policy interventions affecting the soybean complex over the last 30 years has targeted specific industries (Schnepf, Dohlman, & Bolling,

2. *Soybeans cannot be fed directly to livestock. They need to be processed ("crushed") in an industrial facility using heat, mechanical pressure, and chemical extraction. The output is a high protein meal for livestock and oil used in food manufacturing.*

3. *By 2005 the figure was closer to 16,000 mt/d.*

4. *Interesting because soybeans originated in China.*

2001). Differential taxes were often the tool of choice and resource extraction the result. These short-term and narrowly focused policies resulted in significant levels of uncertainty and arbitrariness. In turn, development of the agro-industrial complex in the interior part of the country was negatively affected.

The state of Mato Grosso, in the West Central of Brazil produces a similar quantity of soybeans as the U.S. state of Illinois. The Illinois soybean cluster[5] though has a value eight times the value of its soybean crop, while the Mato Grosso cluster is significantly smaller, producing .78 the value.

While such comparisons, especially within a regional context are imprecise, the inference is important. The 1995 IFPRI study on the *Future of Latin American Agriculture* stated that the most important need for Latin America to reduce poverty was for the expansion of, and improvement in, resource utilization. The tremendous growth in Brazil's soybean harvest would be consistent with such goals. But, an additional need as Latin America attempts to alleviate poverty is not simply harvesting and exporting raw agricultural goods, but developing an agro-industrial sector that produces higher-valued export goods and services, and offers better domestic employment opportunities. For example, a comparison of trade between China and Brazil reveals how Brazil is essentially a raw commodity supplier (soybeans and ore),

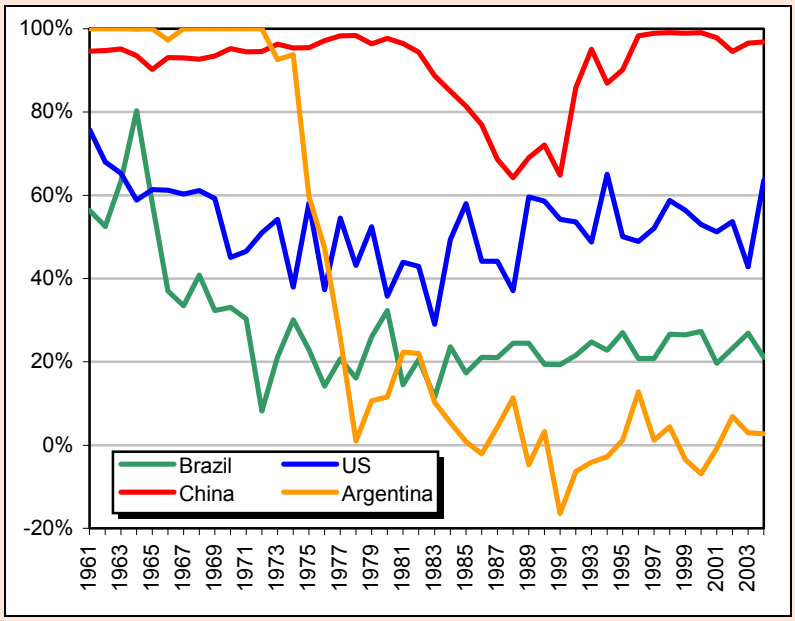

Figure 3. Soybean domestic use levels.
Source: FAO and authors' calculations.

and a higher-valued processed and manufacturer goods importer (*Economist,* 2005).

One of the best examples of distortionary policy is the case of the Kandir Law (1996) and the ICMS tax. ICMS is a state-run, value-added tax that is incurred when production and utilization occur in different states. Resource flows occur at the state, not the national, level. As a result, interstate commerce and exports of value-added goods like soybean meal are discouraged, technology adoption is slowed, and the operating size of firms is reduced. The ICMS tax is one of the most effective tools for state governments to generate revenue, and thus is difficult to reign in (Schnepf, Dohlman, & Bolling, 2001). The Kandir Law attempts to mitigate some of the distortionary effects of the ICMS tax. It focuses on the national interests of export expansion and foreign exchange inflows. The Kandir Law exempts exports of raw and semi-elaborated products, electric energy, and goods of capital assets from the ICMS tax (interstate trade tax). In effect, the law eliminated the difference in the export ICMS tax between the different products in the soybean complex. Before the law, the export ICMS taxes were 13% on soybeans, 8% on soybean oil and 11.1% on soybean meal. The differential favored domestic crushing and resulted in an over-investment in Brazilian crushing capacity (Haffers, 2003). Soybean exports represent about 40% of production after (1996) the law's enactment versus around 18% before its enactment. The Kandir Law was also responsible for increasing the idle capacity of the soybean crushing sector, as firms shifted from exporting soybean meal and oil to exporting raw soybeans.

Brazil's soybean domestic level has remained around 25% since the mid 1980s, with about half of the exports being in the form of raw soybeans (Figure 3). Argentina has an even lower domestic use rate of around 3%, but 80% of Argentina's exports are in the form of higher-valued soybean meal, rather than raw

5. *This is the ratio of direct, induced and indirect output of soy-consuming livestock production and soybean, meat, and dairy processing to the output from soybean production. The data are from 1999.*

soybeans. Argentina is a leading soybean meal exporter because most of the country's immense soybean production region lies within 300 kilometers of a deep water port. This helps make Argentina one of the lowest cost soybean meal processors in the world.

The Soybean Complex as an Ecosystem

There are 91.4 million hectares planted to soybeans in the world. Soybeans now occupy 6% of the world's arable land and are the fastest growing major agricultural crop. Land used for soybeans is increasing at a rate of 5.36% per year over the last five years, more than three times world GDP growth per capita during the same period. The demand for soybeans is essentially a derived demand for meat. Meat consumption is already very high in developed countries and is growing rapidly in developing countries, especially Asia and South America, as incomes increase. Feeders and manufacturers are switching to soybeans as their protein and oil source of choice because of its wide availability across the globe, high value:cost ratio, and its versatility as an input.

Of the 19.3k square kilometers of new soybean land every year, 75% are in two countries, Brazil and Argentina. They are expanding their soybean lands 8.4k and 6.1k square kilometers per year, respectively. Argentina's expansion mostly involves switching among crops. Land used for agricultural purposes has only increased at a rate of 790 sq kilometers per year since 1990. Brazil though has brought 14k sq kilometers a year of new agricultural land into production.

In 2003, Brazil produced soybeans on 18.4 million hectares. Soybeans are grown annually, double cropped with a grain such as corn, sorghum, or milo, or even triple cropped with a green cover crop. Estimates are imprecise, but the potential land available for future field crop expansion in Brazil is between 57 million and 170 million hectares (GEIPOT, 1999; Hirsch, 2004). There are over 160 million hectares of native and planted pasture both inside and outside the Cerrado region that services the world's largest beef herd, and which can be switched over to crop production easily (IBGE.b). As a result, soybean production in Brazil is forecasted to stabilize at almost double the 2003 levels (Hirsch, 2004). Using the most conservative estimate and current yield trends, Brazilian production should level out at 90MMT; adding 20% to the world's 2003 supply. Asian Rust, a devastating fungal disease, has slowed expansion in the low latitude regions in recent years. Resistant varieties are due on the market in 2008 (Calvo, 2005).

The rapid expansion of the soybean production region in response to the world's demand for food and energy is causing dramatic shifts in land use in Brazil as native savannahs, dryland forests, and even certain rain forest sub-regions became potential areas for soybean cultivation. The governance over the land essentially changes from public to private. Correspondingly, the goals and objectives for the land change too.

The interests and practices of agriculture may not always be consistent with broader societal goals. Tillage practices, chemical use, and the management of set-aside lands are important not only for farmer profitability, but for the numerous stakeholders actively involved in the debate over development of Brazil's interior. For example Asian Soybean Rust has meant the spraying of millions of hectares with fungicides on lands that may have never had previously known fungicides.[6]

One policy response is that the law requires that farmers preserve 80% of the land in its native vegetation, while cultivating 20% in the Legal Amazon region. The percentage allowable for cultivation increases as one moves away from the most environmentally sensitive and higher rainfall areas. While the law is fairly explicit, weakly specified property rights, limited government budgets for enforcement, and strategic private land selling practices make enforcement of such laws difficult. Local government is also conflicted because they desire greater economic growth in the region, want to help meet the world's increasing need for foodstuffs, and want to expand social programs.

The Soybean Complex: A Force for Infrastructure Development

Traditionally, the transportation issue has not been strategic to the industry, as soybean production was concentrated in Southern Brazil, near the ports and consumption regions. It was also not as a critical an environmental issue because transportation was consistent with historical population centers of the country. As a result, 74% of the soybeans still travel by road, 23% are transported by railways, and 3% by waterways. As a comparison, waterways carry 61% of U.S. soybeans, and roadways transport only 16%. The roadways though, which serve to link the new soybean production regions, are two-lane roads in very poor condition that cover great distances. This gives

6. *In 2003, 14.8 million hectares (148 thousand square kilometers) received two fungicide treatments (Yorinori, 2003).*

interior Brazil producers significantly higher domestic freight costs than either Argentina or the United States.

Recently the Ferronorte railway was constructed linking Southeast Mato Grosso state to Santos port. The Carajas railway links the interior with the Northeast port of Sao Luis and the Madeira waterway brings soybeans by barge from the western river terminal of Porto Velho (Roraima state) to the deep water port of Itacoatiara in Amazonas State. These changes have significantly improved the competitiveness of the new production regions (Schnepf, Dohlman, & Bolling, 2001; Hirsch, 2004). Inland port soybean price differentials have fallen 13% per year as transportation has improved, supply has become more regular, and transactions have formalized.

The West Central region also holds opportunities for extending the Santos rail to the North and West, and increasing barge transport utilizing the Araguaia, Tocantins, Teles Pires, and Tapajos rivers. Simulation results showed only moderate improvement in the efficiency of the soybean complex from such infrastructure improvements (Hirsch, 2004). One effect that limited significant changes in the system's overall competitiveness is the increased competition that would result among the various alternative routes.

Brazil plans future transportation corridors as part of a Brazilian Government project called *Avanca Brasil*. Transportation access in the North is strategically important to serving markets in Asia and Europe because of cost advantages due to shorter distances. As a result China has expressed significant interest in helping to finance improvements in infrastructure in the North and West (*Economist,* 2005). These projects include the paving of a major Federal south-north highway that links Mato Grosso with the city of Santarem at the mouth of the Amazon. There has been significant livestock and meat processing investment (Carrolls, Perdigao, and Sadia), as well as soybean crushing investment (Bunge, ADM, and Cargill) along the corridor because of the corridor's potential for exports.

The implementation of the Araguaia-Tocantins waterway and the BR-163 pass through remote regions of the country that are of both environmental and cultural interest. As a result, both projects have met significant opposition from governmental and non-governmental interests outside of the agriculture community. Stakeholders are concerned not only that infrastructure will accelerate resource extraction and change the sensitive ecosystems forever, but that the infrastructure development would be premature given Brazil's fragile institutional environment. The region affected is enormous, and enforcing regulations and ensuring due process would take significant resources. Thus, land degradation may be accelerated if infrastructure were improved without a commensurate ability to curtail illegal activities.

Conclusion

As one stands on the main north-south Federal highway in Mato Grosso, the most impressive feature is the constant drone of the trucks... hundreds of trucks moving up and down the route day after day. No matter the rain, the choking dust, unstable bridges, negative exchange rate moves, or soybean price weakening, the trucks keep rolling, just like they have for the last twenty years. The market forces at work that keep the trucks moving are able to surmount any of the challenges offered by contrarian government policies, new environmental awareness, or institutional reform efforts.

There are broad economic, social, and environmental implications specifically for Brazil, in particular and modern agricultural development, in general. Economic growth and development continues to be vital for improving the standard of living in developing countries. The soybean industry is a very efficient supplier of protein and oil. The growing demand for soybeans is exciting and new uses for soybeans are expanding rapidly. At the same time, a new social and political reality exists that questions how the industry should develop. Developing countries are increasingly becoming the supplier of the world's food. Many parties, including the government and industry, are trying to find ways to improve agriculture's social and environmental stewardship.

The Brazilian soybean industry in Mato Grosso takes very seriously the challenge of balancing the need to help meet the world's ever increasing demand for food with enlightened ecosystem management (Hirimoto, 2005). The challenge for Mato Grosso, in particular, but agricultural development, in general, is how to achieve the correct balance that keeps their producers and processors profitable, keeps food and feedstuffs flowing, and provides effective social and environmental stewardship.

It is also important to think beyond simply the development of Brazil. Africa's food needs are great and Brazil has developed technologies that could be applied in the savannahs of Africa. Society will struggle balancing the need to produce more food to alleviate Africa's persistent food shortages with pre-

serving important lands in a natural state.

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Peter Goldsmith (pgoldsmi@uiuc.edu) is Associate Professor and the National Soybean Research Laboratory Fellow in Agricultural Strategy, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, IL. Rodolfo Hirsch (rodolfo.hirsch@rabobank.com) is Food & Agribusiness Research Analyst with Banco Rabobank International, Brasil S.A.