XYZ Corporation: Utilizing Risk Solver Platform to improve soybean crushing profitability

by

Geovano Ceratti

B.S., Passo Fundo University, 2007
M.B.A., Fundação Getúlio Vargas, 2011
M.B.A., Escola Superior Luiz De Queiroz, 2017

A THESIS

Submitted in partial fulfillment of the requirements

for the degree

MASTER OF AGRIBUSINESS

Department of Agricultural Economics

College of Agriculture

KANSAS STATE UNIVERSITY

Manhattan, Kansas

2018

Approved by:

Major Professor
Keith Harris

ABSTRACT

The growing number of participants in the grain market shows just how globalized this sector is in Brazil nowadays. It is difficult to distinguish between mergers and acquisitions of local companies and that of investment funds, which are actively engaged in acquiring a part or even the totality of Brazilian companies. For instance, the soybean crushing company "XYZ" that acquired some assets such as crushing plants in the state of Mato Grosso, located on the center-west region of Brazil and access to two port terminals to export the byproducts.

This thesis contains data from January of 2014 to September of 2017, which includes prices of soybean and by products, freight rates, basis at the ports and operational costs. This information is from different sources including government and private agencies and Thomson Reuters Eikon software. This information was used to build a model in Microsoft Excel and by using the Risk Solver Platform, a statistic calculator tool and to find a solution to improve "XYZ" profitability.

The results of the model suggest changes in the origination of grains, a reduction of the volume in some locations and increasing the volume originated in other locations. After running two different scenarios, "XYZ" profit increased by 3.81 million of Brazilian Reais.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

CHAPTER I: INTRODUCTION

The soybean is a native plant of China, its scientific name is Glycine max and it is part of the family Fabaceae, as well as peas, beans and lentils. It is used for human food in the form of edible oil, soy sauce, soy milk, soy protein, whole grain consumption and mostly in animal feed as an ingredient that makes up the ration (Wikipedia 2018). This oilseed is rich in protein and in minerals such as potassium, calcium, magnesium, phosphorus, copper and zinc, B vitamins such as riboflavin and niacin and also in vitamin C (boric acid), among others (Buranello 2011).

In Brazil, the soybean was introduced in the state of Bahia in the year 1882, but without much success. In 1892, it was cultivated by Instituto Agronomico de Campinas (IAC). In 1914, the crop was introduced in the state of Rio Grande do Sul, where it presented more consistent evolution (Camara 2001).

1.1 Brazil vs USA: Soybean production and exports

According to the US Department of Agriculture (USDA) supply and demand report, released in March of 2018, Brazil is the world's second largest soybean producer with 113.00 million metric tons produced in the 2017/2018 cycle, just behind only the United States which in the same period reached a production of 119.53 million tons (USDA 2018). The Figure 1.1 shows the soybean production and percentage of the global production of Brazil (lighter green) and the USA (darker green).

Figure 1.1: Brazil vs USA soybean production and global share along the last 15 years
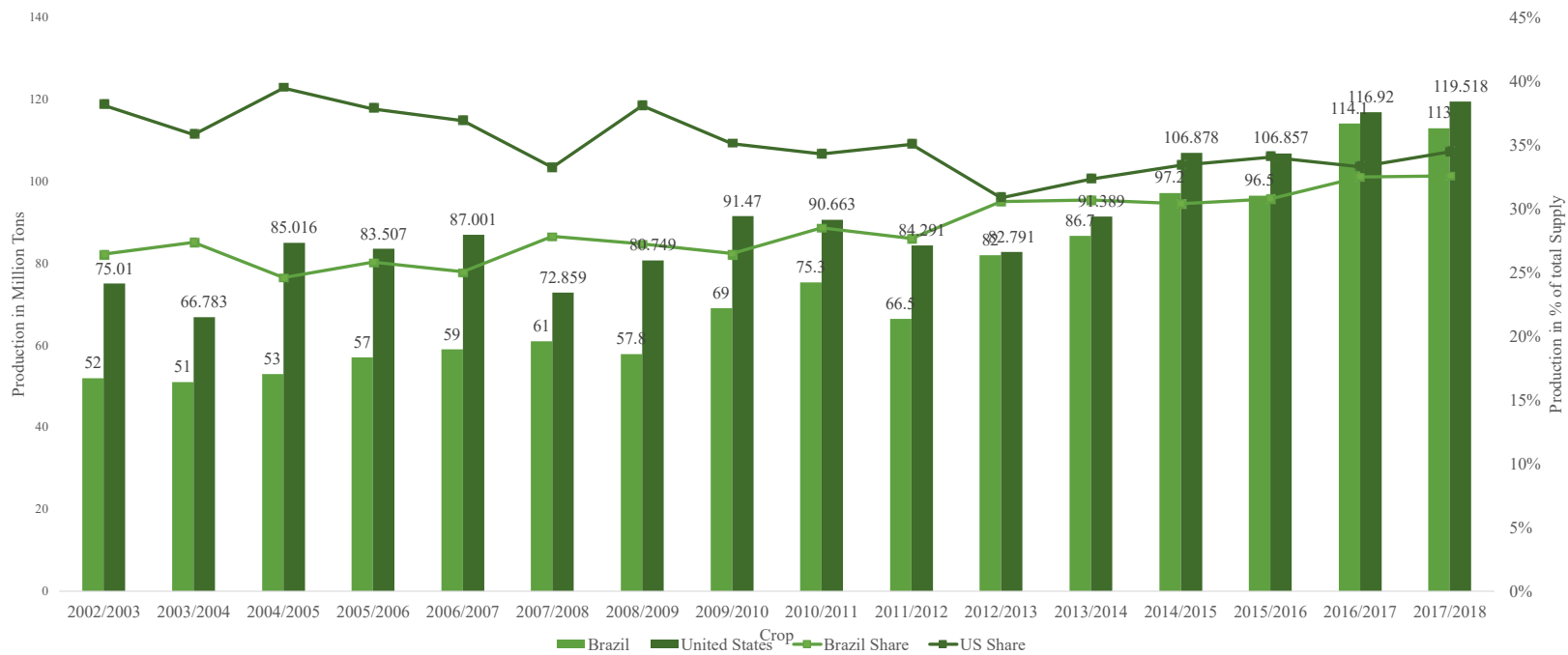
Source: USDA 2018

In terms of exports, Brazil is currently the world's leading exporter for the crop 2017/2018, with 70.50 million metric tons, followed by the United States, which is expected to export 56.20 million tons. Figure 1.2 shows the soybean exports and percentage of the global production of Brazil (lighter green) and USA (darker green).

Figure 1.2: Brazil vs USA soybean exports and global share along the last 15 years
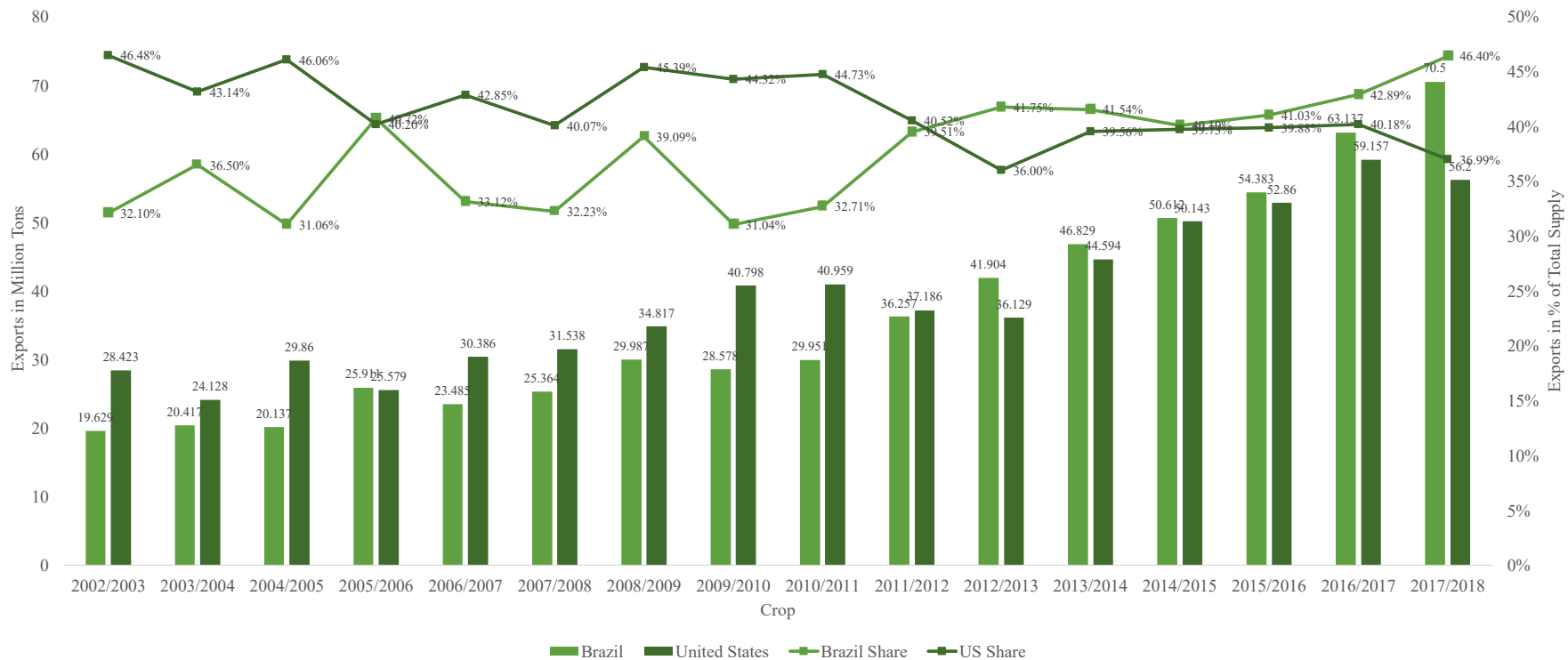
Source: USDA (2018)

According to the quotation of the soybean price indicator of the Economic Research Center of the "Luiz de Queiroz" School of Agriculture [CEPEA / ESALQ], on October 6, 2017, the market value of a 60 kg bag of standard type soybean in the port of Paranaguá, for cash payment was BRL 70.57 reais, equivalent to BRL 1,176.17 reais per metric ton. The value added by Brazilian exports of soybean in grains may exceed the mark of BRL 75.5 billion and the main destination for exports is China (CEPEA 2016).

The harvest survey released in March of 2018 by Companhia Nacional de Abastecimento the Brazilian National Supply Company, indicates an area of 35.04 million hectares sown soybean in Brazil for the 2017/2018 crop. The average yield of 3.22 metric tons per hectare and a total production of 113 million tons. The three-main oilseed producing states are Mato Grosso with 30.86 million tons, Paraná with 18.52 million tons and Rio Grande do Sul with 17.54 million ton (CONAB 2018) .

1.2 Importance of Soybean for the Brazilian Economy

The importance of soybean to the Brazilian economy should be underscored by the generation of jobs and income for thousands of rural producers and workers from various sectors, including the input-producing industry such as fertilizers, pesticides and machinery, the financial sector responsible for rural credit, logistics sector responsible for storage, transportation and port operations, as well as for the processing industry that transforms soybean into bran and oil. The president of the Federação da Agricultura e Pecuária de Mato Grosso do Sul [FAMASUL], Agriculture and Livestock Federation of the state of Mato Grosso do Sul, quantified in July 2013 that 37% of jobs in Brazil have a direct or indirect link with agribusiness (Scot 2014).

1.3 Industry structure and market competition

The commercialization of soybean occurs through cooperatives, grain merchants, chemical/fertilizer input companies, grain brokers, industry and merchandisers. The risk involved in the commercialization of the production explains the three possible commercialization situations: 1) Make a forward cash sale, where the flat price is fixed today with a buyer, for future delivery of the merchandise; 2) To hedge the price of the merchandise by selling a future contract; 3) Do absolutely nothing, acting as speculator, hoping that prices will not fall at the moment of sale (Marques, Mello and Martines 2006).

On one hand, the impressive production and exports of this oilseed and its byproducts, it is possible to perceive the relevance and attractiveness of Brazil in the global market, which justifies the entry of new companies, mainly multinationals, in the soybean origination, processing and export market. On the other hand, the fact that many companies exit the market due to high competitiveness resulting in, insignificant or even negative margins, bad operational and financial practices, difficulties in adapting to the current market conditions of the commercialization complex. Additionally, the lack of knowledge and analytical tools that help identify logistics bottlenecks has an impact on the industry's performance.

1.4 Logistic bottlenecks and risks

Logistics bottlenecks can be noted in the Para's state where there are 65 kilometers of dirty road between Novo Progresso and Moraes de Almeida, two municipalities located on the way where soybean are transported from the state of Mato Grosso to the ports located in the northern Brazil. Freight prices reach twice the price considering the same distances in other Brazilian States. The transportation problem is so serious that in 2017 trucks got stuck in the road because of heavy rains during the harvest season and there was a 20 km

traffic congestion. The Brazilian army was called upon to supply water, food and control the traffic jam (Teixeira 2018).

1.5 XYZ Company's profile

"XYZ" is a soy crusher, subsidiary of a Japanese corporation that just acquired crushing facilities in Mato Grosso State and is trying to understand the market and improve the profitability in the short-term. Their operation has six origination regions and they are able to export soymeal and soy oil through two ports.

1.6 Thesis objective

The objective of this thesis is to provide answers to questions that will help "XYZ" board of directors to better understand the soybean market in Mato Grosso/Brazil so they might make informed decisions to improve the company`s performance. The questions to be answered are:

1) What are the logistical and commercial bottlenecks faced by the company XYZ?

2) What strategy that can be adopted and implemented in the short-term to improve "XYZ" profitability in the first year?

3) What are the other feasible strategies that can be adopted by "XYZ" in the mid and long-term to minimize the risks, maximize the use of assets and keep improving profitability?

CHAPTER II: GETTING TO KNOW MATO GROSSO STATE

According to Instituto Brasileiro de Geografia e Estatística (IBGE), the Brazilian Institute of Geography and Statistics, the state of Mato Grosso has a population of 3,344,544 and 60.7% of the population over the age of 16 has a formal job. Mato Grosso is the third largest state in Brazil with an area of 903,202.44 square kilometers (IBGE 2017).

What is known as Mato Grosso was once Spanish territory because the first excursions made in the territory of Mato Grosso date from 1525, when Pedro Aleixo Garcia goes towards Bolivia, following the waters of the Paraná and Paraguay rivers. Subsequently Portuguese and Spanish explorers are attracted to the region thanks to rumors that there was much wealth in those lands not yet properly exploited. They were looking for gold. Also came Spanish Jesuits who built missions between the Paraná and Paraguay rivers (Governo de Mato Grosso 2018).

In 1977, Mato Grosso was then dismembered into two states: Mato Grosso and Mato Grosso do Sul. Mato Grosso is one of the states of Central-West Brazil. It borders Amazonas, Pará, Tocantins, Goiás, Mato Grosso do Sul, Rondônia and neighboring Bolivia, and has 141 municipalities.

2.1 Mato Grosso state: agriculture and economic overview

IMEA as mentioned in the previous chapters, is a private and not-for-profit institute of Famato in partnership with APROSOJA, AMPA and ACRIMAT (all of them are agribusiness associations). IMEA was created in 1998 and restructured in 2008, based in Cuiabá-MT. IMEA carries out studies and socioeconomic and environmental projects throughout the territory of Mato Grosso, through a system of data collection, processing and analysis, producing strategic information on agribusiness for the sponsors. (IMEA 2018).

According to IMEA, just 10.4% of Mato Grosso is used for agriculture. The map below shows in yellow the farming area in Mato Grosso State, mostly covered by soybean, corn and cotton and represents 10.4% of the state area. 24.6% of the area in purple, are the pasture and 64.8% of the state area represented on the graph in dark green, light green and light red are indigenous land, conservation area and/or environmental preservation area (IMEA, Agronegócio no Brasil e em Mato Grosso 2017).

Figure 2.1 Mato Grosso land use

- 10.4% Agriculture
- 24.6% Pasture
- 0.3% Others
- 16.6% Indigenous land
- 2.5% Conservation area
- 45.7% Environmental preservation area

64.8%
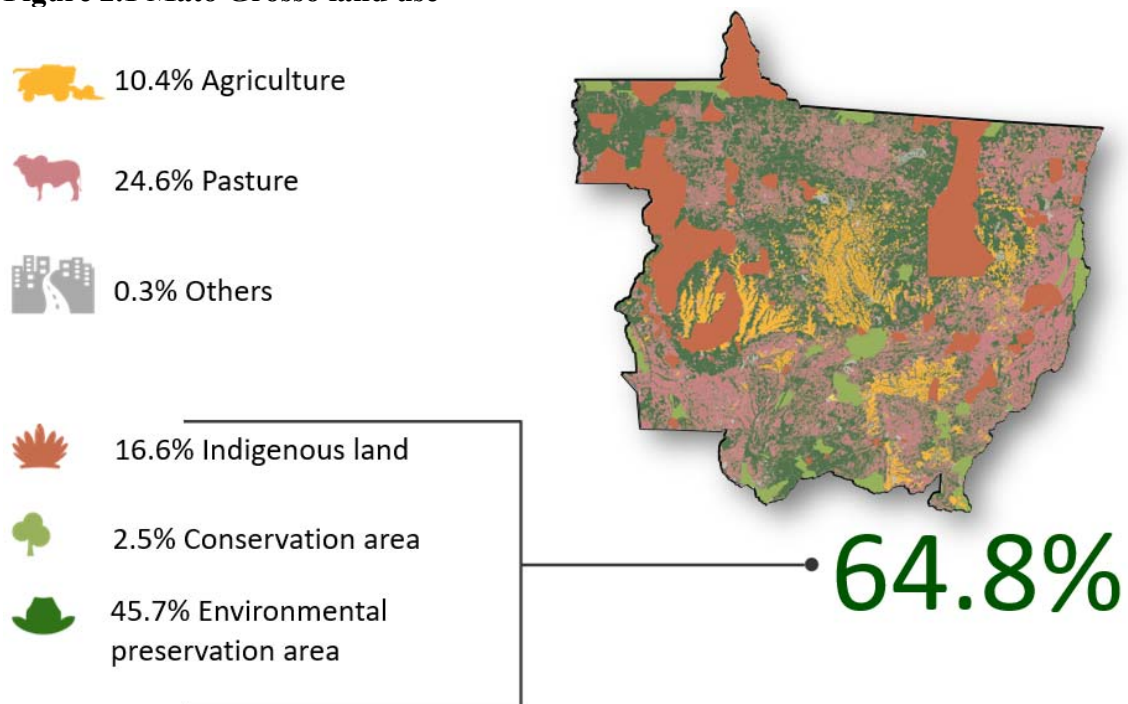
Source: IMEA (2017)

Mato Grosso that produces 28% of Brazilian Soybean and 9% of the world's supply, reported by IMEA (based on CONAB and USDA data). The graph below brings the area planted with soybean in orange and the state production in million tons (IMEA, Agronegócio no Brasil e em Mato Grosso 2017).

Figure 2.2 Soy Area and Production Evelution in Mato Grosso
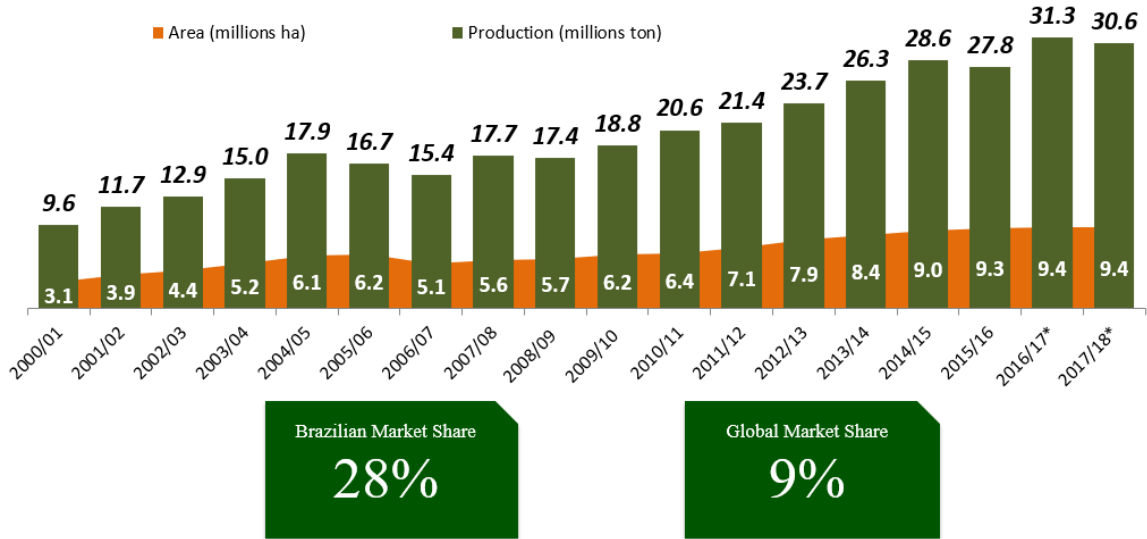
Source: IMEA based on Conab and USDA (2017)

The next chart shows how the soybean production is distributed in Mato Grosso state for the years 2015-2016 and the importance of the central region that produces 34% of the state production, which includes important locations as Lucas do Rio Verde and Sorriso. The reader can realize how agriculture is important by noting the yellow spots that represent areas used for grain production (IMEA 2017) by examining Figure 2.3.

Figure 2.3 Soybean farming fields concentration in Mato Grosso
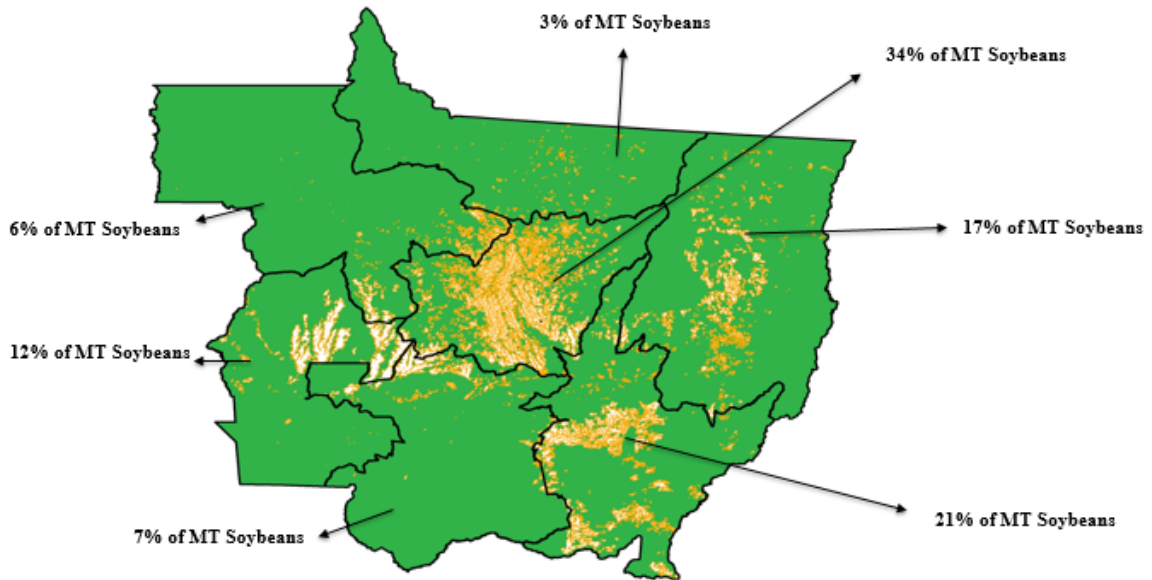
Source: IMEA (2017)

2.2 Transportation

Transportation in Mato Grosso is critical because of the geographic location of this state. In

the chart below it is possible to realize the high demand of trucks for transportation to take

the soybean and the byproducts to the ports and weakens the basis. The costs of freight also

make fertilizers more expensive, thus reduces the profitability of farmers.

The northern ports in Brazil are also known as North Arch and include the ports of

Itacoatiara, in

Amazonas State, Itaqui, in Maranhão State, Santarém and Barcarena, in Pará State, and

Salvador in Bahia State. These ports have begun to gain more importance since 2014 when

national and mainly, multinational corporations started to build new terminals in the region.

Combined, these ports were expected to export 37 million tons of grains and by products

by the end of 2017. The traditional ports on the other regions are Paranagua in Parana State,

Imbituba and São Francisco in Santa Catarina State, Rio Grande in Rio Grande do Sul

State, Vitória in Espirito Santo State and Santos in Sao Paulo State now face competition

from northern ports (Podestà 2017).

The figure below illustrates how Mato Grosso transports the production. Roads are

in red, waterways in blue and railroads in green. The small anchors in a blue square

represent the most important ports.

Figure 2.4 Brazilian multimodal transportation infrastructure to attend Mato Grosso

Source: IMEA (2017)

Additionally, this chapter emphasizes the geographical and economical aspects of

Mato Grosso, its importance for the global food supply, and the challenges faced by the

state impacted by the distance between the production region and the ports. The logistic factor is important because of the long distances, uncertainty that the goods are going to arrive at the ports in time due to the bad road condition, limited drying and storage capacity on the farms and on the grain merchant`s warehouses.

The next chapter will give a better idea of the costs of raw material, distance between locations, the assets owned by the company, operational costs, exchange rate, origination and crushing capacity that provides the needed data for the development of the Risk Solver model.

CHAPTER III: MATERIAL AND METHODS

3.1 Soybean prices and origination regions

The first pieces of information needed for this thesis is the soybean prices. IMEA provided the database in a spreadsheet including prices of soybean collected on a daily basis in the municipalities of Canarana, Campo Novo do Parecis, Lucas do Rio Verde, Rondonópolis, Primavera do Leste and Sorriso, all located in the state of Mato Grosso. The database used covers a period from January 6, 2014 until September 29, 2017 and the prices are in Brazilian Reais per 60-kg-bag, a measure used by most farmers to sell their production.

IMEA has its data collection personnel in the field, but also an internal team that collects data from all over the Mato Grosso state through telephone calls, chats and email.

Based on this data series it is possible to estimate the average, minimum, maximum and standard deviation. For the development of the Risk Solver tool, and to meet the objective of this project, thus study considers the average prices from January 6, 2014 to September 29 of 2017. This is because the "XYZ" profile is to buy what it consumes in a short period of time and do not take any physical position such as a long basis to carry the beans for further months. Company "XYZ" does not take financial positions such as oil share and board crush on the commodity exchange, to guarantee the crushing facility's margins. Taking the example of Rondonopolis, prices varied from BRL 50.30 and 90.20 for the period studied. This wide range is due to the exchange prices on Chicago Board of Trade, but also because of the local basis related to the supply and demand.

Figure 3.1 Continuous price of the sack of soybean in BRL per 60-kg-bag
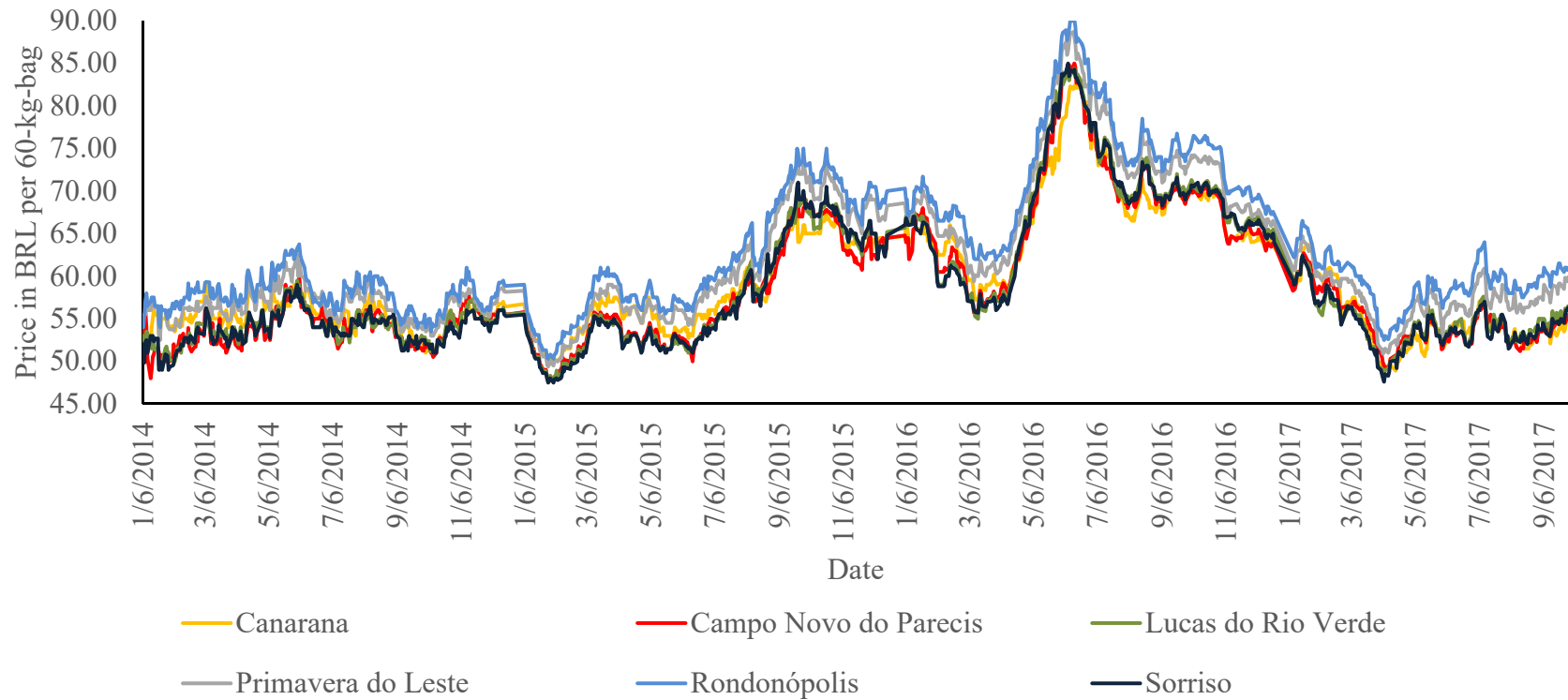
Source: Prepared by author based on IMEA (2017)

The locations mentioned above represent the soybean origination regions that are destined for crushing facilities or ports. It was considered that the company purchases consistent volumes throughout the study period, buying the same monthly volume, without keeping long term stocks.

The table below the identifies the average, minimum price, maximum price and standard deviation (in BRL 60-kg sack) of soybean in Mato Grosso between January 6, 2014 and September 29, 2017, in the different locations of origination.

This table is important to understand the local price ranges across the period and the price differences between the municipalities. Also, because the competitors in the municipality will make the efforts to originate volumes of soybean that is nearby their facilities. This approach will prevent its competitors from buying the available soybean in XYZ`s origination regions. The lack of soybean stocks during the second half of the year for the intercrop period, force XYZ to seek grains in other locations, which increases the freight costs.

Table 3.1: Soybean Prices in Mato Grosso State

	Canarana	C. N. do Parecis	L. do Rio Verde	P. do Leste	Rondonópolis	Sorriso
Mean	59.25	58.66	58.89	61.81	63.36	58.66
Minimum	48.90	47.75	47.80	49.40	50.30	47.50
Maximum	82.60	85.00	84.40	88.70	90.20	85.00
Std Deviation	6.79	7.55	7.91	7.94	8.05	7.93

Source: Prepared by Author based on IMEA (2017)

3.2 Crushing facilities

XYZ has two soybean crushing plants located in the municipalities of Primavera do Leste and Lucas do Rio Verde, highlighted in yellow on the map shown below. Each of these facilities had an annual processing capacity of 500 thousand tons, totaling a consumption of one million tons if both factories worked at maximum capacity. XYZ also

exports through the ports of Barcarena located in the state of Para and Paranagua located in Parana State, both highlighted in blue on the map. The origination regions are highlighted in green and represents the municipalities of Sorriso, Lucas do Rio Verde, Canarana, Campo Novo do Parecis, Primavera do Leste and Rondonopolis. All of the origination areas and crushing plants are located in the state of Mato Grosso.

Figure 3.2 XYZ infrastructure: Crushing Plants, Port Terminals and Origination points
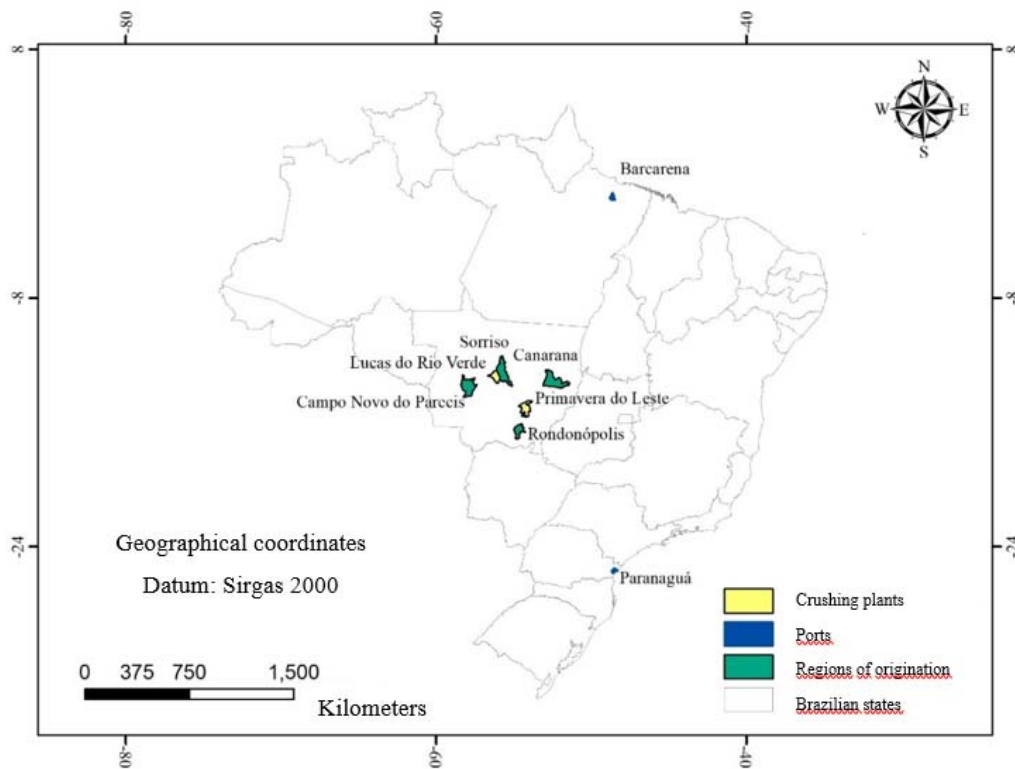
Source: Prepared by the author, based on IBGE (2017)

According to Masiero Engineering company, the soybean must go through the processes of cleaning, weighing, rupturing, peeling, thermal conditioning, lamination and extrusion for the best performance of the extraction to produce soybean meal and oil (Masiero 2017).

3.3 Foreign Exchange (USDBRL)

The costs to crush the soybean and fobbings in ports were also considered in the proposed Risk Solver model. Usually the producers and merchants deliver the goods at a port terminal and the exporter is in charge of the fobbings costs, but in order to calculate the prices, the market considers FOB price (which is the goods loaded at the vessel) minus the fobbing costs to avoid the bureaucracy of having to take care of more documents and services.

Fobbings costs include all services from the truck arrival at the port terminal to load the goods in the vessel having it free on board (FOB). To detail what fobbing costs are, it starts by the product being unloaded at the terminal, taking samples for quality analysis, cleaning the grains or byproducts by using a sieve machine (if necessary), fumigation, loading in the vessel and issuing the custom documents. It is a common market practice for these costs to be calculated in US dollars per metric ton. To convert dollarized prices to Brazilian Reais, the average rate in the period was BRL 3.0812 per US dollar according to the daily PTAX settlement from January 6, 2014 to September 29,2017. (BCB 2017).

Figure 3.3 Dollar value P-TAX (BRL)

Source: Prepared by the author using Thomson Reuters Eikon Software based on Banco Central do Brasil (2017)

Table 3.2. Dollar P-TAX statistics between January 6, 2014 and September 29, 2017

	BRL vs USD
Mean	3.0812
Minimum	2.1968
Maximum	4.1942
Standard Deviation	0.5284

Source: Prepared by the author using Thomson Reuters Eikon Software based on Banco Central do Brasil (2017)

3.4 Crushing Costs

In consultation with several professionals in the commercial and operational areas of soybean crushing facilities in the state of Mato Grosso, it was possible to estimate the crushing costs (fixed and variables) for each of the XYZ facilities. These costs include labor, electric and furnace power, inputs used in the degummed oil extraction process, depreciation, and insurance.

Each region has particularities such as the cost of labor that varies according to geographic location and the availability of skilled labor. Other variables for the composition of the crushing cost are the type of the facility, equipment, technology used and the energy matrix adopted. The matrix in some cases can be propane but most of the facilities use wood which is abundant in Mato Grosso. Considering all of the above, a cost of $20.00 per metric ton for crushing in Primavera do Leste and $18.00 per metric ton for crushing in Lucas do Rio Verde is estimated.

Table 3.3 Cost of soybean crushing in Primavera do Leste and Lucas do Rio Verde

	Dollar/ton	USDBRL Rate	BRL/ton
Primavera do Leste	20	3.0812	61,62
Lucas do Rio Verde	18	3.0812	55,46

Source: Original research data

The crushing plant yields the proportion of 780 kg of soymeal (78%) and 185 kg of degummed oil (18.5%) for each ton of soybean. The remaining 35 kg (3.5%) represent hull,

losses of weight during the crushing process and impurities that can be sold in the local market for animal feed, so this percentage was not considered as a loss at the time of sale.

3.5 Freight rates and distances

Once the soybean is purchased, it is necessary to add the freight cost between the respective regions of origin and one of the two crushing facilities and from the facilities to the respective ports where the products will be shipped to the foreign markets. For the calculation of the freight rates, the database was provided by IMEA's weekly, of data collection is process. This database leads to the calculation of an average freight cost of BRL 0.0924 per ton per kilometer, equivalent to $0.03 per ton per kilometer.

Table 3.4 Freight rates

Origin	Destination	Distance (km)	Freight BRL/ton
Sorriso	Primavera Do Leste In	632	58.42
Sorriso	Lucas do Rio Verde In	66	6.10
Sorriso	Paranagua's Port	2278	210.57
Sorriso	Barcarena's Port	1999	184.78
Rondonopolis	Primavera Do Leste In	129	11.92
Rondonopolis	Lucas do Rio Verde In	544	50.28
Rondonopolis	Paranagua's Port	1617	149.47
Rondonopolis	Barcarena's Port	2454	226.83
Canarana	Primavera Do Leste In	593	54.81
Canarana	Lucas do Rio Verde In	677	62.58
Canarana	Paranagua's Port	1866	172.48
Canarana	Barcarena's Port	1664	153.81
Campo Novo do Parecis	Primavera Do Leste In	634	58.60
Campo Novo do Parecis	Lucas do Rio Verde In	324	29.95
Campo Novo do Parecis	Paranagua's Port	2280	210.75
Campo Novo do Parecis	Barcarena's Port	2386	220.55
Primavera do Leste	Primavera Do Leste In	0	0.00
Primavera do Leste	Lucas do Rio Verde In	561	51.86
Primavera do Leste	Paranagua's Port	1745	161.30
Primavera do Leste	Barcarena's Port	2325	214.91
Lucas do Rio Verde	Primavera Do Leste In	561	51.86
Lucas do Rio Verde	Lucas do Rio Verde In	0	0.00
Lucas do Rio Verde	Paranagua's Port	2213	204.56
Lucas do Rio Verde	Barcarena's Port	2062	190.60
Primavera Do Leste Out	Paranagua's Port	1745	161.30
Primavera Do Leste Out	Barcarena's Port	2325	214.91
Lucas do Rio Verde Out	Paranagua's Port	2213	204.56
Lucas do Rio Verde Out	Barcarena's Port	2062	190.60

Source: Prepared by author based on IMEA (2017)

3.6 Soymeal and oil prices

In order to calculate the sales value of soybean processing by products, this research considers that one thousand tons of soybean can produce 780 kg of soymeal and 185 kg of the soy oil. The volume of byproducts produces is converted back to the price of soybean and finally multiplied by the USDBRL rate. In the period from January 6, 2014 to September 29, 2017, the average price of soybean meal in the port of Paranaguá was

$366.99, with a maximum price of $543.50, a minimum of $260.50 and standard deviation of $72.77 per ton. Degummed soybean oil presented an average price in Paranaguá of $755.89, with a maximum price of $976.00, a minimum of $588.60, and a standard deviation of $66.60 per ton.

In the conversion to the soybean base, where the average price of soymeal and oil is multiplied by the percentages produced of 78% and 18.5% respectively, and then multiplied by the exchange rate where the average price in Paranaguá is $ 1,312.83 per ton. This was the price used in the tool developed as a reference of sale, discounting the freight of the factories from the port of Paranaguá.

To calculate the sale price in the port of Barcarena, the same conversion factors are used, but with a price differential. Barcarena began exporting soybean in larger scale in 2015, where prices were 10 cents per bushel over Paranaguá's price. According to the density of the product, the weight in kilograms of a bushel varies. In the case of soybean, one bushel is the same as 27.22 kilograms and for one metric ton, 36.7434 bushels are needed. In 2016, soybean prices in Barcarena had a premium of only five cents per bushel over Paranaguá and in 2017 Barcarena's premiums were similar to Paranaguá. An average of the three years was thus awarded, which was five cents per bushel, or $1.84 per ton, above than the price paid in the port of Paranaguá.

Converting to BRL at the average exchange rate we have an aggregate value of BRL 5.66 per ton in Barcarena. The difference in basis between ports was obtained through interviews with professionals in the grain market and port agents.

Table 3.5 Average Soybean Premium in Barcarena vs Paranaguá

Basis USD/bu	Bu to Metric Ton	Basis USD/ton	PTAX Rate	Basis BRL/ton
0.05	36.7434	1.84	3.0812	5.66

Source: Original Research Data

The conversion of the 78% of soymeal and the 18.5% of the oil was used again in the conversion to the price of soybean multiplied by the USD quotation added to the differential basis of Barcarena over Paranaguá. Thus, the average price in Barcarena at the soybean base was $1,318.49 per ton and will be used as a sales reference, discounting the freight from the crushing plants to this port.

Table 3.6 Soymeal and oil to soybean conversion in Paranaguá and Barcarena

	Paranagua BRL/ton	Barcarena BRL/ton
Average	1,312.83	1,318.49
Minimum	1,010.87	1,016.53
Maximum	1,796.75	1,802.41
Standard Deviation	205.21	205.21

Source: Prepared by author based on IMEA (2017)

3.7 Taxes

Regarding taxation on the soybean crushing operation, there is exemption of some taxes. An example of the tax exempt is the Circulation of Goods and Services Tax (ICMS) that is not applied to soymeal and soyoil that are destined for export. The same rule applies to soybean which are purchased for export in grain.

The ordinance 67 of the Treasury Department of the State of Mato Grosso (SEFAZ-MT) of May 31, 2005, exempts the incidence of ICMS on export operations, stimulating commercial activities and in Brazil. Other taxes such as State Transport and Housing Fund (FETHAB) and Rural Workers Assistance Fund (FUNRURAL) are charged by the farmers who sell soybean to the industry (Sticca 2008).

CHAPTER IV: BUILDING THE MODEL IN MICROSOFT EXCEL

In the previous chapters the geographical location of Mato Grosso state, the distance to the ports and distance between the locations represent challenges to XYZ's performance.

Once the data is collected, a logistic bottleneck identification matrix was built in "Microsoft Excel" where the raw material and final product prices are inserted, as well as the use of some formulas that supply the data used by the Risk Solver.

The "Risk Solver Platform" uses Monte Carlo methods and other risk tools to enable robust and automatic decision-making optimization using stochastic programming. The developer also points to the use of Risk Solver to build models and obtain results for critical planning moments, especially those involving uncertainty (Solver 2018).

The construction of the spreadsheet and the correct use of the formulas represent the most important part of this project and, therefore, the following information on the preparation of the spreadsheet is necessary.

4.1 "Lower Bound" Column

The first column and represents the minimum expected volume of products for each of the regions considering in the model. For example, considering that in Sorriso it is necessary to generate a minimum volume of 50,000 tons of soybean in case the company has some storage capability at this location, this number should be inserted and would be the minimum to be originated in this city. The minimum volume to be originated in each region for the simulated scenario is considered zero. In the case of the crushing facilities of Primavera do Leste and Lucas do Rio Verde, it is estimated to use at least 250,000 tons each, representing 50% of processing capacity. This column helps with the decision to

either export or process soybeans. The model will suggest to reduce the crushing capacity if the margins are less than desirable for soybean crushing, and it will point it out as the best alternative to export grains.

4.2 "Shipment" Column

The decision to ship, is not inserted because it is precisely the purpose of this column that the "Risk Solver" will define the best flow to maximize the profitability of the operation, moving the soybean, soymeal and the degummed oil between the regions. This column represents the variable cells of the model and will receive the quantities calculated by the formulas inserted in the "Risk Solver".

4.3 "Upper Bound" Column

The "Upper Bound" column in the model represents the maximum volume that each region can move at most. A sequence of numerals "nine" was used in the cells where it is desired that the tool interprets that so that this limit is never reached, and each region can move the maximum of possible volume, being able to consume up to 100% of the volume offered in each location. The sequence of "nines" also avoids redundant limitations. If the company has limitations of movement in one of the regions, as in the facilities that crush a maximum of 500 thousand tons, this number must be used with respect to the limitations, since this is the maximum volume that can circulate in this location. In the origination regions, it is allowed that 60,000 tons of soybean in grains had the purpose of export without being industrialized.

4.4 "Nodes" Column

Each location received an identification number so that the tool could recognize the flows. These node codes are used to identify each origination region, factory or port is represented with numerals from 1 to 12. In these columns, all possible flows must be

entered, so the names of locations repeat themselves as much as necessary simulating all situations. The "nodes" columns represents the inflow and outflow of products. The nodes number are defined as per an auxiliary table where information was fed.

4.5 "From" Column

The column "From" identifies that the raw material leaves the origin and goes to the destination such as from the origination points to the crushing plant and from the crushing plants to the ports.

4.6 "To" Column

The column "To" identifies where the products are going to, after leaving the origin such as soybean originated in Sorriso going to the Lucas do Rio Verde crushing facility.

4.7 "Cash Flow" Column

The "Cash Flow" column a negative values represent the outflow related to the purchase of the raw material in each region plus the freight to the destination and the sale of products with positive values representing the sales based on the port discounting the value of freight. The cash flow represents the price per metric ton.

Costs of crushing appear with negative signs because they represent costs, which is a negative cash flow. Plants have different operating costs, and if the company had more processing capacity at a lower cost in one factory, the model would direct more grain volume to that plant and redirect its processing capacity from plants with higher operating costs.

Another possible situation that Solver will identify is in the case that one of the crushing facilities has larger capacity, but has been built a long time ago and does not have modern technology which make it more costly (demands more energy and labor/maintenance or demands more expensive labor due to its location) and less efficient

(extracts lesser then one with state of art technology), the tool would direct the maximum possible quantity of raw material to the crushing plant that are more efficient even if the plant has smaller capacity.

4.8 "Nodes ID" Column

The column named "Nodes ID" represents the identification of each location. This column also includes the information about Primavera do Leste "In" and Lucas do Rio Verde "In", which show soybean getting in and Primavera do Leste "Out" and Lucas do Rio Verde "Out" to allow the model to capture the crushing costs when the soybean gets to the crushing plants, pass though the crushing process and the byproducts go to the ports.

4.9 "Flow (tons)" Column

This column is calculated with Microsoft Excel's SUMIF formula and the tool calculated how much supply or demand would flow in metric tons, through each nod depending on the potential for generating profit compared to other locations. According to the developer, SUMIF function is applied to sum the values in a range that meet criteria that the user specifies. Range and criteria information are required.

The "Flow (tons)" column did not have any value before the "Risk Solver" calculator is triggered. This column received the formulas that are listed in Appendix A.

Taking as example the location of Sorriso, the formula represents where the node ID is number 1. This Formula is identifies a region for the products according to the node number and the quantity demanded of each region, which is calculated by Solver. Column "D" is the node number on the origin and column "F" is the node number for the destination of the products. The column "B" represents the product output and it is calculated by Solver.

The negative sign between the two formulas is to prevent the tool from interpreting product output from a location and come back to the same location.

4.10 "Supply and Demand" Column

The column of supply and demand receives data regarding the amount of product available in each location. This information must be added manually according to the availability of supply or demand of the regions. The supply and demand column is also relevant once the tool calculates only the quantity needed to supply the plants of the model, considering the maximum volume of one million tons. In other words, the developed model searches for the most attractive origins with the lowest logistic cost and points out the best flow possible for sale, where the final price after subtracting freight represents the greatest gains for the company.

4.11 "Objective" Cell

The objective cell represents what "XYZ" company desires. The objective can vary depending on the need going from choosing the shorter distances between locations to originate where the prices of the raw material is cheaper, without considering the distance. "XYZ's" goal is to maximize the use of assets and improve the profitability.

In the model, this cell is represents total profit and is calculated by summing the products of the cells. This calculation multiplies the quantities determined by the tool in column "B" which covers the volumes in all locations by the values in column "H" and represent the flows from the purchase of the raw material, the cost of processing the volume purchased, the revenue from sales for export and the respective freights. Some regions have volumes equal to zero in column "Shipment", which means that there was no movement of soybean or byproducts in those locations.

CHAPTER V: RUNNING THE RISK SOLVER MODEL

Once the spreadsheet is completed, the objective, variable cells, and constraints that the model needed are entered in Risk Solver.

5.1 Installing the Risk Solver Add-in

"Microsoft Office Excel" does not have "Risk Solver" installed as the default setting. To activate this feature, you need to click the "File" tab in the upper right corner, go to the Options menu, select "Add-ins" and enable "Risk Solver" which will automatically be available in the upper tab named Data (ColumbiaBusinessSchool 2018).

To open the solver calculator, it is necessary to select the tab "Data", then Solver is represented by a question mark logo.

5.2 Setting the Objective on Risk Solver Calculator

After opening the Solver Platform, the next step is to develop the model. On the field called "define objectives field", cell "H36" is selected, which is where the calculator's result would be (objective cell). The objective is achieved by maximizing "XYZ's" profit from crushing soybean, therefore, it is necessary to select the "Maximize" box that is located below. If the objective of this model is to minimize the objective such as the distance traveled or the cost with freights for example, the Minimize field should be activated, however, it is not the objective of "XYZ".

5.3 Variable Cells

Other information that the platform requested refers to which cells should be changed to define the amount of goods transported between each location in order to reach the goal of profit maximization. This field is filled with the transport information for each region, in the "Shipment" column.

5.4 Variable Cells

   The next step is to define the constraints. As many limitations as necessary can be added. For the tool in question, we have defined four constraints:

5.4.1 Constraint 1: upper bound constraint

Constraint 1 ensures the volume moved in this region is equal to or less than the upper bound. The formula is represented and coded in the model to adhere to the constraints imposed by the limitations of the region.

5.4.2 Constraint 2: lower bound constraint

The second constraint ensures the volume moved in these regions was equal to or greater than the lower bound. The formula is coded in the model to adhere t the constraints imposed by the limitation of the region. The first two constraints basically are barriers to set minimum and maximum volume that each node can take.

5.4.3 Constraint 3: non-negative volume constraint

Constraint 3 guarantees that the volume moved in these regions is equal to or greater than zero, avoiding negative volumes of soybean or by products. The formula is coded so that model adheres to the constraints imposed by the limitation of the region.

There is no negative flow in the volume and the constraint three limits the minimum flow to zero.

5.4.4 Constraint 4: overflow constraint

The fourth constraint ensures that it does not originate more than the volume available in each region or that no more capacity is exported than the limit in each port. The formula is coded so that model adheres to the constraints imposed by the limitation of the region.

   Once the formulas are loaded into the Solver calculator, the box is checked to make non-negative unrestricted variables. The LP Simplex model is chosen and, in the option, it

was marked Automatic Scale. Chapter 5 results are summarized in the figure below

(Ragsdale 2016):

Figure 5.1 Risk Solver calculator details
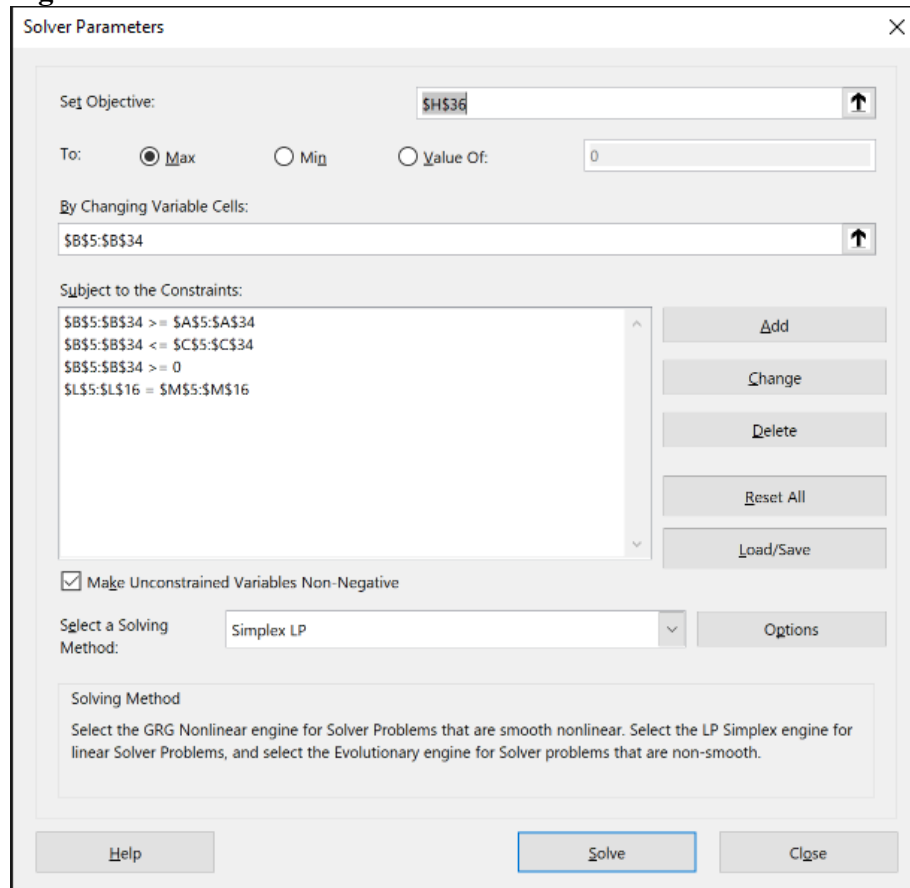
Source: Microsoft Excel/Risk Solver (2018) and Original Research Data

CHAPTER VI: RESULTS AND DISCUSSION

This chapter reports the performance of the company XYZ after the proposed models comparing Scenario1 and Scenario 2 and serve to help the for the board of directors better understand the market in which they are operating, to adopt one or other short-term feasible strategies that improves the company performance for the next year. Chapter VI complements the previous chapters and will show how the logistic bottlenecks impact the XYZ performance and prepare the board of directors for other strategies aiming the excellence of the company activity.

6.1 Scenario 1 on Risk Solver

 As a result simulation of Scenario 1 calculated by the formula that considers the flow between notes multiplied by the cost (in the case of inputs and crushing costs) or revenue (sale of byproducts), XYZ obtained a total profit of BRL 60,893,000.00 which is approximately $19.77 million considering the currency average rate for the period of study.

The Lucas do Rio Verde crushing facility was supplied with 100,000 tons originating locally, 250,000 tons of soybean from Sorriso, and 150,000 tons of Campo Novo do Parecis. The model indicates that all the volume of soybean meal and degummed oil produced in Lucas do Rio Verde should be exported through the port of Barcarena.

Meanwhile, the Primavera do Leste facility was supplied with 100 thousand tons originated locally, 200 thousand tons of soybean from Rondonópolis, 200 thousand tons from Canarana. The model indicates that all the volume of soybean meal and degummed oil produced in Primavera do Leste must be exported by the port of Paranaguá.

Both soybean crushing facilities operated with total capacity and there was no export of soybeans without being industrialized.

Table 6.1 shows the results of the Scenario 1 including the flow between nodes. Columns "From" and "To" identify the origin and the destination of the soybean and byproducts.

The "Cash Flow" column representing the cost of inputs delivered to de crushing facilities, the crushing costs and the revenue obtained by selling soymeal and soyoil.

All possible flows from the locations where XYZ originates soybeans to the soybean crushing plants or ports are considered.

Table 6.1. Scenario 1 Spreadsheet Part 1

Lower Bound	Flow (MT)	Upper Bound	Node	From (Origin)	Node	To (Destination)	Cash Flow (BRL/MT)
0	0	9999999	1	Sorriso	7	P. do Leste In	-1,036.09
0	250000	9999999	1	Sorriso	8	L. do Rio Verde In	-983.77
0	0	60000	1	Sorriso	11	Paranagua's Port	-67.97
0	0	60000	1	Sorriso	12	Barcarena's Port	-37.27
0	200000	9999999	2	Rondonopolis	7	P. do Leste In	-1,067.93
0	0	9999999	2	Rondonopolis	8	L. do Rio Verde In	-1,106.29
0	0	60000	2	Rondonopolis	11	Paranagua's Port	-85.21
0	0	60000	2	Rondonopolis	12	Barcarena's Port	-157.66
0	200000	9999999	3	Canarana	7	P. do Leste In	-1,042.32
0	0	9999999	3	Canarana	8	L. do Rio Verde In	-1,050.08
0	0	60000	3	Canarana	11	Paranagua's Port	-39.72
0	0	60000	3	Canarana	12	Barcarena's Port	-16.13
0	0	9999999	4	C. N. do Parecis	7	P. do Leste In	-1,036.11
0	150000	9999999	4	C. N. do Parecis	8	L. do Rio Verde In	-1,007.45
0	0	9999999	4	C. N. do Parecis	11	Paranagua's Port	-67.99
0	0	9999999	4	C. N. do Parecis	12	Barcarena's Port	-72.87
0	0	9999999	5	L. do Rio Verde	7	P. do Leste In	-1,033.36
0	100000	9999999	5	L. do Rio Verde	8	L. do Rio Verde In	-981.50
0	0	60000	5	L. do Rio Verde	11	Paranagua's Port	-65.80
0	0	60000	5	L. do Rio Verde	12	Barcarena's Port	-46.95
0	100000	9999999	6	Primavera do Leste	7	P. do Leste In	-1,030.17
0	0	9999999	6	Primavera do Leste	8	L. do Rio Verde In	-1,082.02
0	0	60000	6	Primavera do Leste	11	Paranagua's Port	-71.21
0	0	60000	6	Primavera do Leste	12	Barcarena's Port	-119.90
250000	500000	500000	7	P. do Leste In	9	P. do Leste Out	-61.62
250000	500000	500000	8	L. do Rio Verde In	10	L. do Rio Verde Out	-55.46
0	500000	500000	9	P. do Leste Out	11	Paranagua's Port	1,151.53
0	0	500000	9	P. do Leste Out	12	Barcarena's Port	1,103.58
0	0	500000	10	L. do Rio Verde Out	11	Paranagua's Port	1,108.28
0	500000	500000	10	L. do Rio Verde Out	12	Barcarena's Port	1,127.89
						Total Profit (BRL)	60,893,000.00

Source: Microsoft Excel/Risk Solver (2018) and IMEA (2017)

Table 6.2 shows the identification of each origination spot, crushing plant and destination port on the column "Nodes", the name of each facility on the column "Location", the "Supply/Demand" column identifying the availability of goods in the origination points, and the export capacity in each of the ports and the column "Flow" showing that 100% of the available volume is being used on XYZ operation.

Table 6.2 Scenario 1 Spreadsheet Part 2

Nodes	Location	Flow (tons)	Supply/Demand (tons)
1	Sorriso	-250000	-250000
2	Rondonopolis	-200000	-200000
3	Canarana	-200000	-200000
4	Campo Novo do Parecis	-150000	-150000
5	Lucas do Rio Verde	-100000	-100000
6	Primavera do Leste	-100000	-100000
7	Primavera Do Leste in	0	0
8	Lucas do Rio Verde In	0	0
9	Primavera Do Leste Out	0	0
10	Lucas do Rio Verde Out	0	0
11	Paranagua's Port	500000	500000
12	Barcarena's Port	500000	500000

Source: Microsoft Excel/Risk Solver (2018) and Original Research Data

When the Risk Solver model calculates the best strategy for the soybean crushing enterprise,

it has a feature called sensitivity analysis that allows the board of directors to make a decision. The columns "Allowable Increase" and "Allowable Decrease" indicate how much the objective coefficient varies, that is, the current price of each flow, can vary in value terms, without affecting the combination of the decision variables that are the volumes moved between the regions.

Table 6.3 Scenario 1 Sensitivity Report Part 1

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$5	Flow (tons)	0	-23.66	-1036.09	23.66	1E+30
$B$6	Flow (tons)	250000	0	-983.77	1E+30	23.66
$B$7	Flow (tons)	0	-62.12	-67.97	62.12	1E+30
$B$8	Flow (tons)	0	-51.03	-37.27	51.03	1E+30
$B$9	Flow (tons)	200000	0	-1067.93	1E+30	23.86
$B$10	Flow (tons)	0	-67.02	-1106.29	67.02	1E+30
$B$11	Flow (tons)	0	-23.86	-85.21	23.86	1E+30
$B$12	Flow (tons)	0	-115.92	-157.66	115.92	1E+30
$B$13	Flow (tons)	200000	0	-1042.32	23.86	36.42
$B$14	Flow (tons)	0	-36.42	-1050.08	36.42	1E+30
$B$15	Flow (tons)	0	-3.98	-39.72	3.98	1E+30
$B$16	Flow (tons)	0	0	-16.13	74.9	3.98
$B$17	Flow (tons)	0	0	-1036.11	36.42	23.2
$B$18	Flow (tons)	150000	0	-1007.45	23.2	36.42
$B$19	Flow (tons)	0	-38.46	-67.99	38.46	1E+30
$B$20	Flow (tons)	0	-62.95	-72.87	62.95	1E+30
$B$21	Flow (tons)	0	-23.2	-1033.36	23.2	1E+30
$B$22	Flow (tons)	100000	0	-981.5	1E+30	23.2
$B$23	Flow (tons)	0	-62.22	-65.8	62.22	1E+30
$B$24	Flow (tons)	0	-62.98	-46.95	62.98	1E+30
$B$25	Flow (tons)	100000	0	-1030.17	1E+30	47.62
$B$26	Flow (tons)	0	-80.51	-1082.02	80.51	1E+30
$B$27	Flow (tons)	0	-47.62	-71.21	47.62	1E+30
$B$28	Flow (tons)	0	-115.92	-119.9	115.92	1E+30
$B$29	Flow (tons)	500000	83.33	-61.62	1E+30	83.33
$B$30	Flow (tons)	500000	74.9	-55.46	1E+30	74.9
$B$31	Flow (tons)	500000	0	1151.53	1E+30	67.56
$B$32	Flow (tons)	0	-67.56	1103.58	67.56	1E+30
$B$33	Flow (tons)	0	0	1108.28	67.56	3.98
$B$34	Flow (tons)	500000	0	1127.89	3.98	67.56

Source: Microsoft Excel/Risk Solver (2018) and Original Research Data

The "Reduced Cost" column is extremely important because if the number found

there is equal to zero, then you have the best possible solution according to the data

provided. This column represents the difference between the marginal profit and the

marginal cost of the consumed inputs. However, if this column has a negative number, as is the case of shipments of the cell $B$32 from the Primavera do Leste crushing facility to export via port of Barcarena, it represents a loss of BRL 67.56 per ton if this route is chosen. The final volume column effectively shows the flow between the locations. When the "Reduced Cost" column has a negative value, the inputs from this region should not be consumed in the given flow because they represent the loss of equity.

The XYZ decision makers can also realize the impact of unnecessary or excessive transportation. In regards to the origination in Sorriso for example, where the soybean to be processed travel 66 km to the factory in Lucas do Rio Verde and then again takes this route to the port of Barcarena. At the moment that the commercial team decides where to originate, they must pay close attention to the details of local availability of raw material, existing competition, and seasonality of marketing in order to avoid paying twice the freight because of the raw material coming and going back on the same route.

Correa and Ramos studied the situation and prospects of Brazilian road transport for the outflow of soybean from the Midwest and concluded that the modalities of waterway and rail transportation are the most efficient, due to the energy efficiency and the greater productivity to the movement of higher density loads over longer distances, which results in lower circulation costs (Correa and Ramos 2010).

As many multinationals (mainly of Asian origin) acquire stakes or the totality of agribusiness companies, XYZ also focused only on the foreign market as a destination for soybean meal and soybean oil. The exports of the soybean complex in Brazil have a main window of opportunity between February and September when there is availability of raw

material in the market and, between October and January when the winter corn occupies the ports.

Silva analyzed the agents involved in the soybean production chain, in the municipality of Sapezal (near to Campo Novo do Parecis) state of Mato Grosso, using information to understand how the market works in the west region of Mato Grosso. He concludes that this municipality has a large production and export of soybean but there are no cooperatives operating in the municipality and there are no large-scale processes of industrialization. The impact of a lack of industrialization affects the economic growth of that region, creation of new jobs and collection of taxes, compared to a scenario with aggregation of value of this raw material for Brazil (Silva 2012).

For the interpretation of the restrictions of the Risk Solver model, it is important to verify that the columns "Allowable Increase" and "Allowable Decrease" are zero because 100% of the soybean available is being consumed. The acronym R.H. that appears in the model means "Right Hand Side", that is, refers to the second part of the table that is where the restrictions are determined.

Table 6.4 Scenario 1 Sensitivity Report part 2

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$L$5	Sorriso Flow (tons)	-250000	5.85	-250000	0	0
$L$6	Rondonopolis Flow (tons)	-200000	61.35	-200000	0	0
$L$7	Canarana Flow (tons)	-200000	35.74	-200000	0	0
$L$8	Campo Novo do Parecis Flow (tons)	-150000	29.53	-150000	0	0
$L$9	Lucas do Rio Verde Flow (tons)	-100000	3.58	-100000	0	0
$L$10	Primavera do Leste Flow (tons)	-100000	23.59	-100000	0	0
$L$11	Primavera Do Leste in Flow (tons)	0	-1006.58	0	0	0
$L$12	Lucas do Rio Verde In Flow (tons)	0	-977.92	0	0	0
$L$13	Primavera Do Leste Out Flow (tons)	0	-1151.53	0	500000	0
$L$14	Lucas do Rio Verde Out Flow (tons)	0	-1108.28	0	0	0
$L$15	Paranagua's Port Flow (tons)	500000	0	500000	0	1E+30
$L$16	Barcarena's Port Flow (tons)	500000	19.61	500000	0	0

Source: Microsoft Excel/Risk Solver (2018) and Original Research Data

In table 6.4, the column named "Shadow Price" reflects how much the total profit from the operation is impacted if the industry has access to an additional ton of soybean in each of the origination regions, taking in consideration the local available price, adding freight costs from the origin to the crushing facilities and also considering the selling process for the byproducts.

With the shadow price it is possible to find the difference between the amount paid for the inputs consumed and the marginal benefit of the goods sold.

The negative sign in this column is detrimental in originating an additional ton of soybean in a given location because negative means that if XYZ originates one extra ton of soybean, the company is losing money. Just as an example, it is possible to compare that one additional ton of soybean originated in Sorriso increases the XYZ profitability by BRL 5.85 additional ton of soybean originated in Rondonópolis increases the profit by BRL 61.35. In the case of Canarana origin, one additional ton originated there increases the profitability by BRL 35.74. Note that shadow prices demand more availability and the amounts presented on the table represent the positive or negative impact on the objective function. It recommends that one more ton of soybean could be originated which is not the case because the origination capacity is limited to one million tons.

Still interpreting the sensitivity analysis of the restrictions there is a positive impact of BRL 19.61 for one additional ton exported by Barcarena compared to the exports using the Paranagua's terminal. Another relevant fact is that the model suggests through the column "Allowable Increase", the transfer of all installed capacity in Lucas do Rio Verde to Primavera do Leste which would represent higher costs for XYZ. It is precisely for this reason that the values added by an additional ton of soybean originating in Canarana and

41

Rondonópolis have better cost-benefit ratio of one ton of soybean arriving in the Primavera do Leste Crushing facility compared to the value of the derived products for export.

The sensitivity analysis indicates the best alternative in terms of crushing performance and logistics would be the transfer of all volume (1,000,000 tons) to Primavera do Leste, which in practice is not something applicable in the short term due to costs and the time spent, a second model is generated to give more tools for the board of directors to make a decision.

6.2 Scenario 2 on Risk Solver

As a result simulation of Scenario 2 calculated XYZ obtained a total profit of BRL 64,703,000.00,

which is approximately $21 million when taking into consideration the currency average rate for the period of study. In this new scenario, there is a reduction of 100,000 tons of soybean originated in Canarana and also a reduction of 100,000 tons of origination in Campo Novo do Parecis to Lucas do Rio Verde and Primavera do Leste which increase the origination by 100,000 tons of soybean for each location.

Table 6.5 Scenario 2 Spreadsheet Part 1

Lower Bound	Flow (MT)	Upper Bound	Node	From (Origin)	Node	To (Destination)	Cash Flow (BRL/MT)
0	0	9999999	1	Sorriso	7	P. do Leste In	-1,036.09
0	250000	9999999	1	Sorriso	8	L. do Rio Verde In	-983.77
0	0	60000	1	Sorriso	11	Paranagua's Port	-67.97
0	0	60000	1	Sorriso	12	Barcarena's Port	-37.27
0	200000	9999999	2	Rondonopolis	7	P. do Leste In	-1,067.93
0	0	9999999	2	Rondonopolis	8	L. do Rio Verde In	-1,106.29
0	0	60000	2	Rondonopolis	11	Paranagua's Port	-85.21
0	0	60000	2	Rondonopolis	12	Barcarena's Port	-157.66
0	100000	9999999	3	Canarana	7	P. do Leste In	-1,042.32
0	0	9999999	3	Canarana	8	L. do Rio Verde In	-1,050.08
0	0	60000	3	Canarana	11	Paranagua's Port	-39.72
0	0	60000	3	Canarana	12	Barcarena's Port	-16.13
0	0	9999999	4	C. N. do Parecis	7	P. do Leste In	-1,036.11
0	50000	9999999	4	C. N. do Parecis	8	L. do Rio Verde In	-1,007.45
0	0	9999999	4	C. N. do Parecis	11	Paranagua's Port	-67.99
0	0	9999999	4	C. N. do Parecis	12	Barcarena's Port	-72.87
0	0	9999999	5	L. do Rio Verde	7	P. do Leste In	-1,033.36
0	200000	9999999	5	L. do Rio Verde	8	L. do Rio Verde In	-981.50
0	0	60000	5	L. do Rio Verde	11	Paranagua's Port	-65.80
0	0	60000	5	L. do Rio Verde	12	Barcarena's Port	-46.95
0	200000	9999999	6	Primavera do Leste	7	P. do Leste In	-1,030.17
0	0	9999999	6	Primavera do Leste	8	L. do Rio Verde In	-1,082.02
0	0	60000	6	Primavera do Leste	11	Paranagua's Port	-71.21
0	0	60000	6	Primavera do Leste	12	Barcarena's Port	-119.90
250000	500000	500000	7	P. do Leste In	9	P. do Leste Out	-61.62
250000	500000	500000	8	L. do Rio Verde In	10	L. do Rio Verde Out	-55.46
0	500000	500000	9	P. do Leste Out	11	Paranagua's Port	1,151.53
0	0	500000	9	P. do Leste Out	12	Barcarena's Port	1,103.58
0	0	500000	10	L. do Rio Verde Out	11	Paranagua's Port	1,108.28
0	500000	500000	10	L. do Rio Verde Out	12	Barcarena's Port	1,127.89
						Total Profit (BRL)	64,703,000.00

Source: Microsoft Excel/Risk Solver (2018) and IMEA (2017)

The table below shows the flow of goods between regions, according to their availability:

Table 6.6 Scenario 2 Spreadsheet Part 2

Nodes	Location	Flow (tons)	Supply/Demand (tons)
1	Sorriso	-250000	-250000
2	Rondonopolis	-200000	-200000
3	Canarana	-100000	-100000
4	Campo Novo do Parecis	-50000	-50000
5	Lucas do Rio Verde	-200000	-200000
6	Primavera do Leste	-200000	-200000
7	Primavera Do Leste in	0	0
8	Lucas do Rio Verde In	0	0
9	Primavera Do Leste Out	0	0
10	Lucas do Rio Verde Out	0	0
11	Paranagua's Port	500000	500000
12	Barcarena's Port	500000	500000

Source: Microsoft Excel/Risk Solver (2018) and Original Research Data

The Scenario 2 indicates a profit of BRL 64,703,000.00, BRL 3.81 million higher than Scenario 1.

Considering the average currency rate for the period, the profit increased by approximately $1.23 million over Scenario 1, which indicates that Scenario 2 is a more favorable alternative to Scenario 1.

CHAPTER VII: CONCLUSION

The use of the Risk Solver tool made it possible to make changes to the origination strategy impacting the company's total profit in BRL 3.81 millions, only by modifying the 20% place of origin of the soybean demand by XYZ Corporation.

By examining two scenarios with real data of Mato Grosso, the board of directors of XYZ corporation now are able to understand how the logistic bottlenecks affect their operation and because of the long distances between origination and crushing facilities to the ports.

The research results express the current situation of new entrees in the Brazilian soybean crushing market and express the realities of companies that buy regular monthly input volumes to run operations. The high freight rates, availability of inputs, and price/basis pattern for the year are factors that can negatively affect the operation of XYZ Corporation.

The fastest strategy to be implemented was to find origination regions with availability of soybean and able to deliver the inputs to the plants at a reduced price. By maximizing the use of current assets, XYZ directors are able to choose the strategy that immediately improved the company's results.

The objective of this research was accomplished by using the Risk Solver Platform and the data base to add the necessary information to XYZ's decision makers, helping them to understand the market they are dealing with and reach better company performance in the short term.

The research and model proposed has some limitations such as the number of locations where XYZ originates soybean, tenor of the information (because the available information is from 2014 and it was not possible to collect information before this date). Other limitations are the limited source of basis at the ports, crushing costs and yields. Certainly, the models adopted by some of the XYZ's competitors is much more complete in terms of information available.

Other limitation is the "Shadow Price" interpretation due to the restricted volume of input accessed by XYZ. As the board of directors is working in this new operation this year, and the company is part of a conservative Asian Group, they will not increase the volume of origination before understanding the soybean crushing market.

CHAPTER VIII: FUTURE OPPORTUNITIES FOR XYZ

The next step is for the XYZ executives to develop an approach to examine the opportunities for the company related to the following opportunities:

- "Barter": supply fertilizer and chemical to the farmers and getting soybean as payment.

- Improve the soybean crusing yields;

- Upgrade the equipment and software technology on the plants;

- Labor: hire skilled people;

- Hedging strategies: such as "Board Crush", "Oil Share", use of options to protect XYZ's positions;

- Physical strategies: "Long Basis" and "Short Basis";

- Find new suppliers/origination regions: mainly to avoid the counterfreight;

- Multimodal Transportation: railroad and waterways;

- Biodiesel: to add value to the soybean oil;

- Domestic Market: attend the Brazilian market with past of XYZ's byproducts production.

Considering the vast array of opportunities mentioned above, the board of directors of XYZ can improve the current performance of the company, offer new products and services for its customers and expand the business making the company expand to other regions in the future.

WORKS CITED

BCB. 2017. *USDBRL.* 10 10. Accessed 10 10, 2017. http://www.bcb.gov.br/pt-br#!/busca/ptax.

Buranello, R. M. 2011. "Sistema Privado de Financiamento do Agronegocio." In *Sistema Privado de Financiamento do Agronegocio*, by Buranello R.M. Sao Paulo, SP: Quartier Latin do Brasil.

Camara, G.M.S. 2001. *Introducao ao Agronegocio da Soja.* Edited by Fealq. Vol. 2ed. Piracicaba, SP: Fealq.

CEPEA. 2016. *Centro de Estudos Avancados em Economia Aplicada.* CEPEA. Accessed 10 05, 2017. https://www.cepea.esalq.usp.br/br/indicador/soja.aspx.

ColumbiaBusinessSchool. 2018. Accessed 3 11, 2018. https://www8.gsb.columbia.edu/rtfiles/student_support/RSP-Install-Verify-20132.pdf.

CONAB. 2018. *Companhia Nacional de Abastecimento.* 03 13. Accessed 03 18, 2017. http://www.conab.gov.br/OlalaCMS/uploads/arquivos/18_03_13_14_15_33_grao_marco_2018.pdf.

Correa, V.H.P., and P Ramos. 2010. "A precariedade do transporte rodoviário brasileiro para o escoamento da produção de soja do centro-oeste: situação e perpectivas." 442-447.

2018. *Governo de Mato Grosso.* 02 04. Accessed 02 04, 2018. http://www.mt.gov.br/historia.

IBGE. 2017. *IBGE Cidades.* Accessed 02 04, 2018. https://cidades.ibge.gov.br/brasil/mt/panorama.

IMEA. 2018. Accessed 03 11, 2018. http://www.imea.com.br/imea-site/quem-somos.
—. 2017. "Agronegócio no Brasil e em Mato Grosso." Cuiaba, MT, 11 30.

Marques, P.V., P.C.de Mello, and F.J.G. Martines. 2006. *Mercados Futuros e de Opções.* Piracicaba, SP: Série Didática.

Masiero, LC. 2017. *oleos e gorduras.* Accessed 03 11, 2018. http://www.oleosegorduras.org.br/arquivos/sbog/objetivos/preparo-graos-soja-para-extracao.pdf.

Podestà, Inez De. 2017. *http://www.agricultura.gov.br/noticias/portos-do-arco-norte-ganham-importancia-no-escoamento-de-soja-e-milho-ao-exterior.* 08 17. Accessed 02 04, 2018. http://www.agricultura.gov.br/noticias/portos-do-arco-norte-ganham-importancia-no-escoamento-de-soja-e-milho-ao-exterior.

Ragsdale, Cliff T. 2016. "Spreadsheet Modeling & Decision Analysis - A Practical Introduction to Business Analytics." Chap. 5 in *Spreadsheet Modeling & Decision Analysis - A Practical Introduction to Business Analytics*, by Cliff T. Ragsdale, 187-222. Boston, MA: Cengage Learning. Accessed 03 11, 2018.

Scot, Consultoria. 2014. *Canal Rural.* 11 14. Accessed 10 05, 2017. http://www.canalrural.com.br/noticias/agricultura/agronegocio-responde-por-dos-empregos-brasil-diz-riedel-28382.

Silva, A.de 2012. 2012. *Análise da cadeia produtiva da soja de Sapezal/MT.* Thesis Agroscience, Curitiba, PR, Brazil: Universidade Federal do Paraná.

Solver. 2018. *Solver.* Accessed 02 11, 2018. https://www.solver.com/risk-solver%C2%AE-platform.

Sticca, Ralph Melles. 2008. "Tributação Nas Operações de Exportação e de Pré-pagamento á Exportação." In *Tributação Nas Operações de Exportação e de Pré-pagamento á Exportação*, by Ralph Melles Sticca. Piracicaba, SP. Accessed 09 01, 2017.

Teixeira, Gustavo Porto and Daniel. 2018. *Estadao.* 03 04. Accessed 03 04, 2018. http://economia.estadao.com.br/noticias/geral,na-rota-da-soja-caos-logistico-continua-mas-muda-de-lugar-em-2018,70002211859.

USDA. 2018. *USDA.* 03 08. Accessed 3 18, 2018. https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery.

Wikipedia. 2018. *Wikipedia.* 03 04. Accessed 03 04, 2018. https://en.wikipedia.org/wiki/Soybean.

APPENDIX A

SUMIF formulas

SUMIF Formulas
=SUMIF($F$5:$F$34;J5;$B$5:$B$34) - SUMIF($D$5:$D$34;J5;$B$5:$B$34)
=SUMIF($F$5:$F$34;J6;$B$5:$B$34) - SUMIF($D$5:$D$34;J6;$B$5:$B$34)
=SUMIF($F$5:$F$34;J7;$B$5:$B$34) - SUMIF($D$5:$D$34;J7;$B$5:$B$34)
=SUMIF($F$5:$F$34;J8;$B$5:$B$34) - SUMIF($D$5:$D$34;J8;$B$5:$B$34)
=SUMIF($F$5:$F$34;J9;$B$5:$B$34) - SUMIF($D$5:$D$34;J9;$B$5:$B$34)
=SUMIF($F$5:$F$34;J10;$B$5:$B$34) - SUMIF($D$5:$D$34;J10;$B$5:$B$34)
=SUMIF($F$5:$F$34;J11;$B$5:$B$34) - SUMIF($D$5:$D$34;J11;$B$5:$B$34)
=SUMIF($F$5:$F$34;J12;$B$5:$B$34) - SUMIF($D$5:$D$34;J12;$B$5:$B$34)
=SUMIF($F$5:$F$34;J13;$B$5:$B$34) - SUMIF($D$5:$D$34;J13;$B$5:$B$34)
=SUMIF($F$5:$F$34;J14;$B$5:$B$34) - SUMIF($D$5:$D$34;J14;$B$5:$B$34)
=SUMIF($F$5:$F$34;J15;$B$5:$B$34) - SUMIF($D$5:$D$34;J15;$B$5:$B$34)
=SUMIF($F$5:$F$34;J16;$B$5:$B$34) - SUMIF($D$5:$D$34;J16;$B$5:$B$34)

Source: Original Research Data