DECISION 611W – Decision Models
Fuqua School of Business
Term 3, 2015-2016

Grupo Nogueira
Prepare for Class 12
Saturday, February 20

You are to work in your teams on this case.

The goal of this assignment is for you to help Grupo Nogueira improve their sugar refining and molasses production operations.

Assignment: Build an optimization model using Solver to help you advise the Grupo Nogueira production planning team. What production plan do you recommend to them? What advice can you offer on the strategic questions (or on other issues) that Nogueira discusses at the end of the case?

Each team should prepare a 10-15-minute PowerPoint presentation for Class 12 that describes their analysis and recommendations. Write this presentation as if you were presenting to Arlete Nogueira. In each section, I will randomly select one or more teams to give their presentations to the class. I am looking for a correct and thoughtful analysis of the problem with recommendations supported by analysis.

Deliverables:

- Before class, each team should submit an electronic copy (using the Assignments link on Sakai) of both their presentation and their spreadsheet model(s). If there are comments you plan to make in your presentation but did not put in your slides, please include them in the presentation using the "Speaker notes" feature of Powerpoint and print the "Notes Pages." Please include the following in an appendix of your presentation:
  - A copy of your spreadsheet model
  - Copies of any Solver (or SolverTable) reports that support your analysis

  You should retain copies of these materials yourself as you may find them useful for the class discussion.

In grading, I will review your submitted work to examine the details of your model.

Note that there is a spreadsheet file on Sakai (under Class 12) that provides data for the case.

Grupo Nogueira[1]

Background. Brazil is considered to have the world's first sustainable biofuel economy, and its sugarcane-based ethanol is considered by many to be the most successful alternative fuel to date. Sugarcane has been cultivated in Brazil since the early colonial days, when sugar was exported to Europe by Portuguese and Dutch settlers. Although ethanol made from sugarcane was used sporadically as a fuel for automobiles during the 1920-30s, cheap gasoline became the preferred fuel in Brazil after World War II. After the oil crisis in the early 1970s led to widespread fuel shortages, the Brazilian government began promoting ethanol-from-sugarcane as a fuel source. Pure gasoline is no longer sold in Brazil; all light vehicles in Brazil now run either on a mix of gasoline and ethanol or entirely on ethanol.

The processing of sugarcane proceeds in several stages and produces several valuable products. Once harvested, the sugarcane is transported by truck to a plant for processing. The first stage of processing is milling: the sugarcane is washed, chopped, and shredded to produce cane juice and a fibrous residue called bagasse. The cane juice is refined to produce sugar crystals and molasses. The bagasse may be used as a fuel source to generate electricity (e.g., to run the mills) or to make animal feed or paper. The sugar crystals are further refined to produce various kinds of sugar, including table, powdered or brown sugar, as well as various syrups for use in the food industry. The molasses is distilled to produce ethanol. The production processes are integrated in some places, with one plant taking sugarcane as input and producing ethanol, sugar, and bagasse as products. In other places, the production process is distributed across several facilities – e.g., a mill converts the cane to cane juice and bagasse; a refinery converts the cane juice to molasses and sugar; and, finally, a distillery converts the molasses to ethanol.

Grupo Nogueira. Arlete Nogueira, a businesswoman in São Paulo, formed Grupo Nogueira (GN) in 2007. Nogueira was struck by how some sugarcane plantation owners complained about high transportation costs at a time when oil and ethanol prices hit all-time highs. These plantation owners were trucking sugarcane long distances to be processed at integrated processing facilities near the major cities. Even though the ethanol sold for high prices in the market, the plantation owners' profits were undercut by the high transportation costs. Nogueira thought she could start a profitable business that processed sugarcane at locations closer to these plantations.

After studying the capital requirements and transportation costs, Nogueira decided to build two plants that integrated the first two stages of the production process (milling and refining). GN would place these plants in two towns, Londrina and Franca. GN would buy sugarcane from nearby plantations and then mill it and refine it. GN would then ship the resulting molasses to distilleries closer to the major cities. The bagasse would be sold in local markets and the sugar would be sold separately for further processing by other companies. A milling and refining plant, like those in Londrina and Franca, is shown in Figure 1.

To raise money for the venture, Nogueira formed an alliance consisting of eight sugar plantations and seven distilleries. In exchange for the financial contributions towards the capital costs, GN agreed to buy

[1] This case was written by Bob Clemen, Jim Smith, and David Brown at the Fuqua School of Business, Duke University in 2009-10 and revised by Brown and Smith with assistance from Fernando Vargas in 2011, and revised again in 2015. The case is fictitious and some of the data is adapted from Harvard Business School case 189-040, "J.P. Molasses, Inc.," which is set in a different context.

all of the sugarcane produced at its partner plantations at specified prices and to deliver, at market prices, specified minimum quantities of molasses to the partner distilleries. In this arrangement, GN would pay the cost of transporting sugarcane to mills as well as the cost of transporting molasses to the distilleries. Thus, the success of GN relied not only on efficient operations at the plants, but also on its ability to transport the sugarcane and molasses efficiently.

Figure 1: A milling and refining plant. The receiving facility and mill are on the right and the refinery is on the left. (Photo by Mariordo, Obtained from Wikimedia commons.)

Production Planning. Production planning at GN is handled centrally and done on a monthly basis. The production planning team has to allocate the sugarcane from each of its upstream suppliers (the plantations) to one or both of its plants. It also has to allocate the molasses produced at each plant to the downstream customers (the distilleries). The team's goal is to maximize profits for GN, taking into account the various costs and revenue streams and meeting its obligations to deliver molasses to its downstream customers.

With the numerous constraints involved, it is difficult to compare alternative plans without tediously generating an entirely new plan. It should be possible, Nogueira believed, to develop a spreadsheet-based system to create and evaluate possible plans easily and quickly. Such a system would have to incorporate the physical attributes of the production processes, the transportation costs, the market prices for the various products, the available supplies of sugarcane, and the obligations to its partner distilleries.

The overall process diagram for GN is shown in Figure 2. First, due to various losses in transportation, only 97.3% (by weight) of the sugarcane purchased actually makes it to each plant and begins the milling and refining process. GN's two plants use different refining equipment and processes. The Londrina plant converts 35.4% of the sugarcane into molasses and 40.2% into sugar; the remainder (24.4%) is bagasse. The Franca plant converts 30.7% into molasses and 45.6% into sugar, with the remainder (23.7%) being bagasse. Though the Franca plant produces more sugar, the Londrina sugar is higher quality and commands a higher market price.

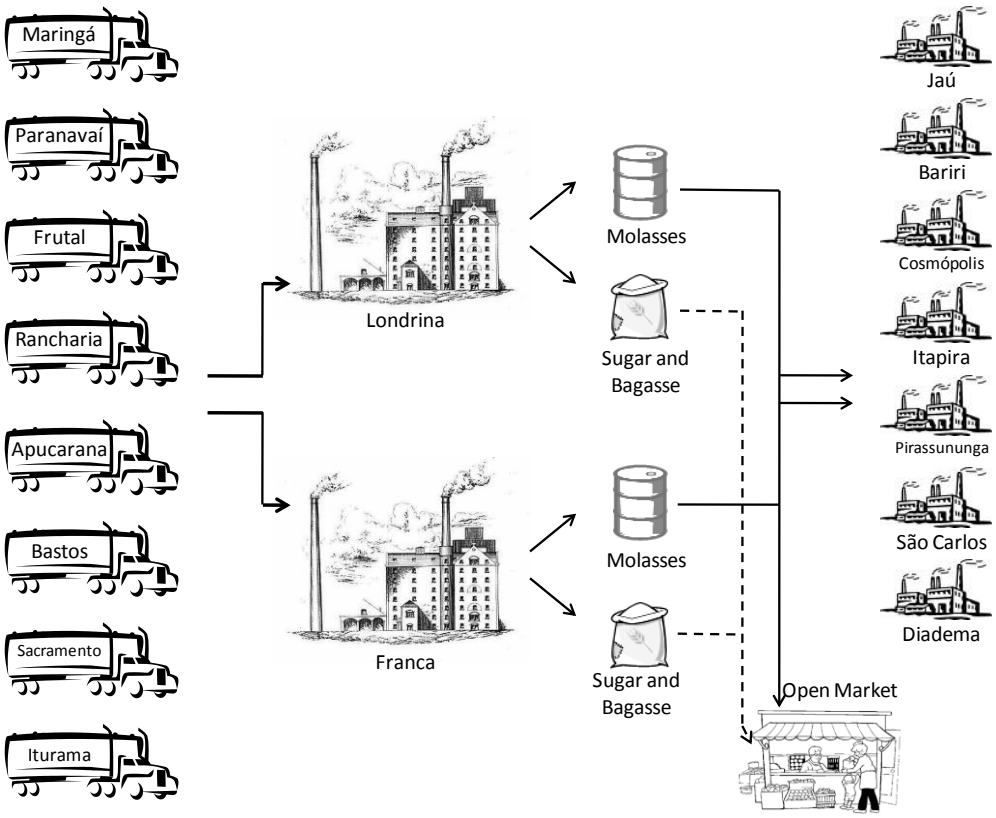

Figure 2: Process diagram for Grupo Nogueira

To work efficiently, both plants needed to operate between 50% and 100% of their respective capacities (8,030 metric tons per month in Londrina and 8,780 metric tons per month in Franca). Variable operating costs were R$31 per metric ton of sugarcane processed at Londrina and at R$38 per metric ton of sugarcane processed at Franca.[2] Fixed operating costs were R$10,000 per month at Londrina and R$14,200 per month at Franca. Limitations in the refining process at the Londrina plant restricted the production of sugar at this plant to a maximum of 2,000 metric tons per month. Sugar production at Franca was limited to 4,000 metric tons per month. These production data are summarized in Exhibit 1.

The quantities of sugarcane produced at GN's partner plantations for the current month are shown in Exhibit 2, along with the current cost of trucking from the plantation to GN's plants and the agreed upon purchase price for the sugarcane. These trucks run on diesel and the cost of diesel fuel accounts for approximately 55% of the freight costs for sugarcane.

The quantities of molasses required by each of the partner distilleries are shown in Exhibit 3, along with the current transportation costs. Many of the distilleries are willing to take additional molasses, beyond the agreed upon quantities. Finally, there is a possibility of "open market" sales of molasses to non-partner distilleries. Specifically, there are distilleries in Santa Bárbara d'Oeste and Araraquara that have no minimum purchase agreement with GN but are willing to purchase molasses from GN at the market price, up to the specified maximum. GN would be responsible for paying the transportation costs

[2] All costs are reported in Brazilian real, with currency symbol R$. The current exchange rate is approximately 0.25 U.S. Dollars per Brazilian Real.

associated with the delivery of molasses to these distilleries. The maximum quantity and transportation costs for these two distilleries are shown at the bottom of Exhibit 3. Diesel fuel costs are included in these transportation costs as well and currently account for approximately 45% of these costs.

The current market prices for molasses, sugar, and bagasse are shown in Exhibit 4. Purified sugar and bagasse are sold at these market prices "freight on board" (FOB), meaning the purchaser pays all freight costs associated with their transport. In contrast, GN must pay freight for all sales of molasses, including "open market" sales to its non-partner distilleries in Santa Bárbara d'Oeste and Araraquara. All of the distilleries would, however, pay the market price for the molasses they purchase.

Assignment. The first task is to develop a production plan for the current month. How should GN allocate sugarcane from its partner plantations to its plants? How should GN allocate the molasses from its plants to its partner distilleries?

In addition to helping GN develop a production plan for this and future months, Nogueira hoped that a spreadsheet-based planning tool could help her address some operational and strategic questions that she had been considering. The questions include the following:

- Nogueira wondered about the configuration of GN's plants: Could they be improved? For example, would it be profitable to increase capacity at either plant?

- Nogueira wondered how much more money GN could make by increasing its purchases of sugarcane. Specifically, she was contemplating approaching a large plantation near Dracena. The transportation cost (R$/t) from this plantation to the plants in Londrina and Franca are as follows:

	Londrina	Franca
Dracena	15.30	13.10

  How much should GN be willing to pay for sugarcane from this potential supplier?

- Though GN had long-term contracts to supply certain minimal quantities to their partner distilleries, it bothered Nogueira to be shipping molasses long distances at great expense to meet these requirements. How might they renegotiate some of these supply agreements to improve GN's profitability?

- Finally, Nogueira worried about GN's exposures to commodity price variations. Petróleo Brasileiro SA (Petrobras), Brazil's state-controlled oil company, currently sets the price of diesel fuel in Brazil. Despite plunging oil prices worldwide, Petrobras is considering increasing the price of diesel in an effort to generate cash to cover its massive debt. Although such a move would increase GN's transportation costs, higher diesel prices would allow ethanol producers to raise their prices, thereby increasing the price of molasses as well. Changes in the prices of sugar and bagasse are relevant to GN as well: these prices are much less tied to fuel costs than molasses, but could fluctuate substantially. How would changes in fuel costs and commodity prices affect GN's profitability and production plans?

Exhibit 1: PRODUCTION DATA

	Londrina	Franca
Physical yield loss *(% of sugarcane purchased)* *Supplier-to-factory transport losses*	2.7%	2.7%
Actual recovery rates *(% of sugarcane delivered)*		
Molasses	35.4%	30.7%
Sugar	40.2%	45.6%
Production costs		
Variable *(R$/t of sugarcane)*	31	38
Fixed *(R$ per month)*	10,000	14,200
Production constraints *(t/month)*		
Sugarcane processing	8,030	8,780
Refined sugar	2,000	4,000
Operating range *(% of capacity)*		
Min	50%	50%
Max	100%	100%

Exhibit 2: SUPPLIER DATA

Supplier	Available Quantity (t/month)	Price (R$/t)	Cost of Freight to Londrina (R$/t)	Cost of Freight to Franca (R$/t)
Maringá	1,000	25.20	5.00	11.60
Paranavaí	1,583	24.50	5.00	13.70
Frutal	2,140	25.50	19.60	11.50
Rancharia	1,370	23.30	4.00	10.60
Apucarana	2,000	24.20	4.20	12.10
Bastos	1,850	23.30	7.65	11.00
Sacramento	1,260	23.30	14.70	4.80
Iturama	1,700	24.20	16.30	10.30

t = metric ton = 1000 kg

Exhibit 3: CUSTOMER DATA

Distillery	Guaranteed Quantity (t/month)	Maximum Capacity (t/month)	Cost of Freight from Londrina (R$/t)	Cost of Freight from Franca (R$/t)
Jaú	480	900	26.00	30.10
Bariri	850	1150	51.70	31.70
Cosmópolis	640	800	16.60	7.30
Itapira	575	775	16.20	21.50
Pirassununga	970	970	24.50	13.20
São Carlos	107	200	26.30	28.00
Diadema	80	400	21.30	46.20
Santa Bárbara d'Oeste	0	310	15.30	28.40
Araraquara	0	470	24.30	14.70

Exhibit 4: MARKET PRICES

Commodity	Price (R$/t)
Londrina sugar	200
Franca sugar	150
Molasses	36
Bagasse	25