# Optimal Trading and Shipping of Agricultural Commodities

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*"We develop and implement a model for a profit maximizing firm that provides an intermediation service between commodity producers and commodity end-users. We are motivated by the grain intermediation business at Los Grobo — one of the largest commodity-trading firms in South America. Producers and end-users are distributed over a realistic spatial network and trade with the firm through contracts for delivery of grain during the marketing season.*

*The firm owns spatially distributed storage facilities, and begins the marketing season with a portfolio of prearranged purchase and sale contracts with upstream and downstream counterparts. The firm aims to maximize profits while satisfying all previous commitments, possibly through the execution of new transactions. Under realistic constraints for capacities, network structure and shipping costs, we identify the optimal trading, storing and shipping policy for the firm as the solution of a profit-maximizing optimization problem, encoded as a minimum cost flow problem in a time-expanded network that captures both geography and time. We perform extensive numerical examples and show significant efficiency gains derived from the joint planning of logistics and trading."*

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## Introduction

The authors describe the "study [of] the interface between grain trading and logistics" in the business activities of Grupo Los Grobo, "a large agricultural commodity firm in South America." They "develop and implement an optimization model for a commodity-trading firm that purchases a bulk commodity over time in different geographic locations and sells it to downstream users also in different geographic locations," summarize the paper's authors.

Logistical planning is key in Argentina's soybean businesses. "Domestically-produced soybeans and its byproducts, such as soybean meal and soybean oil, are produced almost exclusively for the international markets and exported mainly to Europe and Asia. … [T]he agribusiness logistic chain requires transporting grain from geographically distributed farms to ports or crushing mills with up to 600 km of transportation by land," explain the researchers. "Moreover, if the end points of the chain are saturated or if purchase and sale contracts differ in their timing, grains can be stored at the source using silobags, at a storage facility, or at the port," add the authors. Essentially, Grupo Los Grobo "provides an intermediation service between inland farmers and waterfront-based exporters, mills and crushing

factories," sum up the researchers. In practice, continue the authors, this firm "faces a logistical and a financial problem, as it must ship grains across space and time in the most efficient manner and it must sign new contracts to make the whole plan feasible."

The main point of the paper is to advocate that a commodity trading firm's trading and logistics should be coordinated under a single framework that maximizes the overall profitability of the firm. They propose that a firm should do so via a linear programming framework. They specifically provide a case study on how such a framework could have increased the profit margin of their example company during a past marketing season in Argentina. A linear programming problem, in turn, "consists of a linear function to be maximized or minimized subject to certain constraints in the form of linear equations or inequalities," explains Kahlig (2014).

**Why the Paper's Research Question is Important**

The authors point out that Argentinian grain intermediation firms likely do not yet have "computerized systems that can value the[ir] commercial position at any given point in time while simultaneously considering the logistics." Their paper assists Argentinian trading firms in making the case for such systems, which would thereby potentially increase the profitability of their business operations. Given the low profit margins of Argentinian grain intermediaries, such a development could be expected to be a welcome innovation for these firms.

**Data Description**

The paper's data is sourced from the business operations of Grupo Los Grobo. The authors note that this company trades "over a million tonnes of grain per year. The firm trades dynamically over a marketing season and executes its logistics by hiring haulage services and utilizing a proprietary network of storage facilities over the growing season." The authors' case study is based on the soybean marketing season of March-to-August 2012. In addition, the authors "geocoded all relevant locations and computed distances … between any two locations using actual roads and a GIS system. Distances were converted into transportations costs using … a widely accepted price list published by the trucking industry of Argentina."

**Description of Investigation**

Fundamentally, the main tasks of the article are two-fold, as noted below.

(1) The authors initially specify the trading firm's profit equation, which is to be maximized, along with identifying numerous realistic constraints. These constraints include the relevant limitations during the buying, financing, selling, drying, storing, processing, and transporting and shipping of soybeans in Argentina.

(2) The authors then solve this problem using linear programming.

Five further clarifications and conditions are that:

(1) The buying and selling of soybeans can be done in the spot market and also through forward contracts (including contracts in which the price determination occurs during a future timeframe);

(2) Each cash flow needs to be discounted at the proper interest rate, which matches up to the timing of a particular cash payment or receipt;

(3) In order to be feasible, the firm will need to sign (purchase and sale) contracts in addition to the ones that already exist;

(4) The authors choose to limit the allowable number of additional contracts in order to preserve the model's realism; and

(5) The model assumes that there is no chance of failure in all contractual matters.

**Results**

The paper solves for the "globally optimal logistical and financial solution" for Los Grobo's soybean intermediation business of 2012. Their model's solution specifically includes "the detailed routing of trucks in space and time [and] the precise nature of new transactions that the sales force should aim to achieve," write the researchers.

Table 1 on the next page compares the optimal solution versus a representation of the firm's actual decision-making. The table shows the aggregated transactions and fees, as well as the physical volumes, across time for both solutions. The optimal solution could have improved the firm's profit by 4.56%.

"ARS means Argentinean Pesos. In the second half of 2013, one Argentine peso was roughly equivalent to 0.20 US dollars," according to the research paper.

Given how variable Argentinian interest rates are, the optimal solution will change depending on the model's particular interest-rate assumptions.

**Table 1**
**Comparison of Model's Optimal Solution versus**
**A Model of Los Grobo's In-House Solution (Based on "Heuristics")**

| Transactions (in ARS) | Heuristics | Model | % Change |
|---|---|---|---|
| Prearranged purchases | -833,670,645 | -833,670,646 | 0.00% |
| Forward purchases at origins | -107,194,906 | -23,907,818 | -77.70% |
| Spot purchases at destinations | 0 | -75,932,792 | N/A |
| Prearranged sales | 610,429,550 | 610,429,550 | 0.00% |
| Forward and spot sales at destinations | 408,964,582 | 397,361,351 | -2.84% |
| Storage costs at origins and destinations | -6,262,070 | -6,068,385 | -3.09% |
| Loading costs at processing plants | 24,557 | 42,444 | 72.84% |
| Storage costs at processing plants | -1,237,561 | -1,194,399 | -3.49% |
| Processing costs | 84,888 | 84,888 | 0.00% |
| Shipping fees paid by farmers | 81,950,287 | 81,950,288 | 0.00% |
| Real shipping fees | -85,957,382 | -78,900,226 | -8.21% |
| **Profit** | **67,131,302** | **70,194,256** | **4.56%** |
| **Total sales** | **1,019,394,132** | **1,007,790,901** | **-1.14%** |
| **Profit/Total sales** | **6.59%** | **6.97%** | **5.76%** |
| **Tonnage** | **Heuristics** | **Model** | **% Change** |
| Prearranged purchases | 506,719 | 506,719 | 0.00% |
| Forward purchases at origins | 65,969 | 15,211 | -76.94% |
| Spot purchases at destinations | 0 | 43,423 | N/A |
| Prearranged sales | 371,712 | 371,712 | 0.00% |
| Forward and spot sales at destinations | 200,035 | 192,700 | -3.67% |

Source: Table 4 of research paper.

## Conclusion

The paper applies a linear-programming approach to solving for the best logistics-and-trading solution for the business operations of a large Argentinian grain trader during a particular marketing season. This solution could have improved the firm's profitability by an economically significant margin. This result suggests that comparable firms should strongly consider investing in the implementation of such models for their firms. In addition, one would expect that the paper's methodology would also be applicable to large firms in other geographic locations, which are similarly involved in the trading and shipping of grain. That said, one would need to await further case studies to understand what the economic impact would be for such modeling in other geographic locations such as in North America.

## Reference

Kahlig, J., 2014, "Math 141: Business Mathematics," Lecture Notes, Texas A&M University, Summer. Retrieved from http://www.math.tamu.edu/~joe.kahlig/notes/141/ch03-2.pdf on December 30, 2015.

## Keywords

Agriculture, commodities, logistics, finance, network flow problems