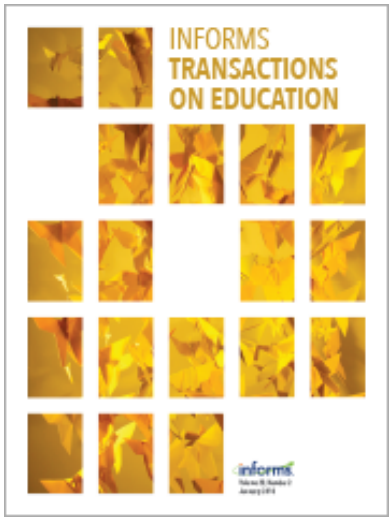

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Case Article

Optimal Movement Plan of Rice in the State of Andhra Pradesh

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Abstract. The case discusses an optimal movement plan for food grains (rice) by a state sponsored agency, the Food Corporation of India (FCI) in the State of Andhra Pradesh in India. There are five resource locations and eleven demand locations in this distribution network. Resource capacity and demand requirement for the three product (rice) variants at each location are known. There is no storage capacity restriction either in the demand or source location. Information related to rail network, its connectivity, distance in kilometers between origin-destination pairs, cost of transportation per tonne of food grain by rail or road are known. The primary issue is to develop a monthly movement plan to minimize the overall transportation costs subject to meeting the demand-supply restrictions. The total supply available for distribution and the total requirement at various locations are both equal at the product variant and aggregate level. The secondary issue is to develop an alternative movement plan to fulfil the demand requirements at a location, Karimnagar, which does not have a direct rail connection. Few plans are proposed to resolve the issues; the case encourages analysis of the problem situation and evaluation of the alternate resolution plans.

Supplemental Material: The teaching note is available at https://www.informs.org/Publications/Subscribe/Access-Restricted-Materials.

Keywords: multi-commodity movement • transportation model

1. Introduction

Our motivation to write this case is to develop an academic material that can be used for teaching operations research modeling. Furthermore, this case (and supplementary files) aims at sharing a real-life problem as well as contextual challenges and an approach or solution procedure to address these challenges.

As business school instructors, we rely heavily on a case based pedagogy. Our preference is to select cases from real-life situations that can be used to provide higher learning potential to a varied audience. The availability of real-life cases that can be used to demonstrate OR modeling in a class-room setting is limited. Many course instructors resort to teach OR approaches using toy problems that are grossly simplified versions of practice situations. Needless to emphasize, real-life problems are complex and pose several challenges in modeling. Problems that are faced by practitioners do not always lend themselves to elegant modeling that can be used in a classroom environment. The OR community instructors' objective in a course is mainly to discuss fundamental theoretical concepts with occasional sprinkling of problems drawn from real life situations or practice. Consequently, the emphasis on application aspects of OR tools and techniques is at best modest. Often business schools and universities resort to an internship approach to students so that they can learn from real-life experience in applying OR techniques.

Abundant published material is available to support the delivery of OR courses. The present case is designed to illustrate the power of a standard transportation model to analyse/resolve a practical situation. The case neither is an extension of literature in transportation nor fills a gap in the existing literature. Therefore, no attempt is made here to provide a set of complementary published research articles. However, we find that the case study by Drake et al. (2011) is somewhat related to the present work. Drake et al. (2011) present a distribution model of office stationery in Pennsylvania region. They present the problem context, decision challenges, distribution network design choices and ethical issues in logistics operations. To support the discussion of this case study, a representative set of textbooks is listed at the end of this article. Modeling and representation of managerial challenges in mathematical formulations are discussed in Dorfman (1953). The classic text by Hillier and Lieberman (2001) provides an optimal

blend of theoretical rigor, conceptual clarity with adequate examples. The text by Taha (2010) is well-known for its academic rigor. The text by Wagner (1976) is popular for its bias towards practice. Teaching of OR can be made more relevant by liberal use of practice oriented cases. Interpretation of mathematical modeling parameters and results in the managerial context is discussed in Rubin and Wagner (1990).

This case on Food Corporation of India (FCI) was developed keeping this pedagogical need in mind. We believe that this case can be used to deliver a primary lesson on transportation modeling, the tools and techniques that can be used in solving a transportation problem, an approach to model managerial challenges in practice and to draw useful inferences and insights from the solutions. The thrust of the case is to communicate fundamental modeling approaches by using the transportation formulation. The case does not envisage discussion of any contemporary, state-of-art material either from a theoretical perspective or practice orientation. Accordingly, the case is prepared to communicate fundamental aspects of transportation modeling and not to satisfy a unique need in the literature related to mathematical formulation of real-life situations. Accordingly, we have referenced classic articles and textbooks which can be used by the instructors to enrich the class delivery and discussion.

This case can be useful in teaching operations research (OR) or operations management (OM) courses at the graduate, MBA and Executive MBA students.

2. Brief Description of the Case

Food Corporation of India (FCI) was created by the Government of India to enable food security. FCI operations are performed through a set of storage locations (warehouses, depots) and a transportation network. Food grains are transported to demand locations from sourcing locations by rail or road. This case deals with the managerial challenges faced by FCI in an Indian state (Andhra Pradesh) in developing an optimal movement plan of food grain rice. An optimal movement plan requires meeting all quantity requirements at demand locations, maximizing utilization of stock available at resource locations and minimizing the total transportation cost.

In this case context, FCI deals with three variants of rice, to be distributed to ten demand locations from five resource locations. Most of the FCI movements are through railways; on a need basis, road transportation is also resorted to. One of the demand locations does not have a rail link. The demand at this location can be fulfilled by road or a combination of rail and road as a transhipment. We discuss the problem context, different modeling approaches in developing the movement plan and the cost implications.

3. Pedagogical Objectives

The major pedagogical objectives of the case in a classroom setting are the following:

1. Introduction to the transportation model as an OR tool (movement planning between multiple source and demand locations in a cost efficient manner) and its extensions;
2. Approaches to modeling challenges that are faced in real-life situations;
3. Structuring real-life challenges with an emphasis on heuristics and intuition;
4. Demonstrate the need to balance technically correct solutions and implementation challenges;
5. Exposure to standard optimisation software.

4. Classroom Experience

We have discussed the case with a diverse set of audiences. In all the occasions we accomplished multiple teaching objectives. Based on our experience, the teaching approach should be influenced by the participants' profile, learning objectives and the time available for discussion. Some illustrative situations are described.

Participants Profile:

A1: Practice oriented, modest exposure to OR tools and techniques, reasonable familiarity in using standard OR packages.

A2: Modest work experience, limited exposure to OR tools and techniques, moderate to high familiarity in using standard OR packages.

A3: Modest work experience, highly skilled in OR tools and techniques, high familiarity in using standard OR packages.

Teaching Objectives:

T1: To provide a comprehensive introduction to the transportation model as an OR technique.

T2: To demonstrate the power of OR modeling in resolving real life managerial/administrative situations.

T3: To develop an appreciation of the usefulness and limitations of formal procedures in resolving real life situations.

The class strategy and discussion duration should be dependent on the participants' profile (A1, A2 and A3) and teaching objectives (T1, T2 and T3). We illustrate a few possibilities.

A1 plus T3: Give the case and background reading material on transportation model prior to the class. Discussion should focus less on theory, technicalities. Use a set of power-point slides summarising the conclusions and insights presented in the case analysis section. Suggested duration: three hours.

A2 plus T1: Give the case and background reading material on transportation model prior to the class. Discussion can be scheduled in two meetings each of 90 minutes duration. In the first meeting, discuss the

base case, formulate the problem and solve it. Handover the set of assignment questions for discussion in the second meeting. The second meeting should focus on multiple modeling approaches, assumptions involved and technicalities of the solutions proposed. Encourage use of software in finding appropriate solutions. Give complete solutions during the class to help participants develop insights and appreciate them. Model extensions may be attempted depending on the dynamics of the class.

A3 plus T2: Give the case, background reading material on transportation model and assignment questions prior to the class. After a brief period (2 weeks) schedule a class discussion. Seek solutions to the assignment from the participants before the class begins. Since the participants are completely familiar with the problem context and they have also made an attempt to respond to the previously assigned questions, discussions can be extensive, exhaustive and technical. Draw insights during the discussion from the solutions submitted. Suggested duration: three hours.

A1 plus T3: Give the case, background reading material on transportation model, assignment questions and solutions as power-point slides prior to the class. Class discussion should focus on problem context, complexities, solution approaches, insights based on the solutions and managerial challenges of implementation. Suggested duration: three hours.

The case has been discussed multiple times with different types of audience. The case is well received and much appreciated for the learning opportunity (to formulate an optimization model) it provides in the context of resolving a real-life situation. The challenges faced by the participants or the students can be classified as follows:

1. Formulation of a single balanced transportation model for all three varieties.

2. Formulation of a stand-alone transportation model for different varieties of food grains.

3. To optimize the rail transportation costs, assuming Karimnagar will be supplied by Krishna by road.

4. To develop a movement plan to supply Karimnagar by road, exploiting locational advantage of demand—supply quantity pertaining to coarse variety of rice.

5. To develop a heuristic to supply Karimnagar by road from various railheads.

6. A comprehensive (generic) model that combines the road and rail transportation cost between the origin—destination pairs.

7. To recognize the inappropriate (even though technically correct) linear programming formulation.

The MBA students usually are able to recognize (1) and (7) without any additional help. Usually it is an eye-opener for them to recognize (2). After a brief discussion in the next meeting, most of the students accomplish (3) and (4). It required significant amount of discussions to help them to see the relevance of (5). Considerable discussions are needed to help students appreciate (6).

When the audience are from the Executive MBA program, invariably they lack the skills and ability to formulate the situations (1) to (7) on their own. However, they recognize the operational challenge on hand. When the results for various formulations are presented to them with appropriate intuitive explanation, they are able to appreciate the power and usefulness of formal methods.

We have taught this case several times to the MBA and Executive MBA participants. It is desirable to distribute the case prior to the class, along with or without a set of suggested questions. By adopting some flexibility in the course delivery we have been able to accomplish the pedagogical objectives of the case for both audiences. The challenges to be addressed are as follows:

1. Formulation of a balanced transportation problem (aggregate quantity) to minimize the overall transportation cost, under the assumption that Krishna supplies Karimnagar.

2. Formulation of three different balanced transportation problems at the disaggregate level (superfine, fine, coarse) and recognize that the operational difficulty (no rail connection to Karimnagar) pertains only to coarse variety.

3. Develop a myopic approach, under which Karimnagar will get its allocation from the nearest railhead by road (greedy approach) and minimize the rail transportation cost of the revised quantity of coarse variety.

4. Develop an appropriate source to supply Karimnagar taking locational advantage of the demand-supply quantities of coarse variety.

5. Formulate and solve a transportation problem where the least cost (rail-road combination, wherever applicable) for every pair of origin—destination for coarse variety is used.

6. Usage of standard software package to obtain optimal solutions in (1) to (5).

7. Interpret the dual variables associated with the optimal solutions obtained in (1) to (5).

Our experience is the MBA audience accomplishes 1, 6 and 7 on their own. However, the Executive MBA audience would need hand-holding for 1 and 6. The interpretations related to 7 are very steep for this audience and usually requires detailed conversation.

The students are seldom able to accomplish 2. There is a greater appreciation by the students, once the instructor is able to argue 2. The MBA audience with limited prodding would accomplish 3. Developing the greedy approach in 4 would require detailed discussion both at the MBA and executive segments. Context discussed in item 5 can be accomplished with significant technical support from the instructor.

With a limited conversation the MBA audience can be helped to formulate, solve and interpret the solutions. Our experience with the executive MBA audience is that they are comfortable in discussing solutions developed in 2 to 5 from a practitioner's perspective. Expecting them to formulate the problem and solve it may not be a pedagogically desirable strategy.

5. Conclusion

The case is amenable for a range of pedagogical approaches such as (a) lecture based sessions, (b) assignments before the class and discussion during the class (c) engaging discussion oriented session and (d) brief overview of the context and solution approach.

The case provides a rich context to appreciate the nuances of a transportation model, poses some real life challenges (in movement planning), and provides an opportunity to develop an approach in resolving them. Every discussion opportunity may not emphasize all these themes equally. Depending on the maturity of the audience, the instructor may judiciously choose a combination of these themes.

Acknowledgments

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