Judges' Commentary: The Frank Giordano Award for 2013

Marie Vanisko
Dept. of Mathematics, Engineering, and Computer Science
Carroll College
Helena, MT 59625
mvanisko@carroll.edu

Richard D. West
Mathematics Dept.
Francis Marion University
Florence, SC 29501
rwest@fmarion.edu

Introduction

The Frank Giordano Award goes to a paper that demonstrates a very good example of the modeling process.

Having worked on the contest since its inception, Frank Giordano served as Contest Director for 20 years. As Frank says,

> It was my pleasure to work with talented and dedicated professionals to provide opportunities for students to realize their mathematical creativity and whet their appetites to learn additional mathematics. The enormous amount of positive feedback I have received from participants and faculty over the years indicates that the contest has made a huge impact on the lives of students and faculty, and also has had an impact on the mathematics curriculum and supporting laboratories worldwide. Thanks to all who have made this a rewarding and pleasant experience!

The Frank Giordano Award for 2013 goes to a team from Colorado College in Colorado Springs, CO. This solution paper, designated as Outstanding, is characterized by a high-quality application of the complete modeling process, including assumptions with clear justifications, a well-defined simulation, a case study, and sensitivity analysis. The paper showed originality

The UMAP Journal 34 (2–3) (2013) 197–200.

and creativity in the modeling effort to solve the problem as given and was written clearly and concisely, making it a pleasure to read.

The Problem Statement

Fresh water is the limiting constraint for development in much of the world. Build a mathematical model for determining an effective, feasible, and cost-efficient water strategy for 2013 to meet the projected water needs of [pick one country from the list below] in 2025, and identify the best water strategy. In particular, your mathematical model must address storage and movement, desalinization, and conservation. If possible, use your model to discuss the economic, physical, and environmental implications of your strategy. Provide a non-technical position paper to governmental leadership outlining your approach, its feasibility and costs, and why it is the "best water strategy choice."

The choice of countries was from the United States, China, Russia, Egypt, or Saudi Arabia.

The Colorado College team chose Saudi Arabia, and this dramatically impacted their modeling approaches. Their focus was on cost minimizing and production maximizing.

The Colorado College Paper

Executive Summary Sheet and Position Paper

This summary was well written and gave the reader a good idea of what to expect. It contained the appropriate specifics with regard to issues and was both concise and thorough. The team's position paper, written in an appropriate nontechnical manner, was longer than expected, but served as a true position paper, giving the government precise instructions and rationale.

Assumptions

After introducing each of three models used, specific assumptions were stated. For the most part, assumptions were reasonable. One assumption made in modeling the distribution problem was that the topography of Saudi Arabia is a plain two-dimensional surface. This was a common assumption made in the vast majority of submitted papers. Although the country has mountains, the assumption of flatness was probably less inappropriate for Saudi Arabia than for the other countries considered. Additionally, the team did recognize the impact of this assumption in their section on strengths and weaknesses of the model.

The Models and Methods

Considering Saudi Arabia's extensive coastline, the team began with a model for maximizing water production in desalination plants. After doing a review of the problem in general, of Saudi Arabia's efforts in this regard, and of previous attempts to model desalinated water production, they extended the Cobb-Douglas model to apply to reverse-osmosis plant production. They maximized the volume of water desalinated, subject to limitations on input factors and on the amount of electrical energy used. For their second model, the team minimized distribution costs of the water in attempting to serve the needs of agriculture, industry, and households. Whereas most teams created models to estimate future demand for water, this team relied on published studies about Saudi Arabia to estimate future needs. Although this technique was less sophisticated than most, for Saudi Arabia it seemed adequate. In minimizing distribution costs, they distinguished between the fixed costs associated with the pipes themselves and the laying of the pipes and the variable costs associated with pumping the water. Selected parameters were estimated using empirical studies in water distribution systems in the United States.

The third model focused on the maximization of production in wastewater treatment plants and once again used the Cobb-Douglas model. The team maximized the production level subject to constraints on the costs of electricity and other factors of production. The model would have been better if they had given additional rationale for the values used and expanded on factors associated with production.

Testing the Models

After determining the maximum amount of desalted water that could be produced each year, subject to limits on input factors and the amount of electrical energy used, the team tested the robustness of the result by doing sensitivity analysis, altering their inputs. To simulate the distribution of water, the team used consumption figures of the three main sectors: agriculture, industries, and households. They used hypothetical distances and did sensitivity analysis to validate that their model was not very sensitive to pipeline length and water consumption. The model would have been stronger if actual distances had been used. Due to a lack of specifics on the input information regarding other factors in wastewater treatment plants, such as labor, chemicals, and utilities, they were unable to properly estimate the power parameters in the Cobb Douglas model. They did demonstrate the impact of the government budget on production.

Recognizing Limitations of the Model

After each of the three models was presented and results demonstrated with sensitivity analysis, there was an analysis of the strengths and weaknesses of each model. They recognized limitations due to assumptions made and incomplete information available. The team also recognized the strengths of Saudi Arabia with regard to what the country has to offer in terms of natural resources and what they are presently doing regarding desalination.

References and Bibliography

The list of references was fairly thorough, and it was very good to see specific documentation of where those references were used in the paper.

Conclusion

The careful exposition in the development of the mathematical model made this paper one that the judges felt was worthy of the Outstanding designation. The team is to be congratulated on their analysis, their clarity, and using the mathematics that they knew to create and justify their own model for planning for the water needs of Saudi Arabia in the year 2025.

About the Authors

Rich West is a Mathematics Professor Emeritus from Francis Marion University in Florence, South Carolina, where he taught for 12 years. Prior to his time at Francis Marion, he served in the U.S. Army for 30 years, 14 of which were spent teaching at the U.S. Military Academy. He is currently working on a National Science Foundation Grant on freshman placement tests. He also serves as a Reading Consultant for AP Calculus and as a developmental editor for CLEP (College Level Equivalency Program) Calculus Exam. He has judged for both the MCM® and HiMCM® for over 10 years.

Marie Vanisko is a Mathematics Professor Emerita from Carroll College in Helena, Montana, where she taught for more than 30 years. She was also a Visiting Professor at the U.S. Military Academy at West Point and taught for five years at California State University, Stanislaus. She chairs the Board of Directors at the Montana Learning Center on Canyon Ferry Lake and serves on the Engineering Advisory Board at Carroll College. She has been a judge for the MCM for 18 years and for the HiMCM for 9 years.