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TEACHING MARKETING SCIENCE WITH SENSITIVITY ANALYSIS

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ABSTRACT

In the workplace, marketing managers routinely deal with decision making. The application of Marketing Science to business decision making requires critical thinking in the form of sensitivity analysis to avoid bad outcomes. This paper deals with building quantitative analysis models that must be tested with sensitivity analysis. Two examples, one an advertising mix decision and a second a price and quality tradeoff decision. These examples are offered as illustrations of applying critical thinking thorough sensitivity analysis to make good marketing decisions.

BACKGROUND

In his book, *The Nature of Managerial Work* (1973) which summarized naturalistic observations of managers actually at work, Henry Mintzberg wrote that, regardless of their role, business managers in the work place deal with people, information, and decisions. The Association to Advance Collegiate Schools of Business (AACSB) has provided a white paper on learning standards for business students (2007). These standards include four learning goals and corresponding objectives. The first, third, and fourth goals deal with people issues surrounding ethics, communication, and a global perspective.

The second goal deals with information and decisions which are the subjects of this paper. The second goal and its objectives are as follows:

“Learning Goal: Our graduates will demonstrate problem solving skills, supported by appropriate analytical and quantitative techniques.”

Although many people associate this learning goal with production and operations management or logistics content areas, it also directly relates to marketing and marketing research. The American Marketing Association website defines Marketing and Marketing Research as follows:

“The following definitions were approved by the American Marketing Association Board of Directors:

Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large. (Approved October 2007)

Marketing research is the function that links the consumer, customer, and public to the marketer through information--information used to identify and define marketing opportunities and problems; generate, refine, and evaluate marketing actions; monitor marketing performance; and improve understanding of marketing as a process. Marketing research specifies the information required to address these issues, designs the method for collecting information, manages and implements the data collection process, analyzes the results, and communicates the findings and their implications. (Approved October 2004)”

Many times, ‘problem solving’ and ‘critical thinking’ are combined in the student learning outcomes defined in a Marketing degree program. The topic of critical thinking is so important that the AACSB is offering a workshop on Curriculum Development for Critical Thinking on February 25, 2013, in Tampa, Florida, USA. In the description of this workshop it says,

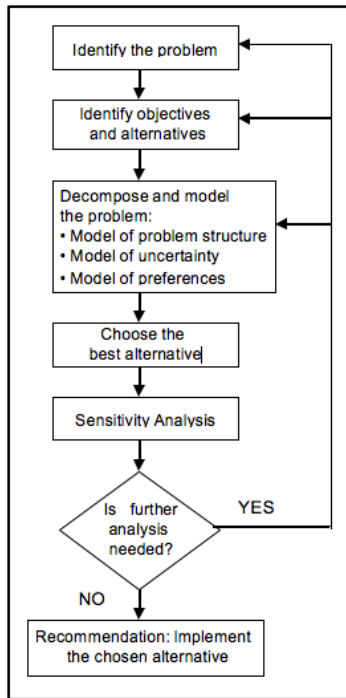
“During this seminar, attendees will develop a new approach to teaching critical thinking for business students and how to implement critical thinking throughout an entire program. Courses are and will be designed to include problem solving and critical thinking in what is broadly defined as Management Science.”

Since John Dewey (1910), critical thinking has been defined in many ways, but is clearly directed at problem solving (Wollcott and Lynch, 2001). There is even a journal published by the Institute for Operations Research and the Management Sciences for professionals in such a discipline. The Institute’s Marketing Science journal defines itself as follows:

“Although our primary focus is on articles that answer important research questions in marketing using mathematical modeling, we also consider publishing many other different types of manuscripts. These manuscripts include empirical papers reporting significant findings (but without any specific contribution to modeling), papers describing applications (emphasizing implementation issues), behaviorally oriented papers that contribute (theoretically or empirically) to the understanding of and/or lead to the development of mathematical models, and scholarly papers reporting developments (in fundamental disciplines) of interest to marketing (see <http://mktsci.pubs.informs.org/> for more).”

Finally, there are specialized degrees for marketing science and its cousins predictive analytics from universities such as Rutgers (PhD) and Northwestern (MS), or certificates in business intelligence (a.k.a., data mining) from universities such as Villanova (Master Certificate) or Stanford (Professional Development Certificates).

This widespread approach to problem solving and critical thinking using marketing and research data suggests that any business curriculum following the AACSB standards should include a



course in business decision-making that focuses on the process of reaching a decision using a framework similar to the one developed by Clemen (1996) illustrated in the diagram to the left. Many business curricula include a “decision-making” course with a title similar to Decision Analysis, Quantitative Analysis, or Problem Modeling. Usually, these courses use a “management science” textbook that introduces the decision-making process in the beginning chapters and then focuses on mathematical modeling of business problems using linear programming, integer programming, or other applications. There is a trend in textbooks in this field to include ‘analysis tools’ like the ‘Decisions Tools Suite’ offered by Pallisades Corporation who describes themselves as makers of Risk and Decision Analysis Software. One popular version is the monte carlo simulation @Risk used as an addin with Microsoft Excel.

In the decision-making course at Coastal Carolina University, mathematical modeling, in particular, linear programming, is an important component not only as a mathematical problem modeling technique, but more importantly, as a clear application of the decision-making process. The narrative of linear programming includes direct references to the decision-making framework.

To illustrate problem solving using Clemen’s approach, the first is step to identify the problem. A common example is a simple product mix decision with two products. The objective is to maximize profit subject to several constraints related to limited production time, raw materials, and relative product mix requirements. The decision process is often illustrated using the narrative of linear programming with a graph. To identify objectives and alternatives, a two-dimensional graph is used to illustrate the set of feasible solutions by graphing the constraints. The objective function is then graphed and used to explain how it interacts with the set of alternatives to find an optimal solution. The graphical illustration of the problem is then transformed into a mathematical model. Based on the methodology, a solution or “best alternative” is reported. In addition, the mathematical models provide an excellent opportunity to illustrate sensitivity analysis.

Many texts, and presumably instructors, present mathematical models and conclude the “modeling” process with the final, optimal solution with recognition of the real world by discussing sensitivity analysis. When the discussion stops with an optimal solution, the opportunity to illustrate the application of critical thinking and mathematical programming to support a managerial decision-making process is lost.

The purpose of this paper is to present two examples of extending the modeling of problems with linear programming to support managerial decision making by performing sensitivity analysis to see how much faith can be placed in the original optimal solution. This is where critical thinking takes over from problem solving as the focus of teaching business decision making. The two examples are adapted and extended problems from Anderson, Sweeney, Williams, Camm, and

Martin (2012).

EXAMPLE 1

The first example is a decision regarding the number of advertisements to purchase using three different media channels: television, radio, and newspaper. The problem follows:

The Westchester Chamber of Commerce periodically sponsors public service seminars and programs. Currently, promotional plans are under way for this year's program. Advertising alternatives include television, radio, and newspaper. Audience estimates, costs and maximum media usage for each medium are shown below.

	Television	Radio	Newspaper
Audience per ad	100,000	18,000	40,000
Cost per ad	\$1665	300	600
Maximum media use	10 ads	20 ads	10 ads

How many ads should be purchased in each medium to guarantee an audience of at least 1,000,000 people while minimizing total costs?

The solution to the mathematical model indicates that the optimal, minimum cost decision is to run six television ads, no radio ads, and ten newspaper ads. We believe that the discussion regarding the decision-making process does not stop here. The model presents a basis for the decision-making process for an applied marketing problem.

An informed marketing manager may recognize that the omission of radio ads in the optimal solution, and the decision, eliminates a significant market segment. What information can the analysis provide that helps the marketing manager include radio ads in the media mix? What would a manager need to do to include radio ads in the mix? What information would the manager need so that radio ads are part of the mix? To extend and adapt the problem, we added the following questions to the problem:

To ensure that radio ads are included in the mix of media, what price would you need to negotiate with the radio sales person? How do you know? What will be the effect of your negotiated price?

Using the sensitivity analysis from the solution, the student finds that the "reduced cost" to include radio ads in the solution is \$0.30. The student now finds that this is very important information to negotiate a lower price for radio ads. So the manager can now go to the salesperson for the radio ads and negotiate with the knowledge that any cost reduction of more

than \$0.30 will now include radio ads. The manager can now use the model to change the radio ad cost and find the new media mix that will support the decisions regarding how many of each ad to purchase.

In summary, modeling is a valuable tool, but cannot stand alone in business decision making. Illustrating how modeling can be used to support the decision making process is step one. Extending the process to include the critical thinking step of sensitivity analysis makes the decision making process more robust.

EXAMPLE 2

The second example is a decision regarding the outsourcing of printing a company's annual report. There are three sources available that differ in terms of price and quality. In addition, the company has a long term working relationship with one of the suppliers who also charges the highest price and has the highest quality. The problem follows:

Gulf Coast Electronics is ready to award contracts for printing its annual report. For the past several years, Johnson Printing and Lakeside Litho printed the four-color annual report. A new firm, Benson Printing, has inquired about the possibility of doing a portion of the printing. The quality and service level provided by Lakeside Litho has been extremely high; in fact, only 0.5% of their reports have been discarded because of quality problems. Johnson printing also has a historically high quality level, producing an average of only 1% unacceptable reports. Since Gulf Coast Electronics has had no experience with Benson Printing, they have estimated its defective rate to be 10%. Gulf Coast would like to determine how many reports should be printed by each firm to obtain 100,000 reports of acceptable quality. To ensure that Benson Printing will receive some of the contract, management has specified that the number of reports awarded to Benson Printing must be at least 10% of the volume given to Johnson Printing. The total volume assigned to Benson Printing, Johnson Printing, and Lakeside Litho should not exceed 30,000, 70,000, and 50,000 copies, respectively. Because of the long-term relationship that has developed with Lakeside Litho, management also has specified that at least 30,000 reports should be awarded to Lakeside Litho. The cost per copy is \$2.45 for Benson Printing, \$2.50 for Johnson Printing, and \$2.75 for Lakeside Litho.

The minimum cost decision is to order the following quantities from Benson, John, and Lakeside: 6495, 64954, and 30,000. What if Gulf Coast Electronics starts to think about the contract with Lakeside especially because it is the highest price supplier. Can Lakeside be more competitive? As a long-time supplier, it is possible that Lakeside Litho is aware that their price of \$2.75 is not competitive. What information can the mathematical model provide if we decide to negotiate with Lakeside. What if Gulf Coast Electronics did not specify a minimum order of 30,000 copies, how many copies would be ordered from Lakeside Litho? If we set the Lakeside minimum quality constraint to zero and resolve the problem, the quantity is 3,719 reports. Lakeside would lose business. In addition, the total cost of the reports declines.

Given this information, consider the following decision making scenario: Gulf Coast Electronics is interested in buying more copies from Lakeside Litho because of the high quality of their production. Gulf Coast is aware that Lakeside Litho is the most expensive supplier. Based on your model, what terms of the contract would Gulf Coast Electronics negotiate to buy more copies from Lakeside Litho while minimizing their costs? Is there a positive outcome for Lakeside Litho?

As in the previous example, the sensitivity analysis of the prices provides information regarding how much the Lakeside price needs to decrease to change the decision about the number of reports contracted from each supplier, and the minimum change is \$0.22 less than the current \$2.75.

If Gulf Coast is successful in getting a \$0.23 decrease in the price from Lakeside, this supplier will be awarded a contract for 24,523, the total cost for the reports is reduced, and there is no need to fix a minimum required number of reports from the long-time supplier.

CONCLUSIONS AND IMPLICATIONS

This paper presents a way to extend linear programming problem models and solutions to a decision-making approach context going one step beyond the initial analysis solutions to critical thinking supported by sensitivity analysis. This last step is an important extension given the need to include explorations of model sensitivity to changing assumptions and uncertainty in the process of making business decisions. Businesses need critical information to structure problems, generate alternative courses of action, and provide analysis-based information as input to negotiations and other business decisions. Critical thinking requires extending traditional linear programming modeling to include questions and scenarios that demonstrate the sensitivity and usefulness of a mathematical model. Sensitivity analysis is required to prevent blindly accepting the results of a model that may or may not accurately represent the business situation. This is one of the reasons business forecasting using market modeling requires a base case, an upside, a downside case at a minimum with extension to worst case and best case scenarios in high stakes situations (e.g., Latta 1998a, Latta 19ab, Latta 2002).

Putting AACSB Learning Goal number two into action with sensitivity analysis will better prepare future marketing managers for decision making situations they will face in their work environment.

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