Judges' Commentary: How Many Languages?

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The Problem

A large multinational service company, with offices in New York City in the U.S. and in Shanghai in China, is continuing to expand to become truly international. This company is investigating opening additional international offices and desires to have the employees of each office speak both English and one or more additional languages. The Chief Operating Officer of the company has hired your team to investigate trends of global languages and location options for new offices.

Part I

A. Consider the influences and factors described in the background paragraph above, as well as other factors your group may identify. Based on projected trends, and some or all of these influences and factors, model the distribution of various language speakers over time.

B. Use your model to predict what will happen to the numbers of native speakers and total language speakers in the next 50 years. Do you predict that any of the languages in the current top-ten lists (either native speakers or total speakers) will be replaced by another language? Explain.

C. Given the global population and human migration patterns predicted for the next 50 years, do the geographic distributions of these languages change over this same period of time? If so, describe the change.

The UMAP Journal 39 (3) (2018) 313–320.

Part II

A. Based on your modeling from Part I, and assuming your client company wants to open six new international offices, where might you locate these offices and what languages would be spoken in the offices? Would your recommendations be different in the short term versus the long term? Explain your choices.

B. Considering the changing nature of global communications, and in an effort to save your client company resources, might you suggest that the company open fewer than six international offices? Indicate what additional information you would need and describe how you would analyze this option in order to advise your client.

Part III

Write a 1–2-page memo to the Chief Operating Officer of the service company summarizing your results and recommendations.

Introduction and Overview

This year's Problem B focused on identifying the factors and metrics necessary for developing an understanding of the changing trend in global languages and its impact on future office locations and employee languages for a service company.

The problem required teams to develop a modeling approach based on these identified factors to address multiple required questions. In addition, there was the traditional required memorandum (nontechnical paper), with this year's focus being on providing the company's Chief Operating Officer a summary of the results and recommendations for office locations and employee languages.

We start this commentary with a short review of the mechanics of this year's judging process and follow that with a discussion and observations from the judging on various elements of the problem. We then discuss the importance of sensitivity analysis, assumptions, and identifying the strengths and weaknesses of a developed model and finish by addressing some points concerning communication.

The Process

We believe that it is beneficial for teams to understand the judging process; so, similar to previous commentaries, we once again review the basic process for this year's Problem B.

Triage

Every paper is read by at least two judges during the triage round to determine if the paper contains all of the required and necessary elements that make it a candidate for recognition. If a paper addresses all of the question components/issues and appears to have a reasonable model, then judges are likely to identify it as a paper that deserves more attention.

A paper must be clear and concise, and its summary is critical at this point in the judging. A good summary provides a brief overview of the problem, the paper's structure, and specific results, stated in a clear and concise manner. Many papers struggle in the triage because they fail to address fully the question, so the judge decides that a team's efforts will not compare well with the better papers. For example, one critical element overlooked by teams this year was directly addressing the prompt to consider the influences and factors described in the background paragraph, as well as other factors the team might identify. Many teams failed actually to acknowledge or address the factors identified in the background to the problem.

Fully developing all of the required modeling elements is critical and is often overlooked in papers. For example, sensitivity analysis remains one of the weakest elements and is often entirely missing in papers; such papers do not do well during the triage.

In addition, it is vital that the team express their general approach and results as clearly and concisely as possible in the memorandum (nontechnical position paper). This means providing a broad overview of the problem, the approach, and specific results in clear, concise, nontechnical terms. Ask yourself if someone without an education in mathematics can read and understand the paper. In this year's problem, the aim of the memo (nontechnical paper) was to provide the service company's Chief Operating Officer (COO) candidate office locations and potential languages for these offices. Many papers provided the memo but failed to adequately provide the results/solution of their modeling process for the COO. This did not hurt papers during the triage process but became more of a factor as papers advanced through the judging process.

Clear and concise writing makes it much easier for a judge to identify the team's effort and for the paper to do well in the triage round. However, the best models and the best effort are not effective if the results are not adequately communicated. It is important to remember that this is a modeling competition and that effective communication is a critical part of the modeling process.

Final Judging

The final judging consists of multiple rounds of judging over several days. As the rounds progress, the judging criteria shift from identifying

papers that warrant further consideration to a process to identify the very best papers.

The first round of the final judging begins with each judge reading a set of papers. Then all judges meeting to discuss the key aspects of the question and what should be included in a "good" paper. This year, these aspects included, in addition to all of the required elements, a clear discussion of the modeling process for locating new international offices, which incorporated a variety of interrelated factors.

As the final judging progresses, each paper is read multiple times, with the final set of papers being read by all judges. In these last rounds, the modeling process and the mathematical integrity of a paper begin to identify the Outstanding papers in the competition.

Critical Elements of the Modeling Process

The MCM is designed to be interesting, yet challenging but achievable in the available time. Successful papers pay attention to all elements of the modeling process. Many teams focus a great deal of their time on developing a fantastic model but find they run short of time and short change many critical elements. Typically, these include adequately addressing all components of the problem, developing a clear and concise summary and memo, and testing the model. We address a couple of these areas.

Components of the Problem

The Problem B final judges collectively believed that this year's problem was fairly difficult because of the multiple components/requirements of the problem. There were two major related components that teams needed to model adequately:

- The first component required teams to model the distribution of languages over time and predict the changing trends in distribution over the next 50 years, considering at a minimum the influences and factors presented in the background of the problem.
- The second component required teams to identify the potential locations for six new international offices, utilizing information gained from the first part of the problem. In addition, this component also required teams to consider what additional information they would need to suggest opening fewer than six new offices.

When faced with multiple component problems, teams typically focus a large portion of their available time on the first component of the problem, thereby failing to fully address the following components. This year's problem was no exception to this trend.

Modeling for Languages (50 Years from Now)

The spread of languages, by its nature, is very dynamic; and there are many potential influences and factors associated with why one language begins to spread through a region over another language. This component of the problem was successfully addressed by many teams, with it typically encompassing the majority of the pages in a paper. Most teams used some form of regression to model this problem. There were a few approaches that used a more dynamic modeling approach, such as agent-based modeling, which were viewed favorably by the judges; because the changing nature of languages is dynamic, there was an expectation that teams would use some form of dynamic modeling. Many teams incorporated and explained many good points, such as migration and immigration; but very few teams, if any, used interaction terms for these or other factors in their model. In addition, the problem clearly requested teams to consider the influences and factors described in the problem background, which included a set of 12 identified influences and factors. Teams were not expected to use all of these factors but they needed to address them in their paper.

The nature of this component of the problem and the set of influences and factors led most teams to use some type of regression. This approach was viewed as acceptable, but judges preferred to see prediction intervals rather than just point estimators in a provided solution. In addition, judges were hoping to see the dynamic nature of languages captured in the regression process. It is possible to have interaction terms in a regression model, which would have addressed the dynamic element. The use of some dynamic elements in the model was seen as a criterion for "good" papers.

Modeling for Locations of Headquarters

Teams used multiple approaches to address this component, ranging from optimization to multi-attribute decision-making (MADM).

The major shortcoming for teams utilizing an optimization technique was a failure to conduct some form of sensitivity analysis.

Many teams that incorporated a MADM approach failed to explain how they developed their judgment matrix. A common approach was simply to state that the team used their own judgment to develop the matrix, but there was no corresponding discussion of the decision process. This is a critical component of the modeling process for the reader. Since a judgment matrix is subjective in nature, the judges were expecting to see that a team conducted a sensitivity analysis to test their results. In addition, it was common for these papers not to calculate the consistency ratio and explain what it means. Many teams failed to address fully all questions of this component or simply picked locations based only on the ranking of the languages from Part I. Generally, these teams failed to address the questions of how the team's recommendation would change in the short

term vs. the long term and how the team would analyze the option of opening fewer than six offices. The judges believed that attempting to address these questions was a criterion for better papers.

Executive Summary

The executive summary is a critical element of any document. The executive summary is always read first and sets the tone for the rest of the paper. The executive summary must include methods and results in a brief, concise manner. It appeared to many judges that the executive summary was written before a team completed their modeling effort! Many executive summaries addressed how a team *planned* to model and solve the problem but failed to include any results. The judges considered a clear, concise, and fully-developed executive summary as a critical criterion for "good" papers.

Memo

The 1–2-page memo is a key element of the modeling process, especially for a decision-maker. The memo is an act of communication designed to translate the technical aspects of the modeling process into clear, concise, and nontechnical terms for the reader. The memo is essentially an executive summary for management, who would read it first; and it sets the tone for the remainder of the paper. The memo must include the solution methods and results for all questions. The judges considered a clear, concise, and fully-developed memo as a critical criterion for "good" papers. Unfortunately, many teams did not provide a satisfactory memo; and in general, most teams would benefit focusing a little more on their nontechnical memo!

Assumptions, Sensitivity, and Strength and Weaknesses

In modeling, assumptions drive the model-building and/or use of the model. The common models used by many teams, such as regression, Grey's modeling, and agent-based models all have inherent assumptions that should be addressed in the paper. The better papers tended to provide a concise list of relevant assumptions together with corresponding justifications. For any model, there is always a set of assumptions about when and how to use it, and these should be included in the paper. Many papers essentially repeated the assumptions from the information given in the problem statement and perhaps a few additional assumptions about second languages. One common trait was a list of assumptions that were not actually addressed or used in the model.

Sensitivity was once again a big discriminator of papers. No paper was moved forward to the final rounds that did not have good sensitivity analysis (error analysis and testing is included here). In sensitivity analysis, we are very interested in if the results change based on changes in the input values. Often, it appeared that the sensitivity analysis was a token analysis, done only to meet the spirit of the requirement, and not a good analysis effort.

Most teams did an adequate job identifying the strengths and weaknesses of their respective models. Teams should address, for example, that knowing the type of multinational company might be useful to the modeling process. It was also surprising that teams did not google an existing multinational company, such as Exxon, to see where they locate their international offices. It would have been a nice check of the team's model.

Communication

Papers were judged on the quality of the writing, with special attention to the summary and to the nontechnical letter. The quality of writing, in general, is continuing to improve; but many papers were not well-written. Basic spelling and grammar errors in a paper are a distraction to the reader. We suggest setting aside some time at the end of your modeling process to ensure that you have time to *read* through your own paper before submission.

Figures

Too many figures are lifted, cut-and-pasted into documents, without attribution to the source. Not having a figure is better than using one "borrowed" without attributions. Many teams were close to being disqualified for this infraction; this year, we decided to call it "poor referencing"—but we may cease such lenient treatment. The judges recognize that it is a time-constrained contest, and creating original figures might not be practical; but make sure to always reference the source for the figure.

Final Thoughts

Winning is participating in the contest. Learning to work as a team to accomplish your team's goals and objectives is success. As a reminder, the COMAP classification of papers (Successful Participant, Honorable Mention, Meritorious, Finalist, and Outstanding) is based on a comparison to other papers and the expectations of the judges. The Outstanding teams

- modeled and presented all the aspects of the problem described in the problem statement, including the fully-developed standard elements

(assumptions, sensitivity analysis, strengths and weaknesses, etc.);

- developed an effective model;
- explained the modeling choices made; and
- wrote clearly and concisely.

Every year, we continue to be impressed with the quality of the submissions, especially considering the time constraints.

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