2024 Fall INDENG 250 Midterm 2

Exam Info:

- This take-home exam is posted on bCourses on 12:01am on Nov 21, Thursday. You need to submit your solution as a .pdf file via bCourses by 11:59pm on Nov 23, Saturday.
- The main body of the exam should be typed.
- You may want to include formulations or draw diagrams. Under this case, legible, handwritten diagrams or formulations are acceptable. Insert your handwritten solution clearly into your typed solution. The submission should be one single .pdf file.
- You can use the lecture slides, your own notes, homework solutions, and papers we have discussed in the lecture as reference.
- No page limit on your solution, but a longer answer will not necessarily earn you more points. For example, a well-defined and clearly presented solution of 3 pages could be sufficient.
- Please assume that your answer will be evaluated by someone who is familiar with the material that we have covered.
- You may consult the instructor for clarifications by email, in-person, or via Zoom appointment, but you should not discuss this exam with anyone else.
- At the end of your exam solution, please include the following statement: "I have not given or received any unpermitted aid on this exam."

1 (80 points)

For this question, you will address some aspects of the manufacturing and distribution supply chain of a company that designs, produces and sells (or plans to sell) skis and/or snowboards. Examples include Burton, K2, Atomic. Given the relatively small customer base for skis and snowboards, in addition, the demand of skis and snowboards is highly seasonally, these companies are typically in a position to establish a relatively small supply chain to support their products.

These companies can sell their products via four channels, (a) sell online from the company's own website, (b) sell in their own flagship stores, (c) sell in local retailer's stores, and (d) sell on a third-party sport gear platforms (e.g. evo and REI).

Imagine a situation where in a year or two from now, K2, which is an American ski/snowboard-producing company, is likely to expand to European market. To simplify the model, we can assume that (i) K2 sells only a small number of different models of skis (assume 1 single type of ski is also acceptable) and a small number of different models of snowboards at the moment; and (ii) the products will be sold either in a flagship store or a local third-party retailer store (the channels (b) and (c) as mentioned in the previous paragraph). For operating a flagship stores, you can assume you could earn revenue from all possible demand of this location, but you have to pay the inventory holding cost by yourself. For working with a local retailer store, they will determine how many skis/snowboards they need (typically less than the actual demand), and the profit margin is smaller, but you don't need to worry about the inventory cost.

You are consulted by K2 as an expert of production planning and logistics management. K2 would like to know what critical decisions they need to make and implement, and how to make optimal decisions.

Your task is to:

1. Pose an interesting decisions-making question that the K2 European expansion team is interested in and want to know more about how you optimize this problem. The question or problem should not be something that can be directly addressed by a model that you have learned in the lecture; it should have one or more additional or different features that you think are challenging and important.
2. Present a formulation for your problem. Start by stating assumptions and justifying them briefly and defining notation before you present your formulation.
    - You can assume that for any parameter needed in your model, there is a dedicated team to collect these parameters for you. For example, you can assume some marketing colleagues have already developed a report for the European market, including several demand clustered locations, the forecasted monthly demand of those demand locations for the future several years, several candidate locations for establishing manufactories, and several candidate inventory warehouses for renting.
3. Sketch your ideas for a solution approach to solve your formulation. You don't need to produce a "perfect" methodology. Utilize the algorithm framework you learned in the lecture, or providing a sensible heuristic which is likely to work well is fine. You do not need to implement your methodology with numerical examples, but should explain the rationale for your approach under the general notations. If you have a subproblem that is a well-known problem (e.g., the Newsvendor problem or the standard vehicle routing problem), you can just briefly mention which typical problem it is and what's the typical solution approach.

For example, you might consider below decisions:

- Production related decisions:
    - Where to open new manufactories?
    - How to design the capacity of these manufactories?
    - Can these manufactory produce both skis and snowboards?
    - Are there any manufactory you can directly rent or buy so you can save certain cost from not buying new production machines?
    - What's the production level of skis and snowboard in each month?
    - Where to store the products?
- Location type of decisions:
    - Where to open manufactories (you can design the capacity)?
    - Where to buy existing manufactories (capacity is fixed)?
    - Where to rent inventory warehouses?
    - Where to open flagship stores?

  - Where to work with third-party local retailers?

- Inventory management decisions:
  - For your own flagship stores, when to replenish inventory and how many?
  - For your warehouses, when to replenish inventory and how many?

- Transportation and routing decisions:
  - How to assign the routes to a fleet of vehicles to transport skis and snowboards from manufactories to warehouses, or from manufactories to stores, or from warehouses to stores?
  - Would the routes change week by week, or month by month?
  - Will you only recruit ad-hoc vehicles for each trip by paying unit cost per distance? Or you might consider form your own fleet of vehicles with a setup cost and a unit cost per day, no matter whether you use this vehicle or not.

In terms of the cost structure, relationship between decisions, parameters, or any restrictions, feel free to make your own assumptions. For example, if working with more than two local retailers, they would like to increase your profit margin as bonus; a production machine which can produce both skis and snowboards are more expensive then a production machine which can only produce skis or snowboards. Again, this question is an open-ended question, you find your own decisions of interest to improve the overall system performance.

All the above decisions are only examples. You are not expected to work on a problem including all of them. And you can definitely work on other meaningful decisions outside of the above list. And you can treat some decisions in the above list as input of your decision problem. But basically, you may address two or more issues (e.g., optimize some production decisions and location decisions together) in an integrated manner if it seems sensible to do so; and addressing issues in an integrated manner will give you more opportunity to be creative. More credit will be given for creative formulations or heuristics rather than those that closely resemble the models discussed in class. We will be more flexible with non-PhD students. If you have difficulty presenting your formulation or solution approach in a precise mathematical manner, do the best you can to explain your ideas.

2 (20 points)

Consider you are interviewed by a reporter for a business publication such as the Wall Street Journal or Business Week or Forbes. Choose two things that you learned in this class that you did not know at the outset, and for each, write one paragraph (about 75-100 words, but we will not count words) explaining what you learned. (10 points each)