UNIVERSITY OF TORONTO

Department of Economics (STG), ECO204, 2023-2024 (Ajaz's Sections)

PROJECT 1: REVENUE MANAGEMENT THROUGH DYNAMIC PRICING AND YIELD MANAGEMENT

This individual (solo) project is worth 14% of your overall course grade.
Submission Deadline (paper & Excel model): 9 pm, Sunday, January 14th, 2024 through Quercus

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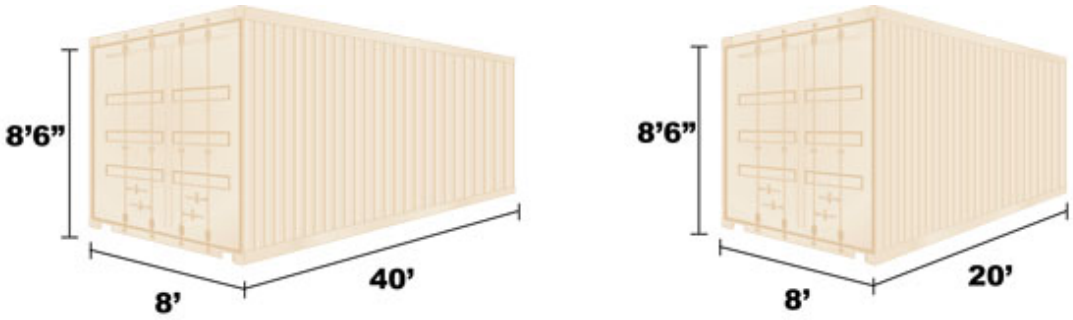
"THE COMPANY":

Based in Vancouver, *The Canuck Container Shipping Company* ("CCSC") owns and operates the HMS *Northern Exposure*, a Maersk Triple-E Class Ultra Large Container Vessel (pictured below):

CCSC's Maersk Triple-E Class Ultra Large Container Vessel, HMS *Northern Exposure*

In line with standard industry practice, the CCSC ferries cargo in 20' and 40' containers:

- ***A 20' Container:*** Known as a Twenty-foot Equivalency Unit ("TEU") with a maximum load of 24 tons/container.
- ***A 40' Container:*** Equal to two TEUs (by volume) with a maximum load of 30 tons/container[1].



Left: a 40' Container (two TEUs); **Right**: a 20' Container (one TEU)

[1] In case analysis, it's a good idea to "cross-check" case figures. For example, you should confirm that a 40' container is in fact twice as voluminous as a 20' container.

"CURRENT OPERATIONAL AND REVENUE MANAGEMENT MODEL":

Twice a year – once during the "low" season and again during the "high" season – the HMS *Northern Exposure* embarks on a voyage from Vancouver (*sans* cargo), with "stopovers" at the following 10 "port-of-calls" to pick up cargo for *final delivery* to Dubai, following which, the vessel returnins to Vancouver (*sans* cargo):

	Origin (Depart empty)	Pick up Cargo at each of the following 10 "Port-of-Calls" for Final Delivery to Dubai										Destination (Unload Total Cargo picked up at port-of-calls)
Port:	Vancouver	Japan	China	HK	Indonesia	India	Korea	Malaysia	Singapore	Taiwan	Thailand	Dubai

For example, during the "High Season" in FY2022-2023, the HMS *Northern Exposure* sailed from Vancouver (without cargo) → travelled to the 1st port of call, Japan, and loaded 320 TEUs destined for Dubai → travelled to the 2nd port of call, China, and loaded 68 TEUs destined for Dubai → … → travelled to the 10th port of call, Thailand, and loaded 9 TEUs destined for Dubai → travelled to the final destination Dubai to deliver 1,799 TEUs of cargo (the combined TEUs picked up from the 10 port-of-calls) → sailed back to Vancouver (without cargo):

	Origin (Depart empty)	Amount of Cargo (in TEUs) picked up from each 10 "Port-of-Calls" for Final Delivery to Dubai during the High Season FY2022-2023										Destination
Port:	Vancouver	Japan	China	HK	Indonesia	India	Korea	Malaysia	Singapore	Taiwan	Thailand	Dubai
TEUs picked up at Port-of-Call:	0	320	68	737	68	340	35	138	43	41	9	**Unload Total Cargo picked up from the 10 port-of-calls**
"Cumulative" TEUs on ship:	0	320	388	1,125	1,193	1,533	1,568	1,706	1,749	1,790	1,799	Delivered: 1,799

The amount of cargo ("demand") [TEUs] loaded at a port-of-call depends on CCSC's "price" ($/TEU) and the "season". For example, the following table contains CCSC's FY2022-2023 "price" and "seasonal demands" for the 10 port-of-calls:

FY2022-2023 Price ($/TEU) and "Total Seasonal Demand" (TEUs) for Loading/Transporting Cargo to Dubai			
Port of Call	**Price ($/TEU)**	**High Season Total Demand (TEUs)**	**Low Season Total Demand (TEUs)**
Japan	$940	320	286
China	$878	68	61
HK	$766	737	660
Indonesia	$840	68	61
India	$790	340	304
Korea	$710	35	31
Malaysia	$643	138	123
Singapore	$649	43	38
Taiwan	$702	41	37
Thailand	$663	9	8
Total TEUs delivered to Dubai:		**1,799**	**1,609**

Notice that for any given port-of-call, CCSC charges a uniform "price" across both seasons (i.e. CCSC is not managing revenues through dynamic pricing). This is where you come in -- you have been hired as a consultant to advise CCSC on (if feasible) boosting revenues through dynamic pricing subject to newly imposed "yield management" constraints specified next[2].

(Going Forward) Dynamic Price Mechanisms & Operational Plus Yield Management Specs:

CCSC's managements wants you to explore the feasibility of boosting revenues through dynamic pricing (charging separate prices in the Low vs. High Seasons) subject to the following "newly imposed" operational and yield management "constraints":

- [See the following table] For each-port-of-call, a pre-specified percentage of its total cargo destined for Dubai must be in 20' containers (and the rest in 40' containers) and the weight of 20' and 40' containers exactly as specified below:

[2] Assume the HMS Northern Exposure has negligible "variable expenses" (so that for all practical purposes, "maximizing profits" is tantamount of "maximizing revenues".

Port of Call	% of Demand (TEUs) that *must* be transported in 20' Containers (see example below)	Exact Weight of a 20' Container (tons)	Exact Weight of a 40' Container (tons)
Japan	30	20	24
China	40	18	23
HK	42	19	22
Indonesia	40	21	25
India	40	22	22
Korea	46	21	25
Malaysia	54	20	22
Singapore	39	19	25
Taiwan	41	19	19
Thailand	20	23	26
"Japan Example": 30% of the total cargo demand (TEUs) picked up in Japan will be transported in 20' containers and the remaining 70% of total cargo demand (TEUs) will be transported in 40' containers where each 20' container must weigh 20 tons and each 40' container must weigh 24 tons. Reminder: one 40' container = two 20' containers by volume.			

- Since 20' containers are "denser" than 40' containers, to thwart the ship from "becoming unbalanced and tipping over", as well as to expedite the loading/unloading process, management stipulates that when the HMS *Northern Exposure* reaches its final destination Dubai:

$$1.2 \leq \frac{\text{Total Number of } 20' \text{ containers on the ship in Dubai}}{\text{Total Number of } 40' \text{ containers on the ship in Dubai}} \leq 2$$

- In order to accommodate "last minute orders from premium customers", CCSC's "yield-management-managers" insist on having a "buffer" (no different from airlines and hotels setting aside seats and rooms for "premium" customers) such that when the HMS *Northern Exposure* reaches its final destination Dubai:

$$\text{Total TEUs on the ship in Dubai} \leq (\text{Seasonal Peak Load Factor}) \times 2{,}000 \text{ TEUs}$$

$$\text{Total weight of the ship (tons) in Dubai} \leq (\text{Seasonal Peak Load Factor}) \times 24{,}000 \text{ tons}$$

$$\text{Seasonal Peak Load Factor} \begin{cases} \text{High Season: } 97\% \\ \text{Low Season: } 92\% \end{cases}$$

The Mechanics of "Micro-Optimization":

Do the following for the Low and High Seasons separately:

1. Use the FY2022-2023 info to calculate, for each port-of-call as well as the "grand total": TEUs, Revenue, Ratio of 20':40' containers, Total weight, etc. You may want to comment on whether some "proposed" constraints are violated at the port/total level.
2. For dynamic pricing, you are going to "simulate-estimate", the "demand-curve" at each port-of-call as follows:
   a. Use the Excel command =rand() to generate a number between 0 and 1 → multiply this number by -1 → "label" it "Price Elasticity" E.
   b. Assume that in FY2022-2023, each port-of-call's "price" and "demand" resulted in every port-of-call having the price elasticity equal to E. For example, given Japan's price and output in season X, its price elasticity was E, identical to the price elasticity of the other nine port-of-calls.
   c. Assume each port-of-call has a linear demand curve. For example, the i^{th} port-of-call demand curve is:

$$P_i = a_i - b_i q_i$$

Here $P_i =$ Price \$/TEU and $q_i =$ Total Demand (TEUs) for the i^{th} port-of-call. From ECO101, recall that the point price elasticity is:

$$E = \frac{dq}{dP}\frac{P}{q}$$

Now, since every port of call has the same value of E, and you know each port's FY2022-2023 P, q figures → you can figure out each port-of-call's linear demand curve parameters a_i and b_i.

3. Watch some (all?) ECO204 Excel Solver YouTube videos (see online math chapter). "Observe" how Solver requires a formula for the "objective" (in this case the grand total revenues across all 10 port-of-calls); in turn that requires you to pick – in this case – either price *or* quantity as the "decision variable". What did you do in ECO101? Ever notice how in that course you always "solved" for the "optimal quantity" (never the price) to maximize "profits/revenues" or minimize "cost per unit"? Why didn't you "select" price as the decision variable in ECO101?
4. In Excel, create a table with the demand curve parameters for each port-of-call and make up a "trial" output value (TEU)→ feed into the port-of-call demand curve to generate the corresponding price ($/TEU) and revenue → perform any additional calculations such as, for example, that 30% of Japanese total TEUs must be in 20' containers; the overall ratio of 20':40' containers must be between 1.2 and 2; etc. → Bring up Solver → Your "objective" is to maximize total revenues from all 10 port-of-calls → your "decision variables" are the ten port-of-call "demands" (TEUs) → enter all constraints → "Solve" and request the "sensitivity report".

For your convenience, here is the complete problem stated in maths:

$$\max_{q_1, q_2, \ldots, q_{10}} \text{Total Revenue from all ten port-of-calls} = \sum_{i=1}^{10} R_i = \sum_{i=1}^{10} P_i q_i = \sum_{i=1}^{10} (a_i - b_i q_i) q_i$$

Subject to:

$$1.2 \leq \frac{\text{Total Number of } 20' \text{ containers on the ship in Dubai}}{\text{Total Number of } 40' \text{ containers on the ship in Dubai}} \leq 2$$

$$\text{Total TEUs on the ship in Dubai} \leq (\text{Seasonal Peak Load Factor}) \times 2{,}000 \text{ TEUs}$$

$$\text{Total weight of the ship (tons) in Dubai} \leq (\text{Seasonal Peak Load Factor}) \times 24{,}000 \text{ tons}$$

$$\text{Seasonal Peak Load Factor} \begin{cases} \text{High Season: } 97\% \\ \text{Low Season: } 92\% \end{cases}$$

5. In your report and Excel model, be sure to compare your solution with the "status quo" and don't forget to interpret and "utilize" the Lagrange multipliers in the sensitivity report.

It's possible that the "Total Revenues from Solver" *may* be lower than the status quo Total Revenues. If so, you should be able to use ECO101 logic to explain *why* (in any case, you should provide insights and intuitive explanations for why *your* Solver model revenues are higher/lower than the status quo.

Deliverables

- You will "analyze and solve" this case in Excel and then write up your analysis/findings/recommendations in a (max) five to six page Business Report "addressed" to CCSC's "management". The report should have a cover page (with your name but *not* your Student ID #) and a (max) one-page executive summary (the cover page and executive summary do not count towards the page requirement.)
- If you wish, you can "attach" a technical appendix to your Business Report (no page limit on the appendix).
- There are no specific restrictions/requirements on fonts, font size, margins, etc. You're an adult – show us your creative side!
- IMPORTANT: Remember you are writing a *business-report* not an academic paper. In your business report: avoid "technical jargon", "fluffy/flowery prose", "overly-verbose" sentences, "staid" grammar, "equations/math". Write simple, clear, direct sentences, in an active voice (take a look at Warren Buffet's Annual Shareholder Letters). Clear thinking is clear writing and clear writing is clear thinking.

- Make judicious use of graphs, tables, Excel screenshots, and pictures in the business report – don't be that "scribe" who crams reports with "filler/decorative" graphs, tables, etc. Do you have a "technical" graph which doesn't "fit" in the Business Report? Put it in the technical appendix (which has "no page limit" *within common reason*).
- The Excel file should be properly formatted and labelled. For example: are the top rows "frozen"? Did you adjust column widths to auto-fit data? Are the numbers formatted to the same number of decimal places? Are the axes labelled? "Set up" the Excel file to make it easy for your "client/audience" to use your model with different input/parameter values (why not shade the "input/parameters" yellow and the Solver cells green etc.?). We *highly* recommend "soft coding" formulas and "naming variables" making it easier for your client/audience to change the parameters, re-solve the problem, and view the "analysis" and "recommendations".

"Submitting Project 1"

The business-report must be submitted in pdf format titled **"LastName_FirstName_Last-5-Digits-Student ID.pdf"** and the Excel file must be in either "xlsx" or "xslm" format titled **"LastName_FirstName_Last-5-Digits-Student ID.xlsx/xlsm"**

Please submit the business-report *and* Excel file **through the Quercus Project 1 Tabs** (one for Excel and another for the Business Report) by **9 pm, Sunday, January 14th, 2024.**

Penalty for submitting *any* component of Project 1 past the deadline: 50% of maximum project score per day that any project component is overdue.

Please review the policy on using Quercus to submit, grade, and detect plagiarism in course assessments: ***Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site https://uoft.me/pdt-faq "***

"Academic Code of Conduct"

It is *your* responsibility to read and abide by the Student Academic Code of Conduct. Please note that *any* attempt to "collaborate", "receive/provide help" to any other individual/organization is a serious violation of the academic code of conduct.

(TENTATIVE) BUSINESS REPORT GRADING RUBRIC				
	Excellent	**Good**	**Fair**	**Problematic**
Score:	**3**	**2**	**1**	**0**
Economic Argument, Concepts & Evidence	Clearly stated argument & concepts. Economic reasoning is sound and indicates thorough understanding of concepts discussed in class.	Fairly clear and convincing argument. Adequate use of economic concepts. Demonstrates understanding of topics discussed in class.	Argument is confusing or contradictory. Weak definition/application of economic concepts. Demonstrates some understanding of topics discussed in class.	No clear argument. Confused or no use of economic concepts. Poor quality and little if any displayed evidence of understanding of topics discussed in class.
Organization & Flow	Each main point is written in a separate paragraph, in a logical order. Paper closes with a clear and convincing call to action.	Each reason is written in paragraphs, but not necessarily separate. Closing gives a fairly clear and convincing call to action.	Reasons are not written in distinct paragraphs. Closing gives a call to action, although not well supported.	Reasons are not written in good paragraphs and have questionable order. No clear or convincing call to action at close.
Writing: Clarity, Conciseness, Sentence Structure, Grammar, Active Voice, Interest to Reader	Easy to read, even for a non-specialist. Writing enhances understanding and interest. Short, clear, correctly structured sentences with active voice throughout. Minimal (if any) errors.	Mostly easy to read. Mostly short, clear, correctly structured sentences with active voice. A few minor errors.	Sentence/word level problems get in the way of understanding, distracting reader in places. Some passive voice and/or jargon.	Significant sentence/word level problems make it difficult for reader to understand argument. Considerable passive voice and/or jargon.

THE EXCEL MODEL GRADING RUBRIC WILL BE POSTED ONE-TWO WEEKS AFTER PROJECT 1'S RELEASE DATE