ECON 180 SUMMER 2021: PROJECT 3

DUE June 14th, 2021 by 11:59 PM VICTORIA, B.C. TIME

Honor Code: I guarantee that this submission is **entirely my own work**. I have **cited any outside sources** in APA or IEEE style. **(You must accept this code to receive a mark.)**

Name or Signature for Honor Code: _____

Last 3 digits of student number: _____

Please enter your answers in the spaces and tables provided. Your submission must be in either PDF or Microsoft 365 (Word, etc.) format, so Brightspace can read it properly.

Question		Marks
1	a-c	78 each
	Q1 (Average)	78
	d (Bonus)	2
2	a	No marks
	b-f	78 each
	Q2 (Average)	78
3	a-b	78 each
	Q3 (Average)	78
Q1 to Q3	(Q1+Q2+Q3)/3	78
4	a	4
	b	4
	c	2
	Q4 (Total)	10
Subtotal	(Q1 to Q3)+Q4 + Bonus	90
Communication		6 (doubles if subtotal ≥ 83)
Total		Max 100

I've provided an Excel spreadsheet with this project, but **you don't have to use it**. None of the questions require that you submit it, but you may find it useful as a starting point. If you think the table is confusing, or difficult to use, feel free to ignore it.

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Question 1: Incremental IRR & ERR (Lectures 7,8)

Data from the 2016 census shows that the salary benefits from graduate degrees in Engineering are surprisingly low. Statistics Canada found[1] that a Master's Degree in Engineering increased income by 0.7% (for men) and 0.4% (for women), relative to a Bachelor's degree. A doctorate in Engineering increased income by 7.8% (for men) and 1.8% (for women) relative to a bachelor's degree. In this question, you will determine whether it makes sense for Sam to spend two years to earn a Master's degree, or six years to earn a PhD, given that the average engineering tuition cost in Canada is $7,000 per year.

1 See Table 4 in Wall, K., Zhao, J., Ferguson, S. & Rodriguez, C. (2018). Results from the 2016 Census: Is field of study a factor in the payoff of a graduate degree? [Web Page]. https://www150.statcan.gc.ca/n1/pub/75-006-x/2018001/article/54978-eng.htm

The Setup

Note: The companion spreadsheet **automates this setup for you**, in the sense that it takes your information and returns a table with the appropriate cash flows. The information below will be useful if you wish to use equations as part of your solution.

For this question, the setup is a bit different to how we thought of income in Project 2. As in previous projects, Sam mar is 2.45% per year, and they are going to spend three years finishing their bachelor's degree in engineering, no matter what. However, they also have the option to spend $7,000 a year[2] for two years to earn a Master's degree, or $7,000 a year for six years to earn a Master's degree, followed by a PhD.

Once Sam finishes their studies, they will start working as an engineer. If Sam completes a bachelor's degree, their starting salary is equal to A, where A is your *highest* baseline salary from Project 1. This time, there is no signing bonus, and Sam's salary increases each year at a rate equivalent to 10% every 14 months[3] (about 8.51% per year)[4], which according to Salary Explorer is the average increase in salary for engineers in Canada. Sam will work for a total of 40 years if earning a bachelor's degree (from Year 3 to Year 42). For simplicity, we will assume Sam is paid their salary once a year.

If Sam goes for a Master's degree, they will pay $7,000 a year for the two years following the completion of their Bachelor's degree. After that, they will receive income equal to (1+m) times what they would have earned, the *same year*[5], if they had only had a bachelor's degree, where m is the bonus for having a Master's degree (0.7% for men, 0.4% for women). Sam will only work for 38 years if they earn a Master's degree (from Year 5 to Year 42). This means Sam's starting salary in this case is equal to (1+m) times the Year 5 salary they would have earned with a bachelor's degree: $A \times (1+8.51\%)^2 \times (1+m)$.

If Sam goes for a doctorate, they will pay $7,000 a year for the six years following the completion of their Bachelor's degree (2 years for a Master's, then 4 for a PhD). After that, they will receive income equal to (1+p) times what they would have earned, *the same year*, if they had a bachelor's degree, where p is the bonus for having a doctorate. Sam will only work for 34 years if they earn a doctorate (from Year 9 to Year 42).

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2 Source: https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2019011-eng.htm

3 Source: http://www.salaryexplorer.com/charts/canada/engineering/annual-salary-increment-rate-canada-engineering.jpg This seems high to me, and I can't find Salary Explorer's data source, but scanning posts by Canadian engineers on Reddit suggests that in non-pandemic years, raises of 5% to 7% per year are not unusual.

4 This conversion is done for you in the companion spreadsheet.

5 This assumption probably over-states the salary benefits from a degree. In this question, I'm erring on the side of making the salary benefits from a degree more attractive.

1.a

Sam is non-binary. Suppose they receive the same salary benefits from graduate degrees as male Canadian engineers (0.7% higher income for a Master's degree, 7.8% higher income from a doctorate, relative to a bachelor's degree).

Use an ***incremental* IRR approach** to determine Sam's preferred project: stop at a bachelor's degree, stop at a Master's degree, or earn a PhD. Show your work.

Note: You may use all numerical/spreadsheet methods, all analytical methods (though the problem may not be tractable), or a mix of numerical and analytical methods. In any case, you need to explain your process, as you are not being marked on your final answer, which may vary by student, but on *how* you obtained your final answer.

Hint: The companion spreadsheet will automatically create a table of the relevant cash flows for you. Even if you are taking a mostly analytical approach, you may find this useful for visualization.

Preferred Project: _____

[Show your work]

1.b

Sam is non-binary. Suppose they receive the same salary benefits from graduate degrees as female Canadian engineers (0.4% higher income for a Master's degree, 1.8% higher income from a doctorate, relative to a bachelor's degree).

Use an ***incremental* IRR approach** to determine Sam's preferred project: stop at a bachelor's degree, stop at a Master's degree, or earn a PhD. Show your work.

Note: You may use all numerical/spreadsheet methods, all analytical methods (though the problem may not be tractable), or a mix of numerical and analytical methods. In any case, you need to explain your process, as you are not being marked on your final answer, which may vary by student, but on *how* you obtained your final answer.

Hint: The companion spreadsheet will automatically create a table of the relevant cash flows for you. Even if you are taking a mostly analytical approach, you may find this useful for visualization.

Preferred Project: _____

[Show your work]

1.c

As in part b., assume that Sam receives the same salary benefits from a Master's degree as Canadian female engineers. This time, if Sam goes for a Master's degree, they will also receive a $2,500 LOUD Scholarship in Year 2. LOUD Scholarships are given to Canadian LGBTQ+ post-secondary students[6].

As a result of this scholarship, the *incremental* cash flow between the 'Bachelor's Degree' and 'Master's Degree' project now has two sign changes. Use an **incremental approximate ERR method** to determine whether Sam should stick to a Bachelor's degree or go for a Master's degree.

Hint: Again, the companion spreadsheet will set up the cash flows for each project for you (but not the incremental flows). The incremental approximate ERR approach is the same as the incremental IRR approach, except you use an approximate ERR instead of an IRR.

Preferred Project: _____

[Show your work]

6 "LOUD stands for Leadership, Opportunity, Unity & Diversity." See https://loudbusiness.com/apply-for-a-scholarship

1.d (2-mark bonus question)

Maintain the assumptions and approach (incremental approximate ERR) from 1.c. What is the minimum size of a scholarship in Year 2 that would convince Sam to go for a master's degree instead of stopping with a bachelor's degree? Show your work.

Note: In some cases this value could be negative, if Sam would choose to go for a Master's degree even without a scholarship.

Minimum scholarship in Year 2: _____

[Show your work]

Question 2: Supply, Demand, Equilibrium & Elasticity (Lectures 9, 10)

This question is based on the following article:

Mathew, N., Wong, J. S. H. & Krausz, M. (2021). An Inside Look at B.C.'s Illicit Drug Market During the COVID-19 Pandemic. *BC Medical Journal*, *63*(1), 9-13. https://bcmj.org/articles/inside-look-bcs-illicit-drug-market-during-covid-19-pandemic

Among other interesting bits of information, the article reveals that because of COVID-19, the wholesale price of opioids went up by about 13% (from $1,500 per ounce to $1,700 per ounce), while the retail price went up by 25% (from $20 per point to $25 per point[7]). At first blush, this suggests that far from the burden of the extra $200 cost per ounce being shared by buyers and sellers, more than 100% of the cost was passed through to buyers. Another item of information in the paper is a possible key to the puzzle: in addition to seller costs going up, the income of opioid buyers was temporarily increased by CERB payments.

In this question, you will use supply and demand analysis to investigate the situation described in the article.

2.a Read the Article (No Marks)

I strongly suggest you read or skim the source article cited above. Doing so should make the questions easier to understand.

7 A point is a tenth of a gram.

2.b Derive the Pre-COVID demand curve for opioids

Assume that supply and demand can be represented by straight lines (as we did in class). Suppose that before COVID, the equilibrium quantity of opioids bought and sold per week is 210 points[8], the equilibrium price is $20 per point, and the price elasticity of demand[9] is -0.8 (so for every 1% increase in the price of opioids, quantity demanded falls by 0.8%).

Use this information[10] to derive the pre-COVID demand curve for opioids. Show your work.

Pre-COVID Demand Function: Q = _____

Pre-COVID Inverse Demand Function: P = _____

(The inverse function is in 'graphing form': recall that supply & demand diagrams have price on the vertical access. Calculating this here will be useful later on.)

[Show your work]

8 John Doe mentions that pre-COVID, he was working 7 days a week and making up to $600 dollars a day. If we assume (to keep things simple) that he means revenue and not profit, and that all the money was from opioids, then ($600/day)/($20/point) = 30 points/day = 210 points/week.

9 This is taken from an estimate for the price elasticity of demand for heroin, in Olmstead, T.A. et al. (2015). The price elasticity of demand for heroin: Matched longitudinal experimental evidence. *Journal of Health Economics*, *41*, 59-71. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.jhealeco.2015.01.008

10 Section 2.5 of Besanko & Braeutigam walks you through this, in the sub-section titled 'Fitting Linear Demand Curves Using Quantity, Price, and Elasticity Information', on pages 55-56. Chapter 2 of B&B can be found at https://higheredbcs.wiley.com/legacy/college/besanko/0471457698/chaps/ch02.pdf

2.c Graph what's going on

Assume that *two* things happen in our market in response to the pandemic:

i. The seller cost of opioids goes up from $1,500 to $1,700 per ounce. On the supply & demand diagram, the supply curve shifts up by $0.70 per point[11].

ii. The demand curve shifts up[12] in response to CERB payments. With more income, opioid buyers are temporarily willing to pay more for opioid.

Assume that at the new equilibrium (the intersection of the upward-shifted supply and demand curves), the price of opioids is $25 per point, and the equilibrium quantity is 280 points[13].

Draw a supply and demand diagram illustrating the above. Label the pre-COVID equilibrium, the post-COVID equilibrium, and the equilibrium prices and quantities.

[Insert your diagram here or attach it as a separate .png, .gif, .jpg or .pdf file. This diagram can be a smartphone photo of a hand-drawn diagram, an Excel image, a Photoshop sketch, a Powerpoint diagram, etc.]

11 Since there are 283.495 points in an ounce, and $200/283.495 is about $0.70.

12 John Doe himself says that there was a fall in supply ("[T]he price of drugs appeared to follow a supply and demand curve (steady demand and increased supply"), he continued to be able to buy wholesale drugs, just at an increased cost. For more on the relationship between higher costs and supply curves, see https://pressbooks.bccampus.ca/uvicecon103/chapter/other-determinants-of-supply/ He also specifically mentions that his clients were spending more money than usual on drugs after the CERB cheques arrived, suggesting the type of upward shift in the demand curve that is common with sudden increases in income. For more on the relationship between income and demand, see https://pressbooks.bccampus.ca/uvicecon103/chapter/3-3-other-determinants-of-demand/

13 John Doe mentions that he earned $1,000 per day after CERB. With similar assumptions to those made regarding the pre-COVID equilibrium, this works out to ($1,000/day)/($25/point) = 40 points/day = 280 points/week.

2.d Solve for the (inverse) supply and demand equations

You've already solved for Pre-COVID demand (and inverse demand, i.e. graphing form demand). Now, you also need to solve for after-COVID demand, pre-COVID supply, and after COVID supply. This is easier than it sounds.

Let the 'graphing form' equations for supply and demand be of the form $P = k_i + k_jQ$, where k_i and k_j are constants. Then:
Inverse Demand before COVID: $P = k_1 + k_2Q$
Inverse Demand after CERB: $P = (k_1 + Y) + k_2Q$, where Y = upward shift due to CERB

Inverse Supply before COVID: $P = k_3 + k_4Q$
Inverse Supply after COVID: $P = (k_3 + T) + k_4Q$, where T = upward shift due to cost increase

You already have k_1, k_2 and T. You need to solve for k_3, k_4 and Y. There are three unknowns, which means you need three equations – and you have more equations than you need.

Here is one possible set of equations to use:

Equation 1: At the pre-COVID equilibrium, the supply and demand curves cross:

→ $k_1 + k_2Q^* = k_3 + k_4Q^*$, where Q^* is the pre-COVID equilibrium quantity.

Equation 2: At the post-COVID, post-CERB equilibrium, the supply and demand curves cross:

→ $(k_1 + Y) + k_2Q^{cov} = (k_3 + T) + k_4Q^{cov}$, where Q^{cov} is the post-COVID equilibrium quantity.

Equation 3: Before COVID, when $P = P^*$, $Q = Q^*$ (equivalently, after COVID, when $P=P^{cov}$, $Q = Q^{cov}$).

→ $P^* = k_3 + k_4Q^*$ (or $P^{cov} = (k_3 + T) + k_4Q^{cov}$)

Before-CERB Inverse Demand (from part b.): P = _____

After-CERB Inverse Demand: P = _____

Before-COVID Inverse Supply: P = _____

After-COVID Inverse Supply: P = _____

[Show your work]

2.e What would the price have been without CERB?

John Doe mentioned that demand was "stable" during the pandemic, apart from the extra spending induced by CERB.

i. What would the retail price of a point of opioids have been during the pandemic, in the absence of CERB? (Hint: You want to solve for the equilibrium price represented by the crossing of the pre-CERB demand curve with the post-COVID supply curve.)

No-CERB price of opioids during COVID: $_____ per point

[Show your work]

ii. Based on your answer to part e., in the absence of CERB, which would have been more elastic – supply of opioids or demand for opioids? Briefly explain your reasoning.

Which is more elastic, supply or demand? _____

[Briefly explain your reasoning]

2.f Elasticity and the COVID/CERB equilibrium

Consider the post-COVID, post-CERB equilibrium. If there were a further small increase in the wholesale cost of opioids, who would end up paying for most of it – the buyers or the seller? Briefly explain your reasoning and back up your answer with calculations.

(Hint: This is a tax incidence question. You have everything you need to calculate the price elasticity of supply and price elasticity of demand at the post-COVID, post-CERB equilibrium, using the calculus definitions of elasticity. Once you have those, you can easily calculate the burdens on the buyers and on the sellers from a small increase in seller cost.)

Who would pay for most of the added cost? _____

[Briefly explain your reasoning and show your work.]

Question 3: Inflation (Lecture 11)

3.a. Using the CPI

i. The Canadian CPI was 11.3 in April, 1920 and 140.3 in April, 2021. Calculate the average annual rate of inflation from April 2020 to April 2021 (101 years). Show your work.

Average annual rate of inflation: _____ % per year

[Work]

ii. In Calgary, in 1920, a dozen eggs cost[14] $0.50. In Calgary, in 2021, a dozen Great Value Large Eggs cost $2.99 at Walmart. Use the CPI information from part i. to determine whether the price of eggs has gone down, gone up, or stayed the same in real terms (after adjusting for inflation). Show your work and briefly explain your reasoning.

The price of eggs in Calgary has _____ in real terms, from 1920 to 2021.

[Reasoning & work]

14 "My weekly budget of Prices" by CAREFUL HOUSEKEEPER. In Willmore, C. (2020). Woman's Sphere of Action: Canadian women, housework and the household, 1858-1921. Victoria: Skeride Publishing. Available for free at https://onlineacademiccommunity.uvic.ca/willmore/wp-content/uploads/sites/5845/2021/01/sphereofactionv1.pdf

3.b Inflation and present values

Suppose that:

- Sam has decided to live and work in Vancouver
- Sam's *nominal* MARR is 2.45% per year, or about 0.202% per month (this conversion is done for you in the companion spreadsheet).
- Yearly inflation is the rate which you calculated[15] in part 3.a.i (the companion spreadsheet will automatically calculate the monthly equivalent rate of inflation for you).
- Month 0 is the base month for inflation calculations, AND the 'present' for present value calculations.
- Sam's monthly rent is constant in real terms, at the baseline level from Project 1. (If your baseline rent for Vancouver was $2,000 a month, then Sam's rent is constant in real terms at $2,000 real dollars per month.)
- Sam pays rent for 40 years (480 months). The first rent payment is in month 36.

i. Calculate the present value of Sam's rent using *nominal* cash flows and *nominal* rates. Show your work. (You're being graded on *how* you obtained the present value, not on the final numerical answer per se.)

Present Value of Rent: $_____

[Work]

15 If you skipped that question, assume that inflation is 2% per year. That's the Bank of Canada's usual inflation target.

ii. Calculate the present value of Sam's rent using *real* cash flows and *real* rates. Show your work. (You're being graded on *how* you obtained the present value, not on the final numerical answer per se.)

(Hint: Since Month 0 is both the present AND the base month for inflation calculations, your numerical results should be identical for parts i. and ii. If they're not, that's a sign that you should re-check your setup and calculations.)

Present Value of Rent: $_____

[Work]

Question 4. (Challenge) Building a Price Index (Lecture 11)

In early 1920, there was a lively debate in Calgary newspapers about the cost of living for an average family. It started when Jean McWilliam, a social reformer, published an itemized estimate of the cost of living in Calgary and used it to argue that "Calgary is inhabited by many starving children." Some readers found McWilliams's estimates comically or confusingly large, and submitted itemized expenditure lists of their own to show how much their families spent, and on what.

These lists just happen to be *perfect* for using as the basket of a Laspeyres price index – and that's what you're going to do in this question.

4.a. Preliminary reading & picking a basket

(4 marks) Read through the articles from 1920 on the cost of living on pages 71 to 83 of

Willmore, C. (2020). *Woman's Sphere of Action. Canadian women, housework and the household, 1858-1921*. https://onlineacademiccommunity.uvic.ca/willmore/wp-content/uploads/sites/5845/2021/01/sphereofactionv1.pdf

Once you've done so, pick one of the monthly budgets listed to use as your 'basket'. You'll be calculating a Laspeyres price index for 2021, using 1920 as the base year, so you'll need to find 2021 equivalents for the prices in your chosen budget. Cite any sources you use to find those prices.

List your basket of goods, with 1920 and 2021 prices (see the solved problems in the appendix if you need help):

[Basket & Prices]

4.b Calculating the Index

(4 marks) Use the information from part a. to calculate a Laspeyres price index for 2021, using 1920 as the base year. Show your work.

Laspeyres price index for 2021: _____

[Show your work]

4.c Comparison to the CPI

(2 marks) The Canadian CPI was 11.3 in 1920, and is 140.3 in 2021. Is average yearly inflation, calculated your Laspeyres index, greater than, less than or equal to average yearly inflation calculated using the CPI? Show your work.

Inflation is _____ when calculated using my Laspeyres index, compared to the inflation calculated using the CPI.

[Work and Reasoning]

Appendix: Solved Laspeyres Index Problems (from Fall 2020)

These are taken from the answer key to the Fall 2020 version of Project 3.

5. **[Laspeyres Index]**

a.

i. Below are the rent and food price indices[16] for Victoria in 1995 and 2020. **Assuming your baseline values for rent and weekly food costs are 2020 values, use the price index information to calculate the 1995 cost of rent and food to the nearest cent.** (Recall that P_x/CPI_x is constant for all years x. You're looking for P_{1995}, and using the rented accommodation and Food price indices instead of the CPI.)

Price Index, Victoria		
Year	Rent	Food
1995	89.3	85.2
2020	128.4	149.0

Victoria Prices		
	Weekly Food Bill	Monthly Rent
1995 dollars	**$911.78**	**$1,311**
2020 dollars[17]	**$23.39**	**$40.91**

Work: Recall from class that by design, P/CPI is constant for all years. The same intuition applies here, for these other price indices.

(1995 Cost) = (2020 Cost) x (1995 Index)/(2020 Index)

Let R = baseline rent (either study or work version is fine), F = baseline weekly food bill

Rent in 1995 dollars = R x 89.3/128.4, Rent in 2020 dollars = R
Food Bill in 1995 dollars = F x 85.2/149.0, Food Bill in 2020 dollars = F

16 See Consumer Price Index (CPI) [Web Page]. (2020). Retrieved from https://www2.gov.bc.ca/gov/content/data/statistics/economy/consumer-price-index
17 These are just your baseline values for Victoria from Project 1.

ii. **Calculate a Laspeyres index for 1995, to two decimal places, using 2020 as the base year**, the prices from part i. and Sam's first month of food and rent costs as the basket. The two items in the basket are 1 x Monthly Rent, and 4 x Weekly Food Bill. Show your work. (Hint: You don't need to consider the time value of money – Sam's MARR is irrelevant.)

Laspeyres Index for 1995 (2020 = 100): __68.18_____

Again, the index # is mostly a checksum. You're being marked on your work, so make sure the TA can follow your thought process.

Work:

Let R1995 and R2020 be rent in 1995 and rent in 2020.
Let F1995 and F2020 be food bill in 1995 and food bill in 2020.

2020 is our base year. Our spending basket consists of 1 x rent + 4 x food

Total spending in 2020 = (R2020 + 4 x F2020)
Share of spending on rent, Sr = R2020/(R2020 + 4 x F2020)
Share of spending on food, Sf = (4 x F2020)/(R2020 + 4 x F2020)

Laspeyres index for 1995 using 2020 as the base year:

100 x (Sr x (R1995/R2020) + Sf x (F1995/F2020))

For my values, this is about 68.18.

b.

i. Among the project files is a spreadsheet with the price of numerous food items by year, from 1995 to 2019. Pick a recipe that is meaningful to you. **(The prices you want are in the 'Yearly Averages' tab of the foodprices spreadsheet.)** Adjust the list of ingredients, if necessary, to match the items you are given prices for. You only need three to eight ingredients, and it's fine to omit minor ingredients (such as salt) you don't have prices for. Find the cost of buying this list of ingredients in 2019, and in 1995. (For example, if one of your ingredients is 500g of Round Steak, the spreadsheet says that in 1995 1kg of Round Steak cost $10.07, so the cost of 500g of Round Steak in 1995 would be $5.035.)

Recipe or Diet Chosen: ___**Basic Breakfast**_____

(3-8 items)	Item	Quantity	1995 Cost	2019 Cost
1	**Bacon (2 slices)**	**24 g**	**$0.1378**	**$0.3418**
2	**Eggs**	**2**	**$0.2667**	**$0.5383**
3	**Orange Juice**	**250 mL**	**$0.4150**	**$1.040**
Total			**$0.8194**	**$1.9201**

ii. **Calculate a Laspeyres index for 1995, to two decimal places, using 2019 as the base year**, the prices from part c. and your list of ingredients as the basket. Show your work.

Laspeyres Index for 1995 (2019 = 100): ____**42.68**_____

Again, the index # is mostly a checksum. You're being marked on your work, so make sure the TA can follow your thought process.

Work:

Shares of spending in 1995:
Bacon: 0.3418/1.9201 = 17.80%
Eggs: 0.5383/1.9201 = 28.04%
Orange Juice: 1.040/1.9201 = 54.16%
L is weighted average of 2019/1995 Cost ratios for each item, with 2019 shares as weights.
L = (17.80% x 0.1378/0.3418 + 28.04% x 0.2667/0.5383 + 54.16% x 0.4150/1.040) x 100
L = 42.68