ECON 180 Summer 2022: PROJECT 3

DUE July 11, 2022 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: Matthew day

Last 3 digits of student number: 298

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	3
	b	3
	c	4
	Q4 (Total)	10
5	BONUS	5
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 14,15)

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 Mandeep 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, Mandeep's MARR is 3.2% 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 Mandeep finishes their studies, they will start working as an engineer. If Mandeep 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 Mandeep's salary increases each year at a rate equivalent to 8.5% every 12 months. Mandeep 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 Mandeep is paid their salary once a year.

If Mandeep 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*[3], 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). Mandeep will only work for 38 years if they earn a Master's degree (from Year 5 to Year 42). This means Mandeep'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: $A \times (1+8.5\%)^2 \times (1+m)$.

If Mandeep 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. Mandeep will only work for 34 years if they earn a doctorate (from Year 9 to Year 42).

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

3 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

Mandeep 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 Mandeep'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: _____Doctorate_____

[Show your work]

Highest baseline is in Regina ($99,000)
For this question I used the provided spreadsheet to calculate the differences between each project plan and take the IRR of each. It can be seen that the best plan is the PhD path as all the highest IRR are the ones involving the PHD path.

IRR total:	2%	6%	2%	5%	6%	5%
Year	M - B	M - P	B - M	B - P	P - M	P - B
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	-$106,000	$0	$106,000	$106,000	$0	-$106,000
4	-$114,415	$0	$114,415.00	$114,415.00	$0	-$114,415
5	$815.82	$124,361.09	($815.82)	$123,545.28	-$124,361	-$123,545
6	$885.16	$134,336.78	($885.16)	$133,451.62	-$134,337	-$133,452
7	$960.40	$145,160.41	($960.40)	$144,200.01	-$145,160	-$144,200
8	$1,042.03	$156,904.05	($1,042.03)	$155,862.01	-$156,904	-$155,862
9	$1,130.61	($11,467.59)	($1,130.61)	($12,598.19)	$11,467.59	$12,598.19
10	$1,226.71	($12,442.33)	($1,226.71)	($13,669.04)	$12,442.33	$13,669.04
11	$1,330.98	($13,499.93)	($1,330.98)	($14,830.91)	$13,499.93	$14,830.91
12	$1,444.11	($14,647.42)	($1,444.11)	($16,091.53)	$14,647.42	$16,091.53
13	$1,566.86	($15,892.45)	($1,566.86)	($17,459.31)	$15,892.45	$17,459.31

14	$1,700.04	($17,243.31)	($1,700.04)	($18,943.36)	$17,243.31	$18,943.36
15	$1,844.55	($18,708.99)	($1,844.55)	($20,553.54)	$18,708.99	$20,553.54
16	$2,001.34	($20,299.26)	($2,001.34)	($22,300.59)	$20,299.26	$22,300.59
17	$2,171.45	($22,024.69)	($2,171.45)	($24,196.14)	$22,024.69	$24,196.14
18	$2,356.02	($23,896.79)	($2,356.02)	($26,252.81)	$23,896.79	$26,252.81
19	$2,556.28	($25,928.02)	($2,556.28)	($28,484.30)	$25,928.02	$28,484.30
20	$2,773.57	($28,131.90)	($2,773.57)	($30,905.47)	$28,131.90	$30,905.47
21	$3,009.32	($30,523.11)	($3,009.32)	($33,532.43)	$30,523.11	$33,532.43
22	$3,265.11	($33,117.58)	($3,265.11)	($36,382.69)	$33,117.58	$36,382.69
23	$3,542.65	($35,932.57)	($3,542.65)	($39,475.22)	$35,932.57	$39,475.22
24	$3,843.77	($38,986.84)	($3,843.77)	($42,830.61)	$38,986.84	$42,830.61
25	$4,170.49	($42,300.72)	($4,170.49)	($46,471.22)	$42,300.72	$46,471.22
26	$4,524.99	($45,896.28)	($4,524.99)	($50,421.27)	$45,896.28	$50,421.27
27	$4,909.61	($49,797.47)	($4,909.61)	($54,707.08)	$49,797.47	$54,707.08
28	$5,326.93	($54,030.25)	($5,326.93)	($59,357.18)	$54,030.25	$59,357.18
29	$5,779.72	($58,622.82)	($5,779.72)	($64,402.54)	$58,622.82	$64,402.54
30	$6,270.99	($63,605.76)	($6,270.99)	($69,876.75)	$63,605.76	$69,876.75
31	$6,804.03	($69,012.25)	($6,804.03)	($75,816.28)	$69,012.25	$75,816.28
32	$7,382.37	($74,878.30)	($7,382.37)	($82,260.66)	$74,878.30	$82,260.66
33	$8,009.87	($81,242.95)	($8,009.87)	($89,252.82)	$81,242.95	$89,252.82
34	$8,690.71	($88,148.60)	($8,690.71)	($96,839.31)	$88,148.60	$96,839.31
35	$9,429.42	($95,641.23)	($9,429.42)	($105,070.65)	$95,641.23	$105,070.65
36	$10,230.92	($103,770.74)	($10,230.92)	($114,001.66)	$103,770.74	$114,001.66
37	$11,100.55	($112,591.25)	($11,100.55)	($123,691.80)	$112,591.25	$123,691.80
38	$12,044.09	($122,161.51)	($12,044.09)	($134,205.60)	$122,161.51	$134,205.60
39	$13,067.84	($132,545.23)	($13,067.84)	($145,613.07)	$132,545.23	$145,613.07
40	$14,178.61	($143,811.58)	($14,178.61)	($157,990.19)	$143,811.58	$157,990.19
41	$15,383.79	($156,035.56)	($15,383.79)	($171,419.35)	$156,035.56	$171,419.35
42	$16,691.41	($169,298.59)	($16,691.41)	($185,990.00)	$169,298.59	$185,990.00

1.b

Mandeep 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 Mandeep'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: _____ bachelors_____

[Show your work]

Because the IRR for all projects is less that the MARR the best project would be the one with the lowest initial cost. In this case that is the bachelors degree. The initial cost is determined by converting the first positive or negative values in each column into present values in year 3.

IRR Total:	-2%	-1%	-2%	-1%	-1%	-1%
Year	M - B	M - P	B - M	B - P	P - M	P - B
0						
1						
2						
3	-$216,867	$499,590.98	$216,867	$714,568	-$499,590.98	-$714,568
4	0	0	0	0	0	0
5	$466.18	0	($466.18)	0	0	0
6	$505.81	0	($505.81)	0	0	0
7	$548.80	0	($548.80)	0	0	0
8	$595.45	0	($595.45)	0	0	0
9	$646.06	($2,261.21)	($646.06)	($2,907.28)	$2,261.21	$2,907.28
10	$700.98	($2,453.42)	($700.98)	($3,154.39)	$2,453.42	$3,154.39
11	$760.56	($2,661.96)	($760.56)	($3,422.52)	$2,661.96	$3,422.52
12	$825.21	($2,888.22)	($825.21)	($3,713.43)	$2,888.22	$3,713.43
13	$895.35	($3,133.72)	($895.35)	($4,029.07)	$3,133.72	$4,029.07

14	$971.45	($3,400.09)	($971.45)	($4,371.54)	$3,400.09	$4,371.54
15	$1,054.03	($3,689.10)	($1,054.03)	($4,743.12)	$3,689.10	$4,743.12
16	$1,143.62	($4,002.67)	($1,143.62)	($5,146.29)	$4,002.67	$5,146.29
17	$1,240.83	($4,342.90)	($1,240.83)	($5,583.73)	$4,342.90	$5,583.73
18	$1,346.30	($4,712.04)	($1,346.30)	($6,058.34)	$4,712.04	$6,058.34
19	$1,460.73	($5,112.57)	($1,460.73)	($6,573.30)	$5,112.57	$6,573.30
20	$1,584.90	($5,547.14)	($1,584.90)	($7,132.03)	$5,547.14	$7,132.03
21	$1,719.61	($6,018.64)	($1,719.61)	($7,738.25)	$6,018.64	$7,738.25
22	$1,865.78	($6,530.23)	($1,865.78)	($8,396.01)	$6,530.23	$8,396.01
23	$2,024.37	($7,085.30)	($2,024.37)	($9,109.67)	$7,085.30	$9,109.67
24	$2,196.44	($7,687.55)	($2,196.44)	($9,883.99)	$7,687.55	$9,883.99
25	$2,383.14	($8,340.99)	($2,383.14)	($10,724.13)	$8,340.99	$10,724.13
26	$2,585.71	($9,049.97)	($2,585.71)	($11,635.68)	$9,049.97	$11,635.68
27	$2,805.49	($9,819.22)	($2,805.49)	($12,624.71)	$9,819.22	$12,624.71
28	$3,043.96	($10,653.85)	($3,043.96)	($13,697.81)	$10,653.85	$13,697.81
29	$3,302.69	($11,559.43)	($3,302.69)	($14,862.12)	$11,559.43	$14,862.12
30	$3,583.42	($12,541.98)	($3,583.42)	($16,125.40)	$12,541.98	$16,125.40
31	$3,888.01	($13,608.05)	($3,888.01)	($17,496.06)	$13,608.05	$17,496.06
32	$4,218.50	($14,764.73)	($4,218.50)	($18,983.23)	$14,764.73	$18,983.23
33	$4,577.07	($16,019.74)	($4,577.07)	($20,596.80)	$16,019.74	$20,596.80
34	$4,966.12	($17,381.41)	($4,966.12)	($22,347.53)	$17,381.41	$22,347.53
35	$5,388.24	($18,858.83)	($5,388.24)	($24,247.07)	$18,858.83	$24,247.07
36	$5,846.24	($20,461.84)	($5,846.24)	($26,308.07)	$20,461.84	$26,308.07
37	$6,343.17	($22,201.09)	($6,343.17)	($28,544.26)	$22,201.09	$28,544.26
38	$6,882.34	($24,088.18)	($6,882.34)	($30,970.52)	$24,088.18	$30,970.52
39	$7,467.34	($26,135.68)	($7,467.34)	($33,603.02)	$26,135.68	$33,603.02
40	$8,102.06	($28,357.21)	($8,102.06)	($36,459.27)	$28,357.21	$36,459.27
41	$8,790.74	($30,767.58)	($8,790.74)	($39,558.31)	$30,767.58	$39,558.31

42	$9,537.95	($33,382.82)	($9,537.95)	($42,920.77)	$33,382.82	$42,920.77

1.c

As in part b., assume that Mandeep receives the same salary benefits from a Master's degree as Canadian female engineers. This time, if Mandeep goes for a Master's degree, they will also receive a $3,000 Scholarship in Year 2.

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 Mandeep 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: _____ bachelors _____

[Show your work]

First, I converted all cash flows into their future value at year 43. For the positive values including the scholarship I used the MARR as the increase rate, however for the negative values I used the guess and check method to find the value foe i than results in the difference of magnitude between the two sums of FV is as close to zero as possible. If the ERR is positive the preferred path is a masters and if the ERR is negative the preferred path is the bachelors. So with a ERR of -0.57% the preferred path is a bachelors.

M-B	FV of Positive Cash Flows	FV of Negative Cash Flows
0	$0.00	
0	$0.00	
3000	$10,575.70	
-107000		-$85,533.85
-115500		-$92,860.23
470.89	$1,510.32	
510.91565	$1,587.88	
554.34348	$1,669.43	
601.462676	$1,755.17	
652.587004	$1,845.31	
708.056899	$1,940.07	
768.24173	$2,039.71	

5	
833.542283	$2,144.46
904.393377	$2,254.60
981.266814	$2,370.38
1064.67449	$2,492.12
1155.17182	$2,620.11
1253.36143	$2,754.66
1359.89715	$2,896.13
1475.48841	$3,044.87
1600.90492	$3,201.24
1736.98184	$3,365.65
1884.6253	$3,538.50
2044.81845	$3,720.22
2218.62802	$3,911.28
2407.2114	$4,112.15
2611.82437	$4,323.34
2833.82944	$4,545.37
3074.70494	$4,778.80
3336.05486	$5,024.23
3619.61953	$5,282.25
3927.28719	$5,553.53
4261.1066	$5,838.74
4623.30066	$6,138.60

5016.28121	$6,453.86	
5442.66512	$6,785.31	
5905.29165	$7,133.78	
6407.24144	$7,500.14	
6951.85696	$7,885.33	
7542.76481	$8,290.29	
8183.89981	$8,716.05	
8879.5313	$9,163.68	
9634.29146	$9,634.29	
SUM =>	$178,397.56	-$178,394.08

$3.48 .--> ERR = -0.57%

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 Mandeep 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 Mandeep 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 16-19)

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[4]). 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.

4 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. Suppose that before COVID, **the equilibrium quantity of opioids bought and sold per week is 210 points**[5], the **equilibrium price is $20 per point**, and **the price elasticity of demand**[6] **is -0.8** (so for every 1% increase in the price of opioids, quantity demanded falls by 0.8%).

Use this information[7] to derive the pre-COVID demand curve for opioids. Show your work.

Pre-COVID Demand Function: Q = _____ 378 – 8.4P _____

Pre-COVID Inverse Demand Function: P = _____ (378 – Q)/8.4 _____

(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.)

Hint: As the Besanko & Brauetigam text linked in the footnote correctly points out, you can derive the demand function in the form Q = a – bP, where a = (1- ε)Q* and b = -εQ*/P*. Here, P* = equilibrium price, Q* = equilibrium quantity, and ε = price elasticity of demand.

[Show your work]

P* = $20
Q* = 210
Ɛ = -0.8
a = (1 + Ɛ)Q* = (1+0.08)(210) = 378
b = - ƐQ*/P = 0.08(210/20) = $8.4
Q = a – bP = 378 – 8.4P
P = (378 – Q)/8.4

5 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.

6 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

7 Need a refresher? 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[8].

ii. The demand curve shifts up[9] 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[10].

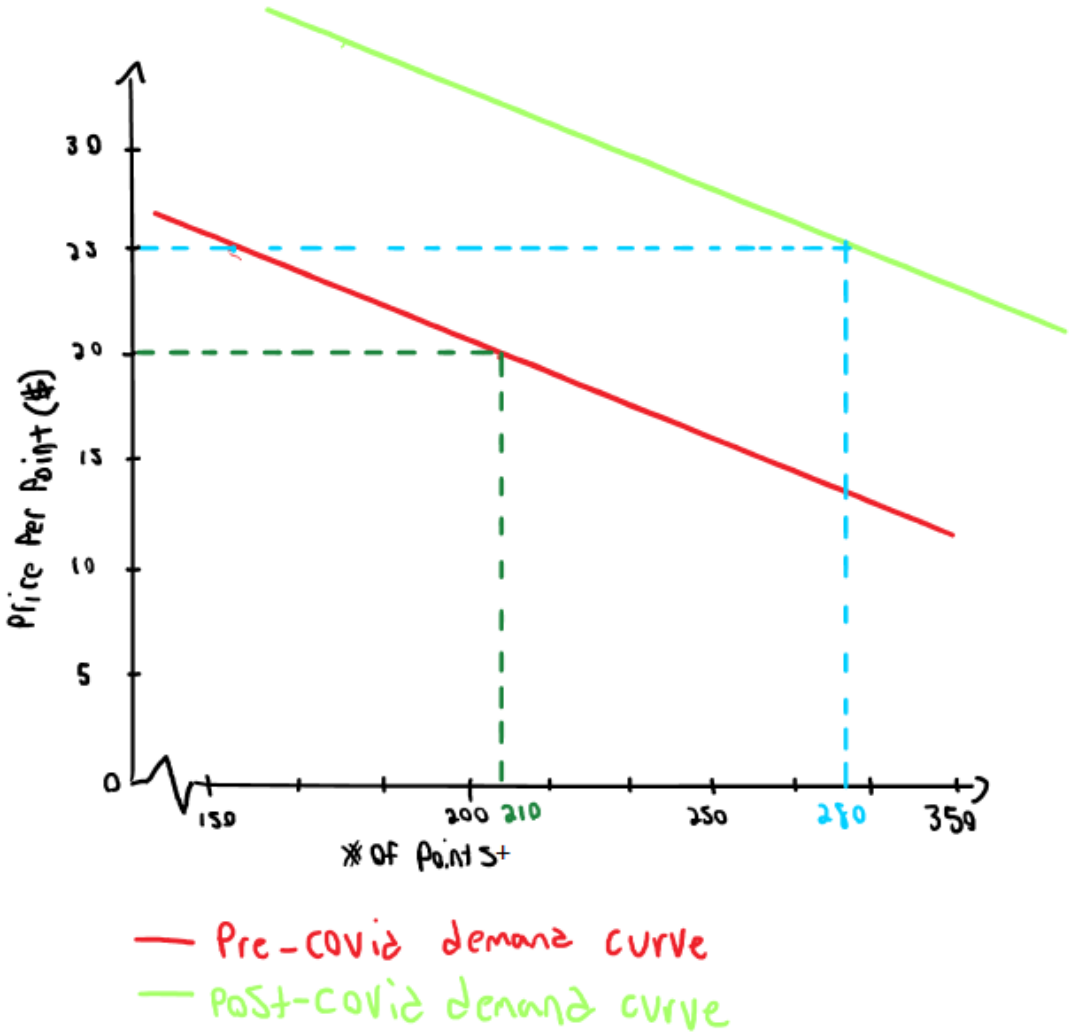
Draw a supply and demand diagram illustrating the above. Label the pre-COVID equilibrium, the post-COVID equilibrium, and the equilibrium prices and quantities.

[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.]

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

9 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/

10 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.


30
25
20
15
10
5
0
Price Per Point ($)
150
200
210
250
280
350
# of Points
Pre-covid demand curve
Post-covid demand curve

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. (See the long hint in blue.)

Before-CERB Inverse Demand (from part b.): P = _____ (378 – Q)/8.4 _____

After-CERB Inverse Demand: P = _____(504 – Q)/8.96_____

Before-COVID Inverse Supply: P = _____4.3/70 (Q – 210) + 20_____

After-COVID Inverse Supply: P = _____4.3/70 (Q – 280) + 25_____

[Show your work]

Hint: Doing the math from what the graph shows us

What are you trying to find when you're trying to find the equation of 'the supply curve'? (There are actually two: before COVID, and after COVID).

You're trying to find the equation of a line.

What do you need to find the equation of a line? Slope and intercept, or two points the line goes through.

Do you have the slope & intercept? Not without more work...

Do you have two points?

Well... Yes. You have two points, total, that you know the supply curves cross.

You have the before-COVID equilibrium (Q=210,P=20) and the post-COVID, post-CERB equilibrium (Q=280,P=25).

By the definition of what the equilibrium IS (supply & demand cross there), you know that the first point has to be on the pre-COVID supply curve, and the second point has to be on the post-COVID supply curve.

But that's ONE point per curve. You need two.

Good news: remember that the increase in drug wholesale costs of $200 per ounce works just like a 'tax' of $0.70 per point paid by producers. From lectures 16-19, you may remember what this does to the supply curve: it shifts it up by the amount of the tax.

So the post-COVID supply curve is the pre-COVID curve shifted up by $0.70. Which means that for any point (Q,P) on the old supply curve, there's a point (Q,P+0.7) on the new supply curve, and for any point (Q,P) on the new supply curve, there's a point (Q,P-0.7) on the old supply curve.

So (280,25-0.7) must be on the old supply curve, and (210,20+0.7) must be on the new supply curve.

So, boom: two points for each of the two lines you need. From there, just use the usual high-school level techniques to find the equation of a line from two points.

For how to find the equation of a line from two points, take a peek at this YouTube video:

McLogan, B. (2011, January 27). The equation of a line given two points [Video File]. https://youtu.be/4vXqMsvPSv4

There are even sites that can automate this for you:

Timur. (2019). Line equation from two points [Web Page]. https://planetcalc.com/8110/

(Don't forget that 'graphing form' supply & demand curves have P on the left, so P=f(Q), and we have P on the horizontal axis, even though the theoretical relationship is closer to Q being the dependent variable. That's why we say that we graph 'inverse demand' and 'inverse supply'.)

From there, you can use similar techniques to find the equation of post-CERB Demand. It's your pre-CERB demand curve, which you have an equation for in the form P=f(Q) (inverse demand), shifted up by some amount Y. And you know it has to cross the new equilibrium, (Q,P) = (280,25). So it must be the case that when 25 = f(280) + Y, where f(Q) is the original inverse demand curve.

After CVRD Inverse Demand assuming same elasticity:
$P^* = \$25$
$Q^* = 280$
$\varepsilon = -0.8$
$a = (1 - \varepsilon)Q^* = (1+0.08)(280) = 504$
$b = - \varepsilon Q^*/P = 0.8(280/25) = \$8.96$
$Q = a - bP = 504 - 8.96P$
$P = (a - Q)/b = (504 - Q)/8.96$

Before COVID Inverse Supply:
Point 1: (210, 20)
Point 2: (280, 25-.7) = (280, 24.3)
Slope = (y2 – y1)/(x2 – x1) = (24.2 – 20)/(280 – 210) = 4.3/70 = 0.06143
Slope-Intercept Equation: P = S(Q – Q*) + P*
P = 4.3/70 (Q – 210) + 20

After COVID Inverse Supply
Point 1: (210, 20 + 0.7) = (210, 20.7)
Point 2: (280, 25)
Slope = (y2 – y1)/(x2 – x1) = (25 – 20.7)/(280 – 210) = 4.3/70 = 0.06143
Slope-Intercept Equation: P = S(Q – Q*) + P*
P = 4.3/70 (Q – 280) + 25

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

Note: An increase in the wholesale price of opioids works similarly to a tax. Parts ii & iii rely on your knowledge of tax incidence from lectures 16-19. If you need a refresher, I recommend this YouTube video and (short) journal article:

- You Will Love Economics. (2018, October 5) Micro: Unit 1.5 – Excise Taxes and Tax Incidence. https://youtu.be/L7rHOwkUD9A
- Zupan, Mark A. (1988). Teaching Tools: The Relative Size of Supply/Demand Elasticity and Tax Incidence. *Economic Inquiry*, *26*(2), 361-363. http://search.proquest.com.ezproxy.library.uvic.ca/scholarly-journals/features/docview/1297364525/se-2?accountid=14846

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

i. (4 marks) 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.)

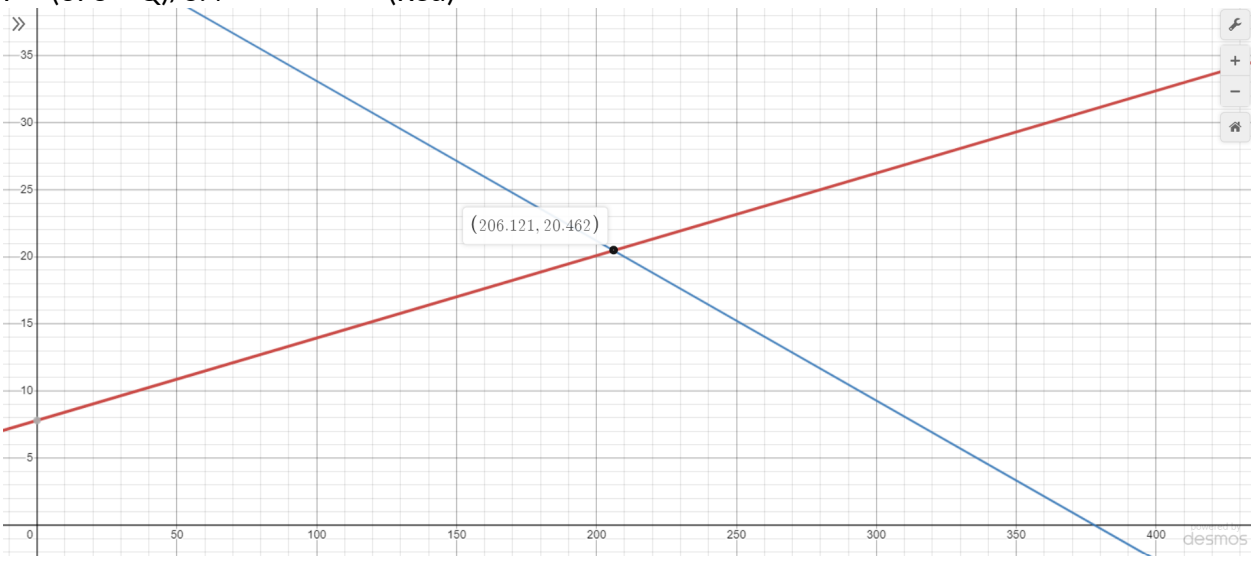
No-CERB price of opioids during COVID: $____20.46_____ per point

[Show your work – Add space as needed]

Using Desmos Online Graphing calculator I plotted the After COVID Inverse Supply curve and the Before CERB Inverse Supply curve from part b.

P = 4.3/70 (Q – 280) + 25 (Blue)

P = (378 – Q)/8.4 (Red)



ii. (3 marks) Based on your answer to part i., in the absence of CERB, which would have been more elastic – supply of opioids or demand for opioids? Briefly explain your reasoning. (Hint: the party with the lowest elasticity ends up paying most of the tax. If we look at the hypothetical 'no CERB' case, what percentage of the added $0.70/point cost of opioids is paid by opioid consumers via higher prices?)

Which is more elastic, supply or demand? _____Supply_____

[Briefly explain your reasoning]

The difference in cost from the before COVID price is $0.46. 0.46/0.7 = 65.7% > 50% so more of the increased cost ends up on the buyers. If the increase of cost is on the buyers, then the demand curve is less elastic that the supply curve.

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? _____Buyers_____

[Briefly explain your reasoning and show your work.]

$\varepsilon = dQ_s^*/dP_s^* \times P^*/Q^*$
$P^* = \$25$
$Q^* = 280$
$P_s = 4.3/70\ (Q - 280) + 25 \Rightarrow Q = (P_s - 25)70/4.3 + 280$
$P_B = (504 - Q)/8.96 \Rightarrow Q = 504 - P_B \times 8.96$
$\varepsilon_S = 1 - (-8.96) \times 25/280 = 0.89$
$\varepsilon_B = 1 - 70/4.3 \times 25/280 = -0.45$

The sellers are nearly twice as elastic as the buyers so we can easily assume that the buyers pay about twice as much of the added cost that the sellers do.

Question 3: Inflation (Lectures 20, 21)

3.a. Using the CPI

i. The Canadian CPI was 11.6 in May 1920 and is 150 in May 2022[11]. Calculate the average annual rate of inflation from 1920 to 2022 (102 years). Show your work.

Average annual rate of inflation: ____11.7_____ % per year

[Work]

1$ in 1920 is (150-11.6)/11.6 = $11.93 in 2022. So, 11.931*100%/102years = 11.7% average increase each year.

ii. In Calgary, in 1920, a dozen eggs cost[12] $0.50. In Calgary, in 2022, a dozen Great Value Large Eggs cost $3.79 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 _____fallen_____ in real terms, from 1920 to 2022.

[Reasoning & work]

$0.50 x 150/11.6 = $6.47
Eggs that cost $0.50 in 1920 would cost $6.47 in 2022. The average price of eggs has fallen over the past 102 years.

---

11 Statistics Canada. Table 18-10-0256-01 Consumer Price Index (CPI) statistics, measures of core inflation and other related statistics - Bank of Canada definitions
DOI: https://doi.org/10.25318/1810025601-eng

12 "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:

- Mandeep has decided to live and work in Montreal.
- Mandeep's *nominal* MARR is 3.2% per year, or about 0.263% per month (this conversion is done for you in the companion spreadsheet).
- Yearly inflation is the rate which you calculated[13] 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.
- Mandeep's monthly rent is constant in real terms, at the baseline level from Project 1. (If your baseline rent for Montreal was $2,000 a month, then Mandeep's rent is constant in real terms at $2,000 real dollars per month.)
- Mandeep pays rent for 40 years (480 months). The first rent payment is in month 36.

i. Calculate the present value of Mandeep'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: $_____544,909.97_____

[Work]

Using (P/A,i,N) with:
A = rent = $2,000
i = 0.263%
N = 480 months
We get: PV = $544,909.97

13 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 Mandeep'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: $_____6,834,297.17_____

[Work]

Using (P/A,g,i,N) with:
A = rent = $2,000
i = 0.263%
g_{yearly} = 11.7% => $g_{monthly}$ = companion = 0.926%
N = 480 months
We get: PV = $6,834,297.17

Question 4. (Challenge) Building a Price Index (Lecture 20)

In early 1920, Edmonton's Local Council of Women sounded the alarm regarding the low wages earned by waitresses (the serving profession was heavily gendered – waitresses were officially paid less than waiters[14], and this wouldn't start to change until the late 1960s[15]). The Edmonton Journal for October 12, 1920 reports this as follows:

"It was [...] disclosed, according to the statement of Mrs. W. J. Ross, secretary of the Local Council of Women, that some waitresses are dependent on the tips they receive for necessary clothing expenses. A girl paid $9 a week as a waitress had to use the whole sum for room rent, laundry, week-end meals and incidentals. She received her meals for five days of the week at the place of employment. Other expenses, such as clothing, amounted to $260 a year. From tips she received $5.25 a week, and with this money she obtained what clothing she could. [...]

Mrs. W. J. Ross produced a statement showing the weekly costs incurred by a waitress. In one case a girl, on a salary of $9, had to pay $4 for a room, $1 for laundry, $2 for the week-end meals between Saturday and Monday, $1 for carfare and $1 for sickness charges.

In one case a girl had not had a new suit for four years, said Mrs. Ross. In another case a head waitress who received $18 a week was assisting to support her mother.

"Do you know if an increase in the minimum wage would have an effect on the tipping system?" asked Mr. Martin.

Mrs. Ross replied that many people know the position the girls are in, and tip them on that account."[16]

That breakdown of weekly spending just happens 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.

14 "One of the oldest waiters in the city [of Toronto], who has gone the rounds, having been employed at one time or another in almost every café and hotel of any importance in the city, and in Canada, places the prevailing average rate of wages paid waiters, waitresses, and domestics about as follows: Waiters, hotels, per week, $6 to $7; waiters, clubs, per month, $20 to $25; waiters, clubs, summer months, $30; waitresses, cafes, per month, $12 to $15; domestics, per month, $10 to $20." From WANT ADVANCED WAGES. (1904, October 14). *The Globe*, p. 4.

15 "A recent Ontario Supreme Court ruling decided that there is no difference between men and women – at least where waiters are concerned. Mr. Justice Alexander Stark ruled that Marina Trepanier, a lounge waitress in a Sault Ste. Marie hotel, was not a waitress but a female waiter and should be paid accordingly." From Court rules waitress a waiter in practice. (1968, August 28). *The Windsor Star*, p. 4. For more information, see the appendix.

16 From MINIMUM WAGE MEANS LETTING CLERKS GO. (1920, October 12). *The Edmonton Journal*, p. 1.

4.a. The basket in 1920 and 2022

(3 marks) Fill out the following table with appropriate values for 2022, and cite your sources. Ideally, you should find Edmonton values, so that you can compare them to the values obtained in Edmonton in 1920, but values from Victoria are also allowed, if you find those numbers easier to get.

Item	1920 Cost	2022 Cost
Rent (1 week, 1 room)	$4	$250
Laundry (1 week)	$1	$ 3
Meals (2 days)	$2	$60
Transportation (1 week)	$1	$35
Health care (1 week)	$1	$8.22

You are trying to find values that are appropriate for a person working full-time as a server in Edmonton (or, if you prefer, Victoria) in 2022. **Please don't spend hours on this, unless you really want to. Rough values are fine. I expect/hope students will spend no more than 25 minutes on this (5 minutes per item), and some students may finish in 5 minutes and receive full marks.**

Rent: One week's worth of rent for a room (studio apartment, room in a larger house, etc.) within commuting distance of major restaurants, where our server works. It's fine to divide a monthly rent by 4 to obtain this value.

Laundry: One week's worth of laundry costs. This may be as small as the cost of a fraction of a bottle of laundry detergent, if the rented room has its washer/dryer and water and electricity included, or it may be the cost of using a coin laundry, plus a bit of detergent, etc., and some dry cleaning for certain kinds of uniform our server wears at work.

Meals: You should only include the cost of *two days' worth of meals*. (In 1920, this was because our server was expected to eat at work, for "free", 5 days out of 7.)

Transportation: The original had 'car fare', but this may be the cost of bus tickets, a bus pass (divide the cost of a monthly bus pass by 4 to get a weekly bus pass), cost of gas if our server owns a car, etc.

Health care: Whatever you think is appropriate for someone in the serving profession. Since it *is* 2022, this may include necessary spending on masks.

Please write down any necessary calculations here (e.g. if you divided a monthly room rent by 4 to get a weekly room rent, or multiplied the cost of a Big Mac combo by 6 to get the cost of 2 days' worth of meals):

[Calculations go here]

Weekly rent in Victoria = $1000.00 / 4 = $250.00
Weekly spending on laundry = $3.00
2 days food = $60
Weekly spending on transportation = $5.00*7days = $35.00 [1]
Weekly spending on health care = $3000.00 / 365days = $8.22

Cite your sources in APA or IEEE format:

[Cite your sources here]

I used my own budget data

4.b Calculating the Index

(3 marks) Use the information from part a. to calculate a Laspeyres price index for 2022, using 1920 as the base year. Show your work.

Laspeyres price index for 2022: ____39.58____

[Show your work]

LPI = SUM((Pi,t) x (Qi,0)) / SUM((Pi,0) x (Qi,0)) x %100
= (250x1 + 3x1 + 60x1 + 35x1 + 8.22x1) / (4x1 + 1x1 + 2x1 + 1x1 + 1x1) x %100
= 356.22 x %100 / 9 = %3958

4.c Comparison to the CPI

i. (2 marks) The Canadian CPI was 11.6 in May 1920, and is 150 in May 2022. Is average yearly inflation, as calculated by your Laspeyres index, greater than, less than or equal to average yearly inflation calculated using the CPI? Show your work.

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

[Work and Reasoning]

LPI >> CPI => inflation due to LPI is greater than inflation due to CPI
(Note, I think something went wrong in my LPI calculations)

ii. (2 marks) *Why* do you think that the two 'average yearly inflation' rates differed in the way you described in 4.c.i? If inflation using your index was higher than the one found using the CPI, why? If inflation using your index was lower than the one found using the CPI, why? (Hint: You may wish to look at the CPI basket weights[17] used by Statistics Canada.)

[Answer and reasoning – a short paragraph is fine]

17 Statistics Canada's summary of CPI basket weights: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1810000701

5. What's missing? (BONUS QUESTION)

THIS QUESTION IS OPTIONAL. YOU CAN EARN 100% ON THE PROJECT EVEN IF YOU SKIP IT.

(5 marks) Questions 1, 2 and 3 deal with Mandeep's situation. For teaching purposes, the analysis has been simplified from what would be done in a professional, realistic analysis. Given that you are one of UVic's finest problem solvers, by now you probably have some thoughts about what's missing from this analysis. This is your place to share your ideas (and get marks for it). What's something that you think is missing from our analysis of Mandeep's situation, but should definitely be added if we were doing it 'for real'? For full marks, you should attempt an implementation (i.e. try it out, at least in a limited fashion).

This question is intended to be fun, not stressful. It's a sandbox for you to show your stuff to an audience of TAs and be rewarded for it. Please don't spend hours on it, unless you really want to. Even a simple, 15-minute answer, is enough for at the very least 1 mark out of 5.

Mandeep would need to be spending a lot more money on a lot of essentials that are not listed here, electricity, phone bills, cleaning supplies, personal hygiene etc. Mandeep cannot go through life with work and survival alone, they would need to have some spending on entertainment and pleasure shopping. Additionally, Mandeep's savings and investments are not considered. If Mandeep gets married and/or has a family, it will change a lot of factors in very unpredictable ways and is likely not possible to emulate accurately in a theoretical study.

Appendix I: 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[18] 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[19]	**$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

18 See Consumer Price Index (CPI) [Web Page]. (2020). Retrieved from https://www2.gov.bc.ca/gov/content/data/statistics/economy/consumer-price-index

19 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 Mandeep'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 – Mandeep'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

Appendix II: (OPTIONAL) Restaurant wages in Edmonton, 1912

From RESTAURANT WORKERS SUBMIT WAGE SCALE. (1912, April 22). *The Edmonton Journal*, p. 5. Note this is from 1912, not 1921.

"The hotel and restaurant employees of the city have presented to their various employers a minimum wage scale to go into effect May 1. The principal changes over the present scale are in the matter of hours and overtime. Two or three of the employers have already signed, and the union expects little or no difficulty in getting all to come into line.

The scale follows:

First class cafes and lunch counters per week: First cook $35, second cook $25, third cook $17.50, night cook $28, night second cook $17.50, yardman $12, disher $12, waiters $17.50, waitresses $12, cashier $12.

Second class cafes and lunch counters, per week: First cook $28, second cook $15, disher $12, night cook $22, yardman $12, waiters $15, waitresses $12, cashiers $12.

First class hotels, per month: Head cook $150, second cook $100, third cook $75, baker $90, disher with room $30, disher without room $40, waitress with room $30, waitress without room $40, butcher $75.

Second class hotels, per month: Head cook $120, second cook $75, third cook $50, pastry cook $75, disher with room $30, disher without room $40, waitress without room $40, waitress with room $30.

Third class hotels, per month: First cook $85, helper $50, waitress with room $30, disher with room $30, disher without room $40, waitress without room $40.

No employees of this union [are] to work more than 10 hours straight, or nine hours in 14 hours, unless when necessary, and then not for more than two shifts.

All overtime to be paid at the rate of time and one-half.

Banquets where waiters wear tuxedos, $5.

Banquets, for waitresses, $4.

Lunch jobs and short shifts, three hours $1.25, and 25c an hour after."