final_project

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1 *Econ 143 - Advanced Econometrics Final Project*

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Introduction and Initial Survey Data

My final project is a fun, Berkeley-related showcase of contingent valuation of students' willingness-to-pay for a campus-wide ski lift. I remember back to three years ago, when reading about Berkeley upon my acceptance, I came across some students' proposal for something called BearLift. Here is the link to the comment under Carol Christ's Reddit Ask-Me-Anything from three years ago: https://www.reddit.com/r/berkeley/comments/9mhs3p/i_am_carol_christ_chancellor_of_uc_berkeley_ask/e7

When we began covering nonparametric analysis in class, I knew that I can put two and two together and apply this nonparametric technique to a very playful topic. So, I first developed a survey through Google Forms and collected 57 responses from fellow Berkeley students (https://forms.gle/jSU8tq5m7x37S58X6). The form has far greater detail about the pros and cons of a potential ski lift. I randomly assigned students to different initial prices ($100, $200, $300, $400, $500), then would direct them to the respective following price points (half or double) depending on their answer.

[ ]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

[ ]:
```python
survey = pd.read_csv("Econ143_Ski_Slope_CV_Responses _Form_Responses.csv")
survey.tail()
```

[ ]:
```
                       Email Address        Timestamp  \
53            rdison@berkeley.edu   5/12/2022 9:53
54          jholobetz@berkeley.edu  5/12/2022 10:18
55     gabrielcharoes@berkeley.edu  5/12/2022 11:16
56  michele.strazza.2000@gmail.com  5/12/2022 12:11
57         1022charlotte@gmail.com  5/12/2022 13:17

   Per the nature of this experiment, these 5 symbols have been sorted into a
random order. Please pick just the top answer.  \
53                                                  $
54                                                  !
55                                                  %
```

```
56                                                     $
57                                                     $

   Are you willing to pay $100 in annual student fees for BearLift?  \
53                                                   NaN
54                                                    No
55                                                   NaN
56                                                   NaN
57                                                   NaN

   You said no to $100 in annual student fees for Bear Lift. Are you willing to
pay $50 in annual student fees for BearLift?  \
53                                                   NaN
54                                                    No
55                                                   NaN
56                                                   NaN
57                                                   NaN

   You said yes to $100 in annual student fees for Bear Lift. Are you willing to
pay $200 in annual student fees for BearLift?  \
53                                                   NaN
54                                                   NaN
55                                                   NaN
56                                                   NaN
57                                                   NaN

   Are you willing to pay $200 in annual student fees for BearLift?  \
53                                                   NaN
54                                                   NaN
55                                                   NaN
56                                                   NaN
57                                                   NaN

   You said no to $200 in annual student fees for Bear Lift. Are you willing to
pay $100 in annual student fees for BearLift?  \
53                                                   NaN
54                                                   NaN
55                                                   NaN
56                                                   NaN
57                                                   NaN

   You said yes to $200 in annual student fees for Bear Lift. Are you willing to
pay $400 in annual student fees for BearLift?  \
53                                                   NaN
54                                                   NaN
55                                                   NaN
56                                                   NaN
```

```
57                                                NaN

   Are you willing to pay $300 in annual student fees for BearLift?  \
53                                                NaN
54                                                NaN
55                                                NaN
56                                                NaN
57                                                NaN

   You said no to $300 in annual student fees for Bear Lift. Are you willing to
pay $150 in annual student fees for BearLift?  \
53                                                NaN
54                                                NaN
55                                                NaN
56                                                NaN
57                                                NaN

   You said yes to $300 in annual student fees for Bear Lift. Are you willing to
pay $600 in annual student fees for BearLift?  \
53                                                NaN
54                                                NaN
55                                                NaN
56                                                NaN
57                                                NaN

   Are you willing to pay $400 in annual student fees for BearLift?  \
53                                                 No
54                                                NaN
55                                                NaN
56                                                Yes
57                                                Yes

   You said no to $400 in annual student fees for Bear Lift. Are you willing to
pay $200 in annual student fees for BearLift?  \
53                                                Yes
54                                                NaN
55                                                NaN
56                                                NaN
57                                                NaN

   You said yes to $400 in annual student fees for Bear Lift. Are you willing to
pay $800 in annual student fees for BearLift?  \
53                                                NaN
54                                                NaN
55                                                NaN
56                                                 No
57                                                Yes
```

```
   Are you willing to pay $500 in annual student fees for BearLift?  \
53                                                NaN
54                                                NaN
55                                                 No
56                                                NaN
57                                                NaN

   You said no to $500 in annual student fees for Bear Lift. Are you willing to
pay $250 in annual student fees for BearLift?  \
53                                                NaN
54                                                NaN
55                                                 No
56                                                NaN
57                                                NaN

   You said yes to $500 in annual student fees for Bear Lift. Are you willing to
pay $1000 in annual student fees for BearLift?
53                                                NaN
54                                                NaN
55                                                NaN
56                                                NaN
57                                                NaN
```

Survey DataFrame Cleaning

Although we have collected our survey data with Google Forms, we still have a ways to go before we can derive students' willingness-to-pay for this ski slope. We still have to reformat this data in such a way that we can continue with our contingent valuation.

[ ]:
```
survey_drop_unnecessary_cols = survey.drop(survey.columns[:3], axis=1) # Drop␣
 ↪emails, time-stamps, and randomizer
survey_fill_nan_and_replace_yes_no = survey_drop_unnecessary_cols.
 ↪replace("Yes", 1).replace("No", 2).fillna(0) # Replace Yes with 1 and No␣
 ↪with 2, fill na w/ 0
survey_cleaned = survey_fill_nan_and_replace_yes_no.iloc[1:].astype(int) #␣
 ↪remove the 1st row (it errors) and set everything from float to int
survey_cleaned.head()
```

[ ]:
```
   Are you willing to pay $100 in annual student fees for BearLift?  \
1                                                  0
2                                                  0
3                                                  0
4                                                  1
5                                                  0

   You said no to $100 in annual student fees for Bear Lift. Are you willing to
pay $50 in annual student fees for BearLift?  \
```

1	0
2	0
3	0
4	0
5	0

You said yes to $100 in annual student fees for Bear Lift. Are you willing to pay $200 in annual student fees for BearLift? \

1	0
2	0
3	0
4	1
5	0

Are you willing to pay $200 in annual student fees for BearLift? \

1	0
2	0
3	1
4	0
5	0

You said no to $200 in annual student fees for Bear Lift. Are you willing to pay $100 in annual student fees for BearLift? \

1	0
2	0
3	0
4	0
5	0

You said yes to $200 in annual student fees for Bear Lift. Are you willing to pay $400 in annual student fees for BearLift? \

1	0
2	0
3	2
4	0
5	0

Are you willing to pay $300 in annual student fees for BearLift? \

1	1
2	0
3	0
4	0
5	0

You said no to $300 in annual student fees for Bear Lift. Are you willing to pay $150 in annual student fees for BearLift? \

1	0

2	0
3	0
4	0
5	0

You said yes to $300 in annual student fees for Bear Lift. Are you willing to pay $600 in annual student fees for BearLift? \

1	2
2	0
3	0
4	0
5	0

Are you willing to pay $400 in annual student fees for BearLift? \

1	0
2	0
3	0
4	0
5	0

You said no to $400 in annual student fees for Bear Lift. Are you willing to pay $200 in annual student fees for BearLift? \

1	0
2	0
3	0
4	0
5	0

You said yes to $400 in annual student fees for Bear Lift. Are you willing to pay $800 in annual student fees for BearLift? \

1	0
2	0
3	0
4	0
5	0

Are you willing to pay $500 in annual student fees for BearLift? \

1	0
2	1
3	0
4	0
5	2

You said no to $500 in annual student fees for Bear Lift. Are you willing to pay $250 in annual student fees for BearLift? \

1	0
2	0

3	0
4	0
5	2

You said yes to $500 in annual student fees for Bear Lift. Are you willing to pay $1000 in annual student fees for BearLift?

1	0
2	1
3	0
4	0
5	0

[ ]:
```
def build_cv(respondent):
    '''
    Will take a respondent's answer to the survey and reformat their answer,
    by marking the answers and prices they chose for both parts of the survey
    '''
    cv = np.empty(4)
    for price_index_pair in [[100, 0],[200,3],[300,6], [400,9],[500,12]]: #␣
↪identifies the 5 prices and their corresponding col index in surveys_cleaned.
↪csv
        price = price_index_pair[0] # initial price
        index = price_index_pair[1] # col index for initial price
        if respondent[index] != 0: # signifies this is the initial price the␣
↪respondent was given
            cv[0] = respondent[index] # 1st response: 1 (yes) or 2 (no)
            cv[1] = price
            if respondent[index] == 2: # if response is no, go to␣
↪price-corresponding "no" col
                cv[2] = respondent[index + 1] # 2nd response: 1 (yes) or 2 (no)
                cv[3] = price / 2 # half price
            else:
                cv[2] = respondent[index + 2] # if response is yes, go to␣
↪price-corresponding "yes" col
                cv[3] = price * 2 # double price
    return cv.astype(int) # set from float to int
```

[ ]:
```
cv_data = survey_cleaned.apply(build_cv, axis=1) # apply build_cv to every row/
↪respondent in the survey
cv_data = np.array([np.array(xi) for xi in cv_data]) # reformat cv_data as a np.
↪array
cv = pd.DataFrame(cv_data, columns=['Yes1DK','PT1','Yes2DK','PT2']) # turn into␣
↪a DF
cv.head()
```

```
[ ]:    Yes1DK  PT1  Yes2DK   PT2
     0       1  300       2   600
     1       1  500       1  1000
     2       1  200       2   400
     3       1  100       1   200
     4       2  500       2   250
```

```
[ ]: cv["LB"] = -9
     cv["UB"] = -9

     # LOWER BOUND construction
     # yes-yes responders
     cv.loc[(cv["Yes1DK"]==1) & (cv["Yes2DK"]==1), "LB"] = cv["PT2"]

     # yes-no responders
     cv.loc[(cv["Yes1DK"]==1) & (cv["Yes2DK"]==2), "LB"] = cv["PT1"]

     # no-yes responders
     cv.loc[(cv["Yes1DK"]==2) & (cv["Yes2DK"]==1), "LB"] = cv["PT2"]

     # no-no responders
     cv.loc[(cv["Yes1DK"]==2) & (cv["Yes2DK"]==2), "LB"] = 0

     # UPPER BOUND construction
     # yes-yes responders
     cv.loc[(cv["Yes1DK"]==1) & (cv["Yes2DK"]==1), "UB"] = np.inf

     # yes-no responders
     cv.loc[(cv["Yes1DK"]==1) & (cv["Yes2DK"]==2), "UB"] = cv["PT2"]

     # no-yes responders
     cv.loc[(cv["Yes1DK"]==2) & (cv["Yes2DK"]==1), "UB"] = cv["PT1"]

     # no-no responders
     cv.loc[(cv["Yes1DK"]==2) & (cv["Yes2DK"]==2), "UB"] = cv["PT2"]
```

Below are 10 of the lower and upper bounds for students' willingness-to-pay for the ski slope based on our double-bounded dichtomous choice process

```
[ ]: cv[["LB","UB"]][0:10]
```

```
[ ]:      LB     UB
     0   300  600.0
     1  1000    inf
     2   200  400.0
     3   200    inf
     4     0  250.0
```

```
5   500  1000.0
6     0   200.0
7   200     inf
8     0    50.0
9     0   150.0
```

Now armed with the pairs of lower and upper bounds, we can build our matrix of dummy variables that indicate what prices respondents are willing to pay.

```
[ ]: cv["D1"] = ((cv["LB"]<=0)   & (cv["UB"]>=50)      )*1
     cv["D2"] = ((cv["LB"]<=50)  & (cv["UB"]>=100)     )*1
     cv["D3"] = ((cv["LB"]<=100) & (cv["UB"]>=150)     )*1
     cv["D4"] = ((cv["LB"]<=150) & (cv["UB"]>=200)     )*1
     cv["D5"] = ((cv["LB"]<=200) & (cv["UB"]>=250)     )*1
     cv["D6"] = ((cv["LB"]<=250) & (cv["UB"]>=300)     )*1
     cv["D7"] = ((cv["LB"]<=300) & (cv["UB"]>=400)     )*1
     cv["D8"] = ((cv["LB"]<=400) & (cv["UB"]>=500)     )*1
     cv["D9"] = ((cv["LB"]<=500) & (cv["UB"]>=600)   )*1
     cv["D10"] = ((cv["LB"]<=600) & (cv["UB"]>=800)   )*1
     cv["D11"] = ((cv["LB"]<=800) & (cv["UB"]>=1000)   )*1
     cv["D12"] = ((cv["LB"]<=1000) & (cv["UB"]>=np.inf) )*1
     cv[["D1","D2","D3","D4","D5","D6","D7","D8","D9","D10","D11","D12"]][0:10]
```

```
[ ]:    D1  D2  D3  D4  D5  D6  D7  D8  D9  D10  D11  D12
     0   0   0   0   0   0   0   1   1   1    0    0    0
     1   0   0   0   0   0   0   0   0   0    0    0    1
     2   0   0   0   0   1   1   1   0   0    0    0    0
     3   0   0   0   0   1   1   1   1   1    1    1    1
     4   1   1   1   1   1   0   0   0   0    0    0    0
     5   0   0   0   0   0   0   0   0   1    1    1    0
     6   1   1   1   1   0   0   0   0   0    0    0    0
     7   0   0   0   0   1   1   1   1   1    1    1    1
     8   1   0   0   0   0   0   0   0   0    0    0    0
     9   1   1   1   0   0   0   0   0   0    0    0    0
```

The entire objective of this process is to find some measure of central tendency regarding students' willingness-to-pay for the ski lift. We can achieve this by working our way towards a satisfactory cumulative distribution function and finding the interval at the 50th percentile.

```
[ ]: def E_Step(F, D):

         """
         F : (F(b1),F(b2),...,F(bL)) willingness-to-pay CDF values, numpy (L-1,)␣
      ↪array
         D : N x L matrix of indicators for WTP
         """

         L = len(F) + 1             # number of disjoint intervals
```

```
    F_star = list(F)          # add 0 and 1 to list of CDF values
    F_star.insert(0,0)
    F_star.append(1)

    F_dif = []                # compute probability assigned to each of the l=1,.
↪.,L WTP intervals
                              # given current value of F
    for l in range(L):
        F_dif.append(F_star[l+1] - F_star[l])

    delta_0   = D * F_dif         # N x L matrix with numerator values for␣
↪delta_il, i = 1,..,N, l = 1,...,L
    delta_1   = D @ F_dif         # N - vector with denominator values for␣
↪delta_il, i = 1,..,N

    delta = delta_0.T / delta_1  # L x N matrix with posterior probability that␣
↪each of the i = 1,..,N,
                                 # units is in the l = 1,...,L bins given the␣
↪data and current value of F
    return delta.T
```

The next block of code uses Turnbull's method to compute "self-consistent" estimates of $F = (F(b_1), F(b_2), \dots, F(b_{L-1}))'$.

[ ]:
```
D = cv[["D1","D2","D3","D4","D5","D6","D7","D8","D9","D10","D11","D12"]]

# starting values for Turnbull algorithm
F_start = np.array([0.065, 0.19, 0.215, 0.276, 0.34, 0.41, 0.5, 0.59, 0.615, 0.
↪84, 0.97])

finished  = False
converged = False
xtol      = 0.0001
maxiter   = 1000

iter = 0  # initialize iteration counter

while not converged:

    # Print optimization output to screen
    if (iter > 0):
        print("Iteration = "        + "%.0f" % iter + \
              ",  2-norm of change in F = " + "%.6f" % epsilon)


    # ----------------------------------------------------------------------#
```

```python
    # - E-Step: Compute posterior unit-specific WTP bin probabilities      -#
    # ----------------------------------------------------------------------#

    delta = E_Step(F_start, D)

    # ----------------------------------------------------------------------#
    # - M-Step: Update estimates of WTP distribution.                      -#
    # ----------------------------------------------------------------------#

    F_em = np.cumsum(np.mean(delta))[0:-1]

    # Assess convergence
    epsilon = np.linalg.norm(F_start-F_em)

    if (epsilon < xtol) | (iter >= maxiter):
            finished = True
            if (epsilon < xtol):
                converged = True

    # Update parameters
    F_start = F_em
    iter += 1
```

```
Iteration = 1,  2-norm of change in F = 0.719990
Iteration = 2,  2-norm of change in F = 0.052285
Iteration = 3,  2-norm of change in F = 0.019912
Iteration = 4,  2-norm of change in F = 0.012506
Iteration = 5,  2-norm of change in F = 0.009025
Iteration = 6,  2-norm of change in F = 0.007418
Iteration = 7,  2-norm of change in F = 0.006689
Iteration = 8,  2-norm of change in F = 0.006321
Iteration = 9,  2-norm of change in F = 0.006074
Iteration = 10,  2-norm of change in F = 0.005855
Iteration = 11,  2-norm of change in F = 0.005635
Iteration = 12,  2-norm of change in F = 0.005406
Iteration = 13,  2-norm of change in F = 0.005172
Iteration = 14,  2-norm of change in F = 0.004936
Iteration = 15,  2-norm of change in F = 0.004702
Iteration = 16,  2-norm of change in F = 0.004472
Iteration = 17,  2-norm of change in F = 0.004249
Iteration = 18,  2-norm of change in F = 0.004035
Iteration = 19,  2-norm of change in F = 0.003829
Iteration = 20,  2-norm of change in F = 0.003633
Iteration = 21,  2-norm of change in F = 0.003447
Iteration = 22,  2-norm of change in F = 0.003270
Iteration = 23,  2-norm of change in F = 0.003103
Iteration = 24,  2-norm of change in F = 0.002946
```

```
Iteration = 25,  2-norm of change in F = 0.002797
Iteration = 26,  2-norm of change in F = 0.002657
Iteration = 27,  2-norm of change in F = 0.002525
Iteration = 28,  2-norm of change in F = 0.002401
Iteration = 29,  2-norm of change in F = 0.002285
Iteration = 30,  2-norm of change in F = 0.002175
Iteration = 31,  2-norm of change in F = 0.002072
Iteration = 32,  2-norm of change in F = 0.001975
Iteration = 33,  2-norm of change in F = 0.001884
Iteration = 34,  2-norm of change in F = 0.001798
Iteration = 35,  2-norm of change in F = 0.001717
Iteration = 36,  2-norm of change in F = 0.001640
Iteration = 37,  2-norm of change in F = 0.001569
Iteration = 38,  2-norm of change in F = 0.001501
Iteration = 39,  2-norm of change in F = 0.001437
Iteration = 40,  2-norm of change in F = 0.001376
Iteration = 41,  2-norm of change in F = 0.001319
Iteration = 42,  2-norm of change in F = 0.001265
Iteration = 43,  2-norm of change in F = 0.001213
Iteration = 44,  2-norm of change in F = 0.001165
Iteration = 45,  2-norm of change in F = 0.001119
Iteration = 46,  2-norm of change in F = 0.001075
Iteration = 47,  2-norm of change in F = 0.001034
Iteration = 48,  2-norm of change in F = 0.000995
Iteration = 49,  2-norm of change in F = 0.000957
Iteration = 50,  2-norm of change in F = 0.000922
Iteration = 51,  2-norm of change in F = 0.000888
Iteration = 52,  2-norm of change in F = 0.000856
Iteration = 53,  2-norm of change in F = 0.000825
Iteration = 54,  2-norm of change in F = 0.000796
Iteration = 55,  2-norm of change in F = 0.000768
Iteration = 56,  2-norm of change in F = 0.000741
Iteration = 57,  2-norm of change in F = 0.000716
Iteration = 58,  2-norm of change in F = 0.000692
Iteration = 59,  2-norm of change in F = 0.000669
Iteration = 60,  2-norm of change in F = 0.000646
Iteration = 61,  2-norm of change in F = 0.000625
Iteration = 62,  2-norm of change in F = 0.000605
Iteration = 63,  2-norm of change in F = 0.000585
Iteration = 64,  2-norm of change in F = 0.000567
Iteration = 65,  2-norm of change in F = 0.000549
Iteration = 66,  2-norm of change in F = 0.000532
Iteration = 67,  2-norm of change in F = 0.000515
Iteration = 68,  2-norm of change in F = 0.000500
Iteration = 69,  2-norm of change in F = 0.000485
Iteration = 70,  2-norm of change in F = 0.000470
Iteration = 71,  2-norm of change in F = 0.000456
Iteration = 72,  2-norm of change in F = 0.000443
```

```
Iteration = 73,  2-norm of change in F = 0.000430
Iteration = 74,  2-norm of change in F = 0.000417
Iteration = 75,  2-norm of change in F = 0.000405
Iteration = 76,  2-norm of change in F = 0.000394
Iteration = 77,  2-norm of change in F = 0.000383
Iteration = 78,  2-norm of change in F = 0.000372
Iteration = 79,  2-norm of change in F = 0.000362
Iteration = 80,  2-norm of change in F = 0.000352
Iteration = 81,  2-norm of change in F = 0.000343
Iteration = 82,  2-norm of change in F = 0.000333
Iteration = 83,  2-norm of change in F = 0.000325
Iteration = 84,  2-norm of change in F = 0.000316
Iteration = 85,  2-norm of change in F = 0.000308
Iteration = 86,  2-norm of change in F = 0.000300
Iteration = 87,  2-norm of change in F = 0.000292
Iteration = 88,  2-norm of change in F = 0.000285
Iteration = 89,  2-norm of change in F = 0.000278
Iteration = 90,  2-norm of change in F = 0.000271
Iteration = 91,  2-norm of change in F = 0.000264
Iteration = 92,  2-norm of change in F = 0.000257
Iteration = 93,  2-norm of change in F = 0.000251
Iteration = 94,  2-norm of change in F = 0.000245
Iteration = 95,  2-norm of change in F = 0.000239
Iteration = 96,  2-norm of change in F = 0.000234
Iteration = 97,  2-norm of change in F = 0.000228
Iteration = 98,  2-norm of change in F = 0.000223
Iteration = 99,  2-norm of change in F = 0.000218
Iteration = 100,  2-norm of change in F = 0.000213
Iteration = 101,  2-norm of change in F = 0.000208
Iteration = 102,  2-norm of change in F = 0.000203
Iteration = 103,  2-norm of change in F = 0.000198
Iteration = 104,  2-norm of change in F = 0.000194
Iteration = 105,  2-norm of change in F = 0.000190
Iteration = 106,  2-norm of change in F = 0.000186
Iteration = 107,  2-norm of change in F = 0.000181
Iteration = 108,  2-norm of change in F = 0.000178
Iteration = 109,  2-norm of change in F = 0.000174
Iteration = 110,  2-norm of change in F = 0.000170
Iteration = 111,  2-norm of change in F = 0.000166
Iteration = 112,  2-norm of change in F = 0.000163
Iteration = 113,  2-norm of change in F = 0.000160
Iteration = 114,  2-norm of change in F = 0.000156
Iteration = 115,  2-norm of change in F = 0.000153
Iteration = 116,  2-norm of change in F = 0.000150
Iteration = 117,  2-norm of change in F = 0.000147
Iteration = 118,  2-norm of change in F = 0.000144
Iteration = 119,  2-norm of change in F = 0.000141
Iteration = 120,  2-norm of change in F = 0.000138
```

```
Iteration = 121,  2-norm of change in F = 0.000136
Iteration = 122,  2-norm of change in F = 0.000133
Iteration = 123,  2-norm of change in F = 0.000130
Iteration = 124,  2-norm of change in F = 0.000128
Iteration = 125,  2-norm of change in F = 0.000125
Iteration = 126,  2-norm of change in F = 0.000123
Iteration = 127,  2-norm of change in F = 0.000121
Iteration = 128,  2-norm of change in F = 0.000119
Iteration = 129,  2-norm of change in F = 0.000116
Iteration = 130,  2-norm of change in F = 0.000114
Iteration = 131,  2-norm of change in F = 0.000112
Iteration = 132,  2-norm of change in F = 0.000110
Iteration = 133,  2-norm of change in F = 0.000108
Iteration = 134,  2-norm of change in F = 0.000106
Iteration = 135,  2-norm of change in F = 0.000104
Iteration = 136,  2-norm of change in F = 0.000102
Iteration = 137,  2-norm of change in F = 0.000101
```

The code below outputs the CDF we are after: the 50th percentile for willingness-to-pay is somewhere between $100 and $150.

[ ]:
```
foo = list(F_em)
foo.insert(0,0)
data_em = {"Willingness-To-Pay" : [0, 50, 100, 150, 200, 250, 300, 400, 500,␣
 ↪600, 800, 1000], "F(y), CDF" : foo}
data_em
WTP_em = pd.DataFrame.from_dict(data_em)
WTP_em['Survivorship of WTP'] = 1 - WTP_em['F(y), CDF']

WTP_em
```

[ ]:

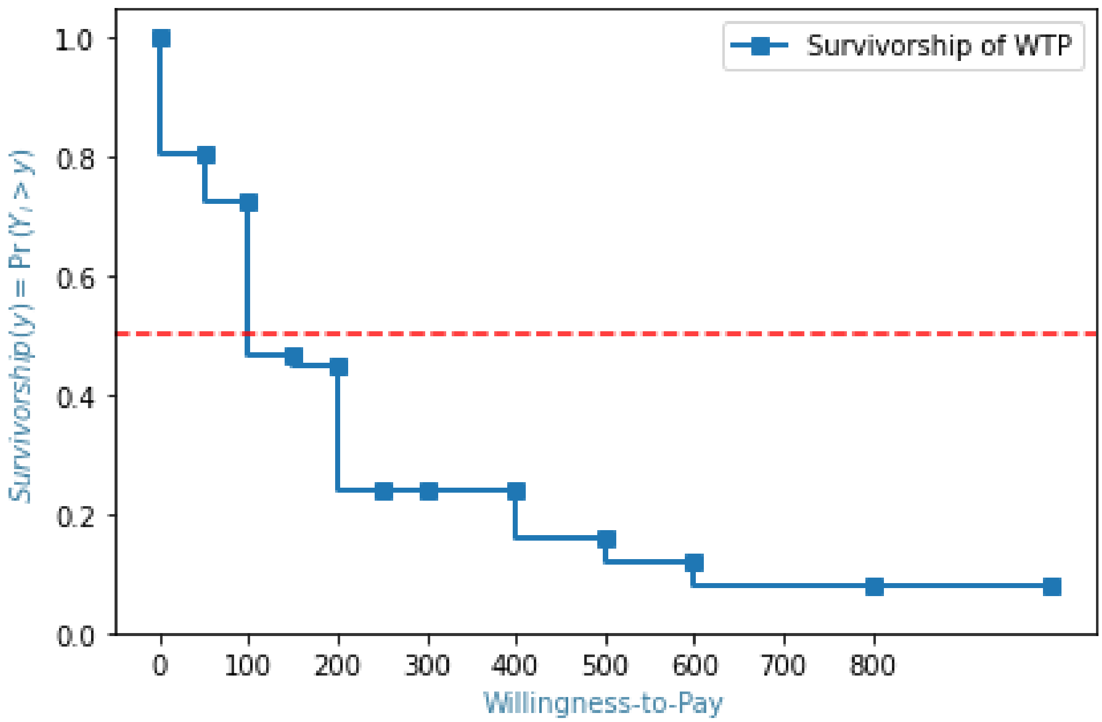
	Willingness-To-Pay	F(y), CDF	Survivorship of WTP
0	0	0.000000	1.000000
1	50	0.196802	0.803198
2	100	0.275522	0.724478
3	150	0.535366	0.464634
4	200	0.550813	0.449187
5	250	0.759008	0.240992
6	300	0.759649	0.240351
7	400	0.760972	0.239028
8	500	0.839917	0.160083
9	600	0.879562	0.120438
10	800	0.919781	0.080219
11	1000	0.920871	0.079129

Below we plot the willingness-to-pay survivor function for the BearLift proposal.

```
[ ]: # Plot estimate WTP survivor function
fig_wtp_cdf, ax = plt.subplots()


WTP_em.plot(x="Willingness-To-Pay",y="Survivorship of WTP", drawstyle="steps",␣
 ↪style='s-', linewidth=2, ax=ax)
color = '#3B7EA1' # Founder's Rock
ax.set_xlabel('Willingness-to-Pay', color=color)
ax.set_ylabel(r'$Survivorship(y)=\Pr\left(Y_{i}>y\right)$', color=color)
plt.axhline(y = 0.5, color = 'r', linestyle = '--')
ax.set_xticks([0,100,200,300,400,500,600,700,800])
ax.set_yticks([0,0.2,0.4,0.6,0.8,1.0])

fig_wtp_cdf.tight_layout()  # otherwise the right y-label is slightly clipped
plt.savefig('fig_wtp_cdf', bbox_inches='tight', dpi=500)
```



2 Conclusion

We went out and gathered real data about an interesting topic that could have a real impact on the everyday lives of Berkeley students. We then conducted a nonparametric analysis of the data and found some measure of centeredness, by optimizing the posterior probabilities and cumulative distribution. We found that the 50th percentile of willingness-to-pay for BearLift lies in the ($100, $150) interval, and we can chart the survivorship function of the willingess-to-pay as we change the proposed price of the annual fee.