# Exercise 2: Policy Memorandum

To: Mayor of Smallville

Regarding: Smallville Sanitation Management

From: Yehzee Ryoo

**Executive summary**

Resolving the current mismanagement of the Sanitation Department in Smallville should be one of the first priorities as a new elected mayor to increase the quality of life of your constituencies. You can consider eliminating the Sanitation department and switching to a private contractor which offers a much lower price – $40.60 – compared to the current cost – $48.50 – the department has used per household for once-a-week curbside pick-up. However, this solution can be politically risky since many of your constituencies may lose their jobs. Thus, I would like to recommend another way of addressing the current problem – appointing a more competent Sanitation Department supervisor. By adopting this solution, the cost of refuse collection can be reduced substantively while preventing any political cost that might follow a massive unemployment of the residents caused by removing the department.

**Comparison with other municipalities**

First of all, I would like to compare the refuse collection cost of Smallville with other 30 municipalities to evaluate if the current cost is a suitable amount. Looking at the summary table in the Appendix, the average cost per household for weekly refuse pickup of 30 municipalities in the region was around $44.97 last year. It is clear that the Sanitation Department of Smallville is expending about $3.53 more per household, which in total $554,210 every week. Given that Smallville is spending more than other municipalities in general, whether this excess of cost is reasonable or not considering the various factors that determine the refuse collection cost should be examined. Probable factors that affect the cost could include the number of households in the city, the density of households, the average wage of collection workers, and the number of snow emergencies that can increase the costs of collection. Incorporating all these factors, I develop a statistical model and predict the appropriate amount that your city should be spending for the refuse collection.

According to my model, the appropriate amount of the collection cost for a city with factor values that your city has seems to be $37.524923. This was calculated by the multivariate regression model having four aforementioned factors – the number of households, the density of households, the average wage of collection workers, and the number of snow emergencies – and a square value of one of them, the number of households, as independent variables. The squared variable was included after I examined a plot of residuals, since it was showing a certain pattern when it should be evenly distributed. Following this result, Smallville can save around $10.98 with a better management of the Sanitation Department.

**Recommendation of reappointment**

To conclude, my model suggests that Smallville can reduce the cost of collection with a better management without eliminating the current department. The expected cost with a new supervisor is around $37.52, which is even lower than the potential bid from the private contractor. Even though there is a range of variation in this computed cost, political backlash from your residents could be very risky since you were elected very recently. Thus, I recommend you promoting a better management of the sanitation services by hiring a new, more competent supervisor to the Sanitation department, rather than switching to a private contractor.

## Appendix

```
. summarize cost_per_household hholds density wage snowdays

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
cost_per_h~d |        30    44.96533    16.27534      20.69      84.15
      hholds |        30    7.563067    2.843379       2.56      12.23
     density |        30    607.6667    83.15088      458.8      743.8
        wage |        30    17.87533     1.90663      15.61      21.36
    snowdays |        30    4.466667    2.849481          0         10


. regress cost_per_household hholds density wage snowdays

      Source |       SS           df       MS      Number of obs   =        30
-------------+----------------------------------   F(4, 25)        =     17.47
       Model |  5657.89948         4  1414.47487   Prob > F        =    0.0000
    Residual |  2023.81858        25  80.9527431   R-squared       =    0.7365
-------------+----------------------------------   Adj R-squared   =    0.6944
       Total |  7681.71806        29   264.88683   Root MSE        =    8.9974

------------------------------------------------------------------------------
cost_per_h~d |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      hholds |    3.63205   .7313792     4.97   0.000     2.125747    5.138354
     density |  -.0268314   .0211887    -1.27   0.217    -.0704702    .0168074
        wage |   .8352337   .9116187     0.92   0.368     -1.04228    2.712748
    snowdays |   1.837679   .6995717     2.63   0.015     .3968837    3.278473
       _cons |   10.66206   20.95837     0.51   0.615    -32.50251    53.82664
------------------------------------------------------------------------------

.
```

```
. **Plot residuals
. predict p_cost_per_household
(option xb assumed; fitted values)

.
. generate resid = cost_per_household - p_cost_per_household

.
. plot resid hholds

 15.6585 +
        | *
        |                                                      *
        |
        |     *
        |                                                 *   *
        | *  *
        |                                      *
   r    |                         *                        *
   e    |                                      *        *
   s    | *                           *          *
   i    |               *          *                    *
   d    |                     *         *
        |                    *  *          *  *
        |        *                      *
        |
        |
        |                            *
        |                         *
        |
-17.7711 +                          *          *
         +-----------------------------------------------------------------+
           2.56                     hholds                    12.23

. **maybe there is a quadratic pattern?
.
. plot resid density

 15.6585 +
        |                                  *
        |                                      *
        |
        |                                  *
        |  *                                                  *
        | *                    *
        |                                *
   r    |                     *                     *
   e    |                *                             *
   s    |          *           *                    *
   i    | *                        *                *
   d    |             *            *
        |                           *       *    *    *
        |       *                                              *
        |
        |
        |                                          *
        |                                         *
        |
-17.7711 +          *                 *
         +-----------------------------------------------------------------+
```

```
          458.8                  density                    743.8

. plot resid wage

 15.6585 +
        |      *
        | *
        |
        |         *
        | *                                              *
        | *                       *
        |                                     *
    r   |                                               *       *
    e   |     *            *
    s   |         *   *           *
    i   |               *                *              *
    d   |  *                                     *
        | *             *               *  *
        |             *                              *
        |
        |
        |                            *
        |           *
        |
-17.7711 + *        *
        +-----------------------------------------------------------------+
          15.61                  wage                      21.36

. plot resid snowdays

 15.6585 +
        |           *
        |                           *
        |
        |      *
        |                                                *      *
        |           *     *
        |      *
    r   |                      *          *
    e   |                 *                               *
    s   |           *          *          *
    i   |                 *                    *                *
    d   |           *          *
        | *               *               *
        |                      *          *
        |
        |
        |                 *
        |      *
        |
-17.7711 +                 *                               *
        +-----------------------------------------------------------------+
              0                snowdays                      10


.
. **Include squared term of hholds
. gen hholds2 = hholds^2
```

```
.
. regress cost_per_household hholds hholds2 density wage snowdays

      Source |       SS           df       MS      Number of obs   =        30
-------------+----------------------------------   F(5, 24)        =     52.29
       Model |  7035.86261         5  1407.17252   Prob > F        =    0.0000
    Residual |  645.855448        24  26.9106437   R-squared       =    0.9159
-------------+----------------------------------   Adj R-squared   =    0.8984
       Total |  7681.71806        29   264.88683   Root MSE        =    5.1875

------------------------------------------------------------------------------
-
cost_per_h~d |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
-
      hholds |  -9.821759   1.926841    -5.10   0.000    -13.79856   -5.844954
     hholds2 |   .9315048   .1301752     7.16   0.000     .6628364    1.200173
     density |  -.0038076   .0126332    -0.30   0.766    -.0298812     .022266
        wage |   2.051062   .5523854     3.71   0.001     .9109951     3.19113
    snowdays |   .9323627   .4227229     2.21   0.037     .0599055     1.80482
       _cons |    20.1717   12.15666     1.66   0.110    -4.918425    45.26182
------------------------------------------------------------------------------
-

.
. **Variance-Covariance model for b
. * s^2*(X'X)^-1
. * but can easily calculate with..
. matrix V = get(VCE)

. matrix list V, nohalf

symmetric V[6,6]
              hholds     hholds2     density        wage    snowdays       _cons
  hholds   3.7127181  -.24474672  -.00752571   -.3536287   .15206464  -1.9521241
 hholds2  -.24474672   .01694559   .00041884   .02211791  -.01646917   .17299576
 density  -.00752571   .00041884    .0001596   .00144048  -.00018558  -.09221544
    wage   -.3536287   .02211791   .00144048   .30512959  -.04460116  -4.8938879
snowdays   .15206464  -.01646917  -.00018558  -.04460116   .17869467   .03253608
   _cons  -1.9521241   .17299576  -.09221544  -4.8938879   .03253608    147.7845

.
. matrix x0 = 6.28 \ 6.28^2 \ 620 \ 19.50 \ 5 \ 1

.
. matrix x0tVx0 = (x0')*V*x0

. matrix list x0tVx0

symmetric x0tVx0[1,1]
           c1
c1  2.7406849

.
. **Estimator of the variance of e (s^2)
. * we can calculate this using RSS
. * s^2 = RSS / df =  645.855448 / 24
. di 645.855448 / 24
26.910644

. * = 26.910644
```

```
.
.
. **Variance of y_hat
. * var(y0_hat) = s^2 + x0tVx0
. di 26.910644 + 2.7406849
29.651329

. * = 29.651329
.
.
. **Y0_hat
. * y0_hat =  -9.821759 * 6.28 +  -.0038076 * 620 +  2.051062 * 19.50 + .9323627
* 5
> + .9315048 * 6.28^2
. di -9.821759 * 6.28 +  -.0038076 * 620 +  2.051062 * 19.50 + .9323627 * 5 +
.931504
> 8 * 6.28^2 + 20.1717
37.524923

. * = 37.524923
.
. **Confidence interval
. * y0_hat +/- tvalue*var(y0_hat)^1/2
. di 37.524923 - 2.064 * sqrt(29.651329)
26.285817

. di 37.524923 + 2.064 * sqrt(29.651329)
48.764029

. * from 26.285817 to 48.764029
.
```