**Chapter 5 Project: Broiler Chicken Production (adapted from a project by the authors of our text)**

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# 1. Background information

The graph and data that form the basis of this project were taken from a very useful web site sponsored by the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA). Broiler chicken production is given on a yearly basis, from 1960 to 2002 (see diagram and table). The units of broiler chicken production are in billions of pounds (109 pounds). Sounds like a lot, but if 250 million U.S. citizens ate 0.5 pounds of chicken a week (one drumstick and one thigh), that's 6 billion pounds! Some of the broilers are exported, and others turn up in strange places such as pet food.

Inspect the graph of the 1960-2002 data. Do the data look linear or exponential? Do you expect a good exponential fit to the data, an OK exponential fit to the data, or a poor exponential fit to the data?

*Data looks linear but we expect a good exponential fit.*

**2. Prep and graph the data**

a) Create an Excel spreadsheet containing the data in columns L1, L2, L3 of the table

on page 7.

b) Using Excel, create and display a scatterplot of L1 and L2.

c) Fit a linear model C = m t + b, where C = chicken production, and t = years since 1960.

*y = 0.9137x + 0.2603*

d) Chickens were raised in the US long before 1960 of course. What about your linear model makes that a less-than-ideal description of the chicken production before 1960? Explain.

*The linear data would show that before 1960 the chicken production would eventually be at 0 or no production and would eventually show negative production of chickens.*

**3. Approximating the data – exponential regression**

Calculate the logarithms of the broiler production data (L2) and store the results in another column of the spreadsheet.

a) Create a scatterplot of the data points (years, log(production)).

b) Use Excel to find the linear regression equation through the original data points (years, log(production)).

*y = 0.0219x + 0.7455*

c) Using the computed slope and intercept of your line from part b, write out the best fitting exponential model. (*Round the y0 to 3 decimal places and the multiplier 1 + r to 4 decimal places.)*

*y= 5.565(1.0517)x*

d) What is the value of the correlation coefficient *r*? *r* = .99541 How well does an exponential model fit the data? Explain.

*The data fits the exponential model very well since r is extremely close (.1 off) to equaling +1. By being close to +1, the data tells us that the regression line is positive or increasing.*

**4. Evaluating the least squares regression model**

a) Let’s evaluate more closely the best-fitting exponential model. Calculate the percentage that the equation value is above or below the actual broiler production values given by the USDA. Fill in the table as directed:

|  |  |  |  |
| --- | --- | --- | --- |
| **year** | **actual value** | **equation value** | **% above or % below** |
| 1970 | 10 x 109 lbs | 9.21 x 109 lbs | -7.8% |
| 1990 | 25.3 x 109 lbs | 25.2 x 109 lbs | -.21% |

b) Does the regression equation give reasonable values for the years 1970 and 1990? Explain.

*Yes, it does give reasonable values for it correctly represents the difference between the two with negative error (since the value went down from the actual value) and has a low error percentage rate.*

c) Here's another way to evaluate the reasonableness of the exponential model. Scan the production data in the table. Approximately how many years did it take for production to double from 5 billion pounds/year to 10? 10 to 20? 20 to 40? Using these numbers, what is the (average) doubling time?

|  |  |
| --- | --- |
|  | doubling time  in years |
| 5 - 10  average doubling time \_\_\_*12.667 yrs*\_\_\_\_\_\_ | 10 |
| 10 - 20 | 16 |
| 20 - 40 | 12 |

d) Now calculate the doubling time by working directly with the calculator’s exponential regression equation. Show work. How does this doubling time compare to the average doubling time you estimated above?

*2\*5.565=5.565(1.0517)x*

*2=1.0517x*

*Log(2)=Log(1.0517x)*

*Log(2)=xLog(1.0517)*

*X=Log(2)/Log(1.0517)*

*X=13.75 Years*

**5. Cause of Exponential Growth of Chickens: Part A**

a) *Why* has broiler production increased exponentially in the United States in the last 40 years? Think of at least two different reasons that would explain an exponential increase in the production of broiler chickens. These answers are hypotheses, potential (but unproven) ideas that may explain the explosive increase in brawwkkkk!

1. *The population has increased so there is more demand for chicken.*

2. *Individuals eat more chicken so there is a higher demand per person.*

Don't modify these two hypotheses; keep what you have written. One potential explanation for the exponential growth of chicken production is an *exponential increase in the number of U.S. residents eating chicken*. We can test this hypothesis by looking at U.S. population, which you have already entered in L3.

b) Using Excel, find the exponential regression equation through the (year, population) data. What is the equation? *Round the y-intercept to 3 decimal places and the multiplier to 4 decimal places.*

*y= 183.4848 (1.0106)x*

c) What is the correlation coefficient *r* for this best-fitting exponential regression?

*r= 0.999162*

d) Is an exponential function a good fit to the data, a moderate fit to the data, or a poor fit to the data? In other words, how exponential is U.S. population growth; how well does an exponential function model U.S. population?

*The exponential function is a good fit according to the data because it is only .0009 away from +1. US population is exponential in growth but in the future could not remain this way.*

e) In conclusion, is the "exponential population" hypothesis supported or negated by your quantitative analysis? Explain briefly.

*The “exponential population” hypothesis is supported by the data because the exponential function fits the data almost perfectly.*

**6. Cause of Exponential Growth of Chickens: Part B**

The spokesperson for the Beef Board says: "you have made a critical assumption in your analysis, and therefore your analysis is wrong." The PR person has a good point. In order to explain exponential chicken production by exponential growth of the U.S. population, you must show that the two are linked or connected. For example, the number of automobiles in the U.S. has also grown exponentially over this 42-year period, but SUVs are not responsible for an increase in drumsticks. So what is the link, the connection, the *cause and effect* between people and chicken?   
  
a) This is a simple but important question. There is a simple three word answer...what is it?

\_\_*People\_\_\_ \_\_\_\_eat\_\_\_\_\_ \_\_\_chicken*\_\_\_\_\_

b) Let's examine this connection by calculating the *per capita* production of broiler chicken for each year in units of “pounds per person.” Note that data in L2 have units of billions of pounds, and data in L3 have units of millions of people. To get the correct units, compute like this: = **(L2\*10^9)/(L3\*10^6)** – you will need to enter the command to do this in Excel, using the first cells in the correct columns. (Entering the previous exactly *will not* work(!)

c) What was the per capita production of broiler chicken in 1960? In 2002? Has the per capita production gone down, stayed the same, or gone up with time?

*In 1960, it was 27.670 pounds per person.*

*In 2002, it was 152.807 pounds per person.*

*The per capita production has gone up with time.*

d) Can the exponential growth of the U.S. population explain *all* the change in broiler chicken production? If not, *what else* happened in this time period? Explain.

*The exponential growth can explain the most obvious reason of why there has been an increase in broiler chicken production but it can’t explain all of the factors. Another factor would be that chicken has become more efficiently produced so chicken has become more affordable to buy. Also before the 1960’s, the people weren’t as concerned with eating healthy and the awareness since 1960 has grown resulting in eating more chicken since it is a healthier choice of meat than others such as beef or pork.*

|  | **L1** | **L2** | **L3** | **L4** | **L5** |
| --- | --- | --- | --- | --- | --- |
| **year** | **years since 1960** | **production  (10 9 lbs.)** | **U.S. population (10 6)** | **log(production)** | **per capita production (pounds/person)** |
| 1960 | 0 | 5.0 | 180.7 |  |  |
| 1961 | 1 | 5.7 | 183.7 |  |  |
| 1962 | 2 | 5.7 | 186.5 |  |  |
| 1963 | 3 | 8.5 | 189.2 |  |  |
| 1964 | 4 | 6.5 | 191.9 |  |  |
| 1965 | 5 | 7.0 | 194.3 |  |  |
| 1966 | 6 | 7.7 | 196.6 |  |  |
| 1967 | 7 | 8.2 | 198.7 |  |  |
| 1968 | 8 | 8.2 | 200.7 |  |  |
| 1969 | 9 | 8.8 | 202.7 |  |  |
| 1970 | 10 | 10.0 | 205.1 |  |  |
| 1971 | 11 | 10.0 | 207.7 |  |  |
| 1972 | 12 | 10.9 | 209.9 |  |  |
| 1973 | 13 | 10.9 | 211.9 |  |  |
| 1974 | 14 | 10.9 | 213.9 |  |  |
| 1975 | 15 | 11.0 | 216.0 |  |  |
| 1976 | 16 | 12.3 | 218.0 |  |  |
| 1977 | 17 | 12.6 | 220.2 |  |  |
| 1978 | 18 | 13.4 | 222.6 |  |  |
| 1979 | 19 | 15.1 | 225.1 |  |  |
| 1980 | 20 | 15.6 | 227.7 |  |  |
| 1981 | 21 | 16.5 | 230.0 |  |  |
| 1982 | 22 | 16.5 | 232.2 |  |  |
| 1983 | 23 | 16.9 | 234.3 |  |  |
| 1984 | 24 | 17.7 | 236.3 |  |  |
| 1985 | 25 | 18.5 | 238.5 |  |  |
| 1986 | 26 | 19.5 | 240.7 |  |  |
| 1987 | 27 | 20.9 | 242.8 |  |  |
| 1988 | 28 | 22.1 | 245.0 |  |  |
| 1989 | 29 | 23.6 | 247.3 |  |  |
| 1990 | 30 | 25.3 | 250.1 |  |  |
| 1991 | 31 | 27.0 | 253.5 |  |  |
| 1992 | 32 | 29.0 | 256.9 |  |  |
| 1993 | 33 | 30.6 | 260.3 |  |  |
| 1994 | 34 | 32.5 | 263.4 |  |  |
| 1995 | 35 | 34.2 | 266.6 |  |  |
| 1996 | 36 | 36.5 | 269.7 |  |  |
| 1997 | 37 | 37.5 | 272.9 |  |  |
| 1998 | 38 | 38.6 | 276.1 |  |  |
| 1999 | 39 | 40.8 | 279.3 |  |  |
| 2000 | 40 | 41.6 | 282.4 |  |  |
| 2001 | 41 | 42.4 | 285.5 |  |  |
| 2002 | 42 | 44.1 | 288.6 |  |  |

