

1. The second column of the table below shows primary energy consumption of the largest consuming countries of primary energy (petroleum, natural gas, coal, net hydroelectric, nuclear, geothermal, solar, wind, and wood and waste), 1999, in quadrillion BTU (source: The World Almanac and Book of Facts, 2002).

Country	Consumption	ln(Consumption)
US	96.87	4.57
China	31.88	3.46
Russia	26.01	3.26
Japan	21.71	3.08
Germany	13.98	2.64
Canada	12.52	2.53
India	12.18	2.50
France	10.26	2.33
UK	9.92	2.29
Brazil	8.51	2.14

- (a) Draw a box-and-whiskers plot for these data. Does the plot identify any outliers?

**ANS:** *The plot is shown in Figure 1. (5 points) It identifies one outlier: the US. (5 points)*

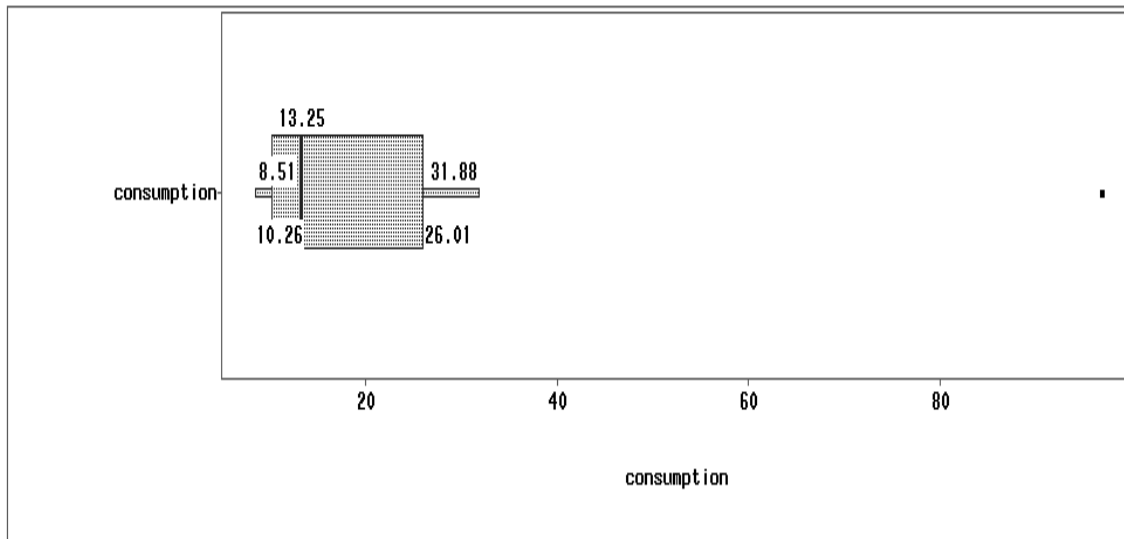


Figure 1: *Box and whiskers plot of energy consumption.*

- (b) The third column of the table contains the natural log of the energy consumption values. Draw a box-and-whiskers plot for these data. Does the plot identify any outliers?

**ANS:** *The plot is shown in Figure 2. (5 points) It shows no outliers. (5 points)*

- (c) Is there a paradox here? Comment.

**ANS:** *There is no paradox. What is an outlier in one unit of measurement will not be an outlier in another. The US is an outlier in terms of energy consumption, which is an additive scale, but not in terms of log of energy assumption, which is a multiplicative scale. Put another way, the US consumption is one, but not two, orders of magnitude larger than that of other large consumers. (5 points)*

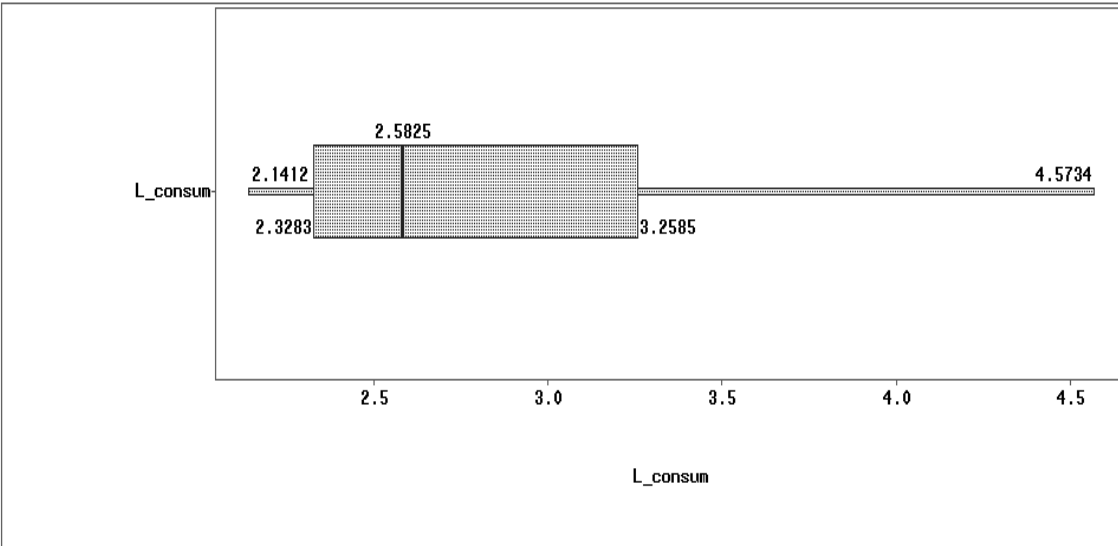


Figure 2: *Box and whiskers plot of natural log of energy consumption.*

2. In order to study the effect of temperature on the rate of chirping in crickets, researchers randomly divided a set of crickets into three groups. Each group was given exactly the same care and kept in identical surroundings except for the ambient temperature, which was kept at a different assigned level for each group. The chirping rates of the three groups were examined for differences.

(a) What kind of study is this? Justify your answer.

**ANS:** *This study is a controlled experiment (6 points) since treatments (temperatures) are applied to experimental units (crickets or groups of crickets) in order to observe a response (chirping rate). (9 points: 3 Each)*

(b) How is randomization used in this study? What is the reason for randomizing here?

**ANS:** *Treatments are assigned at random to the crickets (equivalently, the crickets are randomly assigned to groups).(5 points) This helps ensure that there is no bias in the groups due to unsuspected factors.(5 points)*

(c) How could blocking be used to improve the experiment? Explain what improvements the blocking would confer.

**ANS:** *All treatments could be given to the same group of crickets.(5 points) This would eliminate group to group variation.(5 points)*

3. Recent reports indicate that yogurt consumption may be related to longevity. In order to investigate this phenomenon, a recent study followed a large sample of senior citizens over a ten year period. The researchers found that those who consumed large amounts of yogurt (five or more servings per day) had significantly lower death rates than either those consumed small amounts (two or fewer servings per day), or those who consumed no yogurt.

(a) What kind of study was this? Be as specific as the description allows, and justify your response.

**ANS:** *It is a prospective observational study. (5 points) It is an observational study because no treatments are imposed on experimental units.(5 points) It is a prospective study because different groups are formed based on the treatment (level of yogurt consumption), and the outcomes for those groups compared.(5 points)*

(b) Based on the results of this study, can we conclude that increasing yogurt consumption causes senior citizens to live longer? Why or why not?

**ANS:** *No, we cannot conclude this, since cause and effect cannot be established by an observational study.(5 points)*

4. A metal stamping process consists of four presses simultaneously making metal clips for the automotive industry. The inclination angle of the clips (in degrees) determines the pressure they exert when placed in an assembly. The target

angle is 10 degrees. Figure 3 displays the inclination angles of a set of clips sampled every 15 minutes from production plotted versus press number.

(a) Describe the pattern of variation you see in the plot.

**ANS:** *The angles from presses 2 are centered about the target 10, those from press 1 are centered slightly higher, and those from presses 3 and 4 are centered higher, between 11 and 12. (5 points) The spread of the angles from presses 1 and 4 are of comparable size and noticeably smaller than those from the other two presses. (5 points)*

(b) What should have been checked before using the plot in Figure 3? How would it be checked?

**ANS:** *The stationarity of the process should have been checked. (5 points) It would be checked by doing a plot versus time order for each machine. (5 points)*

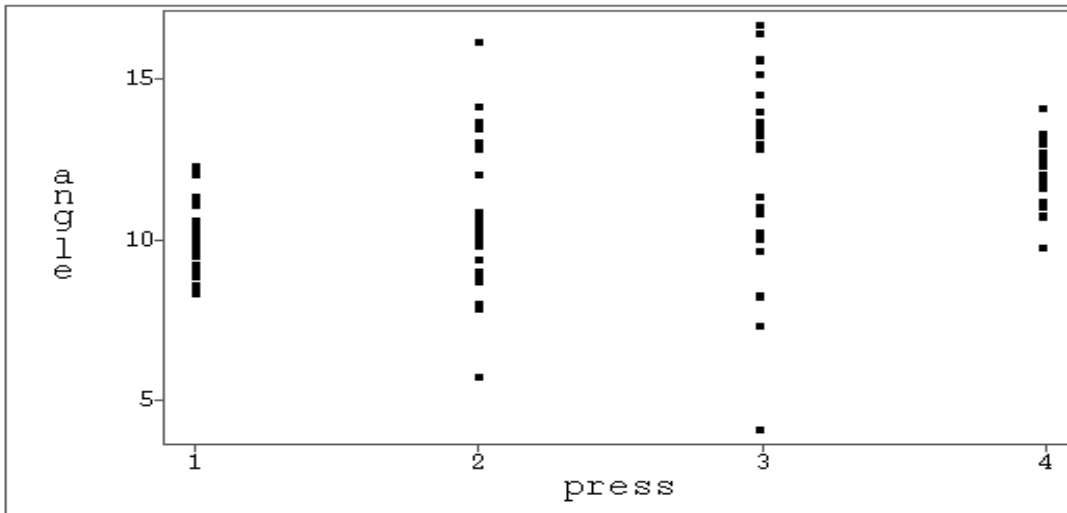


Figure 3: *Plot of Angle versus Press, problem 4.*