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Statistical Comparison; Economic Impact of the Beef Industy on South Dakota

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Statistical Comparison

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This essay shows how to make a comparison using statistical methods. We resort to statistical methods when a population is in question but we only know something based on a sample. For instance, we may want to know the average starting wage of 2010 college graduates in the U.S. (population). For various reasons, it is impossible to collect the wage data for that population. Nevertheless, it is feasible to gather information for a sample, say, the 2010 graduates at SDSU. If we believe SDSU graduates are representative of all college graduates, we can draw conclusions about the population using the following statistical methods.

The easiest case is comparing the average level to a constant number. Suppose we want to compare the average starting wage to $40,000. This problem is formally called hypothesis testing because we have a null hypothesis in mind, i.e., average starting wage equals $40,000. Now the question becomes comparing what number to $40,000? Because the sample of SDSU graduates is ready, the natural choice is comparing the average starting wage of SDSU graduates to $40,000. Mathematically, we are computing the difference of

$$\textit{average wage of SDSU graduates - \$40,000} \qquad (1)$$

A big difference can be seen as evidence *against* the null hypothesis. Are we done? Not yet. There are

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Economic Impact of the Beef Industry on South Dakota

by

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The beef industry in South Dakota makes a significant contribution to economic development in the state. There were 1,644,000 beef cows in South Dakota on January 1, 2008. During the year these cows produced 1,650,000 calves and the industry produced $1,714,535,000 in revenue for ranchers and feedlot operators (South Dakota Agriculture 2009).

Methodology

IMPLAN Pro 3 software was used to estimate the impact of the beef industry on the economy of the state of South Dakota. This software was originally developed for the National Forest Service and has been adapted for commercial use. The economic relationships among industries in South Dakota are internal production functions within the program. After constructing a baseline model of the state, the impact of the beef sector is analyzed to determine its impact on the state's economy.

Analysis of the Beef Sector

The IMPLAN model breaks down the effects of the beef sector into three categories, direct, indirect, and induced. The direct effect is the value of the products produced in the beef industry. The indirect effect is the economic activity that results from industries supplying inputs into the beef sector (business to business activity), and the induced effect is the increase in household spending resulting from the increased economic activity in the state. These dollar values for 2008 are shown in Table 1.
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(***Statistical Comparison*** -- *continued from p.1)*
two drawbacks of using (1). The first is how to quantify a big difference? How big is big?

The second issue is that formula (1) overlooks the fact that SDSU is just *one* sample of all U.S. colleges. What if we use a different sample, say, the graduates at USD? We certainly do not expect that the starting wage of USD graduates is the same as that of SDSU graduates. To take *the variation between samples* into account, we need to modify (1) as

$$\frac{\text{average wage of SDSU graduates} - \$40{,}000}{\text{standard deviation of SDSU graduates}} \qquad (2)$$

Formula (2) is called the t-ratio or t-statistic. Simply put, a t-ratio is a *normalized* difference. The normalizer (denominator) is the standard deviation. The intuition behind formula (2) is that a sample with a big standard deviation has much variation in its observations, and therefore is less conclusive or informative than a sample with a small standard deviation. We may understand the t-ratio from another perspective. Suppose we apply formula (1) to both SDSU and USD graduates, and it happens that we end up with same answer. But then we notice that the variation of the SDSU wage data is less than that of the USD data. Then we believe the SDSU data is more informative than USD data, and the former tells us more about the true difference between average wage and $40,000. The t-ratio for SDSU data will be greater than that for USD data (because the denominator is smaller), providing stronger evidence against the null hypothesis. The t-ratio follows the Student-T distribution. If the computed t-ratio is located at the tail area of the distribution, we conclude that it is big enough to reject the null hypothesis.

Next we move to a trickier question of comparing one population to another population. Suppose we want to compare the starting wage of 2010 graduates to 2009 graduates. We have to utilize statistical methods again because we only have two samples at hand, the 2010 and 2009 graduates at SDSU. It is straightforward to modify (2) as

$$\frac{\text{average wage of 2010 graduates - average wage of 2009 graduates}}{\text{normalizer}} \qquad (3)$$

Formula (3) is termed as two-sample t test, and is widely used in practice. In this case the normalizer takes a complicated form that depends on the assumption of equal variations of two populations. But the intuition is the same. We have to take the variation between samples into account. A difference between two samples with small variation is more informative than a difference between two samples with big variation. To help understand this, in the figure below the box-plots of four samples are displayed side-by-side. The samples S1 and S2 have bigger variation than S3 and S4. As a result, the difference between the averages (marked by a solid black line) of S3 and S4 is more conclusive than the difference between the averages of S1 and S2.

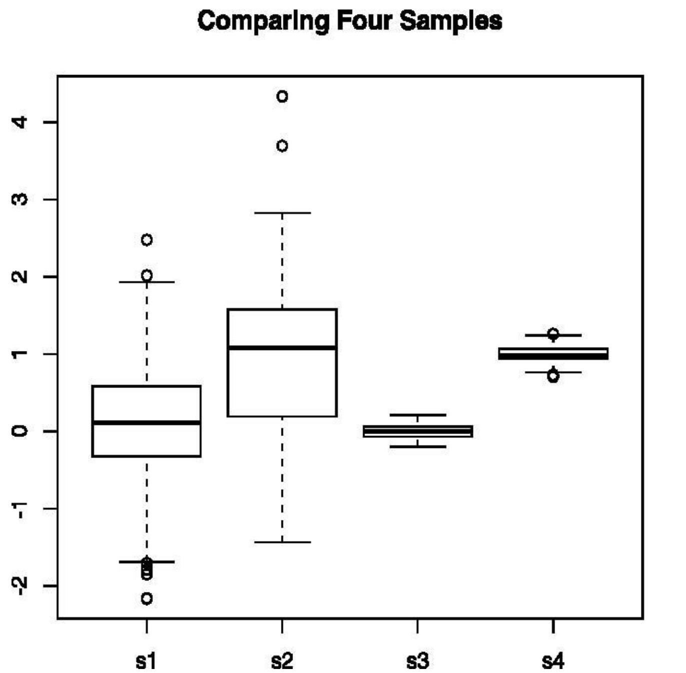
Because the two-sample t test imposes a restrictive assumption about the population variance, a better way to compare two populations is by running a regression with dummy variables. Consider the regression given by

$$Wage = \beta_0 + \beta_1 D + Error\ Term \qquad (4)$$

where the dependant variable is the wage for *both* 2010 and 2009 graduates, and the independent variable D is a dummy variable equaling 0 for 2009 graduates and 1 for 2010 graduates. A significant *heteroskedasticity-robust* t-ratio for β_1 provides evidence against the null hypothesis that the 2010 average starting wage is the same as the 2009 average starting wage.

The dummy-variable-regression approach becomes more convenient when comparing more than two populations. There are at least three approaches. The least recommended approach is to apply a two-sample t test for each pair of populations, one pair at a time. Applying a pair-by-pair t test can be cumbersome and lead to nowhere. The second approach is often used by Bio-Science researchers, and is called an ANOVA (or F test). This approach works well if data are obtained from controlled experiments, and it imposes the restrictive assumption of equal population variances as well.

The third approach is running a regression using dummy variables. If we compare N populations, we need to include N-1 dummy variables in the regression, one variable for each population. Then we can conduct the F test for the joint hypothesis that all the coefficients of the dummy variables equal zero. A significant F test rejects the null hypothesis that all the populations are the same.



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(***Economic Impact of Beef*** *...continued from p. 1*)

Table 1. Beef Industry Output Impact

Direct	$1,714,535,040
Indirect	$935,476,844
Induced	$140,080,605
Total	**$2,790,092,489**

In nominal dollars

The multiplier for the beef industry is 1.63, meaning that one dollar of output in the industry generates an additional sixty-three cents of economic activity in the South Dakota economy. The total impact, when divided by the 1,644,000 cows in the state that calved in 2008 would result in $1699.57 in economic activity per cow/calf pair from the beef production sector of the economy. This impact can also be examined different ways. If we divide the same output level by 757,000 head of cattle marketed from large and small feedlots in 2008 the impact is $3,519.28 per head. If we divide the output by the 80,000 bulls in the state the impact is $34,926 per bull.

The employment effects are similar to the output effects. The direct effect is the number of people employed in the beef production industry. The indirect effect is the number of people employed by the industries supplying inputs to the beef industry, and the induced effect is the employment resulting from the additional economic activity in the state. The employment effects are shown in Table 2.

Table 2. Employment Impacts

Direct	5,930
Indirect	4,298
Induced	1,371
Total	**11,599**

The indirect business taxes are all of the taxes collected (sales, property, excise, etc.) The direct effect is the tax revenue generated by the beef industry, the indirect effect results from the business to business activity, and the induced effect is from the consumer activity associated with beef production in the state. The relative amount of taxes paid at each level is representative of the changes in the type of taxes paid by agricultural producers, supply industries, and consumers. The tax results are shown in Table 3.

Table 3. Indirect Business Taxes

Direct	$39,767,072
Indirect	$35,394,905
Induced	$8,660,724
Total	**$83,822,701**

The dollar values in Table 4 show the distribution of the impacts of one cow/calf pair on the economy of South Dakota. Approximately 80% of the economic impact remains in the agricultural sector of the economy. The remainder of the impact is distributed in a number of other sectors with the next largest portion being 7.7% in the finance, real estate and insurance sector. This distribution of impacts will be specific to the unit being analyzed, i.e. the distribution per head of feeder steers and heifers will be different than if we look at the cow/calf pair because of the different production practices and inputs used in the production process. The one constant will be that the majority of the impact will remain in the agricultural sector of the economy, as the direct effect is always 1. In order for the effects in other sectors of the economy to exceed that in the agricultural sector the sum of the indirect and induced effects would have to exceed 1. This would occur when the multiplier is greater than 2.

Table 4. Distribution of the Impact of a Cow/ Calf Pair in South Dakota

Ag & Forestry	1,361
Construction, Mgmt, Admin	10
Services	10
Accom, Food, Arts	10
Government	10
Miscellaneous	33
Health & Human Services	15
Transportation & Utilities	30
Finance, Insurance, Real estate	132
Manufacturing	5
Wholesale & Retail Trade	60
Mining	22

*Rounded to the nearest whole dollar

Feed Consumption

Another significant impact of the beef industry is supplying a local market for the corn, soybeans, and forages produced in South Dakota. For this analysis it is assumed that the breeding herd is on pasture for 6 months of the year. The remainder of the year it is assumed that corn will be fed at 0.25% of average body weight (Wright) and forage (50% corn silage and 50% hay) fed at 20 lbs of each daily per head. Assuming that the average weight of the 1,644,000 cows, 290,000 replacement heifers, and 80,000 bulls is 1200 lbs. this would result in consumption of 19,420,713 bushels of corn (3 lbs./hd/day) and 3,625,200 tons each of hay and silage. The 467,000 head of cattle marketed in 2008 would consume, on average 13.6 lbs of corn daily and 49 lbs of silage daily along with .68 lbs daily of soybean meal over a period of 200 days on feed (Comerford). This would result in the consumption of an additional 22,682,857 bushels of corn, 31,756 tons of soybean meal, and 2,288,300 tons of corn silage.

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