GOALS AND STANDARDS FOR MEASURING THE EFFECTIVENESS OF BUSINESS STATISTICS
Milo Schield, Augsburg College
Dept. of Business & MIS. 2211 Riverside Drive. Minneapolis, MN 55454

Abstract: Every year some 230,000 business-undergraduates are estimated to take statistics at four-year colleges. In view of the various proposals for change in statistical education, there is a need to assess the effectiveness of statistical education for these business majors. This paper focuses on the academic goals of business statistics and the associated choice of standards for measuring effectiveness. Numerous goals and standards are identified and investigated. This paper argues that the statistical needs of those business majors in more distantly related disciplines such as management and accounting should be at least as important as the statistical needs of those business majors in closely related disciplines such as finance, management science and economics.

Keywords:

1. STATISTICAL EDUCATION IN BUSINESS
Every year, about 230,000 US college business majors are estimated to take an introductory course in statistics. Using a cost of $1,000 per student, business statistics involves some $230 million per year – not including at least $5 million per year in the purchase of business statistics textbooks.

Business majors comprise about 50% of the 435,000 US college graduates who take an entry-level course in applied statistics each year.

Improving the quality of statistical education taken by business majors is a goal of two national organizations: the American Statistical Association (ASA) and an organization whose mission is their name: “Making Statistics More Effective in Schools Of/And Business” (MSMESB). The ASA has focused primarily on those faculty teaching statistics at four-year colleges and universities in departments of Mathematics and Statistics. MSMESB (pronounced “Miz Mez Bee”) has focused on those teaching statistics to business majors.

Statistics textbook publishers typically consider business statistics as a separate area from general statistics. Focusing on business majors to measure the effectiveness of statistical education appears to be relevant for the ASA since business majors are the largest major being served by statistical educators.

2. STATISTICAL EDUCATION GOALS
The goal of many introductory business statistics courses is for students to master certain topics such as conditional probability, independence, Bernoulli trials, the binomial distribution, the normal distribution, sampling distributions of sample statistics, standard error, the central limit theorem, confidence intervals and hypothesis tests.

In mathematics this approach might be more acceptable, but in business the topics in any required course for business majors must demonstrate their relationship – their contribution – to the mission of the business major. Unless one can demonstrate the contribution of business statistics to a business goal, a list of statistical topics is endanger of being valued by statisticians but not by the curriculum managers who are requiring business majors to take business statistics. Consider these goals:

1. To educate students to obtain majors in statistics.
2. To educate students to obtain majors in closely related disciplines such as operations research, actuarial, finance and economics.
3. to educate students for those follow on courses and activities that require statistics as a prerequisite in more distantly related majors such as market research in marketing.
4. to educate students to function efficiently and effectively in using statistics to make business decisions in courses, majors and business activities that don’t specifically require statistics such as auditing and cost in accounting, marketing management in marketing or strategic management in management.

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1 This estimate assumes that every US college graduate with a major in business administration or economics has completed a course in statistics. In 1995, these graduates number 234,323 according to the 1999 US Statistical Abstract, Table 331.
2 This 434,560 estimate includes all US college graduates majoring in business and management (234,323), social sciences and history (128,154) and psychology (72,083). This estimate excludes those in the health sciences (79,855), education (106,079) and mathematics (13,723).
Obviously combinations of these goals are both possible and reasonable. One goal might be to balance 1, 2 and 3. If goal 2 is not pursued, then the faculty teaching finance, management science, etc. may elect to teach business statistics themselves. Yet if goal 4 is not pursued, there is the danger that management, accounting and perhaps marketing might make statistics an elective rather than a requirement. This is certainly the case with cost accounting and investments. Both are important courses to business majors, but they are not required courses for majors in management and marketing despite their relevance in both areas.

3. STANDARD FOR EFFECTIVENESS

The choice of standards for measuring the effectiveness of a business statistics course depends on the goal of the course. The choice of the standard for measuring effectiveness of statistical education is both crucial and difficult. Consider the following possible standards to measure the effectiveness of statistical education in preparing business majors:

3A. for taking statistically-based exams.
3B. for taking business-related professional exams
3C. for follow-on classes that require statistics.
3D. for taking the GMAT.
3E. for obtaining an MBA.
3F. for less closely related business courses
3G. for non-technical business careers.
3H. for reading news stories involving statistics.

3A. PREPARE FOR STATISTICAL EXAMS

There are no US exams specifically in statistics. See www.amstat.org, www.decisionsciences.org or www.informs.org. Statistical content-based exams include the Actuarial exams and the RSS exams. The Society of Actuaries, www.soa.org, administers the actuarial exams. See Appendix 1. While the level of probability required for even the first exam is quite high, there is no mention of sample-based statistical inference. The first-level Royal Statistical Society (RSS) exams, www.rss.org.uk, are most closely related to the first undergraduate statistics course. See Appendix 2.

3B. PREPARE FOR SPECIAL BUSINESS EXAMS

Content-based business exams may require statistics in different ways than do the general-purpose business exams such as the GMAT or than do statistically based content exams such as the Actuarial exams. General business content-based exams include the CPA, CMA, CFA, etc.

The requirements for the CMA, the Certificate in Management Accounting, are available at www.imanet.org.

3C. PREPARE FOR FOLLOW ON COURSES

Statistics is a required course for a number of undergraduate follow-on courses such as market research, some courses in economics, and many courses in finance and operations research. That a required course provides students with the background for the follow-on course seems quite appropriate.

Since many faculty teaching follow-on courses are quite capable of teaching introductory statistics, the failure to prepare students for these courses might result in having other faculty takeover the teaching of introductory statistics.

But so long as there is a significant fraction of business undergraduates who will not take any of these follow-on courses, their role in measuring the effectiveness of the introductory statistics is far from controlling.

It is difficult to estimate what fraction of business majors take follow-on courses. But if Business majors are divided equally into four groups: management, marketing, accounting, and finance and economics, then 50% of these business majors will not take a follow-on course after the introductory statistics course. The high percentage of students who don’t take follow-on courses makes their use (as a standard for evaluating the effectiveness of statistical education) rather inappropriate.

Furthermore although the marketing majors will probably take market research, the majority of their course work will not involve follow-on courses (unlike those in investments or operations research). Thus, even for marketing majors, the role of follow-on courses to determine the effectiveness of introductory business statistics is suspect.

3D. PREPARE FOR THE GMAT

It appears that none of the questions in the GMAT require or presume any study of college statistics, beyond a familiarity of those statistical concepts taught in secondary school such as “% of”, “% change”, “average”, etc.

Sample questions in Quantitative Problem Solving:
- Arithmetic: discount on discount (cumulative)
- Percents: basis points, percentage point differences
- Geometry: conversion from area to perimeter
- Algebra: roots of equations
- Algebra: solve two simultaneous linear equations

Sample questions in Quantitative Data Sufficiency:
• Arithmetic: identifying operator/operation
• Arithmetic: prime numbers.
• Geometry

These questions focus on the distinction between necessary and sufficient. In these sample questions, there is nothing requiring any knowledge of probability or statistical inference. Candidates must have general Quantitative Literacy skills including adequate preparation on percents, rates and percentages. Some questions may involve statistics, but the role of these statistics is typically incidental. See Appendix 4.

3E. PREPARE FOR AN MBA

Even if the topics in a typical introductory business statistics course were a substantial part of the tests used to gain admission to MBA programs, this would not make preparing business majors for the MBA a suitable standard for measuring the effectiveness of statistical education. Only a minority of undergraduate business majors complete an MBA.

The percentage of US undergraduates in business administration and management who complete a US MBA is estimated as less than 25%. This percentage excludes US Business graduates who get an MBA outside the US.

<table>
<thead>
<tr>
<th>Percentage of US undergraduates who earn a US MBA</th>
<th>DELAY Undergrad to MBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of MBAs earned by non US Bus Grads</td>
<td>6 years</td>
</tr>
<tr>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>30%</td>
<td>26%</td>
</tr>
<tr>
<td>40%</td>
<td>23%</td>
</tr>
<tr>
<td>50%</td>
<td>19%</td>
</tr>
<tr>
<td>60%</td>
<td>15%</td>
</tr>
</tbody>
</table>

If less than 25% of US undergraduate business majors earn a US MBA, then using MBA preparation as a dominant criteria for measuring the effectiveness of statistical education in business would seem quite inappropriate.

3F. PREPARE FOR STAND-ALONE COURSES

It may seem odd to use preparation for a subsequent course that does not require statistics as a standard for measuring the effectiveness of statistical education. But to the extent that statistics teaches a method of thinking, it may be applicable in courses for which specific statistical knowledge is not required, but for which statistical thinking of statistical reasoning may be quite helpful. Consider the benefits of statistical education for students in the capstone courses in management, marketing, accounting and the less-quantitative areas of economics.

Case Studies. Students in all areas of business may study cases such as those found in the Harvard Case Series. To what extent will having studies statistics be beneficial to these students in analyzing the Harvard Cases? Unfortunately the Harvard case texts are not machine-readable by a search command. Other machine-readable business case libraries are being sought.

Statistical books: Students in all areas of business must be able to deal with data. An analysis of the 5,000 plus titles of the UK Bookshop Company (www.bookshop.co.uk) indicates that half (2,400) of these titles are mathematical or miscellaneous. Of the remaining 2,600, there are 734 titles under Economics of which 640 are on data and data sources. Of the 367 books classified under social sciences, 267 are on data and data sources.

3G. PREPARE FOR BUSINESS CAREERS

Business careers can be classified as being either statistically related (sampling, survey design, production control, etc.) or non-statistically-related (general management, general sales, general accounting, etc.). While careers can be found that collectively will require everything that anyone might want to teach in introductory statistics, the criteria for effectiveness must relate to the needs of those careers that are non-statistically related.

Two studies have been made of the needs of young non-specialist workers. Both were done in 1985 – before the microcomputer revolution. The results of both studies are certainly worth reviewing as a preview of what might be expected in a similar study conducted today.

In 1985, the RSS Centre for Statistical Education published Statistical Needs of Non-Specialist Young Workers based on a study conducted by Peter Holmes. This study was neither random nor representative. It

• surveyed 25 businesses
• surveyed 155 employees ages: 18 - 25
• used “statistical tools” in the broadest sense
• tabulated number of times each statistical tool was referenced in the surveys

The following are some of the results of that survey. The percentage is the fraction of surveys mentioning that particular...
<table>
<thead>
<tr>
<th>Percentage</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>draw up tables of data</td>
</tr>
<tr>
<td>54%</td>
<td>read and interpret tables of data</td>
</tr>
<tr>
<td>53%</td>
<td>assess the accuracy of someone else’s data</td>
</tr>
<tr>
<td>53%</td>
<td>write reports based on data for others to use</td>
</tr>
<tr>
<td>52%</td>
<td>decide what data to collect</td>
</tr>
<tr>
<td>51%</td>
<td>calculate the mean</td>
</tr>
<tr>
<td>40%</td>
<td>detect and estimate trends</td>
</tr>
<tr>
<td>38%</td>
<td>simplify tabulated data</td>
</tr>
<tr>
<td>37%</td>
<td>allow for variability in data</td>
</tr>
<tr>
<td>37%</td>
<td>make decisions using data</td>
</tr>
<tr>
<td>35%</td>
<td>make projections</td>
</tr>
<tr>
<td>27%</td>
<td>draw bar charts and time series graphs</td>
</tr>
<tr>
<td>20%</td>
<td>use words such as likely and uncertain</td>
</tr>
<tr>
<td>19%</td>
<td>calculate variance or standard deviation</td>
</tr>
<tr>
<td>19%</td>
<td>use logarithm or other specialist scales</td>
</tr>
<tr>
<td>19%</td>
<td>draw trend lines</td>
</tr>
<tr>
<td>19%</td>
<td>read and interpret histograms</td>
</tr>
<tr>
<td>17%</td>
<td>calculate median and quartiles</td>
</tr>
<tr>
<td>17%</td>
<td>assign probabilities to events</td>
</tr>
<tr>
<td>15%</td>
<td>allow for non-response to questionnaires</td>
</tr>
<tr>
<td>14%</td>
<td>select the questions on questionnaires</td>
</tr>
<tr>
<td>14%</td>
<td>read and interpret scatter diagrams</td>
</tr>
<tr>
<td>13%</td>
<td>use statistical tests to compare sets of data</td>
</tr>
<tr>
<td>13%</td>
<td>use probability as a measure of uncertainty</td>
</tr>
<tr>
<td>12%</td>
<td>read and interpret the results of simulations</td>
</tr>
<tr>
<td>9%</td>
<td>calculate correlation coefficients</td>
</tr>
<tr>
<td>8%</td>
<td>calculate moving averages</td>
</tr>
<tr>
<td>6%</td>
<td>use a statistical test of significance</td>
</tr>
<tr>
<td>4%</td>
<td>use the normal distribution</td>
</tr>
<tr>
<td>2%</td>
<td>calculate index numbers</td>
</tr>
</tbody>
</table>

An obvious feature is the lower percentages involving statistical inference (13% or less). A less obvious feature is the influence of the survey date: 1985. It may be that the use of statistical inference will increase as statistical software becomes more readily available. The low percentage (37%) of those who make decisions using data may reflect the junior status of some of these workers. For a complete copy of the documents, go to www.augsburg.edu/~ppages/~schield/1985Holmes.pdf

[Looking for results of Texas study by Dr. Eleanor Jordan based on information from David Levine]

3H. PREPARE FOR READING NEWS STORES

Appendix 5 indicates the amount of usage of various keywords in news stories.

4. MEASURING THE EFFECTIVENESS

The lack of recent data to measure the effectiveness of statistical education in schools of business is very disconcerting to those authors, publishers and teachers currently doing is adding the most value possible. Without a reputable source of what students really need (as opposed to what they might want at the time), statistical education has very little indication of which changes are needed and which changes should be avoided.

5. RECOMMENDATION ON GOALS

Organizations concerned with improving the effectiveness of the statistical education provided in the entry-level undergraduate course should measure the effectiveness of statistical education as viewed by business majors in distantly related areas such management, marketing and accounting (goal #4) – not just by those in closely related areas such as finance and economics. The reasoning is that this group has been the most vocal in saying the entry-level business statistics course does not provide sufficient value added. If a single course cannot provide reasonable value added for those in closely related areas and for those in distantly related areas, then perhaps it is time to consider offering two separate courses.

REFERENCES

Holmes, Peter (1985). Statistical Needs of Non-Specialist Young Workers. RSS Centre for Statistical Education.


Acknowledgments: To Donald MacNaughton and Anne Hawkins who have spoken up consistently and persistently on the need of real data to measure the effectiveness of statistical education. To Linda Schield and Thomas V.V. Burnham for their criticisms, comments and support. Dr. Schield can be reached at schield@augsburg.edu. This paper is currently available at www.augsburg.edu/~ppages/schield.

7 In an end-of-the course survey of a single business statistics
APPENDIX 1: ACTUARIAL EXAMS

www.soa.org/eande/fall01_catalog/fall01_catalog.pdf

A knowledge of probability is listed as a requirement for the first four exams ("basic knowledge" for 2; "thorough knowledge" for 1, 3 and 4). Exam 4 requires a "thorough knowledge of mathematical statistics."

Course 1: Mathematical Foundations of Actuarial Science

This course develops the candidate’s knowledge of the fundamental mathematical tools for quantitatively assessing risk. The application of these tools to problems encountered in actuarial science is emphasized. A thorough command of calculus and probability topics is assumed. Additionally, a very basic knowledge of insurance and risk management is assumed.

In Exam 1, the recommended probability texts are

- Ross, A First Course in Probability
- Ghahramani, Fundamentals of Probability
- Hassett & Steward, Probability for Risk Management
- Hogg & Tanis, Probability and Statistical Inference

The probability-related tools emphasized are:

- General probability (set functions, basic axioms, independence);
- Bayes’ Theorem;
- Univariate probability distributions (probabilities, moments, variance, mode, percentiles, transformations);
- Multivariate probability distributions (Central Limit Theorem; joint, conditional and marginal distributions – probabilities, moments, variance, covariance).

Course 2: Interest Theory, Economics and Finance.

This course develops the candidate’s knowledge of interest theory, intermediate microeconomics and macroeconomics and the fundamentals of finance. It assumes a basic knowledge of calculus and probability.

Course 3: Actuarial Models.

This course develops the candidate’s knowledge of the theoretical basis of actuarial models and the application of those models to insurance and other financial risks. A thorough knowledge of calculus, probability and interest theory is assumed.

Course 4: Actuarial Modeling.

This course develops the candidate’s skills in modeling and covers important actuarial and statistical methods that are useful in modeling. A thorough knowledge of calculus, linear algebra, probability and mathematical statistics is assumed.

APPENDIX 2: RSS STATISTICS EXAMS

The Royal Statistical Society (www.rss.org.uk) offers statistical exams with three sequential levels. The first is shown here. (www.rss.org.uk/exams/index.html)

The ordinary certificate is pitched between GCSE and A-level, but concentrating very much on the practical aspects of data collection and simple analyses. The examination consists of two three-hour papers.

The higher certificate contains work at A-level and into the first year of a typical university course in statistics. Indeed, some of the topics in the higher certificate might well be found in the second year of a university course. This examination consists of three 3-hour papers. Paper 1. Statistical Theory (Probability: Combinatorial, Normal, Poisson, loss, ruin, etc.). Paper 2. Statistical Methods: Confidence Intervals, Hypothesis tests and reporting. Paper 3. Statistical Applications and Practice.

Recommended texts for the first exam:

Chapman & Wykes - Plain Figures
Clarke & Cooke - A Basic Course in Statistics
Freund - Modern Elementary Statistics
Hague - Questionnaire Design
Hague & Jackson - Market Research
Huff - How to Lie With Statistics
Tufte - The Visual Display of Quantitative Information
Upton & Cook - Introducing Statistics

Sources of Data:

For past papers, see www.rss.org.uk/exams/docs.html.

2000 Ordinary Certificate, Paper 1 Questions

1a. 3 questions to qualify respondent on “travel”
1b. Interview-lead questionnaires: 3 adv; 3 disadv.
1c. Explain multi-stage sampling, benefits, timing.
1d. Compute # eligible households. Explain ineligible.
1e. Calculate percentages of response by category.
2a. Design a stratified random sample.
2b. Compare this with a quota sample.
2c. Give 1 adv and 1 disadv of each in this case.
3a. Given survey method, identify & solve 3 problems.
3b. For 1000 population and 5 categories, design SRS.
3c. Use random number table to select a sample.
4. 3 adv/disadv of panel method of survey over SRS.
5a. Given survey method, identify & solve 3 problems.
5b. Given 3 survey questions identify/solve 1 problem.
6a. Design form to collect desired information.
6b. Identify/solve difficulties of doing survey by mail.
2000 Ordinary Certificate, Paper 2 Questions
1a. Define Coef. Variation. When helpful? When not?
1b. Find max/min for rounded values and their CV.
2a. Recalculate mean given an error in one value.
2b. Calculate sum of squares given std. dev.
2c. Calculate correct standard deviation.
2d. Comment on changes to mean and std. dev.
3a. Given survey results, calculate # men and women.
3b. Form frequency table; 2 way contingency table.
3c. Report conclusions with percentages as needed.
4a. Calculate Laspeyres and Paasche indexes of prices.
4b. Interpret values. Which is better for price changes?
5. Find probabilities given two fair 6-sided die.
6a. Plot data on scatter diagram. Comment on results.
6b. Calculate Pierson correlation coefficient; comment.
6c. Given slope of regression, calculate intercept.
6d. Predict Y given X. Indicate “confidence”
7a. Explain “trend” & “seasonal component”
7b. Draw line graph; calculate trend, predict.
8a. Given 3 factor # and sums, create Venn diagrams.
8b. Calculate probabilities for 1, 2 & 3 factor causes.

APPENDIX 3: CMA/CFA PREPARATION
The CMA and CFA exams involve four parts. Part 4C explicitly references “quantitative methods” although statistically related questions can appear in other areas. Here are some examples involving statistics (as opposed to the percentages often found in finance):

Part 1: ECONOMICS:
3. A U.S. company currently has domestic operations only. It is considering an equal-size investment in either Canada or Britain. The data on expected rate of return and the risk associated with each of these proposed investments are given below.

<table>
<thead>
<tr>
<th>Proposed Investment</th>
<th>Mean Return</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Investment</td>
<td>22%</td>
<td>10%</td>
</tr>
<tr>
<td>Canadian Investment</td>
<td>28%</td>
<td>15%</td>
</tr>
</tbody>
</table>

The mean return on the company’s current, domestic only, business is 20% with a standard deviation of 15%. Using the above data and the correlation coefficients, the company calculated the following portfolio risk and return (based on a ratio of 50% U.S. domestic operations and 50% international operations).

Part 2C (CFA):
9. What is the standard deviation of the following two-stock portfolio?

<table>
<thead>
<tr>
<th>Weighting</th>
<th>Standard Deviation</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock A</td>
<td>60%</td>
<td>11%</td>
</tr>
<tr>
<td>Stock B</td>
<td>40%</td>
<td>14%</td>
</tr>
</tbody>
</table>

a. 11.25%. b. 12.20%. c. 12.50%. d. 126.66%.

10. The betas and expected returns for three investments being considered by Sky Inc. are given below.

<table>
<thead>
<tr>
<th>Investment</th>
<th>Beta</th>
<th>Expected Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.4</td>
<td>12%</td>
</tr>
<tr>
<td>B</td>
<td>0.8</td>
<td>11%</td>
</tr>
<tr>
<td>C</td>
<td>1.5</td>
<td>13%</td>
</tr>
</tbody>
</table>

The return on the market is 11% and the risk-free rate is 6%. If the Capital Asset Pricing Model (CAPM) is used for calculating the required rate of return, which investments should the management of Sky make?

Part 4C.
6. The table below shows the estimated probabilities of the percent of defective units resulting from a production run.

<table>
<thead>
<tr>
<th>Percent Defective</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>30%</td>
</tr>
<tr>
<td>3%</td>
<td>50%</td>
</tr>
<tr>
<td>4%</td>
<td>20%</td>
</tr>
</tbody>
</table>

The expected percent defective for a production run would be
a. 1.50%. b. 2.30%. c. 2.90%. d. 3.00%.
APPENDIX 4: GMAT PREPARATION

Critical Reasoning
Since 1975 there has been in the United States a dramatic decline in the incidence of traditional childhood diseases such as measles. This decline has been accompanied by an increased incidence of Peterson’s disease, a hitherto rare viral infection, among children. Few adults, however, have been affected by the disease.

Which of the following, if true, would best help to explain the increased incidence of Peterson’s disease among children?
(A) Hereditary factors determine in part the degree to which a person is susceptible to the virus that causes Peterson’s disease.
(B) The decrease in traditional childhood diseases and the accompanying increase in Peterson’s disease have not been found in any other country.
(C) Children who contract measles develop an immunity to the virus that causes Peterson’s disease.
(D) Persons who did not contract measles in childhood might contract measles in adulthood, in which case the consequences of the disease would generally be more severe.
(E) Those who have contracted Peterson’s disease are at increased risk of contracting chicken pox.

Quantitative Reasoning
Mini Test: A toy store regularly sells all stock at a discount of 20 percent to 40 percent. If an additional 25 percent were deducted from the discount price during a special sale, what would be the lowest possible price of a toy costing $16 before any discount?

$5.60 $7.20 $8.80 $9.60 $15.20

Mini Test: If “basis points” are defined so that 1 percent is equal to 100 basis points, then 82.5 percent is how many basis points greater than 62.5 percent?

0.2 2 20 200 2,000

Problem Solving
20. An earth science class had a 50-minute laboratory period during which 5 minutes were spent in distributing and collecting material and 10 minutes were spent in discussing the project for the day. If the remaining time was spent in work on the project, what percent of