

MODERN COMMERCIAL TEXT-BOOKS

**FOR USE IN SCHOOLS AND COLLEGES
AND FOR MEN OF BUSINESS**

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**AN ELEMENTARY MANUAL
OF STATISTICS**

ELEMENTS OF STATISTICS

BY

A. L. BOWLEY, M.A., F.S.S.

READER IN STATISTICS IN THE UNIVERSITY
OF LONDON

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**P. S. KING & SON, ORCHARD HOUSE
WESTMINSTER.**

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ARTHUR L. BOWLEY, M.A., F.S.S.

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AUTHOR OF "ELEMENTS OF STATISTICS," "NATIONAL PROGRESS SINCE 1882," ETC.

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PREFACE

THIS manual is intended for the use of those who desire some knowledge of statistical methods and statistical results without going deeply into technicalities or undertaking mathematical analysis; it is hoped that it will be of service to all who have occasion to use statistics in their own business or profession, or who take an intelligent interest in public affairs.

It is also designed as a first course in statistics for students who wish to proceed further in the subject and, if it serves its purpose will stimulate interest in the many fascinating problems that await solution, and that can only be attacked by the methods of modern mathematical statistics.

The first part deals with elementary methods and with such technical terms and ideas as are indispensable in the handling of numbers on a large scale. In the second part the origin of many groups of public statistics is shown, their adequacy is criticized, and some of the more interesting results which are based on them are briefly summarized. This part is intended as a guide to official statistics, not as a compendium or dictionary of them; and the problems attacked are given rather as illustrations than as substantial contributions to knowledge.

To facilitate the use of the book in the hands of teachers a number of exercises of various degrees of complexity are given in Appendix I. Every serious student of commercial or public affairs should be acquainted with the nature of the contents of the Statistical Abstract of the United Kingdom; to promote this knowledge, and because many pages of headlines and figures would otherwise have been necessary, a large proportion of the examples relate to tables in the Abstract for 1909, for which future or earlier abstracts can readily be substituted.

Appendix II contains a short list of Blue Books which should be easily accessible in the Library of every institution where the subject of statistics has a place in the curriculum.

My thanks are due to Dr. Dudfield (Medical Officer of Health for Paddington) and Professor Cannan for most useful criticism of some of the chapters, and to Mr. G. W. Palmer for help and advice in the correction of proofs. I shall be grateful for any criticisms which will tend to increase the utility or improve the accuracy of the book.

A. L. B.

Reading,
December 1909.

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APPENDIX I

PART I

EXERCISES ON CHAPTER II

[References are to tables in the preceding pages, or to the *Statistical Abstract for the United Kingdom, 1909, Cd. 4805, price 1s. 8d.*]

1. Write down the number of bushels (p. 6) in the forms (a) to (f).

2. Add together 75,324, 79,476, 432,132, the numbers being correct to 1%, 2%, 3% respectively.

3. The population of a colony consists of 73,243 Europeans, 7,8⁰⁰ Indians and 432⁰⁰⁰ negroes. What is the whole population?

4. The average wage of 2,456⁰⁰⁰ workmen is 26s. 6d. (to nearest 6d.). What is their aggregate wage?

5. The total income of 3,254,6⁰⁰ persons is £243 × 10⁶. What is the average income?

6. The productivity of 4,325⁰⁰⁰ acres is between 38 and 39 quarters of wheat per acre. A quarter weighs between 470 and 490 lbs. What is the yield in tons?

7. £87,547 is to be raised in rates, where the assessed annual value is £943,650. Find the least rate necessary (fractions of one farthing not being used) and the excess collected.

8. The quantity of wheat imported in 1894 was 70,126⁰⁰⁰

cwts., in 1908 91,131⁰⁰⁰ cwts. Express the ratio in the notations of pp. 11, 12.

9. If wages per hour rose 20 %, and the number of hours worked per week fell 10 %, find the change in weekly wages.

10. Wages were raised 10 %, lowered 15 %, raised 20 %, lowered 25 %, and raised 10 % in certain years, each percentage being reckoned on the wages current when the change was made. Find the change in the whole period.

11. Express the 4 summary totals of the value of imports (*Stat. Abs.*, end of Table 41, p. 135) in 1894, 1900, 1908 as percentages of the grand total.

12. In the same table express the totals A to N under III (Articles Wholly or Mainly Manufactured) as percentages of the total of III in 1908.

[For further treatment of Approximations and the Contracted Method, and numerous examples, the student is referred to *Arithmetic, Mainly Examples*, G. W. Palmer, Macmillan & Co.]

EXERCISES ON CHAPTER III

1. Apply the monthly average prices of wheat in 1908 (*Stat. Abs.*, Table 72, p. 287) to the quantities (on p. 289), to find the total values sold as accurately as the data allow.

2. Find the average production per acre of the 6 corn crops shown in Tables 74 and 75 for (1) Great Britain, (2) Ireland, for the years 1894 and 1908.

	Acreage.	Average yield per acre.
3.	A. 3,456,789	35·2 bushels
	B. 2,703,257	30·7 „
	C. 1,432,843	43·8 „

Find the average yield in A, B, C together by the methods of p. 18.

Using the methods of p. 20, check the averages shown in the tables in Part I, Ch. VI, p. 51, in Part II, Ch. VI, p. 149, suggesting the cause of the discrepancies (if any) found.

5. Find the arithmetic average, the median, the quartiles and the mode of the miners' ages given in Part I, Ch. V, p. 36.

6. The prices of 4 kinds of wool are calculated in the *Stat. Abs.* (Table 60, p. 249), from data given in Tables 40 and 41. Check the calculations for the year 1908, and find the average price for the four kinds lumped together. Observing that the data are incomplete in 1900, consider how accurately an average for 1900 (comparable with those of subsequent years) can be computed.

[Observe that camel's hair is 2*d.* to 2½*d.* per lb. cheaper than sheep's wool, and that the maximum import is less than that shown under K, p. 106.]

7. Criticize the following averages: Table 25, p. 57. Total spent in poor relief, 1905-6, England and Wales: £11,675,959. Total relieved (p. 384): July 1st, 1905, 869,777; Jan. 1st, 1906, 926,741. Average number relieved, 898,259. Average cost, £12 19*s.* 11½*d.*

8. If the average wage of 55,000 men is 28*s.* 6*d.*, and of these the average for 30,000 is 25*s.*, find the average for the remainder.

9. Find d_1 , d_9 (the 1st and 9th "deciles"), in the table on p. 23, so that "one-tenth of the wage-earners received d_1 /- or less, and one-tenth received d_9 /- or more."

EXERCISES ON CHAPTER IV

1. Write the net value of Consignments (*Stat. Abs.*, Table 35, pp. 80-81) from the 29 British Possessions for 1904 and 1908 in 6 columns as in the table in Part I, Ch. IV, p. 27, and calculate the ratios of the totals. Make

two new columns also showing the values to the nearest million £, and calculate the ratios.

Find also the relative and the absolute errors in the totals of each of the columns and comment on the results.

2. Write the table of monthly prices (*Stat. Abs.*, Table 72, pp. 286, 287) for the years 1894, 1900, 1908), (1) omitting pence, (2) to the nearest shilling. Find the averages for the years, and express them as percentages of the average found for 1894. Comment on the result.

3. Re-write the table showing the percentage of unemployed monthly from 1897 to 1906 (Part II, Ch. VII, p. 158), (1) omitting the decimals, (2) to the nearest whole numbers. Calculate the yearly means and the 10 years' monthly averages. Comment on the result.

4. Find the total yardage and total value of woollen tissues exported in 1908 from *Stat. Abs.*, Tables 48 and 49. Calculate the average price.

Now write down the average prices of the eight qualities enumerated from Table 61. "Weight" these averages (1) with the number of million yards of each kind, (2) with the values to the nearest £100,000, and find the "weighted average" price. Explain why the result of (1) agrees very closely with average already calculated, while the result of (2) is 40% too large.

EXERCISES ON CHAPTER V

1. Make diagrams of the type on p. 37 of the wages shown in Part II, Ch. VI, p. 149.

2. Make circular diagrams (as on p. 47) of the main items of revenue and expenditure in the first and last years shown in Part II, Ch. X, p. 189.

3. From the Tables of Imports and Exports (*Stat. Abs.*, pp. 74 to 77) make the following diagrams, for the years 1894-1908:—

- (i) Of Imports from Foreign Countries, British Possessions and Total.
- (ii) Of Exports to Foreign Countries, British Possessions and Total.
- (iii) Total Imports and Exports.
- (iv) Imports and Exports to and from British Possessions.

4. From Tables 48 and 49 (*Stat. Abs.*, pp. 162-3, 180-1) make three diagrams of the value and quantity of Cotton Piece Goods exported, (1) representing 100 yds. and £1 by same unit, (2) making the lines start together, (3) making the lines end together.

5. Represent the numbers in the table on p. 180, Part II, Ch. IX, by a diagram.

6. Treat one or more of the columns of the prices in the table on p. 128, Part II, Ch. IV, by the method of p. 42.

EXERCISES ON CHAPTER VI

[Use round numbers throughout and pay attention to clearness of meaning and legibility.]

1. Make a table of Imports and Exports (*Stat. Abs.*, Table 34), grouping together the Foreign Countries in Europe, Asia, Africa and America, and showing British Possessions in 5 groups, from 1894 to 1905.

2. Make a similar table of Consignments (total values) from various groups of countries, 1904 to 1908 (*Stat. Abs.*, Table 35).

3. Make a table comparing Imports from and Consignments from those countries in which the values are markedly different.

4. Make a series of brief tables showing the information as to the Woollen and Worsted industry contained in the *Statistical Abstract*.

5. Make a table combining imports and exports of bullion

and specie with those of merchandise (*Stat. Abs.*, Tables 36, 36, 55 and 56) for each of the principal gold or silver producing countries.

EXERCISES ON CHAPTER VII

1. Find by sampling the number of words (1) in a full line of this book, (2) in lines including those at the beginning and end of a paragraph. Hence estimate the number of words in a page containing 37 lines. Calculate the precision of your estimate, and verify it by counting the number of words in a number of pages.

2. Make a similar estimate for the average number of letters in a word. Also by taking, say, 1000 words, find the frequency of words of different lengths. Estimate the precision of your results, and verify it by tabulating a large number of consecutive words.

3. Find the ratio of the number of commas to the number of full stops in this or any other book.

4. Find whether the digits 0 to 9 are uniformly distributed through the table at the beginning of Chap. IV, Part I.

EXERCISES ON CHAPTER VIII

1. Apply the rules of criticism given to—

- (1) the various statistics relating to Paupers in Table 146, 147, pp. 384-5, *Stat. Abs.* (England and Wales).
- (2) the Post Office statistics, pp. 354 *sqq.*
- (3) the categories of expenditure by Local Authorities in the United Kingdom, Table 23, p. 55, with reference also to Table 25.
- (4) the Income Tax categories, Table 17.

2. How far can the statistics of (1) wages, (2) consumption of meat, (3) value of exported manufacturers, be regarded as tests of National Progress?
3. Which of the average prices, Table 60, satisfy least the criteria of paragraph 5?
4. Do the tables relating to railways, pp. 310–317, give the information that statisticians want?

EXERCISES ON CHAPTER IX

1. Verify the averages in the table in paragraph 3. Deduce the number of miles of track and of route. Show that ton-miles per engine-hour, divided by wagon-miles per engine-hour would equal the average full-and-empty wagon load; and that wagon-miles per engine-hour, divided by train-load would give train-miles per engine- (train and shunting) hour.
2. Consider what data would give the best information for any business or institution with which you are acquainted.
3. Make a blank card suitable for entering details as to a workman applying at a Labour Exchange.
4. Draw up a blank schedule suitable for tabulating details of working-class expenditure.
5. Required to describe the housing accommodation of a district. How would you proceed and what blank forms would you use (1) if you had legal power of entry and measurement, (2) if the inquiry was on a voluntary basis?

PART II

EXERCISES ON CHAPTERS I AND II

1. Calculate some of the *birth-rates* in Table 115 (*Stat. Abs.*, p. 362), from the number of births and from the population stated in the preceding table.

2. Estimate the population of Scotland for each year from 1891 to 1901, using only the data of Table 113 (p. 361), and compare your results with those of Table 114.

3. Work out from the Census Report for your county the density of population in as much detail as possible in your neighbourhood.

4. From the statistics of population, births and deaths (Tables 113, 114, 115), find the excess of emigrants over immigrants for Scotland and for Ireland between 1891 and 1901.

5. With the help of a diagram estimate the actual and relative number of men between the ages 32 and 38 in table on p. 98 above; and also the number of children between 7 and 14. (The whole population is given on p. 89.)

6. Find the actual numbers in various occupations from the per mille table on p. 91, and state in what cases the absolute numbers have increased while the relative numbers have diminished.

7. How is it that the infant mortality rate is lower than the death-rate between 0 and 1 years?

8. In Table 115 (*Stat. Abs.*, p. 362) calculate the population in 1901 from the number of births and the birth-rate, as accurately as these data allow, and compare with the two preceding tables.

9. Find the corrected death-rate for District B to compare with District A by both the methods described on pages 105, 106 from the following data. Find also the general uncorrected death-rates.

		Years 0-5.	Years 5-15.	Years 15-55.	Years 55-
District A.	Relative number of persons	114	110	670	106
	Death-rates	4	3	7	60
B.	Relative number of persons	136	125	619	120
	Death-rates	38	3	6	55

EXERCISES ON CHAPTER III

1. Make the tables corresponding to those in paragraphs 3 and 4 for the years 1900 to 1908.

2. Make a table of the excess of imports over exports (including bullion) for the years 1894-1908, and express this excess year by year as a percentage of the total of imports and exports. On the same diagram show the numbers in this table, and the total tonnage of vessels registered as belonging to the United Kingdom (*Stat. Abs.*, Table 68, p. 282).

3. Draw diagrams showing (1) total value of imports and total tonnage of ships entered with cargoes, and (2) total value of exports and total tonnage of ships cleared with cargoes (*Stat. Abs.*, Table 67, pp. 280-1).

4. Draw smoothed diagrams (as Diagram III, p. 42, above) representing the table of external trade on p. 118 above.

5. Illustrate the process described in paragraph 8 by valuing the quantities of imported meat 1894 to 1908 (*Stat. Abs.*, Table 40, pp. 100, 101) at the prices of 1894 (Table 60, p. 242), and comparing the totals obtained with the declared values (Table 41, pp. 116, 117). Show the result on a diagram. (See also Exercise 1 on Chapter IV.) [Work only to three significant figures.]

6. Express the following categories of exports: Food, drink and tobacco—Coal—Other unmanufactured commodities—Iron and steel manufactures—Cotton and wool products—Other manufactured commodities—as percentages of total exports of home produce, year by year from 1894 to 1908. [Use either the table in paragraph 9, or the *Stat. Abs.*]

7. Draw a diagram illustrating the increase of steamships relative to sailing from *Stat. Abs.*, Table 67, pp. 280-1.

EXERCISES ON CHAPTER IV

1. Make index-numbers of the prices of imported meat from the figures obtained in Exercise V on last chapter.

2. Calculate index-numbers for 1870, 1880, 1890, 1900 and 1908, for the eight commodities together (wheat to coal) shown in paragraph 4 (1) taking 1865-9 as the basis, (2) taking 1873 as the basis, (3) taking 1900 as the basis. In each case re-write the index-numbers so that the number for 1908 is 100. Comment on the differences shown.

[NOTE.—So few commodities are, of course, insufficient for establishing a general index-number.]

3. Transfer Sauerbeck's index-numbers from gold values (in which they are given on p. 128) to silver values.

4. From the *Stat. Abs.* (Tables 60, 61, 82) make a table and diagram comparing the prices of pig-iron imported, exported and produced.

EXERCISES ON CHAPTER V

1. Make a table for 1900-1908 from the *Stat. Abs.* showing the value of imported raw cotton (less re-exports) as compared with the value of exported cotton goods. Assuming that 80% of imported cotton is used for the foreign trade, find the value added by manufacture year by year.

2. The Census of Production shows that the value of the Output of Cotton Factories in 1907 was £47,000,000 more than that of cost of materials used. The value of cotton imported and retained that year was £61,000,000, and of exported cotton manufactures was £95,000,000. If these statements are consistent with the 80% assumption of the last exercise, deduce the value of materials used (coal, etc.) other than raw cotton.

3. Tabulate the values of the home production, imports and exports, of iron, steel and their products for 1908 from Tables 41, 49, 52, and 82 of the *Stat. Abs.*

EXERCISES ON CHAPTER VI

1. The wages of 2,000 men were decreased $\frac{1}{2}d.$ per hour and the normal week was increased 3 hours. If before the change the rate was $10d.$ and the week 50 hours, compute the effect that would be shown in a "change of wages" table.

2. If average weekly wages in Textiles, Agriculture, Building, and Engineering had been respectively $15s.$, $13s.$, $25s.$ and $27s.$; and the relative numbers employed 5, 10, 2 and 3 in 1880, compute the change per cent. for the 4 groups together in 1890, 1900 and 1908 from the index-numbers in paragraph 9, (1) assuming no change in the relative numbers, (2) assuming that the numbers changed gradually till in 1908 they were 5, 7, 3, 5.

3. If average wages rise 20%, and the retail purchasing power of money rises 10%, how much do average real wages rise?

4.

Wages. Grade.	Number of men.	
	Year 1.	Year 2.
26s.-28s.	25	15
28s.-30s.	25	25
30s.-32s.	25	35
32s.-34s.	25	25

Find the maximum and minimum change possible in average wages consistent with promotions as shown in this table, assuming that no man's wage was reduced.

5. Compute the lines for lads and girls on page 149 on the assumption that all receiving less than $5s.$ were half-timers (none earning less than $2s. 6d.$) and supposing each

pair of half-timers replaced by one full-timer at their joint wages.

EXERCISES ON CHAPTER VII

1. Make diagrams illustrating the table on p. 156.
2. For lines A and B of the same table take decennial averages for 50 periods beginning 1851, 1852, to 1900, and represent the result in a diagram. Comment on the result.
3. Compute column D counting B_2 as twice as important at B_1 .
4. Which of the lines in the table on p. 157 can be calculated from the other lines?
5. Make a diagram showing the general percentage unemployment, as shown in paragraphs 6 and 7, pp. 158-160, for every month from January 1897 to October 1909.
If seasonal changes are eliminated, which was the worst month in 1904-5?

EXERCISES ON CHAPTER VIII

1. Express the expenditures shown in the table on p. 164 as percentages of the total expenditure.
2. What information does the *Stat. Abs.* contain as to working-class savings?
3. Check the percentages shown on pp. 168, 169.
4. How far can the higher expenditure shown (pp. 168-9) for English incomes than for French or German over 40s. be accounted for by the larger number of children?

EXERCISES ON CHAPTER IX

1. If the income-tax is 1s. 2d. on unearned incomes and 9d. on earned when the total is less than £2,000, and abate-

ments are as shown on p. 175, find the income-tax payable and the actual rate in the £ in the following cases—

	Earned. £	Unearned. £
Income of A	300	10
B	400	100
C	300	200
D	501	200
E	495	200

	£
2. The net profits of a firm were in 1900	5,500
1	5,000
2	4,500
3	4,400
4	4,000
5	4,000
6	5,000
7	6,500
8	6,000

How would these appear in the returns of income if the average for the three preceding years were taken yearly as described on p. 178.

EXERCISES ON CHAPTER X

1. If the whole of indirect taxation were borne by working-class families and others with incomes below £160, and the whole of direct taxation by income-tax payers, and if the two classes consisted respectively of 7,000,000, and 1,000,000 families and their aggregate incomes of £1,000 mln. and £800 mln., calculate the burden per family in each case and the proportion of taxes to income in each case. [Omit Post Office and Crown Lands, etc.]

2. Estimate the aggregate income of Great Britain on the hypothesis that among persons where the rent is less than £25, the average family income is 8 times the rent

£25 to £50	"	"	10	"
£50 to £80	"	"	12	"
£80 to £500	"	"	15	"
£500 and over	"	"	20	"

APPENDIX II

SELECTED LIST OF BOOKS OF REFERENCE

- JEVONS—Investigations in Currency and Finance.
 GIFFEN—Economic Inquiries and Studies.
 GOSCHEN—Essays and Addresses on Economic Questions.
 The Journal of the Royal Statistical Society. 5s. quarterly.

Government Publications.

Government publications in this list are either "Command Papers" or "House of Commons Reports or Papers." The former are numbered consecutively Cd. 1, Cd. 2, etc., from the year 1900; prior to 1900 they were numbered C. 1, C. 2, etc., to about C. 9500. The latter are numbered consecutively, beginning afresh each year. To order a publication it is sufficient to give, e. g. Cd. 1761 or *House of Commons* 365 of 1908, without title.

Annals.

The reference number is for the last issued prior to December 1909.

	Number.	Price.
Statistical Abstract for the United Kingdom .	Cd. 4805	1 8
Statistical Abstract for the Principal Foreign Countries	Cd. 4265	1 7
Statistical Abstract for the British Colonies .	Cd. 4415	2 0
Statistical Abstract for India	Cd. 4837	1 3
Statistical Abstract for the British Empire .	Cd. 4486	1 2
Labour Statistics	Cd. 4413	1 2
Changes in Wages and Hours of Labour . . .	Cd. 4713	0 9
Registrar General's Report on Births, etc. .	Cd. 4347	3 9
Report of the Local Govnt. Bd.—Eng. & Wales	Cd. 4786	1 4
Trade of the United Kingdom, Vol. I for 1908	Cd. 4687	6 0
Trade of the United Kingdom, Vol. II for 1908	Cd. 4784	3 5

	Number.	Price
Trade of the United Kingdom, Supplement, 1907	Cd. 4296	3 10
Trade Accounts. The 12 Months ending December in each year	H.of.C. 25xi. of 1908	1 2
Navigation and Shipping, 1908	Cd. 4789	2 8
Reports of Commissioners of the Inland Revenue	Cd. 4868	1 7

Special Reports.

	Year.	Number.	Price
Statistical Tables and Charts relating to British and Foreign Trade and Industry	1903	Cd. 1761	3 6
Statistical Tables and Charts relating to British and Foreign Trade and Industry	1904	Cd. 2327	3 6
Statistical Tables and Charts relating to British and Foreign Trade and Industry	1909	Cd. 4954	5 2
Public Health and Social Conditions	1909	Cd. 4671	5 0
Decennial Supplement to Registrar-General's Report, Part I.	1907	Cd. 2618	4 3
Decennial Supplement to Registrar-General's Report, Part II.	1908	Cd. 2619	1 10
Report of Committee on the Census	1890	C. 6071	1 2
Report of Committee on the Income-tax	1906	H.of.C. 365	2 7
Population Census—England and Wales: Summary Tables, 1901	1903	Cd. 1523	2 6
Population Census—England and Wales: General Report, 1901.	1904	Cd. 2174	2 8
Wholesale and Retail Prices	1903	H.of.C. 321	2 1
Census of Production: Preliminary Tables	1909	Cd. 4896	0 4
Wage Census. I. Textiles	1909	Cd. 4545	2 7
Wage Census. II. Clothing Trades	1909	Cd. 4844	2 5
Standard Time Rates	1894	C. 7567 ii.	1 3
		Cd. 3245	0 7
		Cd. 4924	0 6
		C. 7567 i.	1 0
Standard Piece Rates	1900	Cd. 144	0 6
Rents, Prices, Wages, etc., in Towns in the United Kingdom	1908	Cd. 3864	6 0
Rents, Prices, Wages, etc., in Towns in Germany	1908	Cd. 4032	4 11
Rents, Prices, Wages, etc., in Towns in France	1909	Cd. 4512	4 1

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