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Some Difficulties in Percentages

LeRoy L. Perrine

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By Leroy L. Perrine

To an accountant percentages are familiar friends. It is safe to say that few reports are submitted to clients, particularly those reports relating to audits, which are not plentifully sprinkled with percentage signs. The increases or decreases in the current year's business, as compared with the business of the preceding year; the ratio of items of expenses such as advertising, wages, rent and the like to the total of sales or to the total of all expenses—these and various other statistics are frequently expressed in terms of percentages, thus facilitating a more thorough understanding of the various phases of the business. So frequently are percentages used and so simple is it to compute the vast majority of them on tabulating machines or by pencil or "in our heads," that some accountants, more particularly those in the junior grades, are apt to treat them too lightly. In this brief article, an attempt will be made to describe a few of the more difficult percentage computations—probably, however, to most accountants, not particularly difficult, but merely unusual.

Probably one of the most frequent errors in the use of percentages is in their addition or subtraction. Relative to this it is well to remember that percentages can be added or subtracted only when they result from dividing by the same base or divisor. A simple illustration of this principle is shown in the case of determining percentages of the total expenses for various individual expenses. For example:

Expense	Amount	Percentage of total
A	$ 80,000	32%
B	70,000	28%
C	40,000	16%
D	60,000	24%
Total	$250,000	100%

The accuracy of the above percentage computations is obvious. The base, or divisor, for computing all five percentages is the

same, namely, $250,000; and it is correct to add the percentages so derived. The fact that the sum of the first four percentages is 100 per cent is a partial check on the correctness of the work, although such an addition would not disclose any "switches" which might have been made.

A different situation is shown in the following table, and illustrates the fallacy of what accountants sometimes call "getting the average of an average." This situation is frequently confusing. How it works out is set forth below:

Branch	Sales	Cost of sales	Ratio of cost of sales to sales
Store A.....	$100,000	$ 70,000	70.00%
Store B.....	200,000	150,000	75.00%
Store C.....	75,000	60,000	80.00%
Store D.....	25,000	21,000	84.00%
Total	$400,000	$301,000	75.25%

The above is the correct computation of percentages. But instances have been known where the percentage of the total of the four branches has been computed by adding together the first four percentages, and then dividing this result by four; in other words, dividing 309 per cent by 4, giving 77.25 per cent as the incorrect result. Such a method attaches as much weight to the relatively large percentages of the two small stores as to the relatively small percentages of the two large stores and is manifestly erroneous. It is never correct to use this "average of an average" method. To find the final percentage, the right method is to divide the total cost of sales by the total sales. Occasionally the result obtained by the "average of an average" method will coincide with the result obtained by the first method, but this will not be a proof that the latter result is correct. It will be merely a coincidence and not a habit.

The preceding table shows how percentages are sometimes incorrectly added. The following table shows how they may be occasionally incorrectly subtracted:

	Year ended Dec. 31, 1919	Year ended Dec. 31, 1918	Increase	Percentage of inc. or decrease
Gross earnings.....	$90,000	$80,000	$10,000	12.50%
Operating expenses..	60,000	55,000	5,000	9.09%
Net earnings....	$30,000	$25,000	$5,000	20.00%

The only difficulty whcih sometimes arises from tables like the above is in working out the last percentage. It is practically the universal custom to consider the figures of the preceding year as the base (or divisor) figures, and not those of the later year. The different figures in the third column are the dividends, and the percentages in the last column are the quotients. The first three amounts on the net earnings line are, of course, merely the differences between gross earning and operating expenses, and sometimes young accountants make the mistake of assuming that the percentage on this line may also be obtained by differencing. This method will seldom work out the correct result; and if it does, it will, as stated above, be only a coincidence and prove nothing.

The above tables have involved only what are sometimes called "black figures." The most confusing problems in percentage computations, in the opinion of the writer, are those which deal with "red figures," or, more accurately, those which involve both black and red figures. A simple case illustrating this difficulty is shown in the case of a man who lost $500 during his first year in business and gained $1,000 during his second year. What is the percentage of increase? Some accountants give the answer as 300 per cent, meaning 300 per cent black, obtaining this answer by dividing $1,500 by $500. But they would obtain this same result by assuming that this man gained $250 during his first year (instead of losing $500), gaining $750 on $250, which works out to 300 per cent. If two men make the same amount in their second year of business ($1,000), while in their first year one man lost $500 and the other gained $250, it is clear that the percentages of increase must be different. Both answers can not be the same. The explanation is that the first man gained 300 per cent red and that the second man gained 300 per cent black. The answer of 300 per cent red is obtained by dividing a black dividend ($1,500) by a red base ($500). The answer of 300 per cent black is obtained by dividing a black dividend ($750) by a black base or divisor ($250). Numerous errors will creep into percentage computations such as the one illustrated above, unless the distinction between red and black figures is kept clearly in mind.

The following table illustrates some computations in red figures.*

	Year ended Dec. 31, 1919	Year ended Dec. 31, 1918	Inc.—black Dec.—red	Percentage of inc. or decr'se
Gross earnings.....	$80,000	$ 90,000	*$10,000*	*11.11%*
Operating expenses.	85,000	100,000	*15,000*	*15.00%*
Net earnings...	*$ 5,000*	*$ 10,000*	$ 5,000	*50.00%*

Results such as the above are of infrequent occurrence in actual business, but occasionally something along this line develops and causes some study and possible confusion merely because of its unusual features. The first percentage results from dividing the red decrease of $10,000 by the black divisor figure of $90,000, giving a red percentage of 11.11 per cent. A similar explanation applies to the red figure of 15.00 per cent. But the red percentage of 50.00 per cent is hard to explain. Most accountants naturally consider that a red figure indicates a loss, a decrease, a going backward. Occasionally, however, this is not true. It is practically universal in accounting and statistical statements that black figures are in harmony with the caption at the head of a column, while red figures indicate the reverse. For example, in a column headed "Increase," black figures would indicate increases, and red figures would indicate decreases. But in a column headed "Decrease," black figures would indicate decreases, while red figures would have a significance exactly the reverse of their ordinary meaning and would indicate increases. In the case under consideration, therefore, the red percentage of 50.00 per cent would ordinarily convey the meaning that the 1919 net earnings were less than the 1918 net earnings. This is not the case, however, for here is a company whose net earnings actually improved in 1919 over 1918, and yet the percentage of improvement is shown in red. To be sure, the company lost money during both years, but it lost less in 1919 than in 1918 by $5,000. It made a gain in net earnings, and such a gain, it would naturally seem, should be expressed in black and not in red. Nevertheless, the red figure of 50.00 per cent is absolutely correct, and is accounted for by the fact that we are dividing a black $5,000 by a red $10,000, and the result must inevitably be a red 50 per cent.

* The author's so-called "red" figures are printed in italic; the "black" in roman.—EDITOR.

This conclusion will be clear to those familiar with algebra, where the plus sign corresponds with the black figures and the minus sign with the red figures.

In addition to cases involving red or black figures, there are other cases which might result when the figures (or some of them) are neither red nor black, but zero. In fact, by ringing the changes, there are nine possible calculations, based upon nine combinations of black figures, red figures and zeros. These will be illustrated numerically in a subsequent paragraph. Expressed in formulas, they may be stated as follows:

(1) Black (or plus) divided by black (or plus) equals black (or plus).

(2) Red (or minus) divided by black (or plus) equals red (or minus).

(3) Zero divided by black (or plus) equals zero.

(4) Black (or plus) divided by red (or minus) equals red (or minus).

(5) Red (or minus) divided by red (or minus) equals black (or plus).

(6) Zero divided by red (or minus) equals zero.

(7) Black (or plus) divided by zero equals plus infinity.

(8) Red (or minus) divided by zero equals minus infinity.

(9) Zero divided by zero equals—not computable.

The above nine formulas doubtless appear, at first sight, rather theoretical, and to most readers of this article practical illustrations will be more to the point. Following are examples of each of the above nine formulas:

	Net earnings in 1919	Net earnings in 1918	Inc.—black Dec.—red	Percentage of inc. or decrease
(1).....	$7,000	$5,000	$2,000	40%
(2),.....	3,000	5,000	*2,000*	*40%*
(3).....	5,000	5,000	Zero	Zero %
(4),.....	*3,000*	*5,000*	2,000	*40%*
(5).....	*7,000*	*5,000*	*2,000*	40%
(6).....	*5,000*	*5,000*	Zero	Zero %
(7).....	2,000	Zero	*2,000*	Plus infinity %
(8).....	*2,000*	Zero	*2,000*	*Minus infinity %*
(9).....	Zero	Zero	Zero	Not computable

In actual practice, case (1) covers the vast majority of computations, with case (2) next in number. Cases (4) and (5) will

occur in companies where the business of the year preceding the current year has resulted in net losses. Cases (3) and (6), where the figures in the first two columns are identical, will occasionally be met. Cases (7), (8) and (9) are of rare occurrence.

From the preceding paragraph, it is clear that some percentages, even when correctly computed, may be difficult to explain. One of the most important requirements of any report, accounting or otherwise, is that it shall be fairly easy to understand. In line with this idea, the purpose in using percentages in a report should be to clarify and illumine it and to render more comprehensible the various figures contained in it. If there is any percentage computation, or group of such computations, which fails to accomplish this purpose, it would be better to eliminate it altogether. The writer has seen some accounting exhibits which were a puzzle in this respect. It is to be hoped that the clients understood them, for most accountants would not. Such intricate and involved computations remind one of the saying of Talleyrand, the great French diplomat, that speech was invented, not for the purpose of disclosing one's thoughts, but to conceal them.

It is the hope of the writer that this brief article may help to prevent some errors in the computations of percentages, or help to eliminate from reports percentages which are difficult to explain, which might otherwise creep into some of our accounting statistics.