Math vs. Statistics: Context Matters

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In statistics, context matters. Here are three cases where the context distinguishes statistics from mathematics.

First case: The equation for a straight line is Y = a + m*X. In mathematics, the slope of the perpendicular is stated as -1/m. This is true in math, but it may not be true in statistics

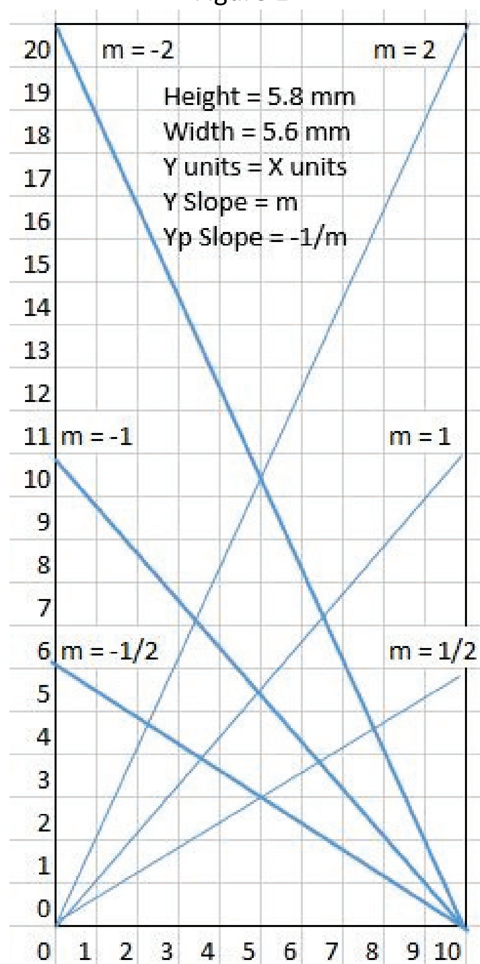
In statistics, the context matters. In mathematics, variables don't have dimensions and their values mean the same thing.

The negative inverse holds in one very special case. It is wrong in all the others.

Figure 1 shows where the negative inverse is truly the perpendicular to a given straight line.

In figures 2 and 3, the slope of the perpendicular is not the negative inverse of the slope of the original line.

Figure 1



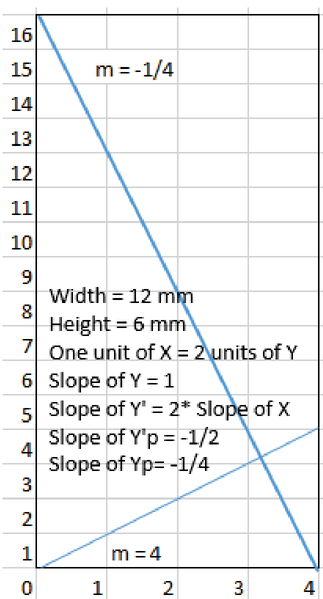


Figure 2

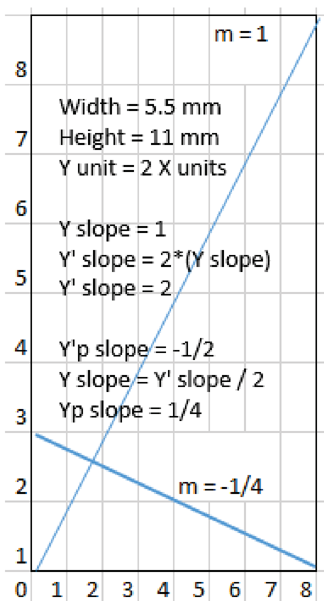


Figure 3

What is happening here? In math, X and Y are assumed to have units of the same size. In reality, this may not be true. But there is a second problem.

Suppose Y is weight measured in pounds; suppose X is height measured in inches. The slope of Y on X has units of pounds per inch. Does the slope of the perpendicular have units of inches per pound?

For now, consider just the case where the units are of different sizes – as shown in Figures 2 and 3.

Conjecture: If k units of X equal 1 unit of Y (Figure 3) and if the slope of a line, dY/dX, is m, then the slope of the perpendicular is given by – 1 / (m * k^2).

Second case: In arithmetic, 6 plus 7 = 13, 60% and 70% = 130%. Suppose a business has a 60% market share in the Eastern half of the US and a 70% market share in the Western half. What is their market share in the entire US? Whatever it is, it is not 130%.

In this case the words matter. The phrase, "market share", changes everything.

Third case. In arithmetic we can always cancel out anything that is identical in both numerator and denominator. So, 2*6/(2*3) = 6/3. Or, 66"/60" = 66/60 = 1.10. But in making ratio comparisons, the units are important. Suppose that John is 66" tall; Jill is 60" tall. Compare their heights as a percentage difference.

We wouldn't say, John is 10% more than Jill. We would say, John is 10% taller (in height) than Jill.

Essentials: Statisticians often say that variability is what distinguishes statistics from mathematics. In so doing, they make minimizing the squared distance in OLS regression statistics. Blitzstein (2013) said, "math is the logic of certainty, while statistics is the logic of uncertainty." Briggs (2013) said, "Statistics is not math; neither is probability." In a more poetic manner, Gelmann (2007) said, "Math is like music, statistics is like literature."

An alternate suggestion is that context is what distinguishes statistics from mathematics. Cobb and Moore (1997) said, "Statistics requires a different kind of thinking, because data are not just numbers, they are numbers with a context."

Summary: This paper supports the claim that context – not just variability – is what distinguishes statistics from mathematics. Context matters!

Bibliography:

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Cobb, George and David Moore (1997). Mathematics, Statistics, and Teaching. *The American Mathematical Monthly*, Vol. 104, No. 9 (Nov., 1997), pp. 801-823