

module_stat4_lecture13

📅 Thu, 2/17 4:18PM ⌚ 16:45

SUMMARY KEYWORDS

alternate hypothesis, null hypothesis, test, school feeding program, sided, μ , check, equal, hypothesis, statistic, remember, looked, program, μ naught, reject, students, case, impact, enrollment, negative

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So we've been talking about testing of hypothesis. And so far, we've been talking about what are called two tailed tests. And in this clip, I'll be talking about a related type of test, which is called a one tailed test. So what's the difference? So, so far we've been looking at hypothesis like this, but checking for H_0 , the null hypothesis has been $\mu = \mu_0$ right versus the alternate hypothesis, where μ is not equal to μ_0 . So, this so, this is either new could be less than μ_0 or new could be greater than μ_0 . So, both of these possibilities are now inbuilt into this alternate hypothesis, right. So, you could you would reject the null hypothesis. So, say this is μ_0 , right you reject the null hypothesis if either μ lay very much lower than this, or if μ lay very much higher than μ_0 or not. And the vast majority of tests that you will see in your courses will probably be the two sided test. But In some circumstances, we have to deal with what's called one sided test. So, for example, so here, so, if your now hypothesis is still $\mu = \mu_0$, but your alternate hypothesis is that μ is actually less than μ_0 . So, what's an actual example of this? So, remember this earlier example, which said about the impact of online learning? Right? So, there our hypothesis was that online learning has some impact on student learning. Right? That impact could be positive, it could be negative. But what if we're interested in making checking the point where the online learning actually has a negative impact on student learning? Right, so does it harm students. So in this case, you would you would have to check for is your alternate hypothesis, remember, the skeptical is that it has no impact $\mu = 0$. Now, the alternate hypothesis is that would you love to check is where the μ is less than or equal to zero. So this is an example of a one sided test. And a more general formulation of this is either $\mu \leq 0$ versus the alternate is $\mu < 0$ or $\mu \geq 0$ versus the alternate is $\mu > 0$. And in some cases, you may also be checking whether μ is greater than μ_0 or not. Right. So for example, if you're checking for drug, so the question is whether this new drug does better than the old one. That should that would be an example of another one sided test that you may be interested in. Right. Now, for doing the side of one sided test. Luckily, for us, the procedure is very similar to what we did for the two sided test. So it's the same mechanics in the sense, remember what we did for the two sided test, we constructed the Z-statistic, right, which was $\bar{x} - \mu_0$ divided by the standard error $s / \sqrt{n}$. Right? And then in the two sided test, we checked for whether it lay within this interval or not. Right. In this case, with one sided test, what we're going to do is that suppose you want to check for whether μ is

less than or equal to zero, right? That's your alternate hypothesis. So in this case, what you need is that the Z- statistic should be sufficiently negative, right? How much negative we needed to be less than or equal to minus one point 6.4 minus 1.645, to reject the null hypothesis. So it's earlier remember to reject the null hypothesis we needed either the Z- statistic to be less than this or greater than this right now, since we're checking it to be whether the null the alternate hypothesis is that this is less than or equal to zero. We only need to check that this should be less than a particular number, right in order to reject the null hypothesis. Okay, so why is this new number? Why don't we just use the earlier ones right? So let me give you an intuition for this. Now this, again comes back to our normal distribution, remember? So here is your new not, this is zero. And what we want to check is the alternate hypothesis is that the μ is less than or equal to μ_0 , right? And your null hypothesis is that μ is equal to μ_0 . Right. Now, if you want to get the null hypothesis, sorry, if you want to get the alternate hypothesis, what you need is that μ should be sufficiently negative, right. So, if we were sufficiently negative, then you will be rejecting this null hypothesis that μ is equal to μ_0 in favor of the alternate hypothesis. And again, remember, what we need is that, see if μ_0 was equal to zero, we want to check that we're like how low must our observation be, so that we can rule out the fact that μ equal to zero with 95% probability. So we look at a point right, so that above it is 95%. Right and below which is 5%. And that particular point is negative 1.645. So, that becomes our critical number, in this case, for the one sided test. For the two sided test, the way we were looking at is we were looking at a point here and a point here such that in between those 95%. Right, and that magical number was negative 1.96 and positive 1.96. Here, we just want that above this number, right, including all of this should be 95%. And below it should be 5%. And that magical number is negative 1.645. And therefore, that becomes a critical value for one sided



test. So what's our



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what's our procedure, right, we construct the Z-statistic. And so if our alternate hypothesis is checking for new less than or equal to μ_0 , we check if Z is less than that number. On the other hand, if your alternate hypothesis is that new should be greater than equal to μ_0 , then we check whether that that statistic is greater than 1.64 or five, right? In both of these cases, we would be rejecting the null hypothesis. So let's do our exact do a couple of examples. Right. So in our online learning example, remember where we sampled an equal 200 students, right and looked at their scores when we're studying online versus in person. And our hypothesis is that online learning has a negative impact. So we are checking where the μ is equal to zero versus μ is less than or equal to zero. So what we're going to do here is we're going to construct the Z-statistic. And it's $\bar{x} - \mu_0$. So $\bar{x}$ here is negative three, so that's negative three minus μ_0 , which is zero divided by the standard error, right? So that's $s / \sqrt{n}$. So that's 2.5 divided by square root of 100. So this is negative three divided by 2.5 by 10. So that's negative three over 0.5. And this is negative two. So that's that statistic in this case. And you see that this that statistic is negative 12. So this is way below that critical point of negative 1.645. So we reject The null hypothesis in favor of each alternate, which says that μ is less than equal to zero. So we now have evidence, right? So our evidence seems to support this alternate hypothesis that, that online learning does have a negative impact on student learning. Let me do one more example. So um, this is evaluating a

policy or a program, right? So one of the very common program these days around, especially around the developing world, is food for education programs, where they either supply meals to school children or, or sometimes the way they do it is that if the student attends a certain percentage of classes, right, it's about 85%. Attendance report, then they get to take home some rations for their home. And this is a very popular program in India, Brazil, a lot of South American and African countries. So what do you mean, ask us the question, right? Do these education programs do they enhance school enrollment at because governments are spending millions and billions of dollars on these programs? Does this help? Right? Does this increase enrollment in school? So how would you put this as a hypothesis, right? So in this case, you're you'd say that they have no impact, right? So that's your all to null hypothesis, versus your alternate hypothesis is that they have a positive impact on enrollment. So this is an example of a one sided test in practice. Now, so looked at around and the lots of studies you'll find of the sort of programs in different countries. I looked at a study from Uganda by Alderman Gilligan and Lehrer in 2012, where they looked at a bunch of schools in Uganda, and they looked at enrollment rates after these programs are instituted, right, so they looked at enrollment rates for students aged six to nine years old. Right. And they looked at two particular programs. One is the school feeding program where they provide lunches to, to students, right. And the second was the take home rations program, which was the other type that if the school if the student attends 85%, of classes or more, then he gets to take home some rations for his or her family. And drink and look at what's the impact of enrollment, right? What was the change in enrollment due to these programs? They found that the estimate under the the school feeding program, that estimate was 0.094. Right? So there was about a 9.4% increase, right? And the standard error of the estimate was 0.040. Right? So remember, the standard error is the term is over square root. So now, if we want to check if this SFP program did have if you're checking, does it actually have an impact, or was it statistically zero, right? Is the evidence strong enough? Right? So to do that, what we need to do is construct the Z-statistic here. Remember, it's the estimate, right? So that 0.094 minus mu naught, that zero divided by sorry, as over square root of nine, that 0.040. Okay, and if you do this calculation, this comes out to be 2.35. And in this case, it's 2.35. And this is greater than the critical value of 1.645. So in this case, we're going to for the SFP program, we're going to reject the null hypothesis that food for education programs don't have any impact on school enrollment. But the evidence here shows that at least for the school feeding program, it enhances school enrollment. What about the other program, which is the thr or the take home rations program. So if you do the same calculation here, the estimate is 0.054. Right? And the standard error is this. So if you calculate the Z-statistic, this divided by 0.0589, so that's the Zed here. So this turns out to be point nine three. And C, this is less than 1.645. So in this case, you cannot reject the H not. Because the Z value for this program is lower than the critical value. So this is how you do one sided tests. And they are specially important, especially if you're looking at the trend to evaluate the impact of policies. And here you see in in the Ugandan case, that the two school programs one of them you definitely have statistical evidence to support that enhance a school enrollment. For the other one, the evidence is not as strong