Business Statistics: A First Course
6th Edition

Chapter 9
仮説検定
Fundamentals of Hypothesis Testing: One-Sample Tests

Learning Objectives

In this chapter, you learn:

- The basic principles of hypothesis testing 仮説検定の基本
- How to use hypothesis testing to test a mean or proportion

  平均を仮説検定する方法
- The assumptions of each hypothesis-testing procedure, how to evaluate them, and the consequences if they are seriously violated仮説検定の前提とその前提に合わない場合の結果
- How to avoid the pitfalls involved in hypothesis testing

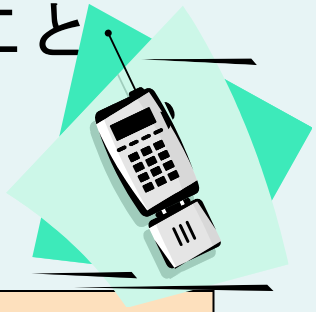
  仮説検定を行う時、落とし穴を回避する方法
- The ethical issues involved in hypothesis testing

  仮説検証に関わる倫理的問題

What is a Hypothesis?

DCOVA

- A hypothesis is a claim (assertion) about a population parameter:仮説とは、真偽はともかくとして、何らかの現象や法則性を説明するのに役立つ命題のこと



  - population mean　母集団　平均

Example: The mean monthly cell phone bill in this city is μ = $42

  - population proportion　母集団　割合

Example: The proportion of adults in this city with cell phones is π = 0.68

The Null Hypothesis, H_0
帰無仮説

DCOVA

”帰無仮説とは、ある仮説”が正しいかどうかの判断のために立てられる仮説です。

- States the claim or assertion to be tested

Example: The average diameter of a manufactured bolt is 30mm ($H_0 : \mu = 30$)

- Is always about a population parameter, not about a sample statistic

$$H_0 : \mu = 30$$

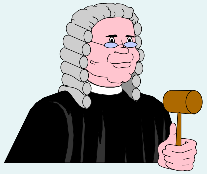
$$\cancel{H_0 : \bar{X} = 30}$$

The Null Hypothesis, H_0

帰無仮説

DCOVA
(continued)

- Begin with the assumption that the null hypothesis is true　まず、肯定されることを期待して立てられる
  - Similar to the notion of innocent until proven guilty



- Refers to the status quo or historical value
- Null always contains “=“sign
- May or may not be rejected

The Alternative Hypothesis　対立仮説, H_1

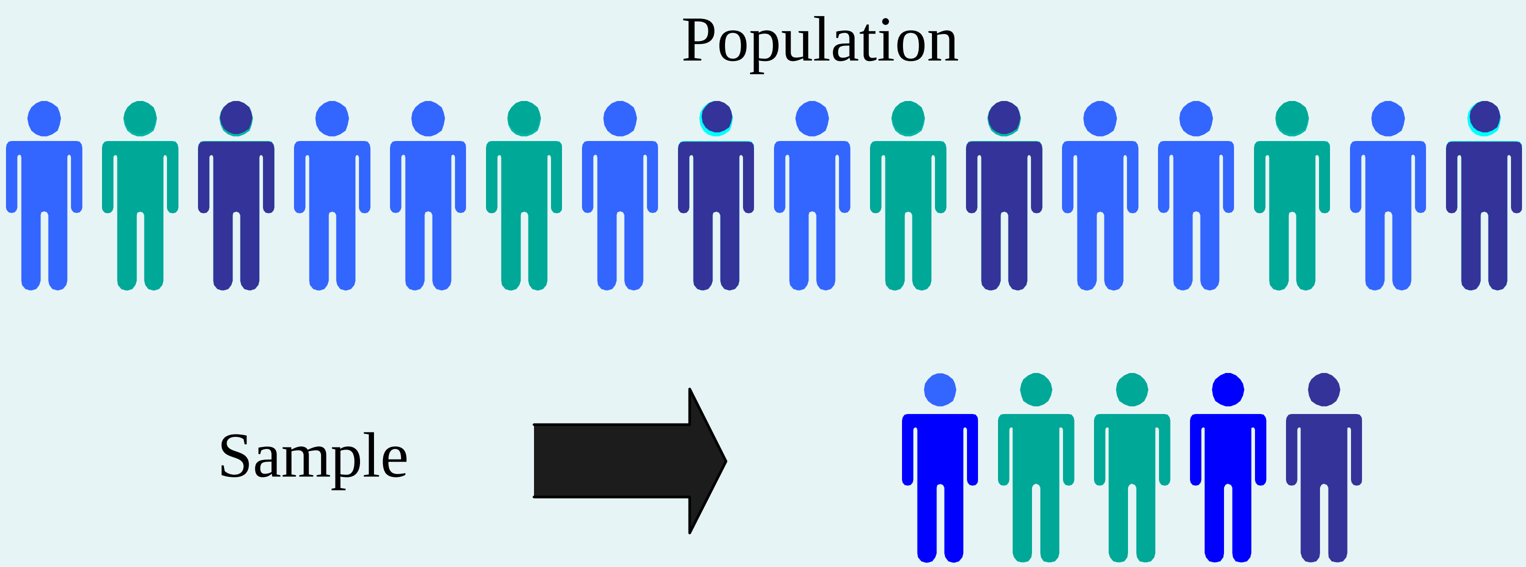
DCOVA

- Is the opposite of the null hypothesis 帰無仮説と対立する仮説である。
  - e.g., The average diameter of a manufactured bolt is not equal to 30mm（H_1: $\mu \neq 30$)
- Challenges the status quo
- Alternative never contains the “=”sign
- May or may not be proven
- Is generally the hypothesis that the researcher is trying to prove　帰無仮説は一般的に研究者が証明しようとしているという仮説である。

The Hypothesis Testing Process 仮説テストのプロセス

DCOVA

- Claim: The population mean age is 50.　母集団の平均年齢は50才である。
  - H_0: $\mu = 50$,　　　H_1: $\mu \neq 50$
- Sample the population and find sample mean.



The Hypothesis Testing Process

DCOVA

(continued)

- Suppose the sample mean age was $\bar{X} = 20$.
  サンプルの平均年齢が20と仮説する。
- This is significantly lower than the claimed mean population age of 50.　サンプルの平均年齢は母集団の平均年齢とかなり差のある。
- If the null hypothesis were true, the probability of getting such a different sample mean would be very small, so you reject the null hypothesis.　帰無仮説が成り立つ確率が小さいので、拒否する。
- In other words, getting a sample mean of 20 is so unlikely if the population mean was 50, you conclude that the population mean must not be 50.　母集団の平均が50であれば、あるサンプルの平均が20である可能性が低い。

The Hypothesis Testing Process

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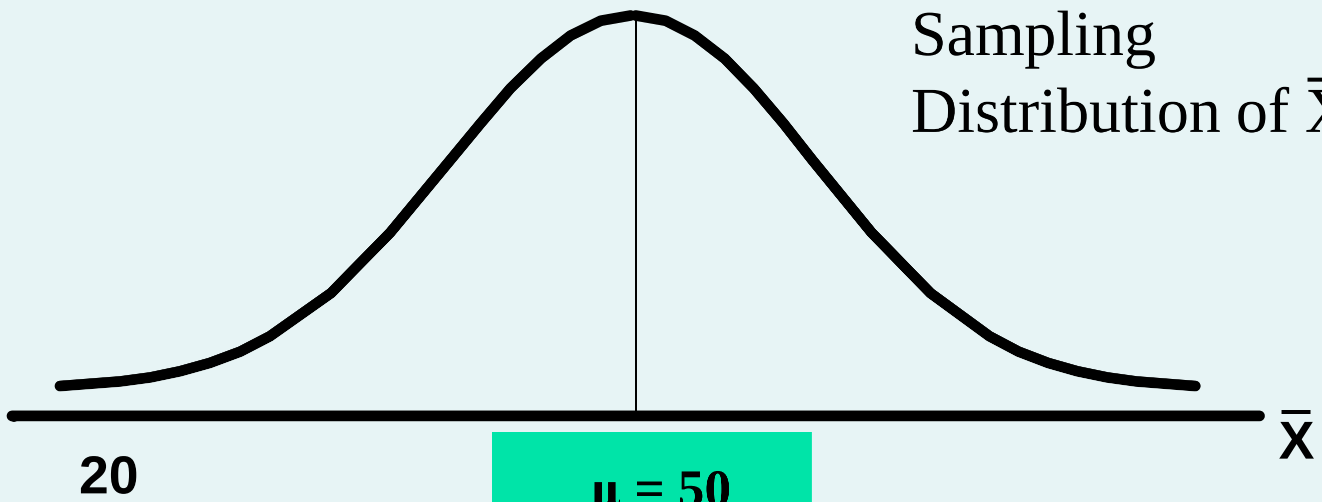
(continued)

Sampling Distribution of $\bar{X}$



μ = 50
If H_0 is true

If it is unlikely that you would get a sample mean of this value ...

... When in fact this were the population mean…

... then you reject the null hypothesis that μ = 50.

The Test Statistic and Critical Values：検定統計量と臨界値

DCOVA

- If the sample mean is close to the stated population mean, the null hypothesis is not rejected.

  標本平均が述べた母集団の平均に近い場合、帰無仮説は棄却されない。
- If the sample mean is far from the stated population mean, the null hypothesis is rejected.

  サンプルの平均は母集団の平均から遥かに離れる場合、帰無仮説は棄却される。
- How far is “far enough” to reject H_0?

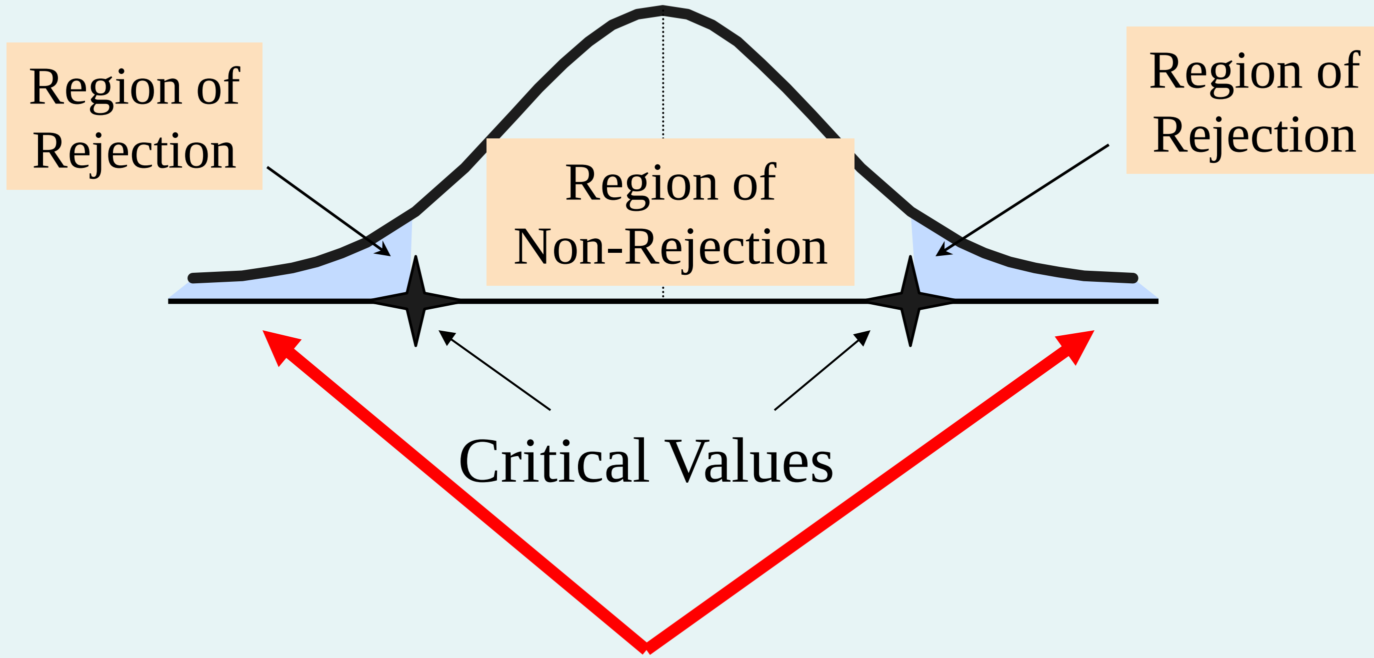
  どのぐらい離れるとき、帰無仮説は棄却されるのか。
- The critical value of a test statistic creates a “line in the sand” for decision making -- it answers the question of how far is far enough.

  検定統計量の臨界値は、意思決定のための「砂の中の行」を作成する - それはどこまでの質問に答える。

The Test Statistic and Critical Values 臨界值

DCOVA

Sampling Distribution of the test statistic



"Too Far Away" From Mean of Sampling Distribution

Possible Errors in Hypothesis Test Decision Making

DCOVA

- **Type I Error**　：第１種の誤り
  - Reject a true null hypothesis　真の帰無仮説が棄却された
  - Considered a serious type of error
  - The probability of a Type I Error is **α**
    - Called level of significance of the test
    - Set by researcher in advance
- **Type II Error：第２種の誤り**
  - Failure to reject a false null hypothesis
    偽の帰無仮説を棄却に失敗した
  - The probability of a Type II Error is **β**

Possible Errors in Hypothesis Test Decision Making
仮説検定の意思決定における可能なエラー

DCOVA

(continued)

Possible Hypothesis Test Outcomes		
	Actual Situation	
Decision	H_0 True	H_0 False
Do Not Reject H_0	No Error Probability $1 - \alpha$	Type II Error Probability β
Reject H_0	Type I Error Probability α	No Error Probability $1 - \beta$

Possible Errors in Hypothesis Test Decision Making

DCOVA

(continued)

- The confidence coefficient 信頼係数 $(1-\alpha)$ is the probability of not rejecting H_0 when it is true.
- The confidence level 信頼水準 of a hypothesis test is $(1-\alpha)*100\%$.
- The power of a statistical test $(1-\beta)$ is the probability of rejecting H_0 when it is false.

Type I & II Error Relationship

DCOVA

- Type I and Type II errors cannot happen at the same time　第一種の誤りと第二種の誤りが同時に発生することがない
  - A Type I error can only occur if H_0 is true
  - A Type II error can only occur if H_0 is false

If Type I error probability (α) ↑ , then

Type II error probability (β) ↓

Factors Affecting Type II Error
タイプIIのエラーに影響する要因

DCOVA

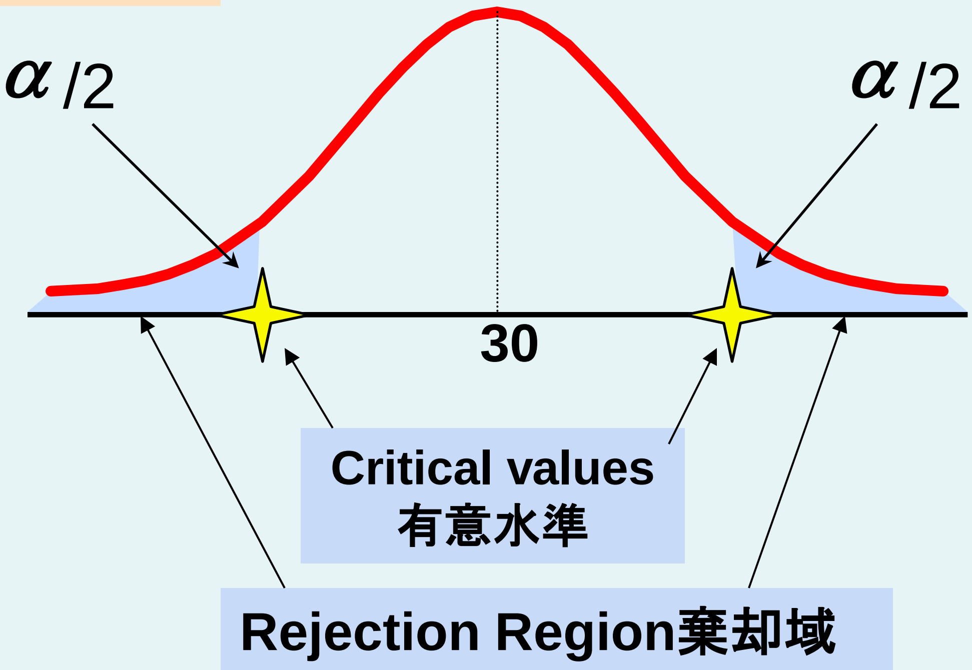
- All else equal,
  - $\beta \uparrow$ when the difference between hypothesized parameter and its true value $\downarrow$
  - $\beta \uparrow$ when $\alpha \downarrow$
  - $\beta \uparrow$ when $\sigma \uparrow$
  - $\beta \uparrow$ when $n \downarrow$

Level of Significance and the Rejection Region 有意水準と棄却域

DCOVA

H_0: μ = 30
H_1: μ ≠ 30

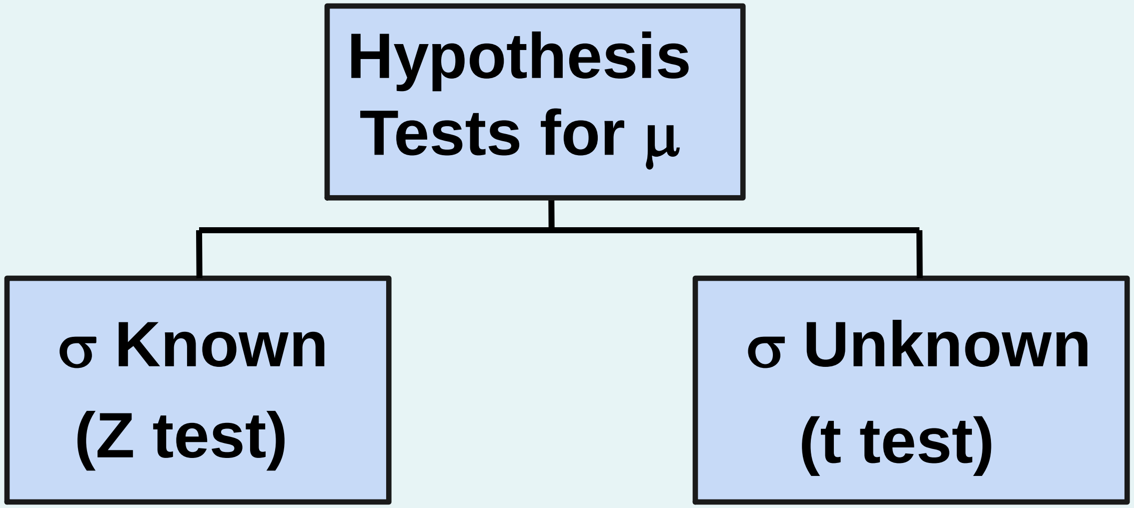
Level of significance = α



This is a two-tail test because there is a rejection region in both tails

Hypothesis Tests for the Mean

DCOVA



Z Test of Hypothesis for the Mean (σ Known)

DCOVA

- Convert sample statistic ($\bar{X}$) to a Z_{STAT} test statistic

Hypothesis Tests for μ

σ Known (Z test)

σ Unknown (t test)

The test statistic is:

$$Z_{STAT} = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}}$$

Critical Value 臨界値 Approach to Testing テストへのアプローチ

DCOVA

- For a two-tail test（両側検定）for the mean, σ known:
- Convert sample statistic ($\bar{X}$) to test statistic (Z_{STAT})

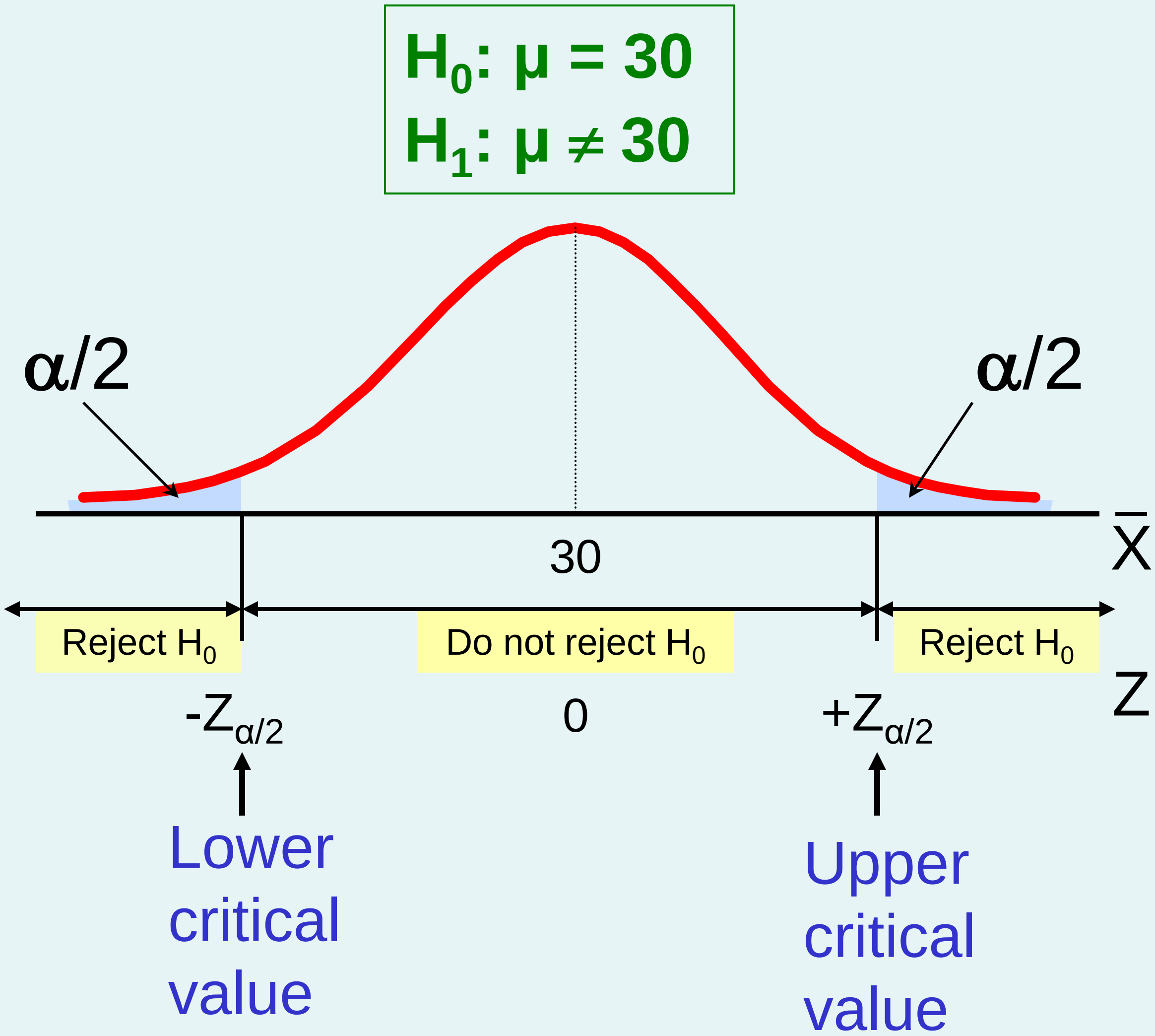
  サンプルの統計量 $\bar{X}$ をテストの統計量(Z_{STAT})に変換する
- Determine the critical Z values for a specified level of significance α from a table or computer

  表或いはコンピューターを調べ、確定した有意水準の下、z 臨界値を決定する。
- Decision Rule: If the test statistic falls in the rejection region, reject H_0 ; otherwise do not reject H_0
- 検定統計量が棄却域に入る場合、H_0を棄却する。

Two-Tail Tests：両側検定

DCOVA

- There are two cutoff values (critical values), defining the regions of rejection



6 Steps in Hypothesis Testing

DCOVA

1. State the null hypothesis, H_0 and the alternative hypothesis, H_1
2. Choose the level of significance, α, and the sample size, n
3. Determine the appropriate test statistic and sampling distribution
4. Determine the critical values that divide the rejection and nonrejection regions

１、帰無仮説を立てる、その対立仮説を述べる

２、有意水準を決め、サンプルのサイズを確定する

３、適切な検定統計量と標本分布を選ぶ

４、臨界値、棄却域を確定する

6 Steps in Hypothesis Testing

DCOVA

(continued)

5. Collect data and compute the value of the test statistic
6. Make the statistical decision and state the managerial conclusion. If the test statistic falls into the nonrejection region, do not reject the null hypothesis H_0. If the test statistic falls into the rejection region, reject the null hypothesis. Express the managerial conclusion in the context of the problem

７、データを収集し、検定統計量の値を計算する

８、結論をおとす

Hypothesis Testing Example
仮説検定の例

DCOVA

Test the claim that the true mean diameter of a manufactured bolt is 30mm. (Assume σ = 0.8)

1. State the appropriate null and alternative hypotheses　適切な帰無仮説と対立仮説を立てる
   - H_0: $\mu = 30$　　H_1: $\mu \neq 30$　(This is a two-tail test)
2. Specify the desired level of significance and the sample size　有意水準と標本空間を決める
   - Suppose that $\alpha = 0.05$ and $n = 100$ are chosen for this test

Hypothesis Testing Example

DCOVA

(continued)

3. Determine the appropriate technique　統計量と分布を選ぶ
   - σ is assumed known so this is a Z test.
4. Determine the critical values　臨界値を決める
   - For α = 0.05 the critical Z values are ±1.96
5. Collect the data and compute the test statistic
   - Suppose the sample results are

     n = 100,　$\bar{X}$ = 29.84　(σ = 0.8 is assumed known)

So the test statistic is:

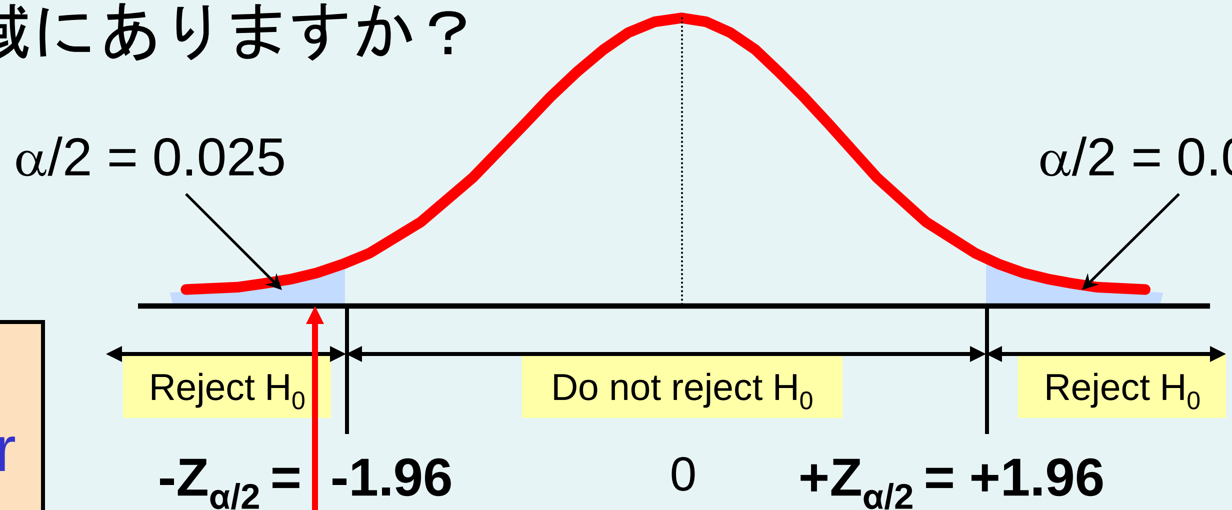
$$Z_{STAT} = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}} = \frac{29.84 - 30}{\frac{0.8}{\sqrt{100}}} = \frac{-.16}{0.08} = -2.0$$

Hypothesis Testing Example

DCOVA

(continued)

- 6. Is the test statistic in the rejection region? 統計量は棄却域にありますか？



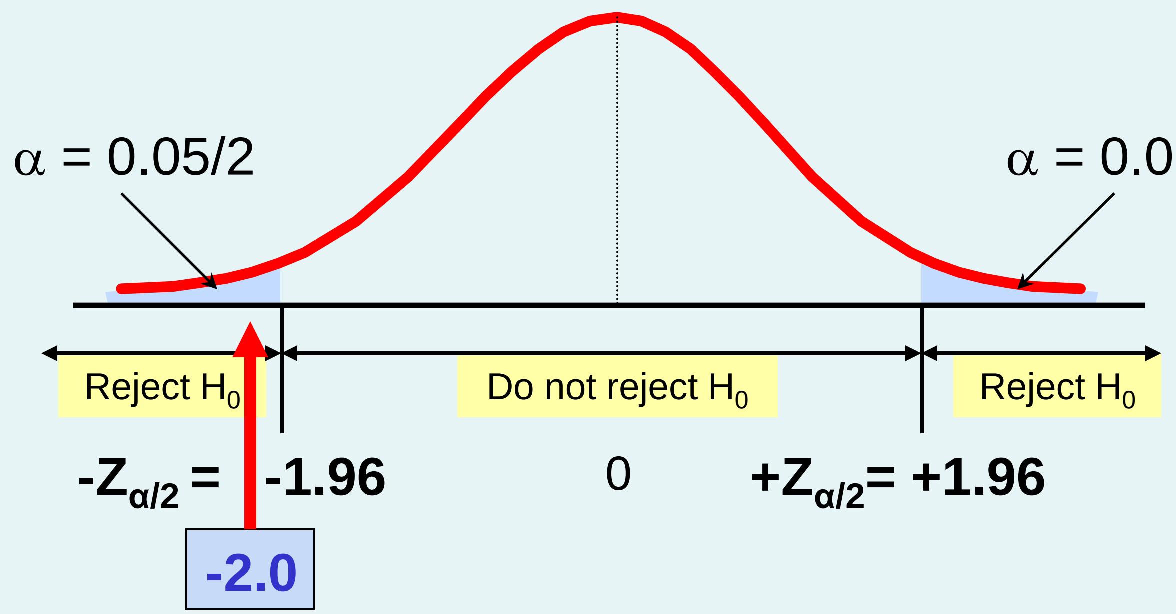
Reject H_0 if Z_{STAT} < -1.96 or Z_{STAT} > 1.96; otherwise do not reject H_0

Here, Z_{STAT} = -2.0 < -1.96, so the test statistic is in the rejection region

Hypothesis Testing Example DCOVA

(continued)

6 (continued). Reach a decision and interpret the result



Since Z_{STAT} = -2.0 < -1.96, reject the null hypothesis and conclude there is sufficient evidence that the mean diameter of a manufactured bolt is not equal to 30

p-Value Approach to Testing P値

DCOVA

- p-value: Probability of obtaining a test statistic equal to or more extreme than the observed sample value given H_0 is true

  帰無仮説の下で実際にデータから計算された統計量よりも極端な統計量が観測される確率を、p値(p-value)という。

  - The p-value is also called the observed level of significance
  - H_0 can be rejected if the p-value is less than α

p-Value Approach to Testing: Interpreting the p-value

DCOVA

- Compare the p-value with α
  - If p-value $< \alpha$, reject H_0
  - If p-value $\geq \alpha$, do not reject H_0
- Remember
  - If the p-value is low then H_0 must go

The 5 Step p-value approach to Hypothesis Testing

DCOVA

1． State the null hypothesis, H_0 and the alternative hypothesis, H_1
帰無仮説とその対立仮説を立てる。
2． Choose the level of significance, α, and the sample size, n　有意水準と標本空間を決める。
3． Determine the appropriate test statistic and sampling distribution
適切な統計量と標本分布を選ぶ。
4． Collect data and compute the value of the test statistic and the p-value　テータを収集し、統計量とｐ値を計算する。
5． Make the statistical decision and state the managerial conclusion. If the p-value is < α then reject H_0, otherwise do not reject H_0. State the managerial conclusion in the context of the problem
結論を出す

p-value Hypothesis Testing Example

DCOVA

Test the claim that the true mean diameter of a manufactured bolt is 30mm. (Assume $\sigma = 0.8$)

1. State the appropriate null and alternative hypotheses
   - H_0: $\mu = 30$ H_1: $\mu \neq 30$ (This is a two-tail test)
2. Specify the desired level of significance and the sample size
   - Suppose that $\alpha = 0.05$ and $n = 100$ are chosen for this test

p-value Hypothesis Testing Example

DCOVA

(continued)

3. Determine the appropriate technique
   - σ is assumed known so this is a Z test.
4. Collect the data, compute the test statistic and the p-value
   - Suppose the sample results are

     n = 100, $\bar{X}$ = 29.84 (σ = 0.8 is assumed known)

So the test statistic is:

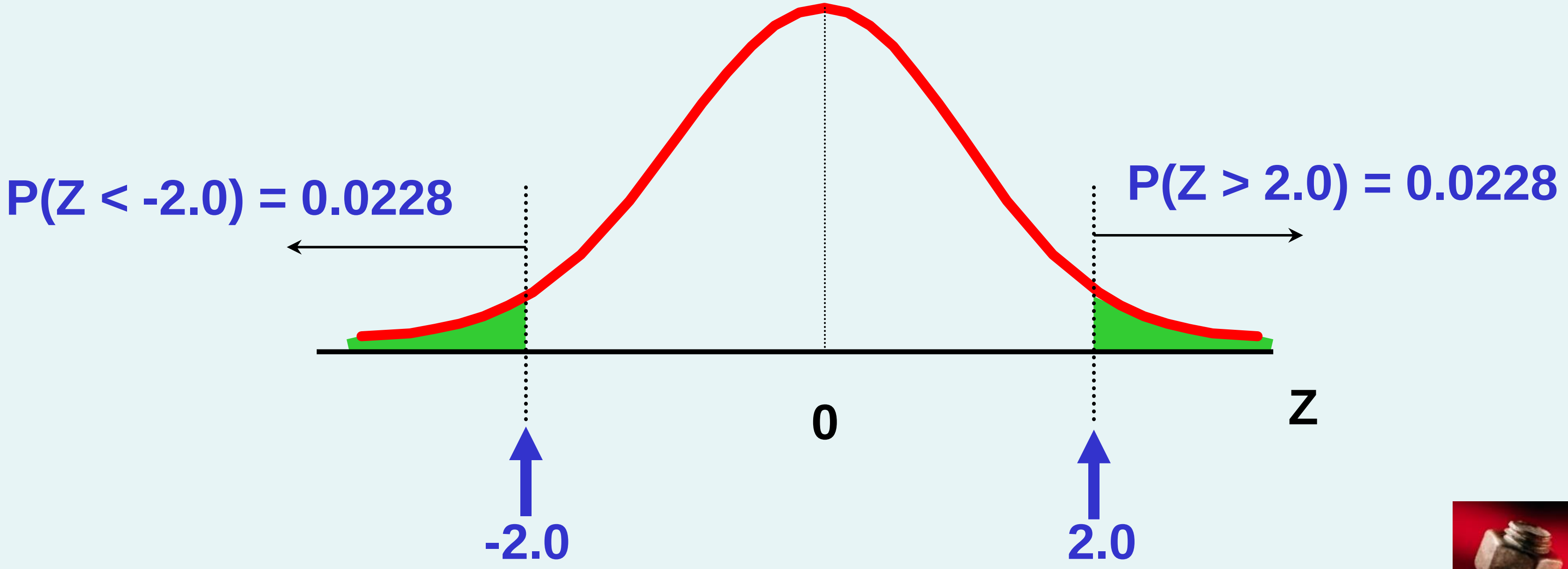
$$Z_{STAT} = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}} = \frac{29.84 - 30}{\frac{0.8}{\sqrt{100}}} = \frac{-.16}{0.08} = -2.0$$

p-Value Hypothesis Testing Example: Calculating the p-value

DCOVA

4. (continued) Calculate the p-value.

- How likely is it to get a Z_{STAT} of -2 (or something farther from the mean (0), in either direction) if H_0 is true?



p-value = 0.0228 + 0.0228 = 0.0456

p-value Hypothesis Testing Example

DCOVA

(continued)

- 5. Is the p-value < α?
  - Since p-value = 0.0456 < α = 0.05 Reject H_0
  - State the managerial conclusion in the context of the situation.
  - There is sufficient evidence to conclude the average diameter of a manufactured bolt is not equal to 30mm.

Connection Between Two-Tail Tests and Confidence Intervals　両側検定と信頼空間

DCOVA

- For $\bar{X}$ = 29.84, σ = 0.8 and n = 100, the 95% confidence interval is:

$$\boxed{29.84 - (1.96)\frac{0.8}{\sqrt{100}} \quad \text{to} \quad 29.84 + (1.96)\frac{0.8}{\sqrt{100}}}$$

$$\boxed{29.6832 \leq \mu \leq 29.9968}$$

- Since this interval does not contain the hypothesized mean (30), we reject the null hypothesis at $\alpha = 0.05$
- 仮説した平均は信頼空間に含まれていないため、帰無仮説を棄却する。

Do You Ever Truly Know σ?

DCOVA

- Probably not!
- In virtually all real world business situations, σ is not known.
- If there is a situation where σ is known then μ is also known (since to calculate σ you need to know μ.)
- If you truly know μ there would be no need to gather a sample to estimate it.

Do You Ever Truly Know σ?

- Probably not!
- In virtually all real world business situations, σ is not known.事実上すべてのビジネス状況において、σは知られていない。
- If there is a situation where σ is known, then μ is also known (since to calculate σ you need to know μ.)　σが既知の場合、μも知られている。
- If you truly know μ there would be no need to gather a sample to estimate it.　本当にμを知っていれば、それを推定するためのサンプルを収集する必要はないであろう。

t Test of Hypothesis for the Mean (σ Unknown)

DCOV<u>A</u>

- Convert sample statistic ($\bar{X}$) to a t_{STAT} test statistic

Hypothesis Tests for μ

σ Known (Z test)

σ Unknown (t test)

The test statistic is:

$$t_{STAT} = \frac{\bar{X} - \mu}{\frac{S}{\sqrt{n}}}$$

Example: Two-Tail Test (σ Unknown)

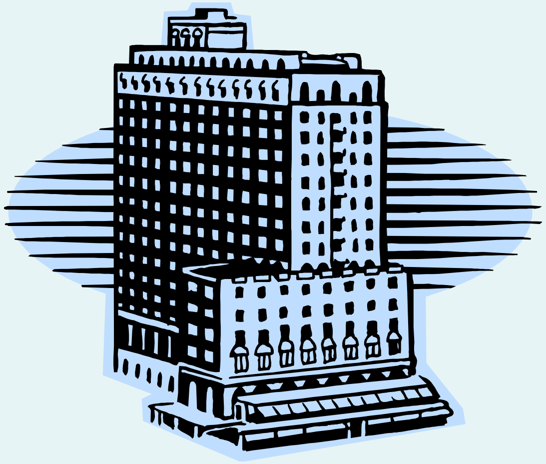
DCOVA

The average cost of a hotel room in New York is said to be $168 per night. To determine if this is true, a random sample of 25 hotels is taken and resulted in an $\bar{X}$ of $172.50 and an S of $15.40. Test the appropriate hypotheses at α = 0.05.

ニューヨークにあるホテルの平均値段は一泊168ドルと言われている、実の状況を検証しましょう。

25軒のホテルをサンプルとして、無作為的に抽出する。平均は172.50、標準偏差は15.40。有意水準は0.05.

(Assume the population distribution is normal)



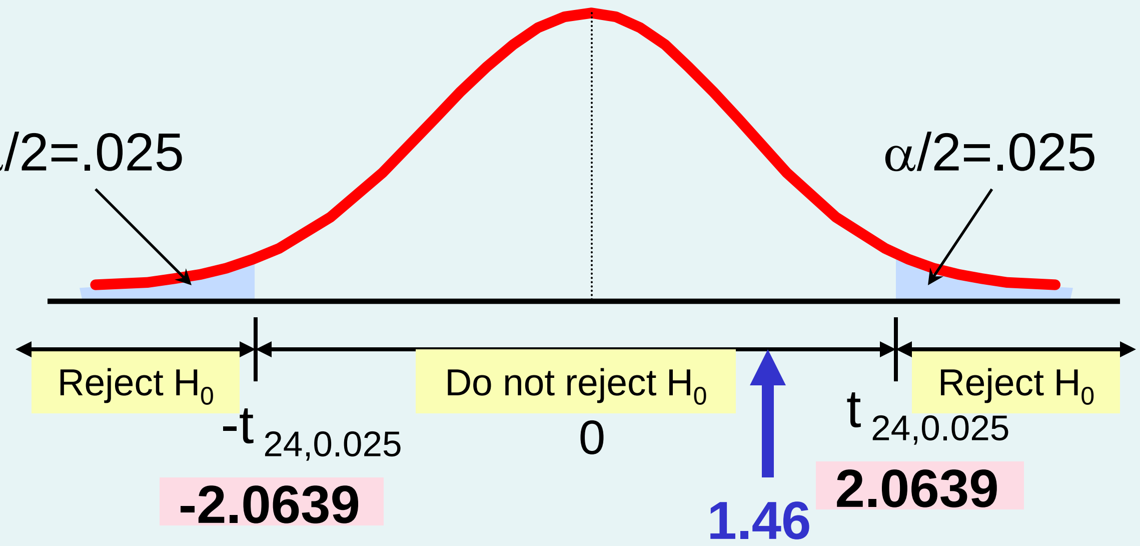
H_0: ________

H_1: ________

Example Solution: Two-Tail t Test

DCOVA

H_0: $\mu = 168$
H_1: $\mu \neq 168$



- $\alpha = 0.05$
- $n = 25$, $df = 25-1=24$
- σ is unknown, so use a **t statistic**
- Critical Value:

$\pm t_{24,0.025} = \pm\ 2.0639$

$$t_{STAT} = \frac{\bar{X} - \mu}{\frac{S}{\sqrt{n}}} = \frac{172.50 - 168}{\frac{15.40}{\sqrt{25}}} = 1.46$$

Do not reject H_0: insufficient evidence that true mean cost is different from \$168

Example Two-Tail t Test Using A p-value from Excel

DCOVA

- Since this is a t-test we cannot calculate the p-value without some calculation aid.
- The Excel output below does this:

t Test for the Hypothesis of the Mean

Data		
Null Hypothesis μ=	**$**	**168.00**
Level of Significance		**0.05**
Sample Size		**25**
Sample Mean	**$**	**172.50**
Sample Standard Deviation	**$**	**15.40**

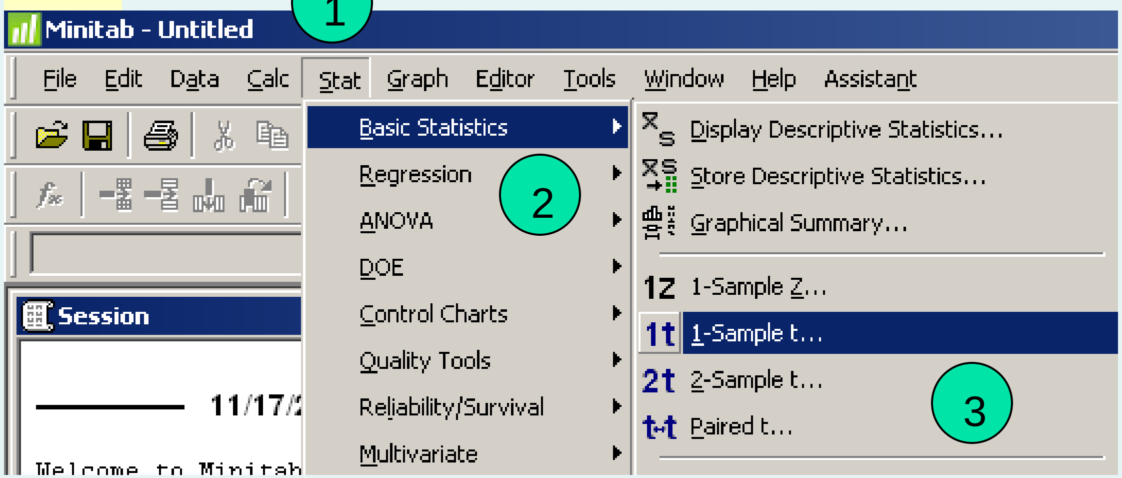
Intermediate Calculations			
Standard Error of the Mean	$	3.08	=B8/SQRT(B6)
Degrees of Freedom		24	=B6-1
t test statistic		**1.46**	=(B7-B4)/B11

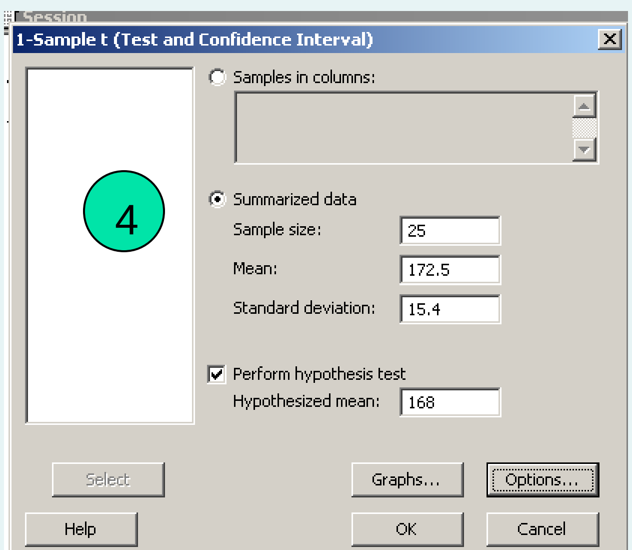
Two-Tail Test		
Lower Critical Value	-2.0639	=-TINV(B5,B12)
Upper Critical Value	2.0639	=TINV(B5,B12)
p-value	0.157	=TDIST(ABS(B13),B12,2)
Do Not Reject Null Hypothesis		=IF(B18<B5, "Reject null hypothesis", "Do not reject null hypothesis")

p-value > α
So do not reject H_0

Example Two-Tail t Test Using A p-value from Minitab

DCOVA





p-value > α
So do not reject H_0

One-Sample T

Test of mu = 168 vs not = 168

N	Mean	StDev	SE Mean	95% CI	T	P
25	172.50	15.40	3.08	(166.14, 178.86)	1.46	0.157

Connection of Two-Tail Tests to Confidence Intervals

DCOVA

- For $\bar{X} = 172.5$, $S = 15.40$ and $n = 25$, the 95% confidence interval for μ is:

$$\boxed{172.5 - (2.0639)\ 15.4/\sqrt{25}} \quad \text{to} \quad \boxed{172.5 + (2.0639)\ 15.4/\sqrt{25}}$$

$$\boxed{166.14 \le \mu \le 178.86}$$

- Since this interval contains the hypothesized mean (168), we do not reject the null hypothesis at $\alpha = 0.05$

One-Tail Tests：片側検定

DCOVA

- In many cases, the alternative hypothesis focuses on a particular direction　多くの場合では、対立仮説は特定の方向に注目する。

H_0: μ ≥ 3
H_1: μ < 3

→ This is a lower-tail test since the alternative hypothesis is focused on the lower tail below the mean of 3

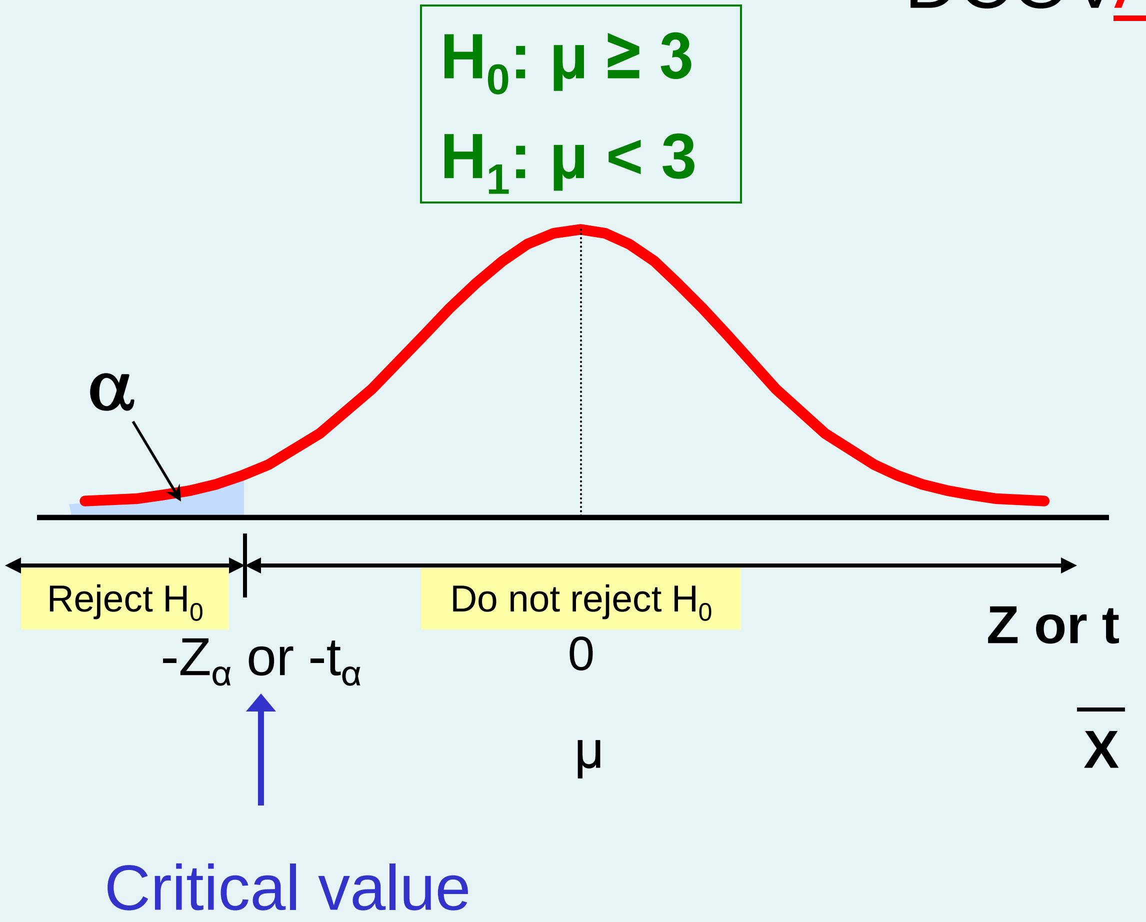
H_0: μ ≤ 3
H_1: μ > 3

→ This is an upper-tail test since the alternative hypothesis is focused on the upper tail above the mean of 3

Lower-Tail Tests：左片側

DCOVA

- There is only one critical value, since the rejection area is in only one tail



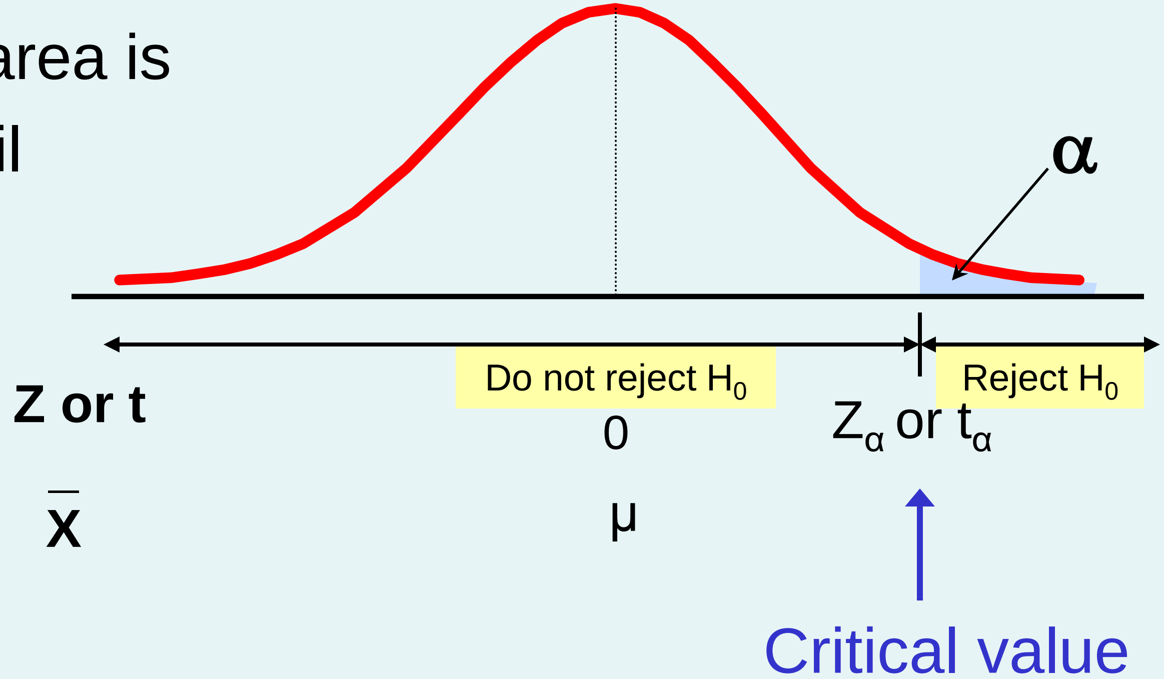
Upper-Tail Tests：右片側

DCOVA

- There is only one critical value, since the rejection area is in only one tail

H_0: $\mu \le 3$

H_1: $\mu > 3$

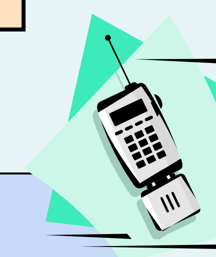


Example: Upper-Tail t Test for Mean (σ unknown)

DCOVA

A phone industry manager thinks that customer monthly cell phone bills have increased, and now average over \$52 per month. The company wishes to test this claim. (Assume a normal population)

ある通信業界のマネジャーはカスタマーの携帯電話の月間コストが増加して、52ドルに達したと思う。会社はこの観点を仮説検証しようと思っている。



Form hypothesis test:

H_0: $\mu \le 52$ the average is not over \$52 per month

H_1: $\mu > 52$ the average **is** greater than \$52 per month (i.e., sufficient evidence exists to support the manager's claim)

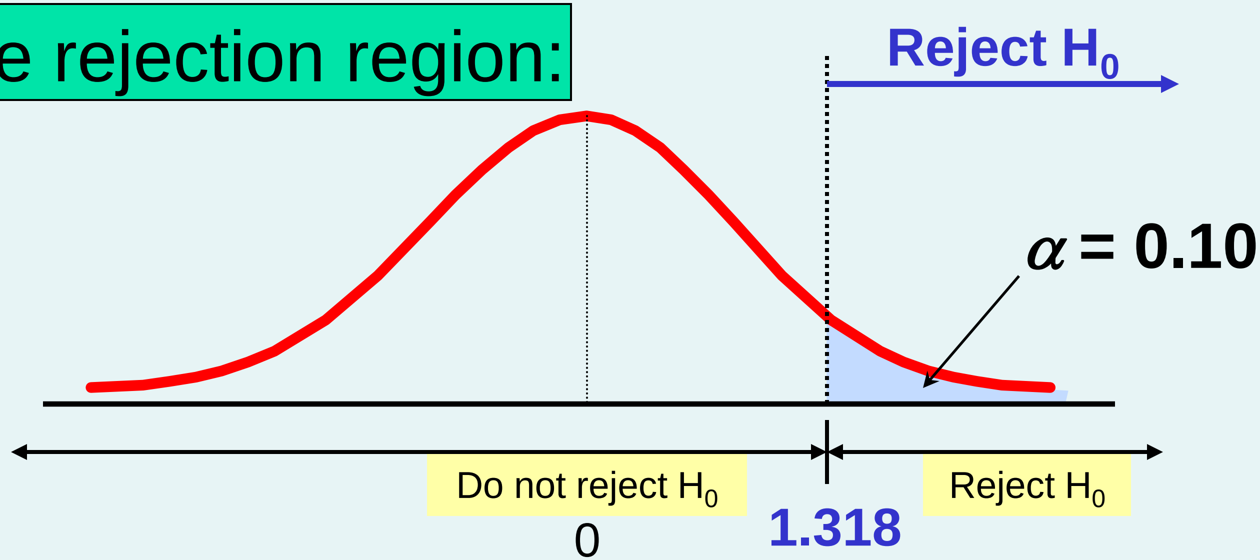
Example: Find Rejection Region

DCOVA

(continued)

- Suppose that α = 0.10 is chosen for this test and n = 25.

Find the rejection region:



Reject H_0 if $t_{STAT} > 1.318$

Example: Test Statistic

DCOVA

(continued)

Obtain sample and compute the test statistic

Suppose a sample is taken with the following results: $n = 25$, $\bar{X} = 53.1$, and $S = 10$

- Then the test statistic is:

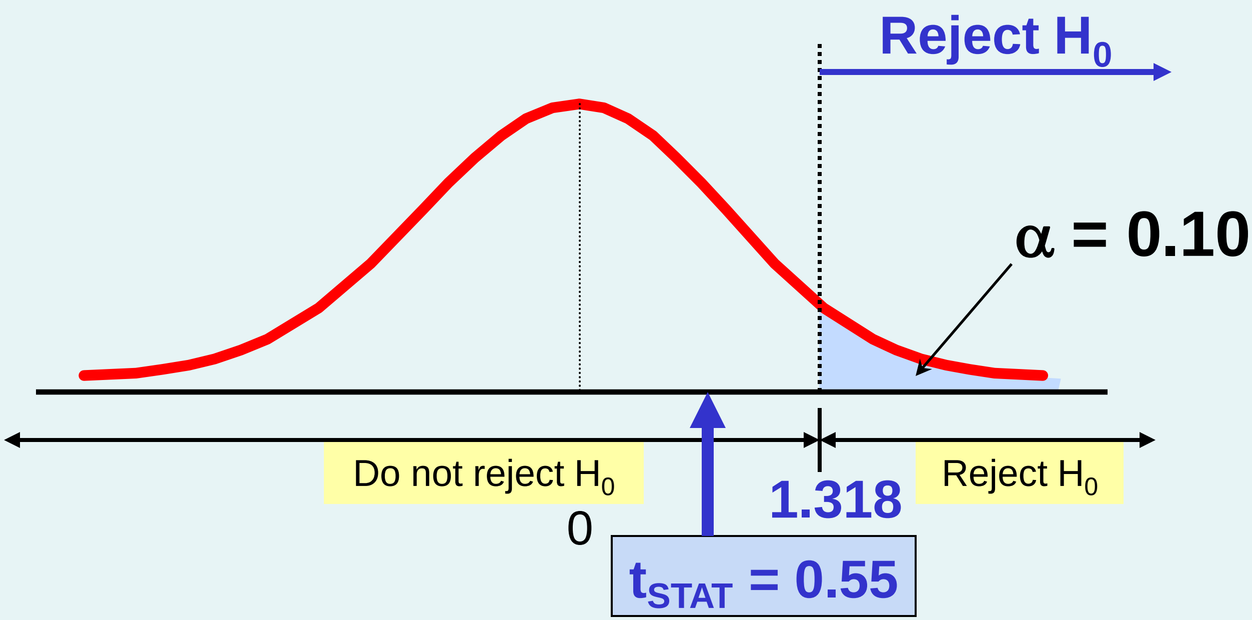
$$t_{STAT} = \frac{\bar{X} - \mu}{\frac{S}{\sqrt{n}}} = \frac{53.1 - 52}{\frac{10}{\sqrt{25}}} = 0.55$$

Example: Decision

DCOVA

(continued)

Reach a decision and interpret the result:



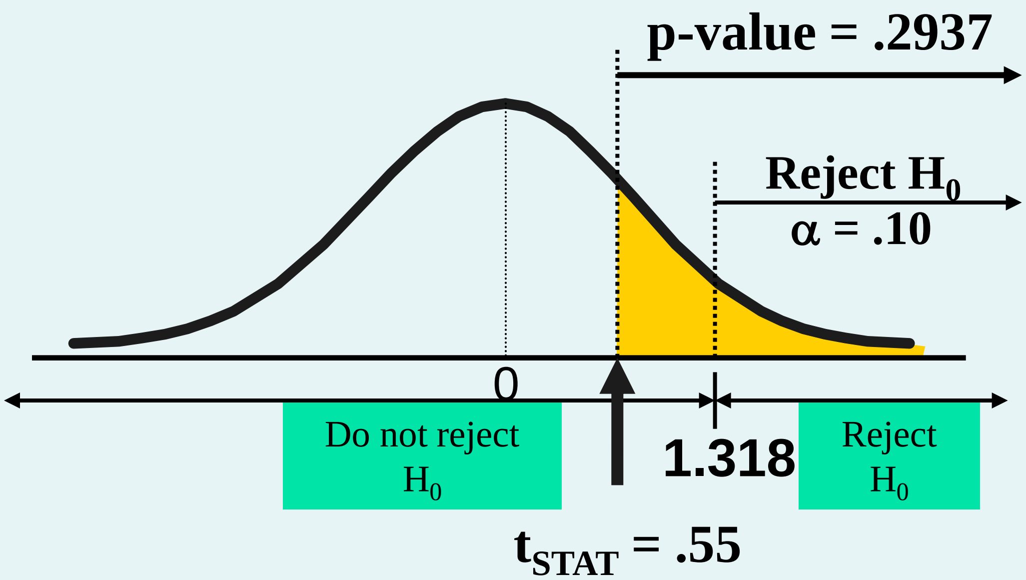
Do not reject H_0 since $t_{STAT} = 0.55 \le 1.318$

There is insufficient evidence that the mean bill is over \$52.

Example: Utilizing The p-value for The Test　P値の応用

DCOVA

- Calculate the p-value and compare to α (p-value below calculated using Excel spreadsheet on next page)



Do not reject H_0 since p-value = .2937 > α = .10

Excel Spreadsheet Calculating The p-value for The Upper Tail t Test

DCOVA

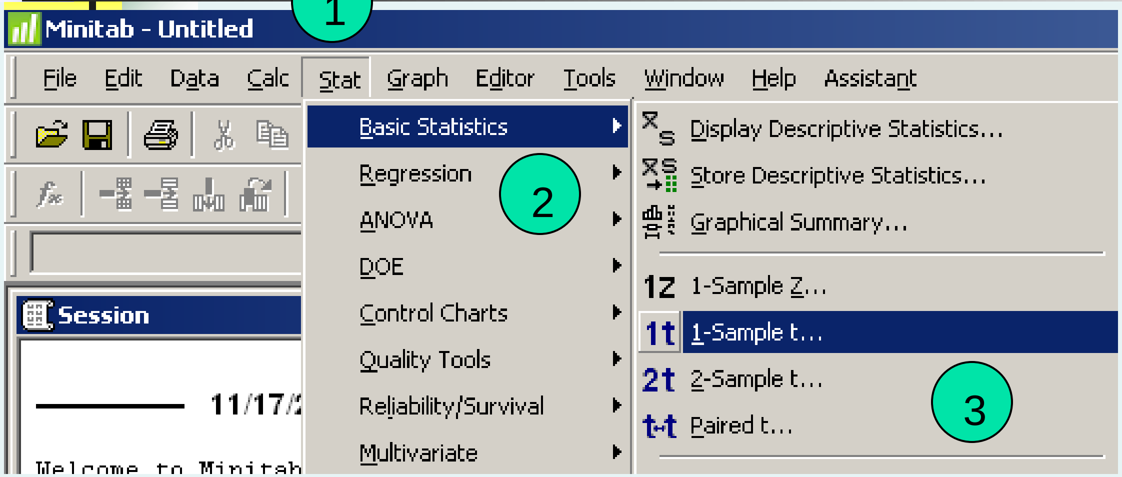
t Test for the Hypothesis of the Mean

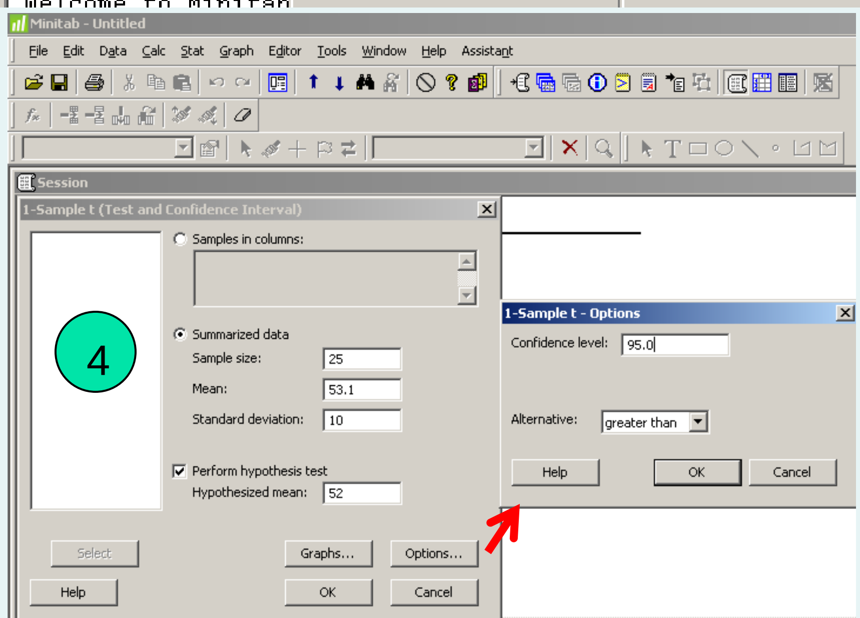
Data	
Null Hypothesis μ=	**52.00**
Level of Significance	**0.1**
Sample Size	**25**
Sample Mean	**53.10**
Sample Standard Deviation	**10.00**

Intermediate Calculations		
Standard Error of the Mean	2.00	=B8/SQRT(B6)
Degrees of Freedom	24	=B6-1
t test statistic	**0.55**	=(B7-B4)/B11
Upper Tail Test		
Upper Critical Value	1.318	=TINV(2*B5,B12)
p-value	0.2937	=TDIST(ABS(B13),B12,1)
Do Not Reject Null Hypothesis		=IF(B18<B5, "Reject null hypothesis", "Do not reject null hypothesis")

Using Minitab to calculate The p-value for The Upper Tail t Test

DCOVA





p-value > α
So do not reject H_0

One-Sample T

Test of mu = 52 vs > 52

N	Mean	StDev	SE Mean	95% Lower Bound	T	P
25	53.10	10.00	2.00	49.68	0.55	0.294

Hypothesis Tests for Proportions
割合の仮説検定

DCOVA

- Involves categorical variables　カテゴリ変数
- Two possible outcomes　二つの可能な結果
  - Possesses characteristic of interest
  - Does not possess characteristic of interest
- Fraction or proportion of the population in the category of interest is denoted by π

Proportions 割合

DCOVA

(continued)

- Sample proportion in the category of interest is denoted by p

$$p = \frac{X}{n} = \frac{\text{number in category of interest in sample}}{\text{sample size}}$$

- When both X and n – X are at least 5, p can be approximated by a normal distribution with mean and standard deviation
  - $$\mu_p = \pi$$ $$\sigma_p = \sqrt{\frac{\pi(1-\pi)}{n}}$$

Hypothesis Tests for Proportions
割合の仮説検定

DCOVA

- The sampling distribution of p is approximately normal, so the test statistic is a Z_{STAT} value:

$$Z_{STAT} = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}}$$

Hypothesis Tests for p

$X \geq 5$ and $n - X \geq 5$

$X < 5$ or $n - X < 5$

Not discussed in this chapter

Z Test for Proportion in Terms of Number in Category of Interest

DCOVA

- An equivalent form to the last slide, but in terms of the number in the category of interest, X:

$$Z_{STAT} = \frac{X - n\pi}{\sqrt{n\pi(1-\pi)}}$$

Hypothesis Tests for X

$X \geq 5$ and $n\text{-}X \geq 5$

$X < 5$ or $n\text{-}X < 5$

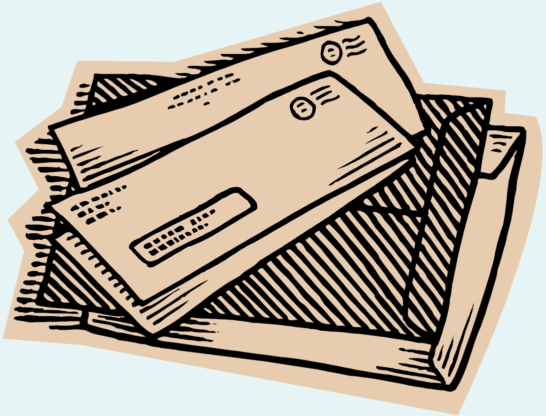
Not discussed in this chapter

Example: Z Test for Proportion

DCOVA

A marketing company claims that it receives responses from 8% of those surveyed. To test this claim, a random sample of 500 were surveyed with 25 responses. Test at the $\alpha = 0.05$ significance level.

マーケティング会社は、調査対象者の8%からの応答を受信することを主張している。この主張を検証するため、調査を行った。無作為的に500サンプルを抽出し、25個の応答を返した。有意水準は0.05である。



Check:

$X = 25$ ✓

$n-X = 475$

Z Test for Proportion: Solution

DCOVA

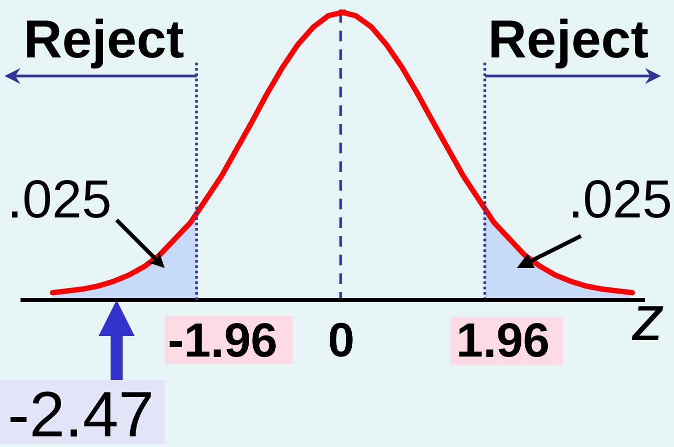
H_0: $\pi = 0.08$

H_1: $\pi \neq 0.08$

$\alpha = 0.05$

$n = 500$, $p = 0.05$

Critical Values: ± 1.96



Test Statistic:

$$Z_{STAT} = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}} = \frac{.05 - .08}{\sqrt{\frac{.08(1-.08)}{500}}} = -2.47$$

Decision:

Reject H_0 at $\alpha = 0.05$

Conclusion:

There is sufficient evidence to reject the company's claim of 8% response rate.

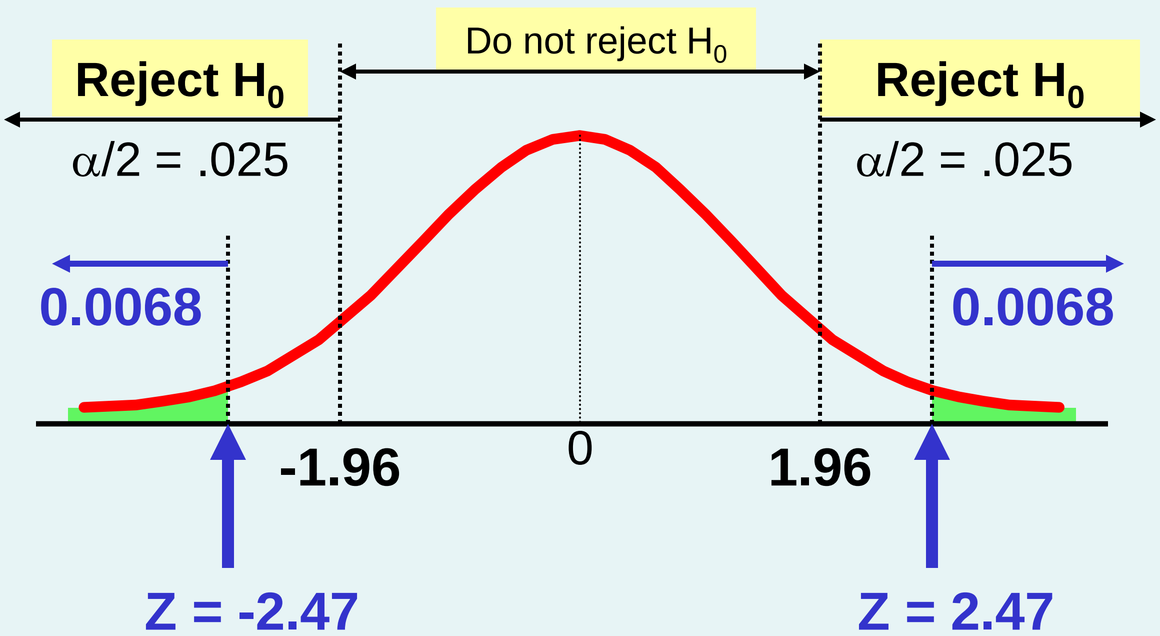
p-Value Solution

DCOVA

(continued)

Calculate the p-value and compare to α

(For a two-tail test the p-value is always two-tail)



p-value = 0.0136:

$$P(Z \le -2.47) + P(Z \ge 2.47)$$

$$= 2(0.0068) = 0.0136$$

Reject H_0 since p-value = 0.0136 < α = 0.05

Potential Pitfalls and Ethical Considerations 潜在的な落とし穴と倫理的考慮事項

- Use randomly collected data to reduce selection biases　選択バイアスを低減するために、ランダムに収集したデータを使用する
- Do not use human subjects without informed consent　インフォームドコンセントなしにヒトを対象とする使用しないでください
- Choose the level of significance, *α*, and the type of test (one-tail or two-tail) before data collection　データ収集の前に有意水準α、およびテスト（片側検定或いは両側検定）の種類を選択してください
- Do not employ “data snooping” to choose between one-tail and two-tail test, or to determine the level of significance　有意水準を選択し、両側検定或いは片側検定を選択し、有意水準を決定する。
- Do not practice “data cleansing” to hide observations that do not support a stated hypothesis　述べた仮説をサポートしていないの観測を非表示にしないこと。
- Report all pertinent findings including both statistical significance and practical importance統計的有意性と実用的な重要性の両方を含む調査結果を報告する

Chapter Summary

- Addressed hypothesis testing methodology

  仮説検定の方法論

- Performed Z Test for the mean (σ known)
- Discussed critical value and p–value approaches to hypothesis testing　臨界値とp値のアプローチ
- Performed one-tail and two-tail tests　両側検定と片側検定

Chapter Summary

(continued)

- Performed t test for the mean (σ unknown)
- Performed Z test for the proportion
- Discussed pitfalls and ethical issues