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Tutorials Software Tutorials Excel Google Sheets MongoDB Python R SAS SPSS Stata TI-84 All The Central Limit Theorem (CLT) stands as a cornerstone in the world of statistics, asserting that the distribution of sample means approximates a normal distribution, regardless of the populations original distribution. This holds true as long as the sample size is sufficiently large and the population has a finite level of variance. Through the versatility of Excel, we can visually and practically understand this profound concept. Step 1: Generating Random DataBegin by creating a dataset that represents a population with a non-normal distribution. Excel offers functions like RAND(), RANDBETWEEN(), and BINOM.DIST() to generate various types of distributions. For instance, using =RAND() in cells A1 to A1000 will generate a uniform distribution of random numbers between 0 and 1.Step 2: Sampling from the PopulationSampling is a crucial step in applying the CLT. Randomly select samples from the population data. Typically, a sample size greater than 30 is considered adequate. For example, draw 30 random numbers to form a sample and repeat this to create multiple samples.Step 3: Calculating Sample MeansFor each sample, calculate the mean using Excels AVERAGE() function. If your first sample occupies B1 to B30, the mean would be calculated with =AVERAGE(B1:B30).Store these means as they are central to demonstrating the CLT.Step 4: Plotting the Distribution of Sample MeansWith a substantial number of sample means, their distribution can be plotted. Excels histogram tool under the Insert tab is ideal for this. As per the CLT, this distribution should resemble a normal curve, which is a powerful illustration of the theorem.See also How to Calculate Mean in ExcelObservations and ConclusionsSeveral key observations can be drawn from this exercise:Shape of Distribution: The distribution of sample means will increasingly resemble a normal distribution as the number of samples grows.Mean of Sample Means: This will approximate the populations true mean, showcasing the accuracy of the CLT.Standard Error: The standard deviation of the sample means (standard error) will be the populations standard deviation divided by the square root of the sample size, validating the theorems predictive power.Excel not only serves as a powerful tool for statistical analysis but also becomes a medium through which the abstract becomes tangible. The CLTs demonstration in Excel is more than a mere academic exercise; it provides practical insights into the nature of sampling and the predictability of data in the real world. As such, Excel proves to be an invaluable ally for students and professionals alike in the realm of statistics. The central limit theorem states that the sampling distribution of a sample mean is approximately normal if the sample size is large enough, even if the population distribution is not normal.The central limit theorem also states that the sampling distribution will have the following properties:1. The mean of the sampling distribution will be equal to the mean of the population distribution:x = 2.The standard deviation of the sampling distribution will be equal to the standard deviation of the population divided by the sample size:s = / nIn this tutorial, we explain how to apply the central limit theorem in Excel to a given distribution.Applying the Central Limit Theorem in ExcelSuppose we have a distribution with a mean of8and a standard deviation of4. We can use the following formulas in Excel to find both the mean and the standard deviation of the sampling distribution with a sample size of15:The mean of the sampling distribution is simply equal to the mean of the population distribution, which is8.The standard deviation of the sampling distribution is equal to the population standard deviation divided by the sample size, which is: 4 /15 =1.0328.We can also use the central limit theorem to answer questions about probabilities. For example, if a given population has a mean of 8 and a standard deviation of 4, what is the probability that a given sample of size 15has a mean less than or equal to7?To answer this question, we can use theNORM.DIST()function in Excel, which uses the following syntax:NORM.DIST(x, mean, standard_dev, cumulative)where:x:the sample mean youd like to testmean: expectedmean of sampling distributionstandard_dev:expectedstandard deviation of sampling distributioncumulative:TRUE returns the value of the normal CDF; FALSE returns the value of the normal PDF. In our case, we will always use TRUE.This function will return the probability that the sample mean is less than or equal to a certain value.Here is the formula we would use in this example:This tells us that for a population with a mean of8and a standard deviation of4, the probability that a given sample of size 15has a mean less than or equal to7is0.1665.We can also find the probability that a given sample size has a meangreaterthan a certain number by simply using the formula 1 NORM.DIST().For example, the following formula shows how to find the probability that a given sample size of 15 has a meangreater than7:Lastly, we can find the probability that a given sample size will have a meanbetweentwo numbers by using the formulaNORM.DIST(larger number) NORM.DIST(smaller number).For example, the following formula shows how to find the probability that a given sample size of 15 has a mean between 7 and 9:Additional ResourcesCentral Limit Theorem CalculatorHow to Apply the Empirical Rule in ExcelHow to Make a Bell Curve in Excel How can financial brands set themselves apart through visual storytelling? Our experts explainhow.Learn MoreThe Motorsport Images Collections captures events from 1895 to todays most recentcoverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of EditorsPicks.Browse Editors' FavoritesHow can financial brands set themselves apart through visual storytelling? Our experts explainhow.Learn MoreThe Motorsport Images Collections captures events from 1895 to todays most recentcoverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of EditorsPicks.Browse Editors' FavoritesHow can financial brands set themselves apart through visual storytelling? Our experts explainhow.Learn MoreThe Motorsport Images Collections captures events from 1895 to todays most recentcoverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of EditorsPicks.Browse Editors' Favorites Share copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Central Limit Theorem (CLT) states that if we take a sufficiently large sample size from a population, the mean of all samples will be approximately equal to the mean of the population. It pretty much means that we dont have to consider the whole population, a sufficiently large sample will be enough. The sample mean will allow us to estimate the whole population.The CLT also states that, regardless of the distribution of the random variables in the population, sample means are normally distributed. Except for Cauchy distribution, because the population must have a finite variance.Also, the CLT applies only to the iid variables.sample meanAnother way to consider the CLT is that, as n goes to infinite the distribution of the sample sum becomes normal.To generate uniformly distributed random numbers rand command can be used and to generate integer values, which is used in discrete random variables, randi command can be used. Another way to generate a discrete random variable is the ceil command. The ceil command is used with the rand command. For example, to create 100 uniformly distributed discrete numbers the following statement can be used.X=ceil(n*rand(1,100));The result for uniform rv2. Exponentially Distributed Random VariablesThe inverse transform formulaExponential random variables can be obtained using the inverse transform method, which converts the uniform random variable into the exponential random variable.The resultsSources: the free encyclopedia that anyone can edit.117,937 active editors 7,001,149 articles in EnglishThe English-language Wikipedia thanks its contributors for creating more than seven million articles! Learn how you can take part in the encyclopedia's continued improvement.GL Mk.II transmitter vanRadar, Gun Laying, MarkI, or GL Mk.I for short, was an early World WarII radar system developed by the British Army to provide information for anti-aircraft artillery. There were two upgrades, GL/EF (elevation finder) and GL Mk.II (pictured), both improving the ability to determine a target's bearing and elevation. GL refers to the radar's ability to direct the guns onto a target, known as gun laying. The first GL sets were developed in 1936 using separate transmitters and receivers mounted on gun carriages. Several were captured in 1940, leading the Germans to believe falsely that British radar was much less advanced than theirs. The GL/EF attachment provided bearing and elevation measurements accurate to about a degree: this caused the number of rounds needed to destroy an aircraft to fall to 4,100, a tenfold improvement over early-war results. The Mk.II, which was able to directly guide the guns, lowered the rounds-per-kill to 2,750. About 410 Mk.Is and 1,679 Mk.IIs were produced. (Fullarticle...)Recently featured: Andrea NavageroNosy KombaMcDonnell Douglas Phantom in UK serviceArchiveBy emailMore featured articlesAboutLieke Klaver ahead in the women's 400 metres final... that a 400-metre race in 2025 (pictured) was won by Lieke Klaver, who pretended that an absent competitor was running in front of her?... that the land snail Drymaeus poecilus is notable for the striking variety of colors and patterns on its shell?... that a forensic investigation of Signalgate has determined how a journalist was included in a group chat about Operation Rough Rider?... that two of the players involved in the 2005 Vietnamese football match-fixing scandal did not accept payment because they felt ashamed?... that a rebellion against a peace treaty with the Yuan dynasty operated out of the Historic Site of Anti-Mongolian Struggle on Jeju Island?... that Nathan Frink fled the United States with enslaved children to settle in Canada, where he was elected as a Member of the Legislative Assembly and caught in a smuggling conspiracy?... that Seattle's women's ice hockey team has an expected rival, despite not even having played their first game?... that Cave Johnson Couts was separately acquitted for shooting his foreman, firing on funeral mourners, and whipping a native laborer to death?... that characters' scars in an episode of The Last of Us were made with a paste-based appliance and a food mixer?ArchiveStart a new articleNominate an articleNgg wa Thiong'oKenyan writer and activist Ngg wa Thiong'o (pictured) dies at the age of 87.In sumo, nosato Daiki is promoted to yokozuna.In association football, Liverpool win the Premier League title.In motor racing, lex Palou wins the Indianapolis 500.Ongoing: Gaza warM23 campaignRussian invasion of UkrainetimelineSudanese civil wartimelineRecent deaths: Phil RobertsonMary K. GaillardPeter DavidAlan YentobGerry ConnollySebastio SalgadoNominate an articleMay 30: Statehood Day in Croatia (1990)Johann Sebastian Bach1431 Hundred Years' War: After being convicted of heresy, Joan of Arc was burned at the stake in Rouen, France.1723 Johann Sebastian Bach (pictured) assumed the office of Thomaskantor in Leipzig, presenting the cantata Die Elenden sollen essen in St.Nicholas Church.1922 The Lincoln Memorial in Washington, D.C., featuring a sculpture of the sixteenth U.S. president Abraham Lincoln by Daniel Chester French, opened.1963 Buddhist crisis: A protest against pro-Catholic discrimination was held outside the National Assembly of South Vietnam in Saigon, the first open demonstration against President Ng nh Dim.2008 The Convention on Cluster Munitions, prohibiting the use, transfer, and stockpiling of cluster bombs, was adopted.Ma Xifan (d.947)Colin Blythe (b.1879)Norris Bradbury (b.1909)Wynonna Judd (b.1964)More anniversaries: May 29May 30May 31ArchiveBy emailList of days of the yearAboutSeventeen performing "Oh My!" in 2018South Korean boy band Seventeen made their debut on May 26, 2015, when they performed a showcase for their debut EP 17 Carat in front of a crowd of 1,000 people. Since then, the group have held 9 concert tours, 13 fan meetings, and have performed at a number of music festivals and awards shows. Their concert tours include the Right Here World Tour, which sold over one million tickets, and the Follow Tour, which was noted by Billboard as being the top grossing K-pop tour of 2023. In 2024, Seventeen made their first appearances at festivals in Europe, when they were the first South Korean act to perform at Glastonbury Festival's Pyramid Stage and as headliners for Lollapalooza Berlin. Seventeen's live performances are well regarded by fans and critics alike, and garnered them the award for Top K-pop Touring Artist at the 2024 Billboard Music Awards. (Fulllist...)Recently featured: Accolades received by Top Gun: MaverickNational preserve76th Primetime Emmy AwardsArchiveMore featured listsIgnace Tonen (1840 or 1841 15 March 1916), also known as Nias or by his Ojibwe name Maiagizis ('right/correct sun'), was a Teme-Augama Anishnabai chief, fur trader, and gold prospector in Upper Canada. He was a prominent employee of the Hudson's Bay Company. Tonen was the elected deputy chief before being the lead chief and later the life chief of his community. In his role as deputy, he negotiated with the Canadian federal government and the Ontario provincial government, advocating for his community to receive annual financial support from both. His attempts to secure land reserves for his community were thwarted by the Ontario premier Oliver Mowat. Tonen's prospecting triggered a 1906 gold rush and the creation of Kerr Addison Mines Ltd., although one of his claims was stolen from him by white Canadian prospectors. This photograph shows Tonen in 1909.Photograph credit: William John Winter; restored by Adam CuerdenRecently featured: Australian white ibisHell Gate BridgeAnemonoides blandaArchiveMore featured picturesCommunity portal The central hub for editors, with resources, links, tasks, and announcements.Village pump Forum for discussions about Wikipedia itself, including policies and technical issues.Site news Sources of news about Wikipedia and the broader Wikimedia movement.Teahouse Ask basic questions about using or editing Wikipedia.Help desk Ask questions about using or editing Wikipedia.Reference desk Ask research questions about encyclopedic topics.Content portals A unique way to navigate the encyclopedia.Wikipedia is written by volunteer editors and hosted by the Wikimedia Foundation, a non-profit organization that also hosts a range of other volunteer projects: CommonsFree media repository MediaWikiWiki software development Meta-WikiWikimedia project coordination WikibooksFree textbooks and manuals WikidataFree knowledge base WikinewsFree-content news WikiquoteCollection of quotations WikisourceFree-content library WikispeciesDirectory of species WikiversityFree learning tools WikivoyageFree travel guide WiktionaryDictionary and thesaurusThis Wikipedia is written in English. Many other Wikipedias are available; some of the largest are listed below. 1,000,000+ articles DeutschEspaolFranaisItalianoNederlandsPolskiPortugusSvenskaTing Vit 250,000+ articles Bahasa IndonesiaBahasa MelayuBn-lm-gCatalaetinaDanskEestiEsperantoEuskaraMagyarNorsk bokmlRomnSimple EnglishSloveninaSrpskiSrpskohrvatskiSuomiTrkeOzbekcha 50,000+ articles AsturianuAzrbaycancaBosanskiFryskGaeilgeGalegoHrvatskiKurdLatvieuLietuviNorsk nynorskShqipSlovenina Retrieved from " 2EP by Seventeen17 CaratEP by SeventeenReleasedMay29,2015(2015-05-29)GenreK-popdance-pophip hopLength16:48LanguageKoreanLabelPledis EntertainmentLOEN EntertainmentSeventeen chronology17 Carat(2015)Boys Be(2015)Singles from 17 Carat "Adore U"Released: May 29, 201517 Carat is the debut extended play (EP) by South Korean boy group Seventeen. It was released on May 29, 2015, by Pledis Entertainment and distributed by LOEN Entertainment. "Adore U" serves as the lead single for the EP.17 Carat features five tracks written, co-written, and co-produced by Seventeen's group members. "Adore U" was chosen as the lead single for the EP and was performed on multiple music shows by the group. "Shining Diamond" was used as a pre-single on the group's reality debut show. The group stated that the tracklist was chosen to reflect Seventeen's core concept of "boys' passion".[1] The album has two physical versions: one with a "black" themed photo card set, and the other with a "white" themed photo card set. All copies include a CD containing the songs and a fold-up poster/lyric sheet."Adore U" is the lead single of the extended play. It was written by Woozi, S.Coups, and Yeon Dong-geon.[2] The Korea Herald states "'Adore U' is a funky pop song about a teenage boy trying to navigate through puppy love."[3] It marks the beginning of the group's trilogy composed of the singles Adore U, Mansae, and Pretty U about a boy meeting, falling in love and asking out a girl. The track was composed and arranged by Woozi, Bumzu, and Yeon Dong-geon. The music video for the single was released on May 29, 2015, and was directed by Dee Shin. The dance choreography accompaniment to the song was choreographed by Hoshi and focuses on "storytelling, and on highlighting each member's strengths onstage".[4] The single has sold more than 38,000 digital copies and peaked at number 13 on the Billboard US World Chart.The EP has sold over 82,972 copies in South Korea.[5] It peaked at number 4 on the Korean Gaon Album Chart[6] and number 8 on the US World Billboard Chart.[7]Year-end listsCritic/publicationListRankRef.BillboardThe 10 Best K-pop Album of 2015Placed[8]Hoshi participated in the choreography of "Adore U" and "Shining Diamond", Dino choreographed "Jam Jam".[9]Official track list[10]No.TitleLyricsMusicArrangementsLength1."Shining Diamond"WooziVernonS.CoupsKim Min-jeongWooziMasterKeyRishiMasterKeyRishi3:242.""Adore U"" (; Akkinda)WooziVernonS.CoupsBumzuWooziBumzuYeon Dong-geonWooziBumzuYeon Dong-geon3:073."Ah Yeah" (Hip-Hop unit)S. CoupsVernonWonwooMingyuCream DoughnutRishiCream DoughnutRishi3:294."Jam Jam" (Performance unit + Vernon)WooziHoshiDinoVernonWooziCream DoughnutCream Doughnut3:255."20" (Vocal unit)WooziWooziWon Yeong-heonWon Yeong-heonDong Ne-hyeong3:23Weekly chart performance for 17 CaratChart (2015-2023)PeakpositionJapanese Albums (Oricon)[11]46South Korean Albums (Gaon)[12]4US World Albums (Billboard)[13]8Year-end chart performance for 17 CaratChart (2015)PeakpositionSouth Korean Albums (Gaon)[14]47^ "Seventeen hopes to shine like diamonds with '17 Carat'". The Korea Herald. 26 May 2015. Retrieved 30 November 2016.^ "Adore U". Color Coded Lyrics. 29 May 2015. Retrieved 29 November 2016.^ "Seventeen hopes to shine like diamonds with '17 Carat". The Korea Herald. 26 May 2015. Retrieved 30 November 2016.^ "Seventeen hopes to shine like diamonds with '17 Carat'". The Korea Herald. 26 May 2015. 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Retrieved February 17, 2024.^ "2015 Album Chart". Gaon Chart (in Korean). Archived from the original on May 7, 2017. Retrieved February 17, 2024.Retrieved from " 3The following pages link to 17 Carat External tools(link counttransclusion countsorted list) See help page for transcluding these entriesShowing 50 items.View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Main Page (links | edit)Pledis Entertainment discography (links | edit)List of 2015 albums (links | edit)2015 in South Korean music (links | edit)Seventeen (South Korean band) (links | edit)S.Coups (links | edit)Vernon (rapper) (links | edit)Wonwoo (links | edit)List of awards and nominations received by Seventeen (links | edit)Seventeen discography (links | edit)Love & Letter (links | edit)Joshua (singer) (links | edit)Seventeen TV (links | edit)17 carat (redirect page) (links | edit)Going Seventeen (links | edit)List of Seventeen live performances (links | edit)Teen, Age (links | edit)Al1 (links | edit)Bumzu (links | edit)Boys Be (EP) (links | edit)You Make My Day (links | edit)You Made My Dawn (links | edit)Jun (Chinese entertainer) (links | edit)List of Stray Kids live performances (links | edit)The8 (links | edit)An Ode (links | edit)Seungkwan (links | edit)Fallin' Flower (links | edit)Heng:gar (links | edit)Semicolon (EP) (links | edit)Your Choice (links | edit)Going Seventeen (web series) (links | edit)Not Alone (Seventeen song) (links | edit)Attacca (EP) (links | edit)Rock with You (Seventeen song) (links | edit)Woozi (links | edit)Hoshi (South Korean singer) (links | edit)Don't Wanna Cry (Seventeen song) (links | edit)Darl+ing (links | edit)Face the Sun (links | edit)Left & Right (Seventeen song) (links | edit)24H (EP) (links | edit)We Make You (links | edit)Hot (Seventeen song) (links | edit)Dream (Seventeen EP) (links | edit)BSS (band) (links | edit)FML (EP) (links | edit)Super (Seventeen song) (links | edit)Always Yours (album) (links | edit)Seventeenth Heaven (links | edit)View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Retrieved from " WhatLinksHere/17_Carat" This guide will explain how to apply the central limit theorem in Excel.You can use the central limit theorem to analyze large datasets by assuming properties about the sampling distribution of the mean. The central limit theorem is an important idea in statistics that you can use to approximate the sampling distribution of a given population.The theorem states that the distribution of a sample variable will always follow a normal distribution as the sample size increases.This theorem applies to all populations regardless of the shape of their distributions. If we try to sample a population that follows an exponential distribution multiple times, the mean of our sample variables will always follow the normal distribution.The central limit theorem also states that the mean of our sampling distribution will approximate the mean of the population.The theorem also indicates that the standard deviation of the sampling distribution follows the following formula:standard deviation of sampling distribution = standard deviation of population / square root of sample sizeSince we can always rely on the central limit theorem in scenarios with larger sample sizes, we can use this theorem to derive certain statistics.Lets take a look at an example where we can apply the central limit theorem in Excel.Suppose you have a dataset with 1000 observations. The population has a mean of 45 and a standard deviation of 20.With a sample size of 100, we want to find the mean of random samples obtained from our dataset. What is the mean of this sampling distribution, and what is the standard deviation?By following the central limit theorem, we can obtain these values without having to actually perform the sampling ourselves.Since the central limit theorem states that the sampling distribution is always normally-distributed, we can use the NORM.DIST function to determine probabilities.For example, we can use the NORM.DIST function to calculate the probability that a random sample of size N from a given population is less than or equal to some value x.Now that we know when we could apply the central limit theorem in Excel, lets learn how to use it and work on an actual sample spreadsheet. A Real Example of Using the Central Limit Theorem in ExcelThe following section details a sample Excel spreadsheet that applies the central limit theorem. We will use the theorem to find probabilities and describe the sampling distribution of the mean.First, lets take a look at our given values. We have a population with a mean of 45 and a standard deviation of 20. We are using a sample size of 100 to obtain the sampling distribution of the population. Based on the central limit theorem, we can solve for the sampling distributions mean and standard deviation. To get the standard deviation, we just need to use the following formula:= C3/SQRT(C4)The formula above divides the populations standard deviation by the square root of the sample size used.Next, well use the properties guaranteed by the central limit theorem to find certain probabilities.We want to know the probability that when we get a random sample of 100 values from our dataset, that sample will have a mean less than or equal to 45. We can use the following formula to find these probabilities:=NORM.DIST(45,C6,C7,TRUE)Since we know that the sample mean distribution is a normal distribution, we will use the NORM.DIST formula to find the probability.You can replace the first argument of NORM.DIST to change the probability you are looking for. For example, the formula reveals that there is a 50% chance that the mean of our random sample will be less than or equal to 45. This result is expected since 45 is the population mean.Do you want to take a closer look at our examples? You can make your own copy of the spreadsheet above using the link attached below. If youre ready to apply the central limit theorem yourself, head over to the next section to read our step-by-step breakdown on how to do it! This section will guide you through each step needed to apply the central limit theorem in Excel. Youll learn how to use this theorem to infer probabilities and determine the properties of random samples from a larger population.Follow these steps to use the central limit theorem in Excel:First, write down the populations mean and standard deviation. You should also take note of the sample size youll be using for sampling.The central limit theorem indicates that the sampling distributions mean is equal to the larger populations mean. We can add a cell reference to the population mean to return the value again.Hit the Enter key to evaluate this formula.Next, well use the formula =C3/SQRT(C4) to find the sampling distributions standard deviation.Type the Enter key to return the standard deviation. In this example, the samples standard deviation is 2.Next, we will apply the central limit theorem to calculate probabilities about a sample mean result. In this example, we want to know how likely that the mean of our random sample is less than or equal to 40, 45, and 50.Use the NORM.DIST formula to return the probability.Hit the Enter key to return the probability. In this example, we now know that the probability that the sample mean is less than or equal to 45 is 50%.We can use the same formula to calculate the remaining two probabilities. These are all the steps needed to apply the central limit theorem in Excel. This step-by-step guide should provide you with all the information you need to apply the central limit theorem in Excel yourself.You should now have a clear understanding of what the central limit theorem is. You should now be able to use it on your own spreadsheets for statistical analysis and inference.The central limit theorem is just one example of the many statistical methods you can use in your spreadsheets. Our website offers hundreds of other functions and methods to help you get more out of Microsoft Excel.With so many other Excel functions available, you can find one appropriate for your use case.Dont miss out on our teams new spreadsheet tips, tricks, and best practices. Subscribe to our newsletter to stay updated on the latest guides from us! The Central Limit Theorem (CLT) is an important topic in mathematics. In this article, we will look at the central limit definition, along with all the major concepts that one needs to know about this topic. The central limit theorem can be explained as the mean of all the given samples of a population. This is an approximation if the sample size is large enough and has finite variation.The central limit theorem can also be explained as the distribution of a sample mean which approximated the normal distribution. This is applicable when the sample size becomes larger. The assumption here is that all the samples are similar and the shape of the population distribution could possibly be anything.To understand the central limit theorem better, lets look at an example. Lets assume that there are ten teams of cricket in your school. Every team has a total of 100 students in it. Now, if we want to measure the average height of all the students in the sports teams, then that would be a humongous task.The best way to go about this task is to find the heights of all the students and add the values. After that, the sum of heights can be divided by the total number of students. The answer that we arrive at after this step will be the value of average height. This method will be quite tiresome in this example. But can you imagine how hard and extensive a similar task would be with 2000 people?Due to this reason, this method is not always possible. Thankfully, one can use the central limit theorem to make his or her calculations easy. In the method of the central limit theorem, the individual would start by randomly picking students from different teams. Every sample will include only 20 students. After that, the individual can follow the steps that are mentioned below.Take all the samples and try to find the mean for every single sample.Once that is done, then find the mean of the means of the samples.The value you receive will be the approximate mean height of all the students in the sports teams.If you plot this data, then you will get a bell curve shape. Check this fact by plotting a histogram of a large sample of mean heights.Once you are done with the plotting of the histogram, then the shape of your graph should be similar to the image of the graph that is attached below.(Image will be uploaded soon)It is important for readers to remember that the sample one takes for plotting the histogram should be sufficiently large. This is because when the sample size is larger, the sample mean distribution will also show normality. This will happen as one goes about calculating the value by using repeated sampling.Central Limit Theorem FormulaTill now, we have discussed the meaning of the central limit theorem along with what it dictates. The next is to focus on the central limit theorem formula. But before we discuss the formula, it should be noted that the central limit theorem is valid for a large sample size only (n 30). The formula for the central limit theorem is mentioned below.x = x = / nIn this formula, = population mean = population standard deviationx = sample meanx = sample standard deviationn = sample sizeThe Statement and Assumptions of Central Limit TheoremWhen it comes to the central limit theorem, then there is a specific statement that students must memorize. The statement is:The central limit theorem mentions that whenever a random sample of size n is taken from any particular distribution, with mean and variance, then the sample mean would be the approximate normally distributed with both variance and mean. It should be noted that the larger the value of the sample size, the better quality the approximation to the normal.There are several assumptions that are made in the central limit theorem. Do you know what those assumptions are? If you dont, then go through the list of those assumptions that are mentioned below.The final sample should ideally be drawn in a random manner after the condition of randomization.The sample that is drawn should also be independent of one another. This means that the sample should not influence other samples.If the sampling is done without any replacement, then the sample size should not exceed 10% of the total population.The sample size should also be quite large.Fun Facts About the Central Limit Theorem ApplicationDo you know about the central limit importance? Do you know about all the different applications of the central limit theorem? According to experts, there are several applications of the central limit theorem. We have created a table of those applications and that table is mentioned below.The Statistical Application of Central Limit TheoremThe Practical Importance of Central Limit TheoremIf the distribution is not normal or known, then the sample distribution is considered to be normal according to the central limit theorem. Further, in this theorem, it is assumed that the population is normally distributed. This helps the individual in analyzing data by using methods like constructing confidence intervals.The election polls showcase one of the most common applications of the central limit theorem. In this application, for calculating the percentage of people supporting a candidate which are observed on news as confidence intervals.It can help in estimating the population mean in a more accurate manner. We can also increase the samples taken from the population. It will ultimately help in decreasing the sample mean derivation.It can also be used for measuring the mean or average value of family income in any particular region.It is useful in creating a range of values that are likely to include the population mean. We can also use the sample mean.The Central Limit Theorem states that the mean of a large sample size of independent and identically distributed random variables will converge to a normal distribution. Excel provides a tool to calculate the mean and standard deviation of a sample and to graph a normal distribution based on the sample data. This can be used to apply the Central Limit Theorem in Excel by inputting sample data into the tool and then graphing the results to see if the mean converges to a normal distribution. The states that the sampling distribution of a sample mean is approximately normal if the sample size is large enough, even if the population distribution is not normal. The central limit theorem also states that the sampling distribution will have the following properties: 1. The mean of the sampling distribution will be equal to the mean of the population distribution: x = 2.The standard deviation of the sampling distribution will be equal to the standard deviation of the population divided by the sample size: s = / n In this tutorial, we explain how to apply the central limit theorem in Excel to a given distribution. Applying the Central Limit Theorem in Excel Suppose we have a distribution with a mean of8and a standard deviation of4. We can use the following formulas in Excel to find both the mean and the standard deviation of the sampling distribution with a sample size of15: The mean of the sampling distribution is simply equal to the mean of the population distribution, which is8. The standard deviation of the sampling distribution is equal to the population standard deviation divided by the sample size, which is: 4 /15 =1.0328. We can also use the central limit theorem to answer questions about probabilities. For example, if a given population has a mean of 8 and a standard deviation of 4, what is the probability that a given sample of size 15has a mean less than or equal to7? To answer this question, we can use theNORM.DIST()function in Excel, which uses the following syntax: NORM.DIST(x, mean, standard_dev, cumulative) where: x:the sample mean youd like to test mean: expectedmean of sampling distribution standard_dev:expectedstandard deviation of sampling distribution cumulative:TRUE returns the value of the normal CDF; FALSE returns the value of the normal PDF. In our case, we will always use TRUE. Here is the formula we would use in this example: This tells us that for a population with a mean of8and a standard deviation of4, the probability that a given sample of size 15has a mean less than or equal to7is0.1665. We can also find the probability that a given sample size has a meangreaterthan a certain number by simply using the formula 1 NORM.DIST(). For example, the following formula shows how to find the probability that a given sample size of 15 has a meangreater than7: Lastly, we can find the probability that a given sample size will have a meanbetweentwo numbers by using the formulaNORM.DIST(larger number) NORM.DIST(smaller number). For example, the following formula shows how to find the probability that a given sample size of 15 has a mean between 7 and 9: This is one of the following eight articles on the normal distribution in Excel Overview of the Normal Distribution Normal Distributions PDF (Probability Density Function) in Excel 2010 and Excel 2013 Normal Distributions CDF (Cumulative Distribution Function) in Excel 2010 and Excel 2013 Solving Normal Distribution Problems in Excel 2010 and Excel 2013 Overview of the Standard Normal Distribution in Excel 2010 and Excel 2013 An Important Difference Between the t and Normal Distribution Graphs The Empirical Rule and Chebyshevs Theorem in Excel Calculating How Much Data Is a Certain Distance From the Mean Demonstrating the Central Limit Theorem In Excel 2010 and Excel 2013 In An Easy-To-Understand Way The Central Limit Theorem, or CLT, is one of statistics most basic principles. The CLT states the following points: When an entire population is grouped into random samples of size n, the following are true: 1) As sample size n increases, the distribution of the sample means approaches the normal distribution regardless of how the population is distributed. A sample size of 30 is often quoted as being the minimum sample size necessary to ensure that the sample means will be normal-distributed. In the real world, sample means will be normal-distributed when the sample size is much smaller. This will be demonstrated with Excel shortly. 2) The sample standard deviation will equal the population standard deviation divided by the square root of the sample size. This will also be demonstrated in Excel shortly Why the Central Limit Theorem Is So Important to Statistics The Central Limit Theorem is very important to statistical work because it enables convenient normal-distribution-based and t-Distribution-based hypothesis testing and confidence-interval creation to be performed based upon a single large sample of data without having to verify that the population from which the sample was taken is normal-distributed. Samples are considered to be large if the size of each sample, n, is greater than or equal to 30. Performing normal-distribution-based and t-Distribution-based hypothesis testing and creating confidence intervals based upon a small sample of data requires verification that the population from which the sample was taken is normal-distributed. The normality of the population is confirmed if the data within the sample is verified to be normal-distributed. This step is not necessary when the sample is large. Samples are considered to be small if the size of each sample, n, is smaller than 30. Hypothesis testing of a population mean and confidence intervals of a population mean are discussed in much greater detail in their own sections of this book. Hypothesis testing and confidence intervals of a population mean are calculated based upon a single sample of data. The fundamental assumption that underlies normal-distribution-based and t-Distribution-based hypothesis testing and confidence interval creation of a population mean is that the sample mean is normal-distributed. The mean of a single sample is normal-distributed if the means of other similar samples are also normal-distributed. In other words, if the means of a number of other same-sized samples randomly taken from the same population were normal-distributed, then the mean of the single sample is normal-distributed. When the single sample taken is large enough (sample size n is greater than or equal to 30), the mean of that sample is assumed to be normal-distributed as per the Central Limit Theorem. When the size of the single sample is less than 30, the samples mean cannot be assumed to be normal-distributed unless one of the following is true: 1) The population from which the sample was drawn is known to be normal-distributed. 2) The data within the single sample is verified through normality testing to be normal-distributed. Quite often it is not possible to confirm the normality of the population. In this case normality testing should be performed on the data within the single sample taken before normal-distribution-based or t-Distribution-based hypothesis testing or the confidence interval creation can be performed based upon that single sample of data. A Demonstration of the Central Limit Theorem Using Excel The Central Limit Theorem is not immediately intuitive can be more quickly understood when an example of how it works is shown in graphical form. The following example will be performed in Excel as follows: A population of 5,000 randomly-generated data points whose distribution is highly skewed will be created in Excel. The population of 5,000 will be randomly into samples of sample size n = 2, sample size n = 5, and sample n = 10. The distribution of the sample means will be shown in an Excel histogram created for each of the three sample sizes. The histograms will demonstrate that the distribution of the sample means become closer and closer to the normal distribution. This exercise will also show that the sample standard deviation equals the population standard deviation divided by the square root of the sample size. This means that the distributions shape become tighter as the sample size increases. Here are the steps in demonstrating how the Central Limit Theorem works using Excel. The first step is to use Excels random-number generator to generate 5,000 random numbers that are highly skewed. In this case, the data will be highly skewed to the right and will following this model, which is an Excel-generated histogram: (Click on the Image To See an Enlarged Version) This population of 5,000 skewed random numbers by creating the following sets of random numbers in Excel: 1,500 random numbers between 0 and 100. Each of these numbers was created with the Excel formula RANDBETWEEN(0,100) 1,100 random numbers between 100 and 200. Each of these numbers was created with the Excel formula RANDBETWEEN(100,200) 700 random numbers between 200 and 300. Each of these numbers was created with the Excel formula RANDBETWEEN(200,300) 500 random numbers between 300 and 400. Each of these numbers was created with the Excel formula RANDBETWEEN(300,400) 400 random numbers between 400 and 500. Each of these numbers was created with the Excel formula RANDBETWEEN(400,500) 300 random numbers between 500 and 600. Each of these numbers was created with the Excel formula RANDBETWEEN(600,700) 200 random numbers between 600 and 700. Each of these numbers was created with the Excel formula RANDBETWEEN(600,700) 100 random numbers between 700 and 800. Each of these numbers was created with the Excel formula RANDBETWEEN(700,800) 100 random numbers between 800 and 900. Each of these numbers was created with the Excel formula RANDBETWEEN(800,900) 100 random numbers between 900 and 1,000. Each of these numbers was created with the Excel formula RANDBETWEEN(900,1,000) These 5,000 numbers need to be randomly placed in a table so that samples can be taken. One way of doing that is to initially place all 5,000 numbers in a single Excel column. These numbers need to be randomly scrambled in the column. This is done as follows: The columns of numbers on the right in column D are the randomly-generated numbers from several of the ranges previously created. The column of numbers on the left in column C are randomly-generated numbers from a single range using the Excel formula RANDBETWEEN(0,1000). (Click on the Image To See an Enlarged Version) The objective is to randomly scramble the numbers in column D. The numbers in Column D will be scrambled randomly be performing a single sort of both column based upon an ascending sort of the numbers in Column C. Prior to the sort, the numbers in the two columns appear as follows: After the sort according to Column C, the numbers appear as follows: The next step is to take the numbers from the column on the right and place them into a table. This is necessary for taking samples and creating histograms in Excel. Converting column data into a table can be done in Excel using the OFFSET() command. As soon as any cell from C2 to E4 has the correct OFFSET() formula typed into it, that cell can be copied to all of the other cells in the table. The result is the following: (Click on the Image To See an Enlarged Version) The data in this exercise was arrange into a table of dimensions 20 rows by 500 columns as follows: Population (Sample size n = 1) (Click on the Image To See an Enlarged Version) A histogram was created in Excel of this population of 5,000 data points. It population parameters are as follows: Population size = N = 5,000 (Note that capital N is used to describe population size) Population mean = = 260 Population standard deviation = = 230 Note that the following Excel histogram shows the populations distribution to be highly skewed to the right. (Click on the Image To See an Enlarged Version) Sample Size n = 2 A table of samples of sample size n = 2 was created by taking the average of every 2 data points going down each column. A table with these samples appears as follows: (Click on the Image To See an Enlarged Version) Total number of samples = 2,500 Sample size = n = 2 Sample mean = x_bar = 260 Sample standard deviation = 163 = / SQRT(n) (with rounding error) Note that the shape of the distribution of the sample means when the sample size is 2 is still highly skewed to the right. The bell shape of the normal distribution is already starting to form at a sample size of 2 even though the population from which the samples were taken is highly skewed. Note how much more narrow the distributions shape has become as sample size increase from n = 1 to n = 2. (Click on the Image To See an Enlarged Version) Sample Size n = 5 A table of samples of sample size n = 5 was created by taking the average of every 5 data points going down each column. A table with these samples appears as follows: (Click on the Image To See an Enlarged Version) Total number of samples = 1,000 Sample size = n = 5 Sample mean = x_bar = 260 Sample standard deviation = 104 = / SQRT(n) (with rounding error) Note that the shape of the distribution of the sample means when the sample size is 5 already has a strong resemblance to the bell-shape normal distributions PDF curve even though the population from which the samples were taken is highly skewed. A mild skew to the right can still be seen. Note how much more narrow the distributions shape has become as sample size increase from n = 2 to n = 5. The reduction in the sample standard deviation indicates how much thinner the distributions shape has become. (Click on the Image To See an Enlarged Version) Sample Size n = 10 A table of samples of sample size n = 10 was created by taking the average of every 10 data points going down each column. A table with these samples appears as follows: (Click on the Image To See an Enlarged Version) Total number of samples = 500 Sample size = n = 10 Sample mean = x_bar = 260 Sample standard deviation = 72 = / SQRT(n) (with rounding error) Note that the shape of the distribution of the sample means when the sample size is 10 now nearly exactly resembles the bell-shape normal distributions PDF curve even though the population from which the samples were taken is highly skewed. Note how much more narrow the distributions shape has become as sample size increase from n = 5 to n = 10. The reduction in the sample standard deviation indicates how much thinner the distributions shape has become. (Click on the Image To See an Enlarged Version) The most important point of the Central Limit Theorem is that the distribution of sample means become closer and closer to the normal distribution as sample size increases regardless of the distribution of the population from which the samples were taken. Most statistics texts state that the sample size must reach at least 30 before the sample means are nearly certain to be normal-distributed. In the real world, the distribution of the sample means converges to normality at significantly smaller sample sizes. The example just provided shows a reasonable resemblance to the normal distributions PDF curve when the sample size is only 5 and the population was highly skewed. A sample size of 10 shows an almost exact resemblance to the normal distributions PDF curve. The Resulting Robustness of the t-Test The quick convergence of sample mean distribution to normality as sample size increases means that the ttest is relatively robust on non-normally-distributed data as long as the sample size is not too small and the data is not too skewed. The example just provided shows that even highly-skewed data will still have near-normal distribution of sample means when the sample size is as low as 10. Data that is not skewed will have sample means achieving near-normality at smaller sample sizes than 10. The t-test is therefore very robust in the face of non-normal data. The t-test can produce a reasonably accurate result for sample sizes as low as 5 to 10 for data that is not skewed. Many statistics texts state that sample size must be large (n > 30) for a t-test to be reliable but that is not the case. The example provided in this section shows the sample means of highly-skewed data converging to near-normality at a sample size of 10. Derivation of the Central Limit Theorem The derivation of the Central Limit Theorem is readily available on the Internet. The CLTs derivation is not trivial and involves a significant amount of calculus. Understanding this complicated derivation does not significantly add to ones understanding of when and how to apply the CLT. For that reason the derivation of the CLT is not discussed here. 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