CHAPTER 2: LITERATURE REVIEW

2. 1 Theoretical Framework

Numerous empirical research have examined financial ratios in various businesses worldwide. A firm's financial performance describes its financial situation throughout time, including both providing and distributing funds. This strategy is commonly used by companies to benchmark their performance against competitors (Daryanto C., 2019). Financial performance is one of the most important factors in a firm, both internally and externally. Financial statements are important indicators of a company's economic performance and future viability (Sari & Daryanto, 2021).

2. 1. 1 Financial Ratio Analysis

Ratio analysis analyzes and monitors a company's performance by calculating and understanding its financial ratios (Ross N. L., 2021). Financial ratios are calculated by dividing two accounting data. Financial ratios are used to assess a company's financial health and performance. This can provide insight into a company's health. This method evaluates management performance against specified targets over a given period. Management's ability to properly utilize corporate resources can also be evaluated (Aprilia & Daryanto, 2021). Financial statements are the primary source of data used for calculating a company's financial ratios. Gitman and Zutter (2015) state that financial statements indicate a company's financial health (performance).

Financial ratio analysis is important for administration, owners, staff, clients, providers, competitors, administrative offices, citizens, and loan specialists to assess a company's financial health and make decisions. Financial ratio analysis focuses on financial results that align with the proprietors' perspective (Daryanto, Widjaya, & Hakim, 2021). Financial ratios used to assess a company's performance include the liquidity ratio, solvency ratio, activity ratio, and profitability ratio.

2. 1. 1. 1 Profitability Ratio

Profitability ratios compare a company's earnings to its revenue, operational costs, balance sheet assets, and shareholder equity over a specific period (Daryanto, Maharani, & Wiradjaja, 2021). Profitability is crucial for a company's long-term survival as it reflects future opportunities (Yusuf & Suratmadja, 2018). There are two types of profitability ratios: margin ratios and return ratios. Margin ratios assess a company's ability to convert sales income into profits, whereas return ratios assess a company's profitability for shareholders (Daryanto, Maharani, & Wiradjaja, 2021). The profitability ratios include Net Profit Margin (NPM), Gross Profit Margin (GPM), ROIC, ROA, and ROE. These ratios measure a company's profitability and financial performance (Coulon, 2020). In this study, the author used ROA and ROE.

1. **Return on Equity (ROE)** measures a company's capacity to make a return on equity investments. The ROE ratio indicates how much profit each dollar of common stockholders' equity generates (Ross, et al., 2012).

$$\mathbf{ROE} = \frac{\text{Income after tax}}{\text{Shareholder's Equity}} \times 100\%$$

Formula 2.1 Return on Equity (ROE) (Daryanto, Maharani, & Wiradjaja, 2021)

2. **Return on Assets (ROA)** is the ratio of net income to total assets that assesses management's ability to maximize profits from available assets (Коршунова, et al., 2019). A higher ROA suggests improved performance, perhaps leading to more capital gains or dividends for shareholders (Atidhira & Yustina, 2017). It will encourage investors to put money into the company.

$$\mathbf{ROA} = \frac{\text{Net Income}}{\text{Total Assets}} \times 100\%$$

Formula 2.2 Return on Assets (ROA) (Daryanto, Maharani, & Wiradjaja, 2021)

2. 1. 1. 2 Liquidity Ratio

Liquidity ratios, often known as "short-term solvency," measure a company's ability to make payments in the short term without experiencing financial difficulty. These ratios primarily measure current assets and liabilities (Ross, Westerfield, & Jordan, 2010). The liquidity ratio is the ratio of liquid assets to current obligations. The liquid ratio assesses liquidity more rigorously than the current ratio, as it excludes inventories and prepaid expenses from current assets (Bhunia, et al., 2012). Low or deteriorating liquidity is a common precursor to financial trouble and insolvency, therefore these ratios might indicate potential cash flow issues and business collapse (Gitman & Zutter, 2015). The following are the most typical liquidity ratios. Liquidity ratios include cash ratio, acid test ratio, current ratio, working capital ratio, and times interest earned ratio. In this research, the author used the current ratio and cash ratio.

1. **Current Ratio** measures the company's ability to pay down short-term creditors with present assets (Ross, et al., 2012). The Current Ratio is a financial metric that measures a company's ability to meet its short-term liabilities with short-term assets. The calculation involves dividing current assets by current liabilities. A firm's current assets, including cash, receivables, and inventories, support its short-term operations (John, et al., 2021).

$$\textbf{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}} \text{ x } 100\%$$

Formula 2.3 Current Assets (Daryanto, Lazuardi, & Rachman, 2020)

2. **Cash Ratio** measures a company's capacity to meet current obligations using its cash and cash equivalents. It also serves as a warning for outstanding debts or unused cash (Daryanto, Leonard, & Wijaya, 2020).

$$\textbf{Cash Ratio} = \frac{\text{Cash+cash equivalents}}{\text{Current Liabilities}} \text{ x } 100\%$$

Formula 2.4 Cash Ratio (Daryanto, Leonard, & Wijaya, 2020)

2. 1. 1. 3 Solvency Ratio

Solvency ratios assess a company's financial leverage and capacity to satisfy obligations over time. As a result, they are sometimes referred to as leverage ratios. Solvency ratios and liquidity ratios both assess a company's capacity to meet obligations, but solvency ratios prioritize long-term sustainability over present liabilities (Ross, Westerfield, & Jordan, 2010). Solvency refers to a company's capacity to meet its obligations in the case of liquidation or sale. A firm may be considered bankrupt if its shareholders' equity becomes negative. This indicates that it owes more than it owns (Vernimmen & Quiry, 2005). Research reveals that a higher solvency ratio reduces the incidence of financial trouble, whereas a lower ratio increases the risk of bankruptcy (Coulon, 2020).

The most frequent solvency ratios are: Debt to Equity Ratio, Debt to Asset Ratio, Long Term Debt to Equity Ratio, and Total Equity to Total Asset Ratio.

Particularly in this study, the author used only Debt to Equity Ratio and Total Equity to Total Asset Ratio.

1. **Debt to Equity Ratio** compares a company's obligations to its equity. The calculation involves dividing a company's total liabilities by its entire equity. This ratio measures a company's debt-to-equity ratio. A higher debt-to-equity ratio indicates a corporation with more debt than equity, perhaps indicating increased financial risk. A lower debt-to-equity ratio indicates lesser financial risk (Daryanto, Lazuardi, & Rachman, 2020).

$$\textbf{Debt to Equity Ratio} = \frac{\text{Total Liabilities}}{\text{Shareholders' Equity}} \text{ x } 100\%$$

Formula 2.6 Debt to Equity Ratio (Daryanto, Leonard, & Wijaya, 2020)

2. **Total Equity to Total Assets Ratio** measures the proportion of a company's assets earned through equity share issuance versus debt. A lower ratio indicates a corporation has utilized more debt to pay for its assets. It also indicates the potential payout for shareholders if the company is liquidated. Companies with a ratio close to 100% have more assets financed with stock rather than debt (Kenton, 2020).

$$\textbf{Total Equity to Total Assets Ratio} = \frac{\text{Total Equity}}{\text{Total Assets}} \text{ x } 100\%$$

Formula 2.7 Total Equity to Total Assets Ratio (Daryanto, Leonard, & Wijaya, 2020)

2. 1. 1. 4 Activity Ratio

The Activity Ratio is a financial ratio that assesses a company's effective utilization of assets to overall sales (Ross N. L., 2021). It assesses how effectively a corporation manages its resources to maximize revenues. The activity ratio measures a company's ability to transform assets into sales or cash flow. This comprises inventory turnover ratios, accounts receivable turnover ratios, and total asset turnover ratios. These ratios offer insight into the company's operational efficiency, inventory management, and revenue creation skills (Spanò, 2019). In this study, the author used total asset turnover and collection periods.

1. **Total Assets Turnover** is a financial indicator that assesses a company's ability to generate revenue from its assets. The calculation involves dividing the

company's sales by its total assets. The ratio measures how effectively a company uses its assets to create revenue (Spanò, 2019).

$$\textbf{Total Asset Turnover} = \frac{\text{Net Sales}}{\text{Capital Employed}} \text{ x } 100\%$$

Formula 2.9 Total Assets Turnover (Mulia & Daryanto, 2021)

2. **Collection Periods** is the length of time it takes a company's accounts receivable (AR) to get payments from clients who owe it. Companies determine the Collection Periods to ensure they have enough money on hand to cover their debts (Ross N. L., 2021).

$$\textbf{Collection Periods} = \frac{\text{Account Receivables}}{\text{Sales}} \text{ x } 365$$

Formula 2.10 Collection Periods (Mulia & Daryanto, 2021)

2. 1. 2 Altman Z- Score

Z-Score is one of the multivariate analysis models first created and introduced by Edward Altman based on his research in 1968, which serves to assess and determine the tendency of corporate bankruptcy and can also be used as a measure of overall financial performance and a relatively reliable level of accuracy (Fau, 2021). The Z-score assesses a company's financial health by analyzing multiple indicators from balance sheets and corporate income statements (Panigrahi, 2019). The formula of Altman Z-Score will be explained in **Figure 2.1.**

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5$$

X_1 = Working Capital/Total Assets

X_2 = Retained Earnings/Total Assets

X_3 = Earnings before Interest and Taxes/Total Assets

X_4 = Market Value of Equity/Book Value of Total Liabilities

X_5 = Sales/Total Assets

Z = Overall Index/Score

Figure 2.1 The Altman Z-Score Formula

Source : (Altman & Hotchkiss, 1993)

Altman and Hotchkiss (1993) found that a Z-Score of 2.9 or higher reflects a company's financial soundness. A score between 1.23 to 2.9 indicates the company's financial performance is in the grey zone. A score of less than 1.23 indicates the company is in distress.

The Z-Score model is modified to exclude X5 sales/total assets to reduce the impact of industry-sensitive variables like asset turnover on the model's accuracy. The classification accuracy results match the revised (Z-Score) five-variable model (Altman & Hotchkiss, 1993). The updated Z-Score model is:

$$\text{Z-Score} = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

In this z-score formula, if the z-score value is below 0 then the company is in distressed condition. All of the coefficients for variables X_1 through X_4 differ from the original Z-Score model, as do the group means and cutoff scores. Altman and Hotchkiss (1993) argue that this model is better suited for non-manufacturers than the original Z-Score model.

2. 1. 2. 1 Working Capital/Total Assets (X1)

Working capital refers to net working capital. Net working capital is defined as the difference between a company's total assets and liabilities over a given period (Fau, 2021). Working capital is important to businesses because it demonstrates how effectively they manage their money. The company's status can be considered healthy if the difference between its short-term assets and debt is increasing. However, if the entire amount of debt exceeds the asset ceiling to the point that the nominal working capital is negative, the business is in distress.

2. 1. 2. 2 Retained Earnings/Total Assets (X2)

The company's retained earnings include both operational and non-operational activities. Although the corporation retains its income, this cash will still be needed in the future. Retained earnings can still be given to shareholders or used to expand the business in the future. Retained earnings might be used to settle debts, carry out operational tasks, or invest in the future growth of the company's business (Altman, 2017). When retained earnings are minimal, a company must seek additional funding, such as debt or cash from shareholders. Retained earnings reflect a company's ability to invest in business growth.

2. 1. 2. 3 Earning Before Interests and Taxes/ Total Assets (X3)

EBIT is a measure of a company's ability to earn income from its operations during a given year. It is calculated by subtracting the company's revenue from its expenses (such as overhead), but not deducting any tax liabilities or loan interest. EBIT indicates money available to repay creditors in the event of bankruptcy and is closely monitored, especially when the company incurs little depreciation or amortization (Joshi, 2015). This ratio shows a company's ability to produce revenue, maintain profitability, finance operations, and service debt.

2. 1. 2. 4 Market Value of Equity/Total Liabilities (X4)

This ratio assesses the company's ability to meet obligations based on the market value of its equity. The market value of equity, also known as market capitalization, is calculated by multiplying the current stock price by the number of outstanding shares. Total liabilities include both current and non-current obligations (Al-Sulaiti & Almwajeh, 2021).

2. 1. 3 The Inferential of Statistics

2. 1. 3. 1 Determine A Statistical Test

The method of statistical test depends on the study design, data structure, and scientific question that needs to be addressed. The question to be addressed and the null hypothesis must be formulated before the data is collected and the statistical test is applied. Before the study is carried out, the test and the degree of significance must be established in the protocol. Whether the test should be two-tailed or one-tailed must be decided.

The direction of the expected difference is uncertain if the test is two-tailed. The effectiveness of the new medication compared to a placebo, for example, may differ; this is unknown. It's unclear which way the difference could be. It is only appropriate to do a one-tailed test in situations where it is abundantly evident that the intervention should only have one possible outcome (Prel, et al., 2010).

The formulation of the question to be answered coincides with the definition of the result variable (endpoint). The choice of statistical test is determined by two factors:

1. The scale of measurement of the test variable (continuous, binary, categorical)
2. The type of study design (paired or unpaired)

According to the type of study design, there are often two treatments:

1. Paired samples. If every samples can receive findings under every experimental circumstance, the study design is paired (dependent). For instance, two measurements could be compared, or other attributes may be used to pair the two groups. Studies conducted on a single subject's arm or eye are typical instances of pairs. Pre- and post-treatment comparisons are prevalent in paired designs (Prel, et al., 2010).
2. Unpaired samples or independent samples are the condition where the subjects in both groups are independent of each other (persons in first group are different from those in second group). With an unpaired or independent study design, results for each patient are only available under a single set of conditions. The results of two (or more) groups are then compared. There may be differences in the sizes of the groups (Prel, et al., 2010).

Figure 2.2 illustrates the decision procedure for statistical test selection of continuous endpoint, as reported by Du Prel & Röhrig (2010).

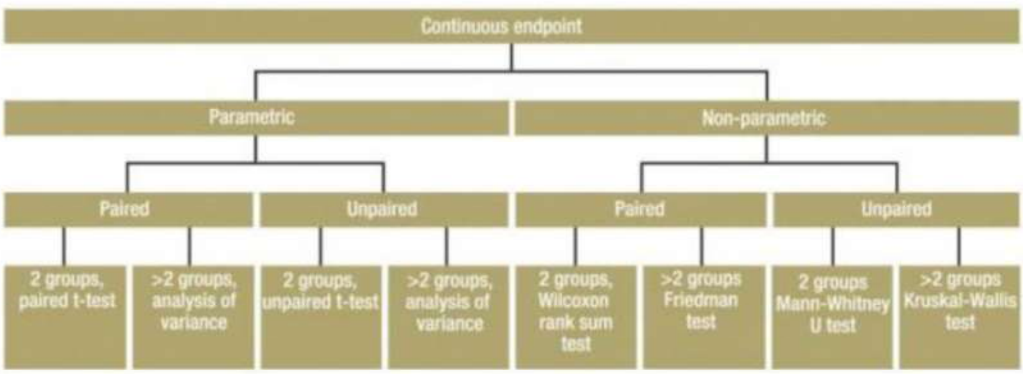

Figure 2.2 Decision algorithm for statistical test selection

Source : (Prel, et al., 2010)

The distribution of variables is a key factor in selecting the right statistical tests when assessing data from clinical trials and other research projects.

Normally distributed variables—parametric tests : If there is a normal distribution at the endpoint, parametric tests may be employed. A trial outcome value that is measured for every patient is called an endpoint. Continuous Endpoints, on the other hand, refer to endpoints that are quantified, such as changes in tumor size in clinical oncology research, blood pressure reduction, and walking distance within a specific amount of time. Binary (such as yes-or-no questions) and categorical (such as multiple category choices and Likert-type scale measurements) endpoints are the other types.

Non-normally distributed variables—non-parametric tests : Non-parametric statistical tests are performed if the parameter of interest is not normally distributed, but is at least scaled ordinally. One of these tests, known as the "rank test," is based on the rank numbers that are produced rather than the actual values. This means assigning a running number to each value and sorting them according to size. These rank numbers are then used to calculate the test variable. Parametric tests are more powerful than non-parametric tests if the required prerequisites are met. However, if the requirements are not met, parametric test power may substantially decrease.

2. 1. 3. 2 Assessing Normality of Distribution

Most statistical approaches need the assumption of normalcy to be evaluated. Assessing the normalcy assumption is crucial, and one of the best ways to demonstrate this is through parametric statistical analysis. A specific distribution of the data is assumed by parametric statistical analysis, typically the normal distribution. Validity and reliability of interpretation and inference may be compromised if the assumption of normalcy is broken. Thus, before beginning any pertinent statistical methods, it is crucial to verify this assumption (Razali & Wah, 2011).

The skewness and kurtosis coefficients are two examples of numerical approaches, whereas the normality test is a more formal procedure that determines whether a given set of data has a normal distribution. The literature contains a substantial number of normality tests. However, the Shapiro-Wilk, Kolmogorov-Smirnov, Anderson-Darling, and Lilliefors tests are the most widely used normality test procedures that may be found in statistical programs (like SPSS, for example).

The Shapiro-Wilk test is the most effective test for all distribution types and sample sizes, according by Razali & Wah (2011).

When assessing a distribution's form, statisticians have focused primarily on two factors: tail weight, or the percentage of data in the distribution's extreme tails, and the degree of skewness, or departure from symmetry. Statistics on skewness are intended to capture deviations from symmetry. The values of skewness would have been zero in the event if the distributions were fully symmetric. If a distribution or data set has the same appearance to the left and right of the center point, it is said to be symmetric (Mayers & Well, 2003).

Kurtosis is a metric used to determine how close the data are to a normal distribution and how heavy or light the tails are. This is because heavy tails, or outliers, are typically present in data sets with significant kurtosis. Low kurtosis data sets typically have light tails, or very few outliers. The worst-case scenario would be a uniform distribution. Any symmetric data should have a skewness close to zero since the skewness of a normal distribution is zero. Data that are skewed left are indicated by negative skewness values and slanted right by positive skewness values. The left tail is longer than the right tail when it is said to be tilted left. Similar to this, a right-skewed distribution indicates that the right tail is longer than the left. Skewness and kurtosis values between -2 and +2 are regarded as appropriate for demonstrating a normal univariate distribution (George & Mallery, 2010).

The Shapiro-Wilk test determines whether a random sample is representative of a normal distribution by calculating the W and W' statistics, respectively. W or W' values that are minimal imply a deviation from normality. It is only possible to compute the Shapiro-Wilk W statistic with a sample size of 3–5000 (inclusive) (Razali & Wah, 2011). The test's result, collectively with the P value, is reported as either "accept Normality" or "reject Normality." It can be considered that the data have a normal distribution if P is greater than 0.05. The hypothesis that the distribution of the observations in the sample is normal should be rejected if P is less than 0.05 (UOL, 2022).

2. 1. 4 Hypothesis Testing

Hypothesis testing determines the probability of an event occurring by chance. If the change did not cause an event, the treatment likely had an impact on the measured outcome (Allua & Thompson, 2009). Hypothesis testing distinguishes between two sorts of hypotheses: the null hypothesis, which is accepted without evidence, and the research hypothesis, which requires convincing evidence for acceptance. The decision rule in hypothesis testing determines which test statistic values will invalidate the null hypothesis and support the alternative hypothesis. Hypothesis testing gives a p-value, showing the level of surprise if the null hypothesis produced the data. In hypothesis testing, there are two sorts of errors: type I mistake, which involves incorrectly rejecting the null hypothesis, and type II error, which involves incorrectly accepting the research hypothesis (Siegel & Wagner, 2012).

Developing and testing hypotheses is an important aspect of statistical analysis. Typically, hypothesis testing involves four steps. First, define the null (H_0) and alternative research (H_a) hypotheses. The null hypothesis assumes no difference between treatment and control groups. The research hypothesis suggests that there is a difference between treatment and control groups (Allua & Thompson, 2009). The alternative hypothesis assumes the mean to be greater than, less than, or not equal to zero. A left-tailed test is used when the alternative hypothesis predicts a mean less than zero. H_a states that the mean is bigger than zero, indicating that it is right-tailed. The two-tailed test occurs when the mean is not equal to zero, as stated by H_a.

Compute a test statistic as the second step in the hypothesis testing process. The P value from the table of z-distributions, which is based on the normal distribution known as the bell curve, can be found based on the value of the test statistic. You will decide whether or not to reject the null hypothesis based on the p-value.

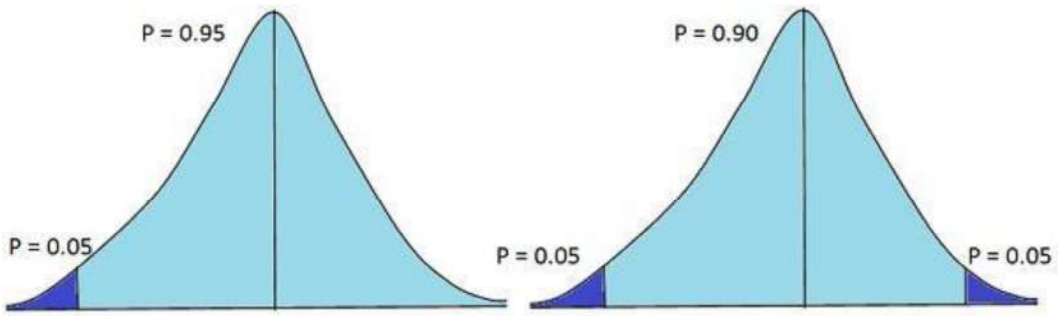

Figure 2.3 One-Tailed and Two-Tailed Test

Source: Mark and Workman (2003)

Based on Figure 2.3, the calculated P-value is compared with the significance level, α (alpha). The probability of making a Type I error determines the level of importance. Rejecting H_0 while it is true is a Type I mistake. A mistake is referred to be a Type II error if H_0 is accepted even though it is false. One less confidence level equals the alpha level. The area under the curve represents the confidence level. The confidence level typically has values of 0.90, 0.95, and 0.99. Having a confidence level of 0.95, it is the most often used of the three. This implies a 95% confidence level in the validity of the null hypothesis. Therefore, 0.05 (ranging from 1 to 0.95) is the generally used level of significance. Therefore, α set at 0.05 indicates a 5% probability of committing a Type I error (S & I, 2024).

According to Wilkerson (2008), the null hypothesis must be rejected if the p-value is less than or equal to α. If the p-value exceeds α, H_0 ought to be accepted. A statistical metric called the p-value is employed in hypothesis testing to ascertain whether or not the null hypothesis has to be rejected. It shows the likelihood that, under the null hypothesis, outcomes as extreme as those observed will occur. The test's results and the analysis's conclusions are explained in the final phase.

2. 1. 4. 1 t-Test for Dependent and Independent Samples

The t-Test is one of the most popular statistical techniques used to test whether the mean difference between two groups is statistically significant. The alternative hypothesis proposed that the two means are statistically distinct from one another rather than statistically equal, which is the null hypothesis. There are three different kinds of t-Tests: paired samples, independent samples, and one sample (Mishra, et al., 2019).

The t-Test necessitates that observations come from a normally distributed population, and for the two-sample t-Test, it is required that both populations have equal variances. Traditional parametric tests should not be utilized with very small samples, because these tests are based on several strong assumptions that cannot be tested with tiny sample sizes (Mishra, et al., 2019). After estimating the sample sizes needed for two-group comparisons, Campbell et al. (1995) concluded that N = 5 per group would be appropriate if one is willing to tolerate extremely low statistical power.

The general formula for the t-statistic is as follows :

$$t = \frac{difference\ of\ means}{standard\ error}$$

Formula 2.11 t-Test formula (Ambrosius, 2007)

In which the numerator's standard error is the standard error. The t-distribution does not presume any knowledge of the true parameters, making it a "sampling" distribution. It's crucial to keep in mind that the t-distribution is a family of distributions, with each one being distinguished by a sample size-related parameter known as the degrees of freedom (df). The t distribution and the normal distribution are fairly similar, as **Figure 2.4** illustrates. The primary distinction is that the t-distribution has thicker tails than the normal distribution, indicating a higher likelihood of extreme values. The t-distribution resembles the normal distribution more and more as sample size and degrees of freedom rise.

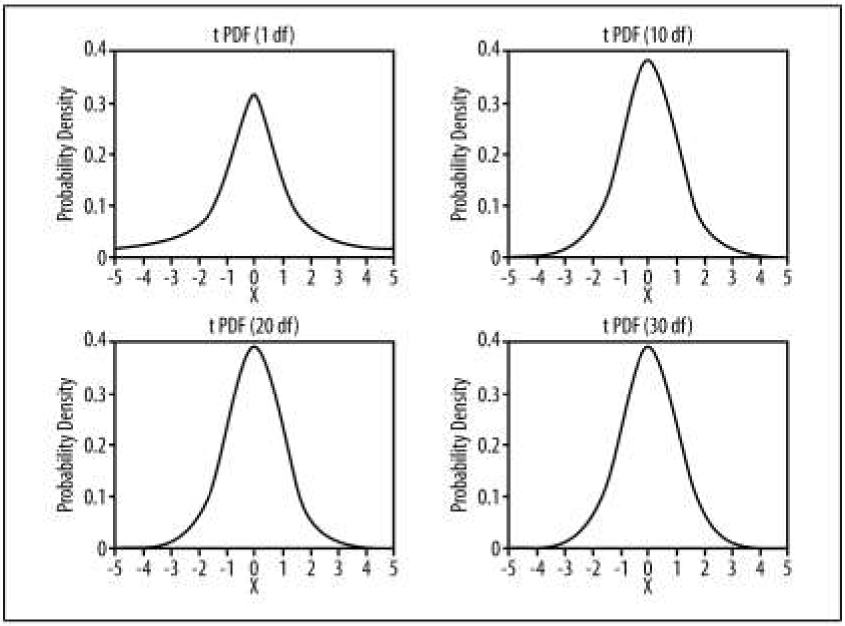

Figure 2.4 The t-distributions

Source: (Boslaugh, 2013)

2. 1. 4. 1. 1 The One-Sample t-Test

A statistical test called the one-sample t-Test is used to ascertain if a sample of data is representative of the population. It determines the ratio between the estimated value of a parameter's deviation from its predicted value and its standard error. The ratio of the standard error of the sample mean to the difference between the sample mean and the population mean is computed using the t-Test. The statistical significance of the difference is then ascertained by comparing this ratio, sometimes referred to as the t-statistic, with a critical value.

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}}$$

Formula 2.12 One-sample t-Test

Source: (Boslaugh, 2013)

The sample standard deviation is denoted by S. After that, the t-value that is generated can be compared to the crucial t-value can can be found in the t-distribution table for the necessary degree of significance and appropriate degrees of freedom (number of cases minus 1). The null hypothesis, or hypothesis of no difference, should not be rejected if the computed t-value is smaller than the critical t-value and there is no discernible distinction between the sample mean and population mean.

On the other hand, the null hypothesis should be rejected and a significant difference in means should be noted if the estimated t-value is greater than the critical t-value. In the scenario when the population standard deviation is known, the normal curve statistic (z) is substituted for t in the formula above, and σ, the known value, for s. The measured significance of the z-statistic is then compared with the intended level using the normal distribution as a reference (Boslaugh, 2013).

To compute the t-value and ascertain significance, one can utilize a graphing calculator, an Excel spreadsheet, SPSS, or an alternative software application. The importance of the difference is indicated by the p-value, which may also be computed using these methods. The researcher may proclaim a significant difference (and reject the null hypothesis) if the p-value is less than the level of significance. Usually, a 0.05 level is applied. Remember that the chance that we could obtain an odd sample that, although abnormal and producing an extreme mean, actually comes from the distribution with the assumed mean m is 0.05. In 5% of the randomly selected samples from the population, this may occur (Boslaugh, 2013).

2. 1. 4. 1. 2 Independent t-Test

A statistical test used to compare the means of two groups is the independent t-Test, sometimes referred to as the student's t-Test. When comparing a single measured variable between two breakout groups, it is frequently employed. For each group, the data are intervals. The two standard deviations are assumed to be equal, but there is no assumption of a normal distribution (the t-Test will not produce meaningful findings with uneven sample sizes if the distribution of one or both groups is extremely uncommon). Even that assumption will not be true if the sample sizes are equal or extremely similar. The t-value's general formula can be expressed as follows:

$$t = \frac{\overline{X_1} - \overline{X_2}}{s_{\overline{X_1} - \overline{X_2}}}.$$

Formula 2.13 Independent t-Test (Boslaugh, 2013)

Using the following formula, equal sample sizes can be determined:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Formula 2.14 Independent Sample t-Test with Same Sample Size (Boslaugh, 2013)

On the other hand, a pooled variance estimate is applied in cases where the sample sizes differ, yielding the following formula:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Formula 2.15 Independent Sample t-Test with Different Sample Sizes (Boslaugh, 2013)

According to Ross and Wilson (2018), if the ratio of the bigger standard deviation to the smaller standard deviation is less than 2, it can be used as an acceptable rule of thumb to determine whether or not the standard deviations are equal. It won't matter if sample sizes are equal, but if they are not, there may be an issue with how to interpret the t-test if the smaller sample size has a higher standard deviation. In that instance, the significance level may differ significantly from your expectations; therefore, to overcome the requirement violation, the researcher should set the alpha level very low, perhaps as low as 0.001. Fortunately, it is possible to compute this t-value using a graphing calculator or software program.

2. 1. 4. 1. 3 Paired t-Test

Paired Samples are as follows: two sets of samples, no unpaired samples in either group and each set of samples in the first group is connected to exactly one