EMPLOYMENT RATES IN THE PHILIPPINES: A COMPARATIVE ANALYSIS BEFORE AND DURING THE COVID-19 PANDEMIC USING HOTELLING'S T^2

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BIOGRAPHICAL DATA

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She graduated with honors in her senior high school at Philippine Christian University-Dasmariñas Campus last 2019.

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BIOGRAPHICAL DATA

Chona Mae C. Buguis was born on the 1st day of October year 2000. She resides in Barangay Lapidario, Trece Martires City, Cavite. She is the second child of Carlos F. Buguis and Alma C. Buguis and she has sisters named Cazandra and Prisca Ashera Kish.

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In the same year, she enrolled at Cavite State University, Indang, Cavite under the program of Bachelor of Science in Applied Mathematics and obtained her degree in August 2023.

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KIYOSHI C. RIO

ABSTRACT

BUGUIS, CHONA MAE C., DELPOSO, BABY ANN P., and RIO, KIYOSHI C., Employment Rates in the Philippines: A Comparative Analysis Before and During the Covid-19 Pandemic Using Hotelling's T². Undergraduate Thesis. Bachelor of Science in Applied Mathematics. Cavite State University Indang, Cavite. July 2023. Adviser: Mr. Paul Vincent E. Botin.

This study aimed to analyze the difference in employment, unemployment, and underemployment rates before and during the Covid-19 Pandemic. Specifically, this study was to determine the behavior of the employment, unemployment, and underemployment rates in the Philippines from 2017–2022, Assess the rates before and during Covid-19 Pandemic regarding the employment, unemployment, and underemployment in the Philippines, and analyze if there is a significant difference between before and during Covid-19 Pandemic regarding the employment, unemployment, and underemployment rates.

This study used quarterly data on the employment rate in the Philippines from 2017-2019 to 2020-2022, based on Philippine Statistics Authority (PSA) data titled " Labor Force Participation Rate, Employment Rate, Unemployment Rate, and Underemployment Rate, Philippines: January 2005 to October 2021". With the use of multivariate analysis of employment rate before and during a pandemic, the researchers used an analysis technique namely: Hotelling's T².

As a result of using Hotelling's T² test between before and during the pandemic using the covariance assumption. The outcome indicates that Hotelling's T² is equal to 0.0930, meaning that the variances are identical. This indicates that there is no statistically significant evidence to suggest a difference in the group means for the employment rate before and during the COVID-19 pandemic.

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INTRODUCTION

The COVID-19 pandemic shook the world, affecting not only people's health but it has also affected the global rates of employment, unemployment, and underemployment. The Philippines suffered greatly from lockdown measures, leading to job losses and business closures. The pandemic has not only resulted in health problems and death but some people were also forced to quit their jobs, and some establishments were forced to close due to the lack of income. The researchers explore how employment rates changed before and during the pandemic, witnessing the challenges and glimpses of hope during this extraordinary time.

According to Dorfman (2022), COVID-19 led to stay-at-home orders and government-mandated shutdowns of businesses. Fear of the virus caused consumers to avoid interpersonal contact with others; many chose to stay away from stores. All of this led to a decrease in employment in retail trade. Motor vehicle and parts dealers, miscellaneous store retailers, and gasoline stations, all of which experienced employment growth from 2017–19, combined for just over one-quarter of retail sector employment loss between 2019 and 2020. Stay-at-home orders and travel limitations caused many consumers to reduce expenditures on gasoline and

automobile maintenance and repair. Furthermore, stay-at-home orders and the pandemic-related recession led to significant deferrals of new automobile purchases, which contributed to the large cyclical decline in employment.

Simionescu & Faura (2022) stated that the severe economic crisis and the sudden strong decline in economic activity, the unemployment variable is currently of particular interest to the general public and scientists. The improvement of macroeconomic predictions has been a continuous concern of forecasters and policymakers interested in proposing the best solutions to addressing social and economic issues. The topic is the subject of current economic debates, marked by skepticism – enhanced by the recent global crisis and Covid-19 pandemic – regarding the predictive capacity of quantitative analysis.

A low unemployment rate means that the economy is more likely to be producing near its full capacity, maximizing output, driving wage growth, and raising living standards over time (Investopedia, 2022). One of the common family structures that everyone considers is for one spouse to work while the other stays at home to care for the family. Because they are either unable to work or do not require full-time employment, these large parts of the population are not taken into consideration for determining employment as well as unemployment rates.

Comparing employment rates before and during the pandemic is crucial for several reasons. Firstly, it helps us understand the overall impact of the COVID-19 pandemic on global economies and labor markets. By examining the changes in employment rates, researchers can assess the causes of the pandemic and gain insights into the challenges faced by the workforce.

Secondly, comparing employment rates allows for the evaluation of policy measures implemented during the crisis. If employment rates have a real change because of a pandemic, governments and policymakers employ various strategies to mitigate the adverse effects on employment, and analyzing the differences in employment rates provides valuable information on the effectiveness of these

interventions. This evaluation helps identify successful policies and informs future decision-making to protect jobs and support workers and businesses.

By using Hotelling's T^2 approach to compare employment rates before and during the pandemic, the goal of researchers is to comprehend and analyze if there are significant changes before and during a pandemic. The study seeks to provide relevant information to employers, unemployed workers, and policymakers. Researchers aim to help contribute to informed making choices, offer useful initiatives, and support an effective and inclusive recovery by revealing the impact that the pandemic has on employment.

Statement of the problem

The Philippines is one of the countries that suffered from the Pandemic. The study answered the following questions regarding employment, unemployment, and underemployment rate before and during the pandemic.

1. What is the behavior of the employment, unemployment, and underemployment rates before the pandemic? How about during the pandemic?
2. What are the assessments of the rates before and during pandemic regarding the employment, unemployment, and underemployment in the Philippines?
3. Is there a significant difference between the rates of employment, unemployment, and underemployment before and during the pandemic period in the Philippines?

Objectives of the Study

Generally, this research study aimed to analyze the difference in employment, unemployment, and underemployment rates before and during the Covid-19 Pandemic.

Specifically, this research aimed to:

1. determine the behavior of the employment, unemployment, and underemployment rates in the Philippines from 2017–2022;

2. assess the rates before and during Covid-19 regarding employment, unemployment, and underemployment in the Philippines; and

3. analyze if there is a significant difference between before and during Covid-19 regarding employment, unemployment, and underemployment rates.

Research Hypothesis

In the field of research, **a** research hypothesis was used to guide the process of the study. Additionally, hypotheses play a crucial role in research as they provide the basis for making predictions and testing relationships between variables. The subsequent hypotheses form the framework of the study:

H_o. There is no significant difference among the rates of employment, unemployment, and underemployment before and during the covid-19 pandemic;

H_a**.** There is a significant difference among the rates of employment, unemployment, and underemployment before and during the covid-19 pandemic.

Significance of the Study

The study could help understand how the global crisis affected jobs. By examining information from before the pandemic and comparing it to what happened during the pandemic, we learned a lot about the challenges people faced with finding work. The study could benefit to different sectors in different ways.

Employers could have learned how the pandemic affected their sector and how they could have changed their hiring strategies to fit the current job market by reviewing employment rate data from before and during the pandemic.

This study might be used to guide unemployed workers on their job search strategies, spot potential employment opportunities, and spend efforts on improving desirable skills.

It could help the National Economic and Development Authority (NEDA) to anticipate information regarding employment rate and this might help them to evaluate the effectiveness of government policies and programs aimed at mitigating the economic impact of the pandemic, especially on the workforce.

It could help future researchers to have an idea regarding the employment rate before and during Covid-19 Pandemic by the results that the researchers gather. That way, they will be able to further discuss the topic by fulfilling the gaps the present researchers have missed.

Time and Place

The study was conducted from the beginning of the first semester of the academic year 2022-2023 and was finished after the second semester of the academic year 2022-2023. The study took place at the Cavite State University–Main Campus.

Scope and Limitations of the Study

This study focused on the comparative analysis of employment rates in the Philippines. The rates that were compared included employed, unemployed, and underemployed rates before and during the Covid-19 Pandemic.

The data used in the study was gathered from the Philippine Statistics Authority to analyze the difference in employment rates before and during the Covid-19 Pandemic. The study did not address any additional issues that were not dealt with by the three variables.

Conceptual Framework

This study is to compare the employment, unemployment, and unemployment rate before and during the Covid-19 pandemic.

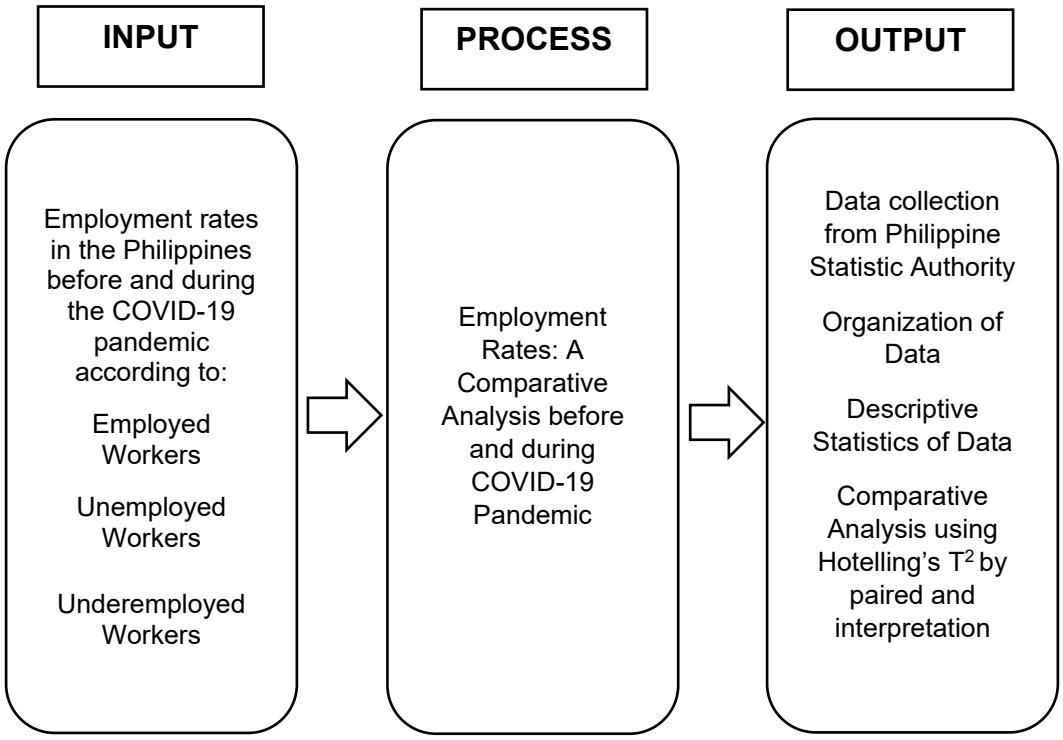

Figure 1. Conceptual Framework of the Study

Figure 1 shows the conceptual framework of the study. The input comprises employment rates in the Philippines before and during the COVID-19 pandemic, categorized into employed, unemployed, and underemployed workers. The process involves data collection from the Philippine Statistics Authority, organizing and applying descriptive statistics to the data, and comparing the employment rate before and during the COVID-19 Pandemic, the researchers will use Hotelling's T-squared method for paired samples. The output of this research will be a comprehensive report titled "Employment Rates: A Comparative Analysis before and during COVID-19 Pandemic," providing valuable information about the pandemic's impact on employment and informing decision-making for a resilient and inclusive recovery

Definitions of Terms

There is a need to define some terms for clarity and a better understanding of the study. Hence, the following terms are operationally defined.

Comparative Analysis. It is a method of comparing the employment rates before and during the pandemic in the Philippines with the idea of uncovering and discovering new ideas about them. It is the chosen research design to identify and evaluate the performance differences between the two time periods.

Employment. In this study, it refers to the condition of having p aid work for individuals residing in the Philippines. The study aims to determine if there is a significant change in employment rates before and during the COVID-19 pandemic

Employment rate. Defined as a measure of the extent to which available labor resources (people available to work) are being used. Falls under this are employment, unemployment, and underemployment, which is the focus of the study.

Pandemic. It is a disease outbreak that spreads across countries or continents, which recently started last March 2020. It is the timeline we will use for the during covid-19 pandemic, from Jan2020-Dec2022; and before covid-19 was Jan2017-Dec2019.

Underemployment. Underemployment is a measure of the total number of people in an economy who are unwillingly working in low-skill and low-paying jobs or only part-time because they cannot get full-time jobs that use their skills.

Unemployment. Refers to a situation where a person actively searches for employment but is unable to find work.

Unemployment rate. It is calculated as the number of unemployed individuals as a percentage of the labor force, which includes both employed and unemployed individuals actively seeking work.

REVIEW OF RELATED LITERATURE

This chapter presents the related literature the researcher sought to give enough background to understand the study.

Overview of employment, unemployment, and underemployment rates before and during the pandemic.

Foreign Studies

According to OECD Employment Outlook (2022), there are significant variations across countries and groups. Labor force participation and employment rates remain below pre-crisis levels in some countries, as does employment in low-pay and low-skilled jobs. Wage growth is struggling to keep pace with price rises. The result? Vulnerable households, already lagging in the recovery, are facing the biggest erosion of their real incomes. The Bureau of Labor Statistics US Department of Labor (2022) stated that the COVID-19 pandemic prompted an economic recession from February 2020 to April 2020, leading to substantial declines in output and employment. While the recession only lasted a few months, the pandemic persisted through 2021, continuing to disrupt economic activity, prevent or discourage individuals from re-entering the labor force, and impact other economic conditions that affect employment. The economy rebounded in 2021, regaining approximately 4.6 million jobs; however, this equates to only about half of the jobs that were lost from 2019 to 2020.

According to the international labor organization (2022) estimates, in the low scenario where the global GDP growth drops by around 2 percent: Global unemployment would increase by 5.3 million. “Mid” scenario where GDP growth drops by 4 percent Global unemployment would increase by 13 million. “High” scenario where COVID-19 has serious disruptive effects, reducing GDP growth by around 8 percent: Global unemployment would increase by 24.7 million, with an

uncertainty ranging from 13 million to 36 million from a base level of 188 million in 2019. The estimated level of unemployment is above the total increase in unemployment at the time of the global financial crisis of 2008-2009.

As shown by the data from the study of Beno (2021), the T-Test confirmed the difference in unemployment before and during the crisis in the age categories 15-24 and 25-54. The analysis of unemployment among different age groups presents differences related to different variables, the sample of countries, the time horizon, and the statistical method used. Based on the received data, unemployment decreases with age. The 15-24 group shows significantly higher unemployment. A gender unemployment difference was confirmed only in the Czech Republic and Slovakia. Unemployment has risen during the Covid-19 pandemic. An unemployment gap before and during Covid-19 was not confirmed for females. In the Czech Republic, there is a significant difference only between the youngest group and the other two. In all countries, the largest number of people with employment of up to one year are in the age group 25-54 years. In none of the examined countries was a gender unemployment gap before Covid-19 proved.

Bell & Blanchflower (2020) reported the findings from an online poll fielded from 11–16 April 2020 showing that a third of workers in Canada and the US report that they have lost at least half of their income due to the Covid-19 crisis, compared with a quarter in the UK and 45% in China. They estimate that the unemployment rate in the US is around 20% in April. It is hard to know what it is in the UK given the paucity of data, but it has gone up a lot.

According to Dorfman (2022), employment in the retail trade sector experienced strong growth from 2010 to 2017 while recovering from the 2007–09 Great Recession. Employment grew from its Great Recession low of 14.4 million workers in 2010 to a peak of 15.8 million in 2017, growing by an average annual rate of 1.3 percent. During this period, retail employment was similar to overall employment growth in the broader nonagricultural wage and salary and service-

providing sectors (1.7-percent annual growth for both). However, beginning in 2017, employment in retail trade began to decline and significantly diverge from the rest of the economy. From 2017–19, employment in retail trade contracted by approximately 200,000 jobs (0.7-percent annual average decline). Total nonagricultural wage and salary employment grew by 1.5%, and service-providing employment increased by 1.4% during the 2017–19 period. COVID-19 led to stay-at-home orders and government-mandated shutdowns of businesses. Fear of the virus caused consumers to avoid interpersonal contact with others; many chose to stay away from stores. All of this led to a decrease in employment in retail trade. Motor vehicle and parts dealers, miscellaneous store retailers, and gasoline stations, all of which experienced employment growth from 2017–19, combined for just over one-quarter of retail sector employment loss between 2019 and 2020. Stay-at-home orders and travel limitations caused many consumers to reduce expenditures on gasoline and automobile maintenance and repair. Furthermore, stay-at-home orders and the pandemic-related recession led to significant deferrals of new automobile purchases, which contributed to the large cyclical decline in employment.

Local Studies

In 2017, the Philippine Statistics Authority stated that of the total employed persons, 65.2 percent were full-time workers, while 33.8 percent were part-time workers. Those who did not report for work during the reference week comprised 0.9 percent.

The underemployed persons or those employed persons who expressed the desire to have additional hours of work in their present job, or to have an additional job, or to have a new job with longer working hours was estimated at 6.5 million persons corresponding to an underemployment rate of 16.1 percent. Underemployed persons who work for less than 40 hours a week are called visibly underemployed persons. They accounted for 56.0 percent of the total underemployed in 2017. By

comparison, the underemployed persons who worked for 40 hours or more in a week made up 42.5 percent. By sector, 39.0 percent of the underemployed worked in the agriculture sector, while 34.7 percent were in the services sector. Those in the industry sector accounted for 26.3 percent.

They also stated that the unemployed persons numbered about 2.4 million resulting in an annual unemployment rate of 5.7 percent. Of this number, 76.1 percent belonged to the age group 15 to 34 years. Those in the age group 15 to 24 years comprised 46.7 percent and those in the age group 25 to 34 years, 29.4 percent (Table 3). Among the regions, Ilocos Region (8.9%), NCR (7.4 percent), and CALABARZON (7.0 percent) were the regions with the highest unemployment rates.

In 2018, 68.4 percent were full-time workers, while 30.8 percent were part-time workers. Those who did not report for work during the reference week comprised 0.9 percent. In 2017, full-time workers composed 65.2 percent of the total employed while part-time workers, were 33.8 percent. In 2018, workers worked 42.1 hours per week, on average, while in 2017, the mean hours worked per week was 41.4. By definition, employed persons who express the desire to have additional hours of work in their present job, to have additional jobs, or to have a new job with longer working hours are considered underemployed. In 2018, the number of underemployed persons was estimated at 6.7 million persons corresponding to an underemployment rate of 16.4 percent.

Underemployed persons who work for less than 40 hours a week are called visibly underemployed persons. They accounted for 53.2 percent of the total underemployed persons in 2018 and 56.0 percent in 2017. By comparison, the underemployed persons who worked for 40 hours or more in a week made up 45.6 percent. By sector, 45.5 percent of the underemployed persons worked in the services sector, while 34.6 percent were in the agriculture sector. Those in the industry sector accounted for 19.9 percent. In 2018, the unemployed numbered about 2.3 million resulting in an annual unemployment rate of 5.3 percent. Among the regions, Ilocos

Region (6.8 percent), NCR, and CALABARZON (6.6 percent) were the regions with the highest unemployment rates. Of the total employed persons in 2019, 67.6 percent were full-time workers, while 31.7 percent were part-time workers. Those who did not report for work during the reference week comprised 0.7 percent by definition, employed persons who express the desire to have additional hours of work in their present job, or to have additional jobs, or to have a new job with longer working hours are considered underemployed. In 2019, the estimated number of underemployed persons was estimated at 477.5 thousand persons corresponding to an underemployment rate of 14.9 percent. In 2018, the underemployment rate was 17.8 percent. In 2019, unemployment in Central Visayas was estimated at 5.2 percent which is lower than the following regions: BARMM (6.6 percent), CALABARZON (6.1 percent), NCR (5.8 percent), and Ilocos Region (5.3 percent).

In 2020, the total number of employed persons was estimated at 33.8 million. The proportion of employed persons to the total labor force, also known as the employment rate, was reported at 82.4 percent. Employment declined in all regions in April 2020 as compared with the same period in 2019. Seven of the 17 regions, namely: Davao Region (82.1%), SOCCSKSARGEN (78.8 percent), Ilocos Region (77.7%), Zamboanga Peninsula (76.1 percent), Cordillera Administrative Region (CAR) (74.7 percent), Central Luzon (72.7 percent), and BARMM (70.2 percent) registered an employment rate lower than the national figure (82.4 %).

Underemployed persons who work for less than 40 hours a week are called visibly underemployed. They accounted for 52.5 percent of the total underemployment in April 2020. By comparison, the underemployed persons who worked for 40 hours or more in a week made up 14.2 percent.

In April 2020, the number of unemployed persons was 7.2 million resulting in an unemployment rate of 17.6 percent. This is a record high for the unemployment rate reflecting the effects of the economic shutdown to the Philippine labor market due to the COVID-19 pandemic. All regions registered a double-digit unemployment rate. The

regions with unemployment rates higher than the national figure (17.6 percent) were the following: BARMM (29.8 percent), Central Luzon (27.3%), CAR (25.3 %), Zamboanga Peninsula (23.9%), Ilocos Region (22.3 %), SOCCSKSARGEN (21.2 percent), and Davao Region (17.9 %). The lowest unemployment rate was in Northern Mindanao at 11.1 percent.

In April 2020, the category ECQ/Lockdown/COVID-19 pandemic was included in the reasons for not looking for work to assess the impact of the COVID-19 pandemic in the Philippine Labor Market. Among the unemployed persons, the majority (88.1 percent) expressed their lack of interest to look for work in April 2020 due to the COVID-19 pandemic. This was followed by awaiting results of previous job applications at 5.1 percent and waiting for rehire or job recall at 3.7 percent.

In 2021, the Unemployment rate in the country slightly picked up in December 2021 at 6.6 percent from the 6.5 percent reported in November 2021. In terms of magnitude, the total number of unemployed persons in December 2021 was estimated at 3.27 million, higher by 113 thousand than the 3.16 million unemployed persons reported in November 2021. The country's employment situation in December 2021 was registered at 93.4 percent, the second highest rate since January this year. Employed persons increased by 797 thousand in December 2021 estimated at 46.27 million from 45.48 million in November 2021.

The underemployment rate was estimated at 14.7 percent in December 2021 from 16.7 percent in November 2021. This was the fifth-lowest underemployment rate in 2021. Underemployed persons are employed persons who expressed the desire to have additional hours of work in their present job or to have an additional job, or to have a new job with longer hours of work.

Visible underemployment rate or the proportion of those persons working less than 40 hours in a week and expressed the desire to have additional hours of work in

their present job or to have an additional job, or to have a new job with longer working hours, to the total employed, was estimated at 9.8 percent in December 2021, lower than the 11.5 percent in November of the same year.

On the other hand, invisibly underemployed or those working at least 40 hours a week but still expressed the desire to have additional hours of work in their present job or to have additional job, or to have a new job with longer working hours, were estimated at 4.9 percent of the total employed individuals in December 2021. This was lower than the 5.2 percent estimate in November 2021.

Overview of Multivariate Analysis

According to Greenacre & Primicerio (2013), Multivariate analysis is the area of statistics that deals with observations made on many variables. The main objective is to study how the variables are related to one another, and how they work in combination to distinguish between the cases in which the observations are made.

The analysis of multivariate data permeates every research discipline: biology, medicine, environmental science, sociology, economics, education, linguistics, archaeology, anthropology, psychology, and behavioral science, to name a few, and has even been applied in philosophy. All natural and physical processes are essentially multivariate—the challenge is to understand the process in a multivariate way, where variables are connected and their relationships understood, as opposed to a bunch of univariate processes, i.e. single variables at a time, isolated from one another.

Hotelling's T^2

Based on Hotelling (1931) cited by Glen (n,d), Hotelling's T-squared is the multivariate counterpart of the T-test. Multivariate means that you have data for more than one parameter for each sample. For example, let's say you wanted to compare how well two different sets of students performed in school.

It is used in multivariate datasets as a measure of distance from the center of distribution and follows the *F* distribution. Its use is compared with Chi-squared, and it is shown that for modest sample sizes, quite different conclusions may be drawn about whether observations are outliers. The low probability of finding observations in the center of a multivariate distribution is also described. Hence, Hotelling's T^2 follows the *F* distribution and can therefore be used as a means of converting the Mahalanobis distance from a centroid to a probability of belonging to a predefined multivariate distribution. As an approximation, this statistic equals the squared Mahalanobis distance from the mean divided by the number of variables unless sample sizes are small. (Brereton, 2015)

Synthesis

This study is important because it helps us to compare the employment rates in the Philippines before and during the pandemic. Other studies have shown that different countries and groups have experienced different changes in employment rates. Some countries have had fewer people working, especially in low-paying and low-skilled jobs. The COVID-19 pandemic caused a big economic downturn, which led to a lot of job losses around the world. Although the economy started to recover in 2021 and some jobs were regained, it still didn't make up for all the jobs lost between 2019 and 2020.

This study is like other research that has been done on this topic, but the researchers believe it's important to do this study now to get clearer information specifically about employment rates in the Philippines before and during the pandemic. This information can be useful for the government, employers, and people who are currently unemployed. The researchers looked at other studies and research to get a starting point for understanding employment rates in the Philippines during this time because there hasn't been much focus on this country specifically.

METHODOLOGY

This chapter focused on the methodological procedures that were employed to perform the research. It covered the research design, data collection, multivariate analysis, and statistical software used.

Research design

This study used a quantitative comparative research design. This research design allowed the researcher to compare the two variables. The researchers compared the employment, unemployment, and underemployment rate before and during the Covid-19 Pandemic in the Philippines for the years 2017-2019 and 2020-2022 using Hotelling's T^2 for paired samples.

Sources of Data

The data of this study were obtained from the official site of the Philippine Statistics Authority. The researcher utilized secondary data from 2017-2019, comprising a total of 36 observations, as data before the pandemic. Additionally, data from 2020-2021, consisting of 36 observations, were used to represent the period during the COVID-19 Pandemic. The researcher collected quarterly data on employment, unemployment, and underemployment rates in the Philippines.

Multivariate Analysis

Multivariate Line Chart

A horizontal x-axis and a vertical y-axis make up the line graph. Since most line graphs only deal with positive numbers, these axes usually cross towards the y-bottom axis and the x-left axis's end. The intersection of the axes is always the same (0, 0). A data type is assigned to each axis. In a "dot-to-dot" form, data points are plotted and connected by a line. Since its values are independent of anything, the x-axis is also known as the independent axis. Because its values are reliant on those of

the x-axis, the y-axis is also known as the dependent axis. As a result, the graph's line always moves horizontally, and each x value has only one y value. As a comparison, more than one line can be plotted on the same axis.

Descriptive Analysis

Descriptive analysis allows objective, complete, and useful sensory data; it serves as a varied source of product information in industry, government, and research settings. The researchers employed a descriptive analysis to describe the rates before and during Covid-19 Pandemic regarding employment, unemployment, and underemployment in the Philippines. Multivariate descriptive analysis can be determined by calculating the sample mean.

Mean Vectors

Given a sample of size n for each variable x_i of the form $x_{1j,\dots,}x_{nj}$ and k random variables $x_1, x_2, \dots, x_k$. The $k\ x\ 1$ column vector X (also known as a random vector) can be defined as follows:

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_k \end{bmatrix}$$

(also known as $X = ([x_{\mathrm{k}}])$ and then the sample mean (vector) of X as

$$\bar{X} = \begin{bmatrix} \bar{x}_1 \\ \bar{x}_2 \\ \vdots \\ \bar{x}_k \end{bmatrix}$$

and similarly for the sample variance, standard deviation, and other statistics.

Covariance Matrix

A covariance matrix represents the covariance values between pairs of items in a random vector. The variance-covariance matrix is another name for the covariance matrix. This is because each element's variance is represented along the matrix major diagonal. The variance and covariance formulas are needed to calculate

the covariance matrix. The variance and covariance can be found for both sample data and population data, depending on the type of data available.

The general form of a variance-covariance matrix can be calculated using these formulas:

$$\begin{array}{c} \\ X_1 \\ Y_1 \\ X_2 \\ Y_2 \\ X_3 \\ Y_3 \end{array} \begin{array}{c} \begin{array}{cccccc} X_1 & Y_1 & X_2 & Y_2 & X_3 & Y_3 \end{array} \\ \begin{bmatrix} var(x_1) & cov(y_1x_1) & cov(x_2x_1) & cov(y_2x_1) & cov(x_3x_1) & cov(y_3x_1) \\ cov(x_1y_1) & var(y_1) & cov(x_2y_1) & cov(y_2y_1) & cov(x_3y_1) & cov(y_3y_1) \\ cov(x_1x_2) & cov(y_1x_2) & var(x_2) & cov(y_2x_2) & cov(x_3x_2) & cov(y_3x_2) \\ cov(x_1y_2) & cov(y_1y_2) & cov(y_2y_2) & var(y_2) & cov(x_3y_2) & cov(y_3y_2) \\ cov(x_2x_3) & cov(y_1x_3) & cov(x_2x_3) & cov(y_2x_3) & var(x_3) & cov(y_3x_3) \\ cov(x_1y_3) & cov(y_1y_3) & cov(x_2y_3) & cov(y_2y_3) & cov(x_3y_3) & var(y_3) \end{bmatrix} \end{array}$$

where:

X_1 = Employed before pandemic Y_1 = Employed during pandemic

X_2 = Unemployed before pandemic Y_2= Unemployed during pandemic

X_3 = Under-employed before pandemic Y_3= Under-employed during pandemic

Hotelling's T^2 for paired samples

Assumptions for the Hotelling's T^2

Various assumptions were considered before conducting Hotelling's T^2 statistics. Some of the assumptions state that:

the data are multivariate normally distributed, the Jarque-Bera test is the normality test used to determine if a data set is multivariate normally distributed.

H_o. The dataset is multivariate and normally distributed.

H_a. the dataset does not come from multivariate normal distribution.

Decision rule: If p-value > significance level (α) then we reject the null hypothesis.

the data have a common variance-covariance matrix-$\sum$, the null hypothesis can be tested using Bartlett's Test

H_o. $\sum_1 = \sum_2$

H_a. $\sum_1 \neq \sum_2$

Decision rule: If p-value > significance level (α) then we reject the null hypothesis.

The T^2 test statistic for Paired Samples

The T^2 test statistic of Hotelling's T^2 for paired samples is defined as:

$$T^2 = n\bar{Y}'S_y^{-1}\bar{Y}$$

It is a function of sample size n, the sample mean vectors, $\bar{Y}'$, and the inverse of the variance-covariance matrix S_y^{-1}.

First, we will define Y to denote the sample mean vector of the vectors Y_i. And we will define S_y to denote the sample variance-covariance matrix of the vectors Y_i.

$$S_Y = \frac{1}{n-1}\sum_{i=1}^{n}(Y_i - \bar{Y})\,(Y_i - \bar{Y})'$$

Then we will define an *F*-statistic as given in the expression below:

$$F > F_{p,n-p,\alpha}$$

If the p-value is less than the significance level (α), typically 0.05, the researchers would reject the null hypothesis. This rejection would suggest that there is evidence to support a significant difference in the rates before and during the pandemic. Conversely, if the p-value is greater than the significance level, the researchers would retain the null hypothesis. This retention would indicate that there is insufficient evidence to suggest a significant difference in the rates between the two periods.

Statistical Software Used in the Study

This study was conducted using R-Studio, an Integral Development Environment (IDE) for R, a statistical computing, and graphics programming language. It comes in two flavors: RStudio Desktop is a traditional desktop program, and RStudio Server is a web-based application that runs on a remote server. Microsoft Excel is a powerful and flexible tool. It can assist in finding information more quickly and automatically extracting data from changing data. XLSTAT also used this study to

assess the normal distribution of data. It provides various tools and tests that help researchers evaluate the normality assumption of their data within the Microsoft Excel environment.

RESULTS AND DISCUSSION

This section presents the findings of a multivariate line chart, which illustrates the behavior of the employment, unemployment, and underemployment rates in the Philippines before and during the COVID-19 Pandemic, descriptive analysis, which shows the rates before and during the Covid-19 Pandemic regarding the employment, unemployment, and underemployment in the Philippines; Covariance matrix, which explains the relationship between the two dependent samples, and finally applying the multivariate Hotelling's T^2 and multivariate line chart to determine the significant difference between before and during Covid-19 Pandemic regarding the employment, unemployment, and underemployment rates.

Multivariate Analysis

Multivariate Line Chart

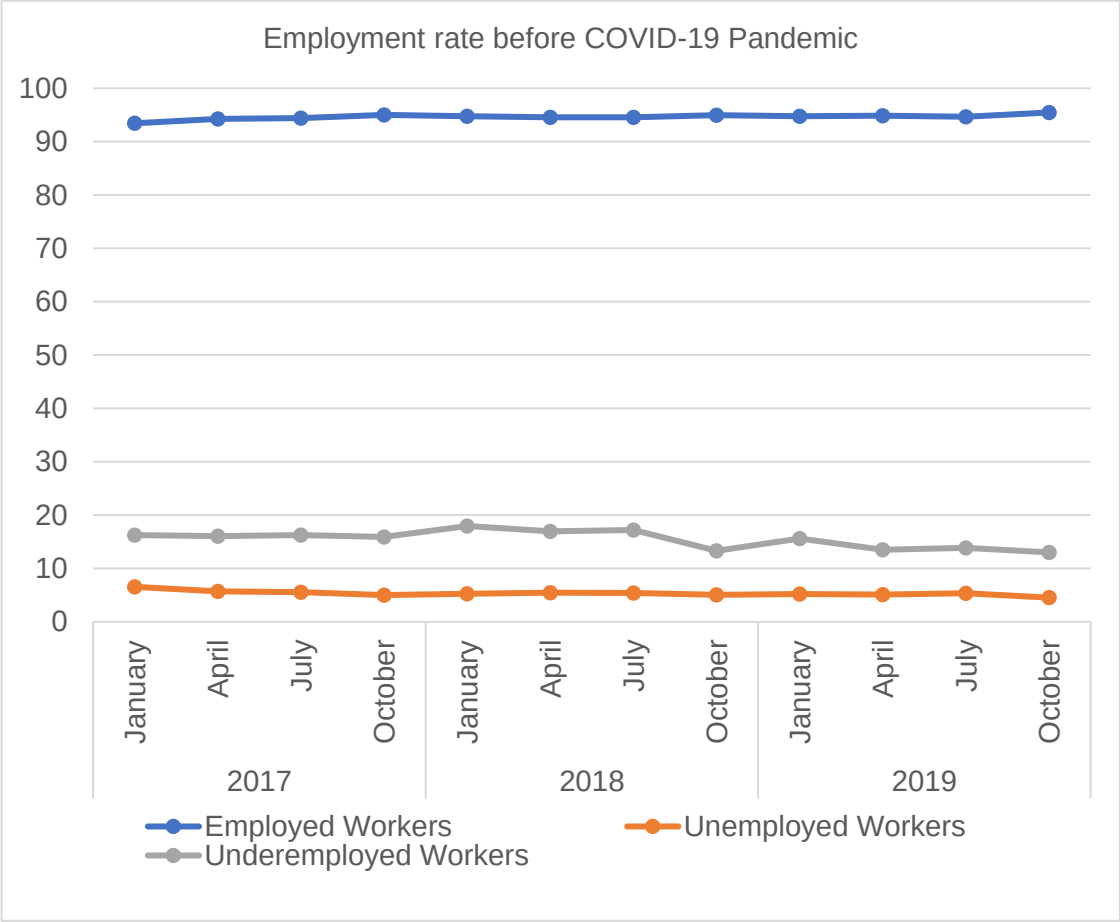

Figure 2. Employment rate in the Philippines before COVID-19 pandemic

Figure 2 shows the multivariate line chart of behavior of the employment, unemployment, and underemployment rates in the Philippines from 2017–2019. The data reveals a relatively stable trend in the employment rate throughout the period before the pandemic. In January 2017, the rate stood at 93.44 percent and gradually increased to 95.46 percent by October 2019. This suggests a steady level of employment with a few swings noted before the pandemic. On the other hand, the percentage of unemployed workers exhibits an ongoing downward trend. The unemployment rate steadily decreased from 6.56 percent in January 2017 to 4.54 percent in October 2019. These data point to an improvement in the labor market as a whole and a decline in the unemployment rate.

Regarding the underemployment data, it peaked in January 2017 at 16.26 percent and fell to 13.02 percent in October 2019. But at the rate of 17.96 percent in January 2018, signal times when part-time or low-skill work was more common.

Based on the International Labour Organization's study entitled "COVID-19 labor market impact in the Philippines" conducted in Q4 2019, it was found that approximately 25 percent of the total employment in the Philippines, equivalent to around 10.9 million jobs, was estimated to be at medium or high risk of disruption due to the COVID-19 pandemic. This assessment specifically pertains to the year 2020, during the COVID-19 pandemic. Among these jobs, approximately 38 percent were held by women. The gender imbalance in the impact can be attributed to the predominant representation of men in the medium- and high-risk sectors of the economy.

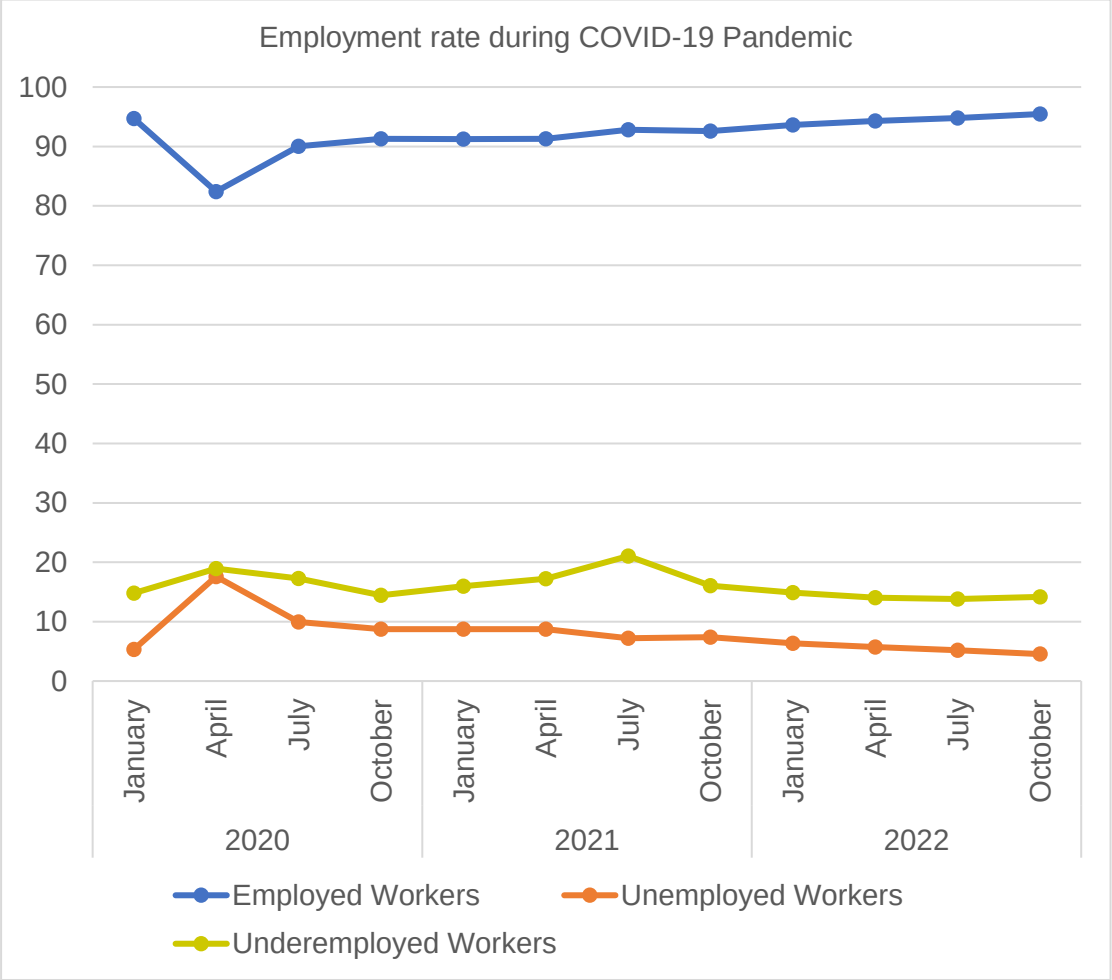

Figure 3. Employment rate in the Philippines during COVID-19 pandemic

Figure 3 shows the multivariate line chart of behavior of the employment, unemployment, and underemployment rates in the Philippines from 2020-2021. In April 2020, there was a significant drop in the employment rate to 82.4 percent, which can be attributed to the global COVID-19 pandemic and the resulting economic disruptions. According to the International Labour Organization, between 7 to 30 April, additional measures were implemented to ease the negative blow of the pandemic. COVID-19 temporarily stopped the operation of more than 390,000 small businesses while about 1 million more were forced to operate with a skeletal workforce.25 To address this issue, the Department of Finance (DOF) proposed an aid package worth 51 billion

Philippine pesos for workers in micro, small, and medium-sized enterprises (MSMEs) affected by the lockdown. Recognizing that COVID-19 will necessarily entail adjustments in the educational system, the Department of Education (DepEd) drafted a learning continuity plan for the upcoming school year.26 To increase the accessibility of technical vocational training amid ECQ, the Technical Education and Skills Development Authority (TESDA) encouraged the public to enroll in any of its 68 short online courses.27 Meanwhile, a program that provides cash aid to displaced artists and cultural workers was implemented by the National Commission for Culture and the Arts (NCCA).28 In addition, plans to revamp Philippine tourism given the pandemic context were outlined by the Department of Tourism (DOT). Another extension of the ECQ in Metro Manila and other regions in Luzon was announced on 24 April.

However, the rate gradually recovered and reached its highest point of 95.46 percent in October 2022. This recovery indicates a resilient labor market and the gradual restoration of employment opportunities. However, the data on unemployed workers shows a different pattern. When the pandemic reached its height in April 2020, the jobless rate increased sharply to 17.6 percent.

Underemployment peaked in July 2021 at 21.04 percent, showing a higher percentage of people working part-time or in occupations below their skill level. However, the rate fell to 14.17 percent by October 2022, indicating a slow but steady improvement in the standard of work prospects.

According to the Philippine Statistics Authority's report on Friday, the country's unemployment rate reached its lowest point in four months in April, although the quality of jobs experienced a slight decline. Preliminary data from the April Labor Force Survey (LFS) showed that the unemployment rate decreased from 4.7 percent in March and 5.7 percent in April of the previous year to 4.5 percent in April. This meant that 2.26 million Filipinos were unemployed in April, which was a decrease of 160,000 from March and over half a million from April 2022. The unemployment rate in April was the lowest in four months since December 2022, which stood at 4.3 percent. The statistics

authority reported that the average unemployment rate for the year so far was 4.7 percent, down from the 5.4 percent average in 2022 and 7.8 percent in 2021. On the other hand, the employment rate in April increased to 95.5 percent from 95.3 percent in March and 94.3 percent in April of the previous year. This resulted in 48.06 million employed Filipinos in April, a decrease of 523,000 from March but an increase of 2.43 million compared to April last year. To maintain the trend of lower unemployment rates, the government was encouraged to capitalize on digital technologies, implement economic liberalization reforms, and collaborate with various stakeholders to equip the workforce with digital technology skills and foster innovation.

According to Malonzo (2022), the employment rate in the country reached 95.5 percent in October 2022, marking the highest level since the onset of the Covid-19 pandemic in 2020, as reported by the Philippine Statistics Authority (PSA) on December 7, 2022. The PSA suggests that this figure indicates a complete recovery of the employment rate to its pre-pandemic level. In October, the estimated number of employed individuals in the country was 47.11 million, representing an increase of over seven percent compared to the same period the previous year. However, this figure was slightly lower than the 47.58 million employed persons reported in September 2022. Concurrently, the unemployment rate has dropped to 4.5 percent, which is equivalent to approximately 2.4 million individuals, reaching levels comparable to the pre-pandemic period.

Descriptive Analysis

For the goals of the study, the researchers used descriptive analysis to assess the rates before and during Covid-19 Pandemic regarding employment, unemployment, and underemployment in the Philippines. The sample mean is used to determine a descriptive analysis multivariate.

Table 1: Sample mean of employment rate in the Philippines

SUBGROUP	BEFORE PANDEMIC (2017-2019)	DURING PANDEMIC (2020-2022)
Employed	94.6400	92.0400
Unemployed	5.3600	7.9600
Underemployed	15.5000	16.0500

The mean values in Table 1 represent the average percentages of the working-age population in each subgroup before and during the pandemic. Before the pandemic (2017-2019), the mean employment rate was 94.64 percent, indicating that, on average, around 94.64 percent of the working-age population was employed during this period. This suggests a relatively high proportion of people were able to find jobs. The mean unemployment rate was 5.36 percent, implying that, on average, approximately 5.36 percent of the labor force were actively seeking employment but couldn't find it. A lower unemployment rate indicates a smaller percentage of people facing unemployment. The mean underemployment rate was 15.50 percent, meaning that, on average, about 15.50 percent of the labor force were employed but not fully utilizing their skills or abilities. This suggests that a significant proportion of people had jobs but were not working to their full capacity.

During the pandemic (2020-2022), the mean employment rate decreased to 92.04 percent. This suggests that, on average, around 92.04 percent of the working-age population was employed during this period. It indicates a decline compared to the pre-pandemic period, implying that fewer people were able to find employment opportunities during the pandemic. The mean unemployment rate increased to 7.96 percent, indicating that, on average, approximately 7.96 percent of the labor force were actively seeking employment but couldn't find it. It shows a higher percentage of people

facing unemployment compared to the pre-pandemic period. The mean underemployment rate slightly increased to 16.05 percent. This suggests that, on average, about 16.05 percent of the labor force were employed but not fully utilizing their skills or abilities. Although there was a slight increase compared to the pre-pandemic period, the difference is relatively small.

These findings tell us that the job situation became more challenging during the later period. Students and young people need to be aware of these changes when they enter the job market. It also shows that policymakers and employers need to find ways to create more job opportunities and match people's skills with the right jobs.

Covariance Matrix

	X_1	Y_1	X_2	Y_2	X_3	Y_3
X_1	0.2367	0.3740	-0.2367	-0.3740	-0.3884	0.2705
Y_1	0.3740	12.1382	-0.3740	-12.1382	-2.3209	-4.3724
X_2	-0.2367	-0.3740	0.2367	0.3740	0.3884	0.2705
Y_2	-0.3740	-12.1382	0.3740	12.1382	2.3209	4.3724
X_3	-0.3884	-2.3209	0.3884	2.3209	2.7622	2.1150
Y_3	-0.2705	-4.3724	0.2705	4.3724	2.1150	4.9269

Legends:
X_1 = Employed before pandemic
X_2 = Unemployed before pandemic
X_3 = Under-employed before pandemic
Y_1 = Employed during pandemic
Y_2 = Unemployed during pandemic
Y_3 = Under-employed during pandemic

Figure 4. Covariance Matrix of Employment Rate before and during the pandemic

Figure 4 shows the Covariance Matrix of the Employment Rate before and during the pandemic. The variance measures the dispersion or spread of data within a variable. In this case, the variance for employed individuals before the pandemic is 0.2367, and for employed individuals during the pandemic, it is 12.1382. The variances for unemployed individuals before and during the pandemic are also 0.2367 and 12.1382, respectively. For underemployed individuals, the variance before the pandemic is 2.7622, and during the pandemic, it is 4.9269.

It is interesting to note that the employed and unemployed individuals during the pandemic have the same largest value of variance. This suggests that the employment rate during the pandemic is highly dispersed, indicating a wider range of employment outcomes. On the other hand, the variance for unemployed individuals before the pandemic is the lowest, indicating that the employment rate before and during the pandemic is closer in comparison to other years.

Regarding the relationship between variables, the employment before and during the pandemic and unemployment rates before and during the pandemic, as well as the employment before and during the pandemic and underemployment rates before and during the pandemic shows an inverse relationship with negative covariances. The negative covariances, represented by the respective values -0.2367, -0.3740,-0.3884, -0.2705, -12.1382, -2.3209, and -4.3724, indicate that an increase in one variable is associated with a decrease in the other variable. This means that when the employment rate goes up, unemployment and underemployment go down. Furthermore, unemployment before and during the pandemic and underemployment before and during the pandemic have a direct relationship having a positive covariance, which means that when one goes up, the other also goes up.

Significant difference in Employment Rate before and during the pandemic in the Philippines

The assumption for Hotelling's T^2

Jarque-Bera tests

In this study, Jarque-Bera tests were to assess the normality distribution of two variables: before and during the pandemic.

Table 2. Jarque-Bera test

VARIABLE\TEST	STATISTICAL TEST	P-VALUE	REMARKS
Before Pandemic	Jarque-Bera	0.05*	Both have followed
During Pandemic	Jarque-Bera	0.05*	Normal Distribution

**significant at 5 percent level of significance*

Testing the normality of observations has become a standard feature in statistical work. The Jarque-Bera test is a goodness-of-fit test of departure from normality, based on the sample skewness and kurtosis (Jarque,2014). Table 3 shows the results using the Jarque-Bera test of employment rate before and during the Pandemic. The Jarque-Bera test is a statistical test used to assess whether a given dataset follows a normal distribution. It shows that the p-value is equal to 0.05, which implies that we failed to reject the null hypothesis, and the data could potentially follow a normal distribution.

Based on the results of the tests, we can confidently conclude that the employment rates before and during the pandemic do have a multivariate normal distribution.

Bartlett's test

The results of Bartlett's test for homogeneity of variances comparing before and during pandemic data are as follows:

Table 2. Bartlett's Test of homogeneity of variance

	BARTLETT'S TEST	DEGREE OF FREEDOM	P-VALUE	REMARKS
Before and during the pandemic	57.4170	5	0.0000	The Vector Variance is not Equal

**significant at a 5 percent level of significance*

This table shows Bartlett's Test of homogeneity of variance. Bartlett's Test value is 57.4170. The degrees of freedom associated with the test are 5,

representing the number of independent pieces of information available for estimating the parameter or conducting the test. The p-value obtained from the test is 4.148e-11 or 0.0000, which is an extremely small value. The p-value suggested rejecting the null hypothesis, indicating that the variances of employment rates before and during the pandemic are significantly different. Since the sample size of the data is equal, hotelling's t^2 can be conducted even with this violation of assumption since the data follows a multivariate normal distribution. But if the sample size is not equal, and the data does not follow a multivariate normal distribution, hotelling's t^2 can not be done.

Hotelling's T^2

For the scenario of two dependent samples, the researchers use Hotelling's T^2 statistic. To see if the population means of the Employment Rate before and during the pandemic in the Philippines are equal, the null hypothesis H_o: $\mu_x = \mu_y$ is tested; reject the null hypothesis and accept the alternative hypothesis if H_o: $\mu_x \neq \mu_y$ and the estimated p-value is larger than the level of significance.

Table 4. Summary results using Hotelling's T^2

	Df_1	Df_2	HOTELLING'S T^2	P-VALUE	REMARKS
Before and During the Pandemic	1	35	0.0930	0.7620^{ns}	There is no significant difference

ns*: not significant at a 5% level of significance*

The table presents the results of Hotelling's T^2 test conducted to compare the employment rates before and during the COVID-19 pandemic, assuming covariance. There were 29 degrees of freedom in the test, and Hotelling's T^2 value was 0.092966. The p-value associated with the test is 0.7622, which exceeds the significance level of 5% that was selected. Therefore, based on this analysis, we fail to reject the null hypothesis. This indicates that there is no statistically significant evidence to suggest a difference in the group means for the employment rate before

and during the COVID-19 pandemic. In other words, the test suggests that the average employment rate remained unchanged between the two periods. Since the findings of the employment rate before and during the pandemic are equal, it could have several implications. Firstly, it suggests a level of stability in the employment rates in the Philippines, indicating that the pandemic did not have a significant impact on overall employment levels. This finding implies that the economy managed to maintain a consistent level of employment despite the challenging circumstances posed by the pandemic. Understanding the underlying reasons and implications of equal employment rates will help policymakers and researchers gain a comprehensive understanding of the employment landscape and make informed decisions to support the labor market in the future.

Post et al. (2021) conducted a study examining the global impacts of COVID-19, the findings indicated that there was a non-significant decrease in student employment, although 22% of all students reported experiencing work loss due to COVID-19. Furthermore, there was a statistically significant decrease in the proportion of students engaging in sufficient levels of physical activity. Additionally, there was a significant increase in reported family stressors associated with employment loss or the inability to secure employment between March and May 2020. Two-thirds of the respondents reported increased stress as a result of the transition to online learning.

By contrast, based on the study of Adamowicz conducted in April 2022, involving 170 respondents who were active in the labor market. The findings contribute to understanding the specific effects of the pandemic on the Polish labor market.

The pandemic has had disruptive and both immediate and long-term effects on the labor market in Poland. The state's anti-crisis policies have been relatively effective in mitigating the negative economic and social consequences. Employers generally appreciated these measures more than employees did.

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This section includes a summary of the findings based on the data studied in the preceding chapter, major conclusions regarding the results, and recommendations that will be valuable to readers and future researchers.

Summary

The research "Employment Rates in the Philippines: A Comparative Analysis Before and During the Covid-19 Pandemic using Hotelling's T^2" compared and analyzed the employment rates before and during the pandemic. Its specific goal was to determine the behavior of the employment, unemployment, and underemployment rates in the Philippines from 2017–2022, assess the rates before and during Covid-19 Pandemic regarding the employment, unemployment, and underemployment in the Philippines; and analyze if there is a significant difference between before and during Covid-19 Pandemic regarding the employment, unemployment, and underemployment rates using Hotelling's T^2.

The data utilized in this study were secondary data from 2017 to 2022, based on Philippine Statistics Authority (PSA) data titled "Labor Force Participation Rate, Employment Rate, Unemployment Rate, and Underemployment Rate, Philippines: January 2005 to October 2021" from 2018. The data analysis approach was followed by the procedure on multivariate analysis methods such as Multivariate Line Chart, Descriptive Analysis, Covariance Matrix, Assumption for Hotelling's T^2, and Hotelling's T^2 for paired samples. The employment rate of the Philippines before and during the pandemic was compared using Hotelling's T^2 for paired samples and a multivariate line chart, which was based on preliminary data analysis

Conclusion

The following conclusions are formed based on the findings: Employment Rate before the pandemic has the highest rate among the three, with a mean rate of 94.64 percent. The unemployment rate, on the other hand, has the lowest rate, with a mean rate of 5.3600. The Employment Rate has the highest rate among all during the pandemic, with a mean growth rate of 92.04 percent, 7.9600 has the lowest mean rate of 7.9600. Overall, the year 2017-2022 shows that employed before and during the pandemic has the highest rate, and unemployed before and during the pandemic shows the lowest rate.

The Hotelling's T^2 test between before and during the pandemic utilizing covariance assumption is shown in the table. The result shows that Hotelling's T^2 equals 0.0930, implying that the variances are equivalent. It fails to reject the p-value (0.7622) is greater than alpha. Therefore, based on this statistical analysis, there is no significant difference in the employment rate before and during the pandemic.

Recommendations

Based on the findings and conclusions, the following recommendations are:

1. Researchers suggest that future researchers perform a study before and during the pandemic in other specific industries and understand how different industries and demographics are affected by the pandemic's economic effect.

2. Researchers advise employed workers that they should consider employment in industries even if found out the employment rate before and during the pandemic are equal.

3. The NEDA should focus on implementing policies that support businesses and industries that have been severely impacted by the pandemic and help unemployed workers develop the skills that are in demand in the coming years.

4. The researchers recommend statistically validate the results using appropriate statistical techniques. This could involve performing additional analyses, such as hypothesis testing or conducting sensitivity analyses, to strengthen the reliability of the conclusions drawn from the study.

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APPENDICES

Appendix 1. Raw data of employment rate in the Philippines from 2017 to 2022

YEAR	MONTH	Employment Rate	Unemployment Rate	Underemployment Rate
	January	93.63	6.37	14.87
2022	April	94.29	5.71	14.02
	July	94.8	5.2	13.81
	October	95.46	4.54	14.17
	January	91.25	8.75	15.97
2021	April	91.27	8.73	17.22
	July	92.81	7.19	21.04
	October	92.6	7.4	16.07
	January	94.68	5.32	14.81
2020	April	82.4	17.6	18.91
	July	90.04	9.96	17.28
	October	91.27	8.73	14.43
	January	94.77	5.23	15.59
2019	April	94.87	5.13	13.52
	July	94.64	5.36	13.87
	October	95.46	4.54	13.02
	January	94.74	5.26	17.96
2018	April	94.54	5.46	16.96
	July	94.58	5.42	17.23
	October	94.94	5.06	13.31
	January	93.44	6.56	16.26
2017	April	94.28	5.72	16.06
	July	94.42	5.58	16.28
	October	95	5	15.92

Source:https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__1B__LFS/0011B3ALFS0.px/?rxid=4a226df2-e075-48f3-9035-58224ddc7e69

Appendix 2. Assumptions using XLSTAT

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum
BEFORE	36	0	36	4.540
DURING	36	0	36	4.540

Shapiro-Wilk test (BEFORE):

W	0.695
p-value (Two-tailed)	**<0.0001**
alpha	0.05

Anderson-Darling test (BEFORE):

A^2	5.144
p-value (Two-tailed)	**<0.0001**
alpha	0.05

Lilliefors test (BEFORE):

D	0.343
D (standardized)	2.059
p-value (Two-tailed)	**<0.0001**
alpha	0.05

Jarque-Bera test (BEFORE):

JB (Observed value)	6.052
JB (Critical value)	5.991
DF	2
p-value (Two-tailed)	**0.049**
alpha	0.05

Shapiro-Wilk test (DURING):

W	0.673
p-value (Two-tailed)	**<0.0001**

Alpha	0.05

Anderson-Darling test (DURING):

A^2	5.496
p-value (Two-tailed)	**<0.0001**
Alpha	0.05

Lilliefors test (DURING):

D	0.361
D (standardized)	2.164
p-value (Two-tailed)	**<0.0001**
Alpha	0.05

Jarque-Bera test (DURING):

JB (Observed value)	6.081
JB (Critical value)	5.991
DF	2
p-value (Two-tailed)	**0.048**
Alpha	0.05

Summary:

Variable\Test	Shapiro-Wilk	Anderson-Darling	Lilliefors	Jarque-Bera
BEFORE	**<0.0001**	**<0.0001**	**<0.0001**	**0.049**
DURING	**<0.0001**	**<0.0001**	**<0.0001**	**0.048**

Appendix 3. R codes in Bartlett's test

```
> bartlett.test(list(mydata$x1,mydata$y1,mydata$x2,mydata$y2,mydata$
x3,mydata$y3))
      Bartlett test of homogeneity of variances

data:  list(mydata$x1, mydata$y1, mydata$x2, mydata$y2, mydata$x3, m
ydata$y3)
Bartlett's K-squared = 57.417, df = 5, p-value = 4.148e-11
```

Appendix 4. Rcodes in Hotelling's T^2

```
x1    y1   x2    y2    x3    y3
1  93.44 94.68 6.56  5.32 16.26 14.81
2  94.28 82.40 5.72 17.60 16.06 18.91
3  94.42 90.04 5.58  9.96 16.28 17.28
4  95.00 91.27 5.00  8.73 15.92 14.43
5  94.74 91.25 5.26  8.75 17.96 15.97
6  94.54 91.27 5.46  8.73 16.96 17.22
7  94.58 92.81 5.42  7.19 17.23 21.04
8  94.94 92.60 5.06  7.40 13.31 16.07
9  94.77 93.63 5.23  6.37 15.59 14.87
10 94.87 94.29 5.13  5.71 13.52 14.02
11 94.64 94.80 5.36  5.20 13.87 13.81
12 95.46 95.46 4.54  4.54 13.02 14.17
```

```
>
> library(ICSNP)
Loading required package: mvtnorm
Loading required package: ICS
Warning messages:
1: package 'ICSNP' was built under R version 4.2.3
2: package 'ICS' was built under R version 4.2.3
> library(mvtnorm)
> x1=c(93.44,94.28,94.42,95,94.74,94.54,94.58,94.94,94.77,94.87,94.
64,95.46)
> x2=c(6.56,5.72,5.58,5,5.26,5.46,5.42,5.06,5.23,5.13,5.36,4.54)
> x3=c(16.26,16.06,16.28,15.92,17.96,16.96,17.23,13.31,15.59,13.52,
13.87,13.02)
> y1=c(94.68,82.4,90.04,91.27,91.25,91.27,92.81,92.6,93.63,94.29,94
.8,95.46)
> y2=c(5.32,17.6,9.96,8.73,8.75,8.73,7.19,7.4,6.37,5.71,5.2,4.54)
> y3=c(14.81,18.91,17.28,14.43,15.97,17.22,21.04,16.07,14.87,14.02,
13.81,14.17)
> mydata= data.frame(x1,y1,x2,y2,x3,y3)
> View(mydata)
> attach(mydata)
The following objects are masked _by_ .GlobalEnv:

    x1, x2, x3, y1, y2, y3

> mydata
      x1    y1   x2    y2    x3    y3
1  93.44 94.68 6.56  5.32 16.26 14.81
2  94.28 82.40 5.72 17.60 16.06 18.91
3  94.42 90.04 5.58  9.96 16.28 17.28
4  95.00 91.27 5.00  8.73 15.92 14.43
5  94.74 91.25 5.26  8.75 17.96 15.97
6  94.54 91.27 5.46  8.73 16.96 17.22
7  94.58 92.81 5.42  7.19 17.23 21.04
8  94.94 92.60 5.06  7.40 13.31 16.07
9  94.77 93.63 5.23  6.37 15.59 14.87
10 94.87 94.29 5.13  5.71 13.52 14.02
11 94.64 94.80 5.36  5.20 13.87 13.81
12 95.46 95.46 4.54  4.54 13.02 14.17
```

```
 >
```

```
> mean(x1);sd(x1)
[1] 94.64
[1] 0.4864902
> mean(x2);sd(x2)
[1] 5.36
[1] 0.4864902
> mean(x3);sd(x3)
[1] 15.49833
[1] 1.66198
> mean(y1);sd(y1)
[1] 92.04167
[1] 3.483992
> mean(y2);sd(y2)
[1] 7.958333
[1] 3.483992
> mean(y3);sd(y3)
[1] 16.05
[1] 2.219656
> df1= y1-x1
> df2= y2-x2
> df3= y3-x3
> mean(df1);sd(df1)
[1] -2.598333
[1] 3.40983
> mean(df2);sd(df2)
[1] 2.598333
[1] 3.40983
> mean(df3);sd(df3)
[1] 0.5516667
[1] 1.859838
install.packages ("psych")


WARNING: Rtools is required to build R packages but is not currently
installed. Please download and install the appropriate version of
Rtool

s before proceeding:


https://cran.rstudio.com/bin/windows/Rtools/

Installing package into 'C:/Users/windows 10/AppData/Local/R/win-
11bra

ry/4.2'

(as lib' is unspecified)

also installing the dependency 'mnormt'


trying URL https://cran.rstudio.com/bin/windows/contrib/4.2/normt_2.

1.1.zip'

Content type "application/zip length 179981 bytes (175 KB)

downloaded 175 KB
```

```
trying URL
"https://cran.rstudio.com/bin/windows/contrib/4.2/psych_2.
3.3.zip'
Content type application/zip length 3875382 bytes (3.7 MB)
downloaded 3.7 MB

package 'mnormt' successfully unpacked and MD5 sums checked
package 'psych' successfully unpacked and MD5 sums checked

The downloaded binary packages are in
C:\Users\Windows 10\AppData\Local\Temp\RtmpOc5Es7\downloaded_p
ackages
library (psych)

warning message:
package "psych' was built under R version 4.2.3

> Ydiff= data.frame(df1,df2,df3)
> Ydiff
      df1   df2   df3
1    1.24 -1.24 -1.45
2  -11.88 11.88  2.85
3   -4.38  4.38  1.00
4   -3.73  3.73 -1.49
5   -3.49  3.49 -1.99
6   -3.27  3.27  0.26
7   -1.77  1.77  3.81
8   -2.34  2.34  2.76
9   -1.14  1.14 -0.72
10  -0.58  0.58  0.50
11   0.16 -0.16 -0.06
12   0.00  0.00  1.15

> error.bars(Ydiff,bar=FALSE,ylab="Group Means",xlab="Dependent Vari
ables",ylim=c(-5,5),eyes=FALSE)

Employment Rate, before and during
> muHO=c(O)
> HotellingsT2(df1,mu=muHO)

      Hotelling's one sample T2-test

data:  df1
T.2 = 6.968, df1 = 1, df2 = 11, p-value = 0.02301
alternative hypothesis: true location is not equal to c(0)

Unemployment Rate, Before and During
> muHO=c(O)
> HotellingsT2(df2,mu=muHO)

      Hotelling's one sample T2-test

data:  df2
T.2 = 6.968, df1 = 1, df2 = 11, p-value = 0.02301
alternative hypothesis: true location is not equal to c(0)
```

```
Underemployment rate, Before and during
> muH0=c(0)
> HotellingsT2(df3,mu=muH0)

      Hotelling's one sample T2-test

data:  df3
T.2 = 1.0558, df1 = 1, df2 = 11, p-value = 0.3262
alternative hypothesis: true location is not equal to c(0)


> g= 3
> N= 12
> Group= matrix(rep(1:3, each=N))
> Pre= c(x1,x2,x3)
> Post= c(y1,y2,y3)
> All= data.frame(Pre,Post,Group)
> names (All)= c("Pre","Post","Group")
> factor(Group)
 [1] 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3
 3 3 3 3
Levels: 1 2 3
> View(All)
    Pre  Post Group
1  93.44 94.68     1
2  94.28 82.40     1
3  94.42 90.04     1
4  95.00 91.27     1
5  94.74 91.25     1
6  94.54 91.27     1
7  94.58 92.81     1
8  94.94 92.60     1
9  94.77 93.63     1
10 94.87 94.29     1
11 94.64 94.80     1
12 95.46 95.46     1
13  6.56  5.32     2
14  5.72 17.60     2
15  5.58  9.96     2
16  5.00  8.73     2
17  5.26  8.75     2
18  5.46  8.73     2
19  5.42  7.19     2
20  5.06  7.40     2
21  5.23  6.37     2
22  5.13  5.71     2
23  5.36  5.20     2
24  4.54  4.54     2
25 16.26 14.81     3
26 16.06 18.91     3
27 16.28 17.28     3
28 15.92 14.43     3
29 17.96 15.97     3
30 16.96 17.22     3
31 17.23 21.04     3
32 13.31 16.07     3
33 15.59 14.87     3
34 13.52 14.02     3
35 13.87 13.81     3
36 13.02 14.17     3


Before and During Pandemic

> mean(Pre)
[1] 38.49944
> mean(Post)
[1] 38.68333
```

```
> Diff=cbind(Post-Pre)
> Diff
        [,1]
 [1,]   1.24
 [2,] -11.88
 [3,]  -4.38
 [4,]  -3.73
 [5,]  -3.49
 [6,]  -3.27
 [7,]  -1.77
 [8,]  -2.34
 [9,]  -1.14
[10,]  -0.58
[11,]   0.16
[12,]   0.00
[13,]  -1.24
[14,]  11.88
[15,]   4.38
[16,]   3.73
[17,]   3.49
[18,]   3.27
[19,]   1.77
[20,]   2.34
[21,]   1.14
[22,]   0.58
[23,]  -0.16
[24,]   0.00
[25,]  -1.45
[26,]   2.85
[27,]   1.00
[28,]  -1.49
[29,]  -1.99
[30,]   0.26
[31,]   3.81
[32,]   2.76
[33,]  -0.72
[34,]   0.50
[35,]  -0.06
[36,]   1.15

> mean(Diff)
[1] 0.1838889


>  muH0=c(0)
> HotellingsT2(Diff,mu=muH0)

      Hotelling's one sample T2-test

data:  Diff
T.2 = 0.092966, df1 = 1, df2 = 35, p-value = 0.7622
alternative hypothesis: true location is not equal to c(0)
```

Appendix 5. Routing Slip

CAS Thesis Form 10

Republic of the Philippines
CAVITE STATE UNIVERSITY
(CvSU)
Don Severino De Las Alas Campus
Indang, Cavite

COLLEGE OF ARTS AND SCIENCES
Department of Physical Sciences

ROUTING SLIP FOR THESIS

Researcher: **Buguis, Chona Mae C., Delposo, Baby Ann P., Rio, Kiyoshi C.**

Title: **EMPLOYMENT RATES IN THE PHILIPPINES: A COMPARATIVE ANALYSIS BEFORE AND DURING COVID-19 PANDEMIC USING HOTELLING'S T^2**

Designation		Name of Concerned Faculty Member	Date Received	Date Released	Action Taken/ Remarks	Signature
Adviser	1st Draft	PAUL VINCENT BOTIN	07/05/2023	07/06/2023	minor revision	
	2nd Draft	PAUL VINCENT BOTIN	07/10/2023	07/10/2023	ok	
	3rd Draft					
Technical Critic	1st Draft	Jayson Savilla	7/10/23	7/10/23	Edit	
	2nd Draft	Jayson Savilla	7/12/23	7/13/23	ok	
	3rd Draft					
Statistician						
Program Research Coordinator		LANI S. RODIS	7/14/2023	7/14/2023	ok	
Dept. Chairperson		RENE B. BETONIO	7/14/23	7/14/23	ok	
English Critic	1st Draft	Analyn T. Dico	7/14	7/15		
	2nd Draft	Analyn T. Dico	7/15	7/15		
	3rd Draft	Analyn T. Dico	7/17	7/17		
College Research Coordinator		ALDINA MAE P. BALTAZAR	07-17-23	07-17-23	ok	
College Dean		BETTINA JOYCE P. ILAGAN	JUL 17 2023	18 JULY 2023	ok.	