Impact of COVID-19 on Manufacturing Overhead Cost: A Case of an Electronic OEM Company in Guangdong, China

Juishan Hsu[1, *], Zijie Yu[2]

[1]RDF International School, Shenzhen, China

[2]Royal School, Beijing, China

*Corresponding author: 2014011@zsc.edu.cn

Abstract. This research analyzes the data of the manufacturing overhead costs (MOHC) of a plant in an electronic OEM company (located in Guangdong, China) during and after the COVID-19 pandemic. A paired t-test and a multiple variable regression analysis are conducted. MOHC and other indications are visualized by time sequence diagrams to facilitate the identification of the difference between mid- and post-pandemic. Through diving deeper into the effect of COVID-19 on the MOHC, Unit MOHC, and shipment, the overall influence of COVID-19 on the entire electronic OEM industry can be inferred. It is concluded that COVID-19 has influenced MOHC, Unit MOHC, shipment, and employee size, which may bring forth a paradigm-shifting experience on how people view the influence of COVID-19 on the entire electronic OEM industry and pave the way for further research afterward. This paper fills the research gap by focusing on one plant in one company, avoiding the difference in MOHC among different companies and plants.

Keywords: Manufacturing overhead cost; COVID-19; electronic OEM industry; time sequence diagram; regression analysis.

1. Introduction

COVID-19 has greatly impacted the global market, especially the electronic industry in terms of demand and supply. To limit the spread of virus, the global supply chain was largely disrupted and many electronical hubs were closed [1]. A McKinsey survey of supply chain leaders shows that over 75% them struggled with problems in their supplier base, production or distribution footprint, or insufficient digital technologies [2].

However, each catastrophic challenge is followed by opportunities, the pandemic also brought opportunities to electronic companies in terms of demand. While electronic companies suffered from the disruption of supply chains, social media and products related to working at home encountered a dramatic increase in demand in consumption [3, 4]. For example, AT&T saw an addition of 163,000 new monthly phone subscribers whereas its sales in the Warner Media group, dropped 12% to $7.4 billion due to losses in advertising revenue [5]. Therefore, without a doubt, COVID-19 had hugely influenced the electronics industry. However, based on the evidence stated above, it could also act as a double-edged sword.

To investigate the impact of COVID-19 on electronic companies, this paper focuses on the extent of COVID-19’s influence on a company’s Manufacturing Overhead Costs (MOHC) which is a fair indication of a company’s production costs. Unlike other costs, it accounts for operational costs that are not directly related to a facility’s production. The three types of MOHC include fixed, variable and semi-variable. Fixed overhead costs include rent, mortgages, and government fees; variable costs include electric, shipping and maintenance costs, and maintenance employees [6]. As mentioned before, even though COVID-19 disrupted the global supply chain, it also brought forth a drastic increase in demand, which is reflected as the substantial increase in “shipment” from the data. Therefore, it is hypothesized that the mid-pandemic MOHC would be higher than the post-pandemic MOHC due to the disrupted global supply chain; whereas the mid-pandemic Unit MOHC would be lower than the post-pandemic due to the increase in shipment during the pandemic.

Banker et al. performed the test of linearity using cross-sectional data ranging from different plants among various companies. They pointed out that an improved design was to analyze data of the same plants at different periods in time to discover the relationship between the change of MOHC and other hypothesized causal factors. It can also examine data from periods before and after major changes in manufacturing configuration leading to a dramatic change in MOHC. Cross-sectional data may also lead to variations in overhead costs among industries because some organizational functions are not included in some plants but some are, such as designing and engineering [7]. Based on the work from the aforementioned scholars, this paper intends to compare and analyze the MOHC, Unit MOHC, and shipment data from one plant in a company during and after the pandemic.

The analyzed company is a manufacturing electronic factory located in Guangdong province, China. In this company, MOHC is regarded as a very important indicator of the company's financial situation. It is used for accurate product costing, cost control and decision making, budget and forecasting, pricing and profitability analysis, and performance evaluation [8]. Additionally, the analyzed company is an Original Equipment Manufacturer (OEM), which refers to a company that manufactures products for or parts which are designed to be incorporated into an end product from a different company [9]. Hence, unlike Original Brand Manufacturer (OBM) which are companies that are responsible for the entire production process, including design, supply chain to marketing, the MOHC of the analyzed company does not include certain costs such as advertisement which is expensive during the pandemic. As a result, the analyzed company has a lower MOHC and Unit MOHC compared to other OBM companies [10].

In summary, after due consideration of the previous works, this paper will mainly analyze the monthly MOHC, shipment and Unit MOHC from during and after the pandemic of the same plant in an OEM in Guangdong. By comparing the MOHC, shipment and Unit MOHC during and after the dramatic change of COVID-19, this paper addresses the impact of COVID-19 on manufacturing overhead cost and the implications on the electronic OEM industry as a whole.

2. Methodology

2.1. Data Sources

The data in this paper is collected from the same plant in an electronic manufacturing company in Guangdong province, China. The data analyzed in this paper is the monthly MOHC, shipment and Unit MOHCC from January, 2022 to June, 2023, a total of 18 data.

2.2. Definition of Mid- and Post-Pandemic

In this paper, December, 2022 is marked as the end of the pandemic and January, 2023 as the beginning of the post-pandemic era. The specific date when the pandemic ends is uncertain and varying across locations, and the pandemic still hasn't end in some places, hence it is only possible to determine the date when COVID restrictions were canceled. The end of the pandemic is marked at December, 2022 because the travel code was canceled on December, 13th, 2022, symbolizing the end of COVID restrictions in China.

2.3. Research Protocol

This paper uses time sequence diagram to illustrate the changing trend of MOHC during and after pandemic, shipment and Unit MOHC. Additionally, it enables the identification of the difference in MOHC and Unit MOHC between mid- and post-pandemic. Besides, this paper uses SPSSAU to perform a paired t test to verify whether the difference in MOHC between mid-pandemic and post-pandemic is statistically significant. Also, a multiple variable regression analysis is done to investigate how COVID-19 impacted the production configuration which in turn affected MOHC.

2.4. Research Principle

As shown below in Figure 1, the following is a flow chart that demonstrates the research procedure of this paper. In order to investigate the impact of COVID-19 on MOHC, the first step is to identify the difference between mid and post-pandemic MOHC by plotting time sequence diagrams and performing a paired t-test. Additionally, in order to discover the relationship between multiple variables and MOHC, a multiple variable regression analysis is performed. Lastly, a hypothesis test for the correlation coefficient in the regression analysis is conducted. The goal is to verify whether shipment and employee size have a significant influence on MOHC.

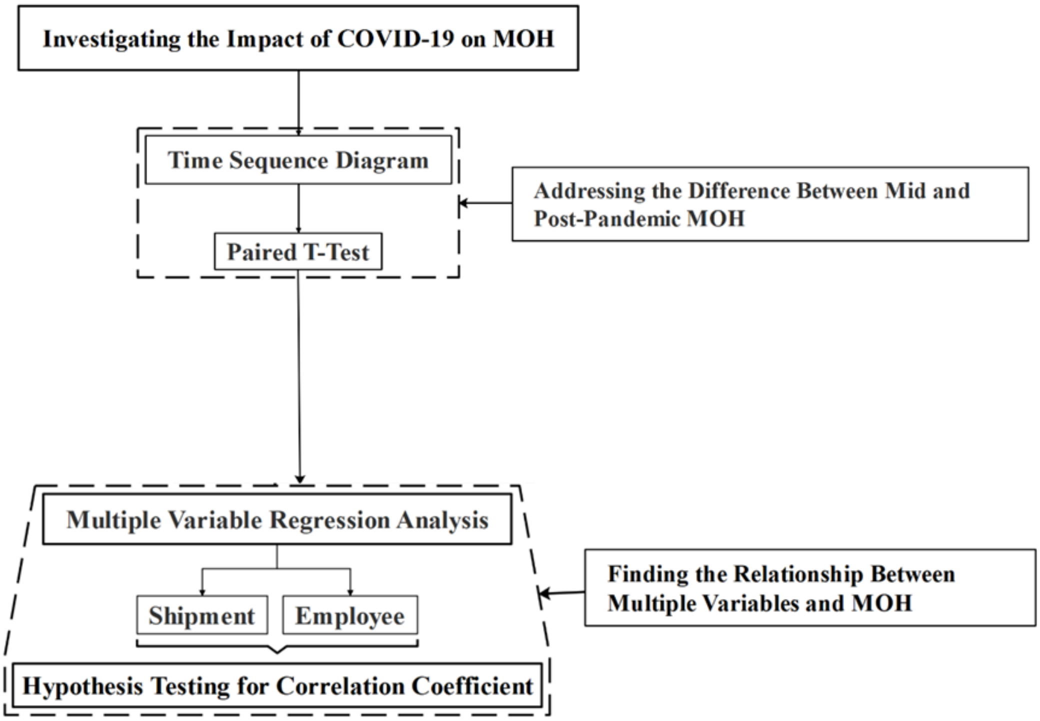

Fig. 1 Research Procedure Flow Chart

3. Results and Discussion

3.1. Time Sequence Diagram

As shown in Figure 2, the MOHC during the pandemic was hovering around 347 million RMB from January to June, 2022. However, it began to decrease ever since then and drop to about 160 million. It is inferred that the pandemic cases were decreasing since June, 2022.

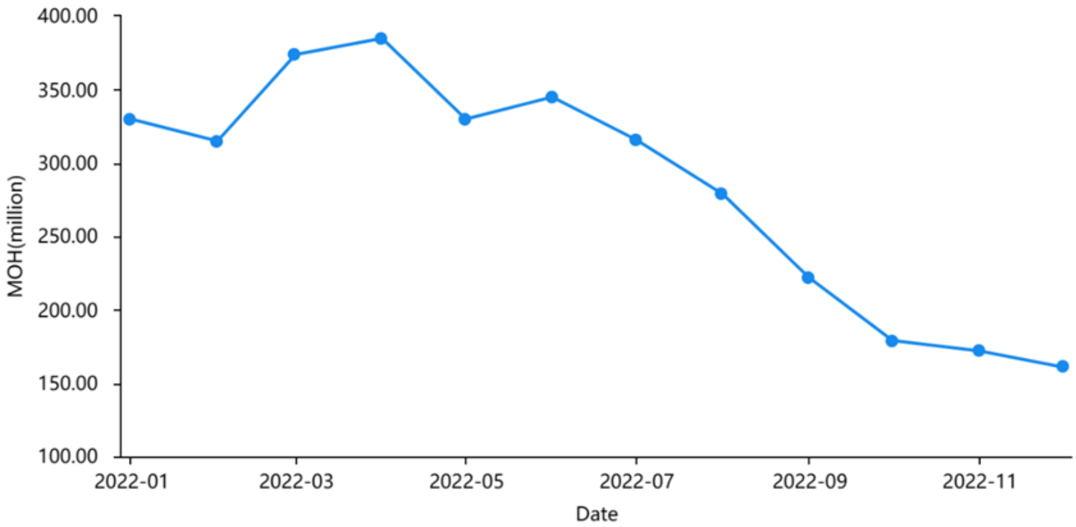

Fig. 2 Mid-Pandemic MOHC Time Sequence Diagram

As shown below in Figure 3, the post-pandemic MOHC generally fluctuated around 20 million RMB. The data in January, 2023 is viewed as an outlier. It is suspected that the company was still adjusting toward the post-pandemic era, but it was clearly shown that the MOHC substantially decrease from about 150 million RMB in December, 2022 to only 30 million RMB in January, 2023.

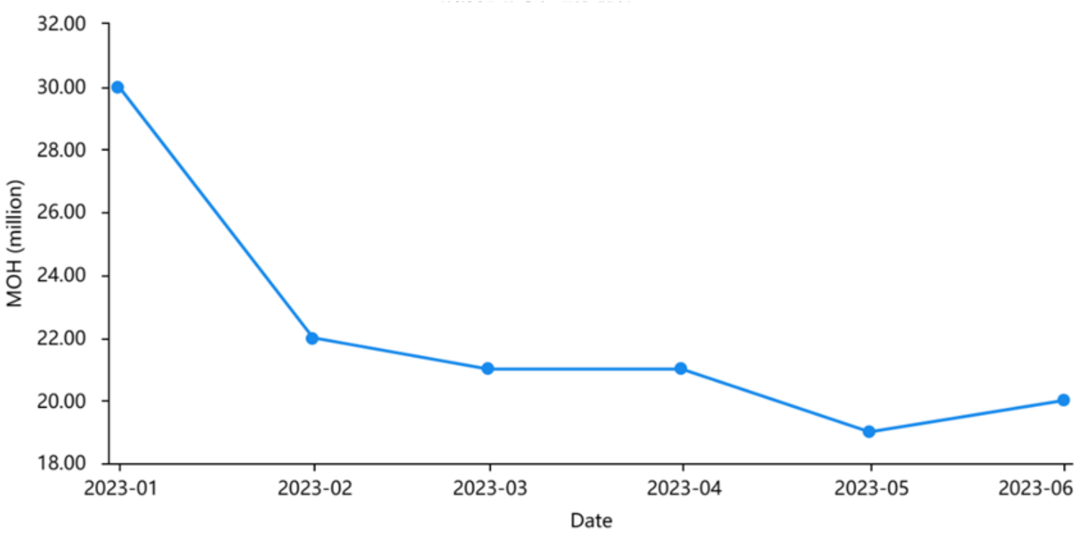

Fig. 3 Post-Pandemic MOHC Time Sequence Diagram

As illustrated below in Figure 4, MOHC from mid-pandemic and post-pandemic are combined into a figure for better comparison. It is evident that there is a significant difference in MOHC between mid-pandemic and post-pandemic. The calculated mean difference is 324.33 million.

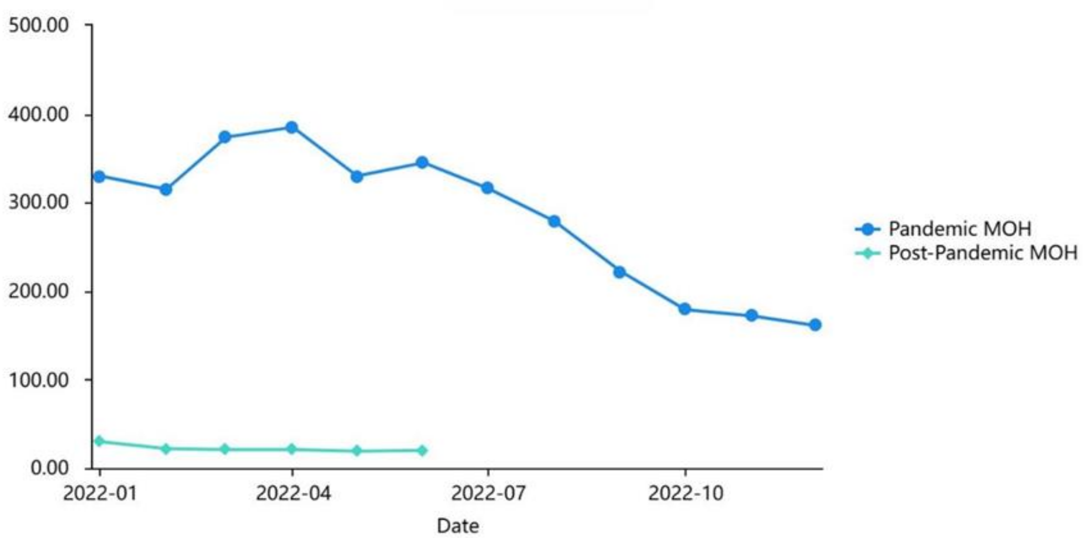

Fig. 4 Mid and Post-Pandemic MOHC Time Sequence Diagram

However, when the Unit MOHC (MOHC/shipment) of mid-pandemic and post-pandemic is plotted, the situation is reversed. It is manifested in Figure 5 that the post-pandemic Unit MOHC is significantly higher than mid-pandemic.

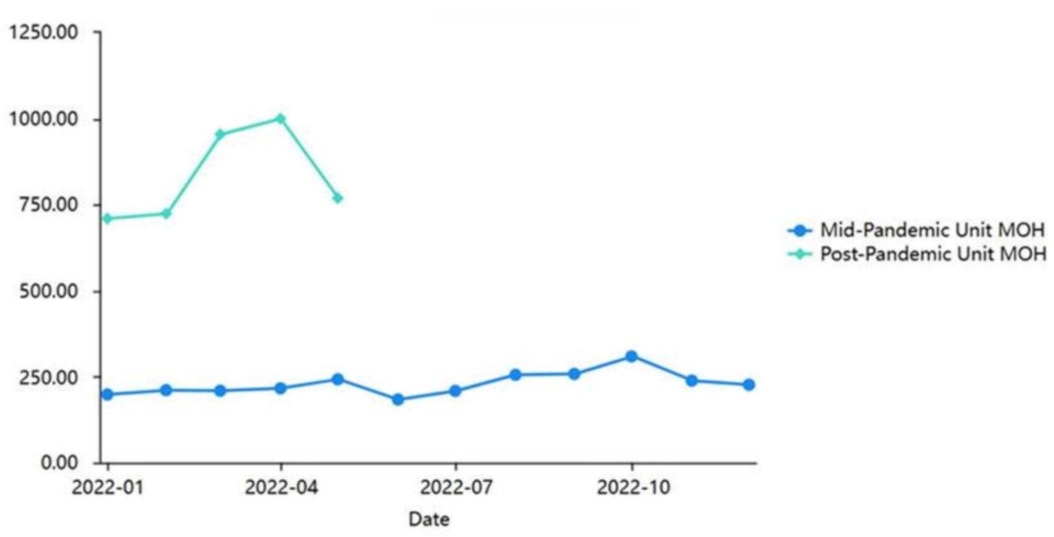

Fig. 5 Mid and Post-Pandemic Unit MOHC Time Sequence Diagram

To investigate the reason behind this phenomenon, the time sequence diagram of shipment from mid-pandemic and post-pandemic is plotted.

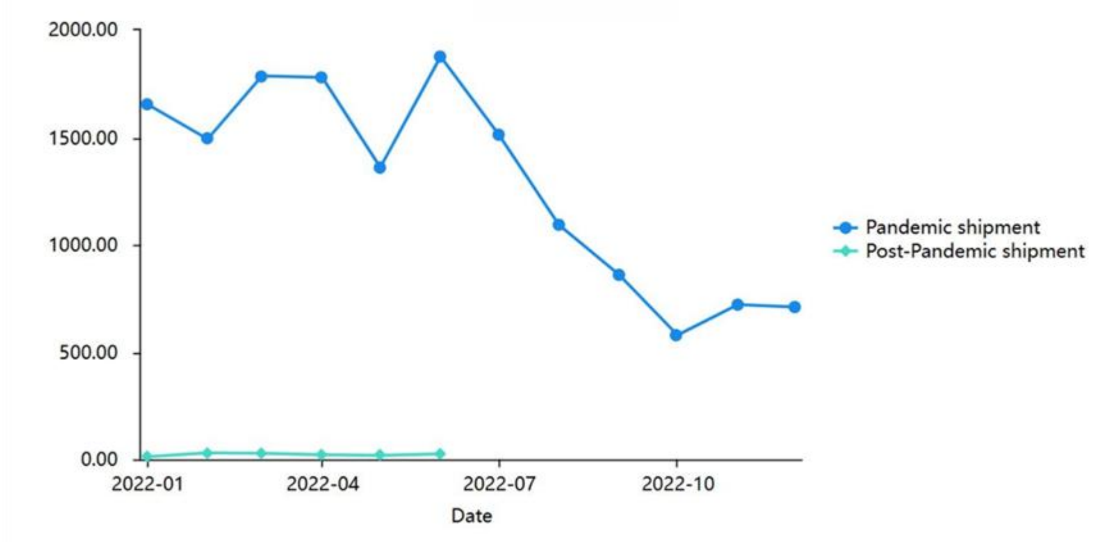

Fig. 6 Mid and Post-Pandemic Shipment Time Sequence Diagram

In above Figure 6, it is evident that the shipment during the pandemic is significantly higher than the post-pandemic shipment. Therefore, it may be the answer to why the post-pandemic MOHC is substantially less than the mid-pandemic while its Unit MOHC is greater.

3.2. Paired T-Test

To further verify the difference in MOHC between mid-pandemic and post-pandemic is statistically significant, a paired t test is performed. The mean difference, t value and p-value are shown below.

Table 1. Paired T Test for Difference in MOHC

Items	Paired (M±SD)		Mean difference (Paired 1-Paired 2)	*t*	*p*
	Paired 1	Paired 2			
Pandemic MOHC *Paired* Post-Pandemic MOHC	346.50 ± 27.49	22.17 ± 3.97	324.33	27.585	0.000**

* $p<0.05$ ** $p<0.01$

As shown above in Table 1, since the p-value is less than 0.01, it can be concluded that the difference between pandemic MOHC and post-pandemic MOHC is statistically significant, and the null hypothesis that there is no difference between the two is rejected. To further prove that it is appliable in real life, effective size is calculated.

Table 2. Intelligent Analysis - Effective Size Index

Items	Mean Difference	Difference 95% CI	*df*	Standard Deviation	Cohen's *d*
Pandemic MOHC *Paired* Post-Pandemic MOHC	324.33	294.109~ 354.558	5	28.800	11.261

Table 2 manifested that Cohen's d value is 11.261 which is substantially greater than 0.8. Cohen's d value demonstrates the effective size, and the extent of the difference between the two groups of data. The greater the value, the greater the difference between the two data sets. A Cohen's d value greater than 0.8 indicates that there is a big difference between Pandemic MOHC and Post-Pandemic MOHC which suggests that this difference is significant in real life.

3.3. Linear Regression

To further study the relationship between shipment and MOHC from mid-pandemic and post-pandemic, liner regression is performed to represent the algebraic relationship between shipment and MOHC from both mid and post-pandemic.

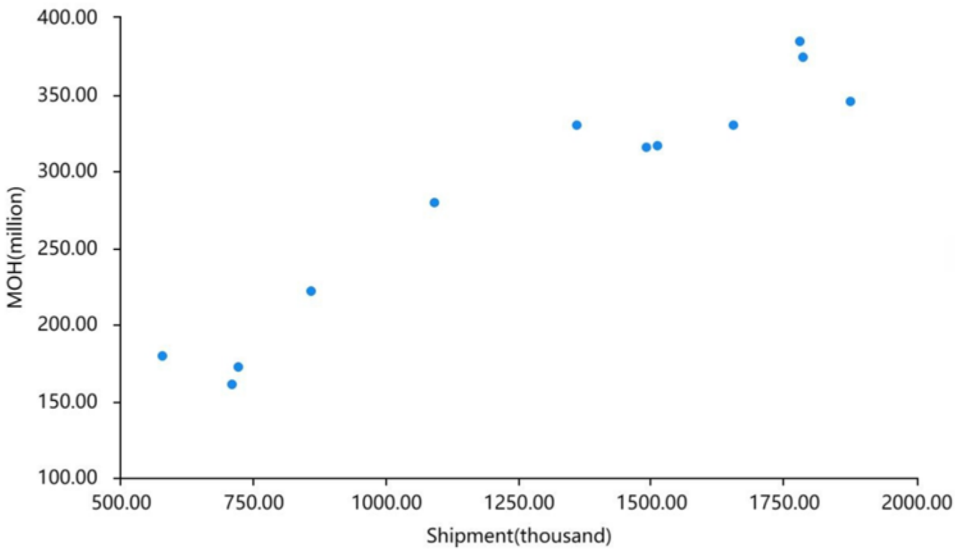

Fig. 7 Mid-Pandemic MOHC Scatter Plot

As displayed in Figure 7, the dots indicate a strong, linear, positive relationship between MOHC and shipment. The best-fit line equation for mid-pandemic MOHC is as follows with a R^2 of 0.926:

$$MOH = 73.66883 + 0.1636 \times shipment \tag{1}$$

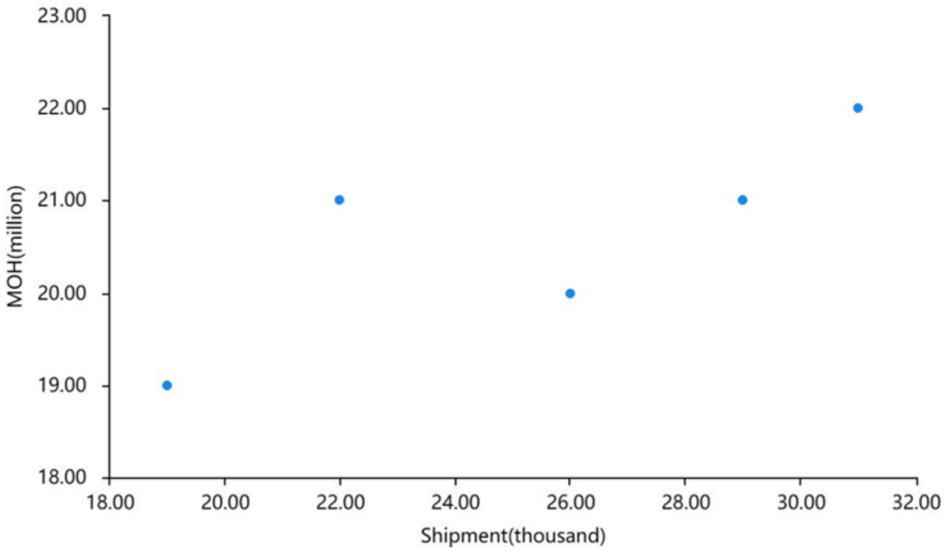

Fig. 8 Post-Pandemic MOHC Scatter Plot

As illustrated in Figure 8, it is observed that the MOHC data in January 2023 is an outlier. It has lower shipment and higher MOHC than the rest of the data, so it is excluded from the analysis in order to better observe a trend between the two variables. As mentioned before in this paper, the reason for the appearance of this outlier is because the company was still adjusting toward post-pandemic era. And the best-fit line equation for post-pandemic MOHC is as follows with a R^2 of 0.627:

$$MOH = 15.94856 + 0.18313 \times shipment \tag{2}$$

By comparing the intercepts of the two equations, it can be inferred that if a company's shipment is very low, the mid-pandemic MOHC will be much higher than post-pandemic. However, since post pandemic, each addition of shipment would bring forth a higher MOHC than mid-pandemic.

However, to further explore the variables correlated to MOHC, another variable, employee size is added into consideration. Hence, a multi-variable regression analysis is performed to explore the relationship between shipment, employee size and MOHC.

Table 3. Multiple Variable Regression Analysis (Mid-Pandemic)

	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Collinearity Diagnose	
	B	Std. Error	*Beta*			VIF	Tolerance
Constant	59.596	18.728	-	3.182	0.011*	-	-
Employee Size	0.029	0.015	0.598	2.023	0.074	15.515	0.064
Shipment (thousand)	0.065	0.050	0.384	1.299	0.226	15.515	0.064
R^2	0.949						
Adj R^2	0.938						
F	F (2,9) = 84.244, p < 0.000						
D-W Value	1.066						

Dependent Variable: MOHC (million)
* p<0.05 ** p<0.01

As shown above in Table 3, the adjusted R^2 is 0.949 which is greater than the R^2 of the two-variable regression model. Additionally, the p-value is less than 0.001, indicating that this model passes the F-test and at least one of the independent variables can influence MOHC. However, the VIF value is greater than 5, indicating that the multi-variable regression model contains a collinearity problem. The best fit line equation of this multiple-variable regression is as follows with a R^2 of 0.949:

$$MOH = 59.596 + 0.029 \times \text{Employee Size} + 0.065 \times \text{Shipment} \tag{3}$$

Furthermore, as shown below in Table 4, for the post-pandemic multiple-variable regression analysis, the results are not as satisfying. The p-values of the two variables are both greater than 0.1, indicating that the model is not very statistically significant. It is suspected that the post-pandemic multiple variable regression model is not very accurate because the sample size is very small. It is because MOHC is a monthly index, and there are only six months after the pandemic. Moreover, the data from January, 2023, is considered an outlier, and hence excluded from our sample. Therefore, there are only 5 samples in this model, resulting in a less accurate prediction.

Table 4. Multiple Variable Regression Analysis (Post-Pandemic)

	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Collinearity Diagnose	
	B	Std. Error	*Beta*			VIF	Tolerance
Constant	21.959	14.773	-	1.486	0.276	-	-
Employee Size	-0.002	0.004	-0.272	-0.413	0.720	2.530	0.395
Shipment (thousand)	0.134	0.153	0.580	0.880	0.472	2.530	0.395
R^2	0.656						
Adj R^2	0.312						
F	F (2,2) =1.908, p=0.344						
D-W Value	1.765						
Dependent Variable: MOHC (million)							
* p<0.05 ** p<0.01							

4. Conclusion

This paper concludes that there is a significant difference in MOHC from mid and post-pandemic. It is demonstrated in the time sequence diagram and verified by the paired t-test. Therefore, it can be concluded that COVID-19 has influenced MOHC. Additionally, other indications such as Unit MOHC, shipment, and employee size all displayed a substantial difference between mid and post-pandemic. Moreover, a multiple regression analysis between shipment, employee size, and MOHC is performed. However, with a small sample size, the relationship between the variables is not shown clearly. Similar research on the drivers of MOHC are all based on the data from various plants in multiple companies. This paper fills the research gap by focusing on one plant in one company, avoiding the difference in MOHC among different companies and plants.

As mentioned in the results and discussion part, due to the cutting-edge nature of this research, the sample size is comparably small, resulting in a less accurate prediction from the regression analysis. Specifically, because there are only six months after the pandemic, obtaining a small sample is inevitable. Nevertheless, a way to solve this problem is by gathering data from various companies and using a certain statistical method to eliminate the difference in MOHC among different companies. Furthermore, only two variables are considered to influence MOHC, employee size and shipment, but there are many other variables that may influence a company's MOHC, so an improved study would be to adopt more influencing factors into the multiple-variable regression analysis.

In conclusion, this paper investigates the difference in various indications related to a company's production cost between mid and post-pandemic. Through observing this difference, it brought forth a paradigm-shifting experience on how people view the influence of COVID-19 on the entire electronic OEM industry. Specifically, as mentioned previously in the introduction part, COVID-19 is viewed as a double-edged sword due to the various implicit benefits it brought to the electronic industry such as the sudden surge in shipment during the pandemic. Additionally, it provides reference for future research on the implications of COVID-19 on production costs afterward.

5. Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Meahjohn, Inshan, Prakash Persad. The Impact of COVID-19 on Entrepreneurship Globally. Journal of Economics and Business, 2020.

[2] Johnson, Susan A. Impact of COVID-19 on Global Supply Chains| AT&T Supply Chain. About.att.com. 2020, about.att.com/inside_connections_blog/2020/supply_chains_new_normal.html.

[3] COVID-19 Tests Resilience in the Electronics Industry. IBM, 15 Apr. 2020, www.ibm.com/thought-leadership/institute-business-value/blog/covid-19-electronics.

[4] Zou Peng, et al. The Impact of the COVID-19 Pandemic on Firms: A Survey in Guangdong Province, China. Global Health Research and Policy, 2020, 5(1): 2.

[5] Reardon, Marguerite. AT&T Suffers Financial Hit from COVID-19. CNET, 2020.

[6] Wen W, et al. Impacts of COVID-19 on the electric vehicle industry: Evidence from China. Renewable and Sustainable Energy Reviews, 2021.

[7] Foster George, Mahendra Gupta. Manufacturing Overhead Cost Driver Analysis. Journal of Accounting and Economics, 1990, 12: 309–337.

[8] Daily Lisa. Manufacturing Overhead Costs: How to Calculate with Examples. SkuVault, 8 Dec. 2022.

[9] Shi, Yongjiang, Mike Gregory. From original equipment manufacturers to total solution providers: Emergence of a global manufacturing virtual network in the electronics industry. International Journal of Services Technology and Management, 2003, 331-346.

[10] Yeung, Wing Fung. Understand ODM, OEM, OBM [Explained with Examples] | Difference. Starlity, 2020.