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Article

Influence of COVID-19 on Taiwan's manufacturing, procurement, and sales relationship

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Abstract: Against the backdrop of the COVID-19 pandemic, Taiwan's economic sectors have experienced a decline in activity. Addressing this situation effectively necessitates Taiwan to strategically align its transnational supply ecosystem with global consumption patterns, positioning itself as a crucial industrial collaborator for co-creation and shared prosperity. This study utilizes a comprehensive framework that encompasses manufacturing, procurement, and sales. Data related to Taiwan's industries are collected through a questionnaire, and the Structural Equation Modeling (SEM) multivariate statistical method is utilized for factor and path analyses to evaluate the impact of COVID-19 on these industries. Based on the responses from the questionnaire, the dominant sectors in Taiwan's industries are electronics/electrical machinery, accounting for around 40.84% of the industry, followed by metals/machinery at approximately 20.90%. Notably, specific aspects concerning manufacturing manpower, procurement and delivery processes, sales revenue, and product costs were reported as "somewhat serious" on average during the COVID-19 period. The results of this research indicate that manufacturing does not significantly influence sales. Additionally, there is a significant positive correlation between manufacturing and procurement. Given the unpredictable changes that companies and entire industries are currently facing, it is crucial to implement strategic measures. Because of COVID-19 influence, organizations, companies, and sectors have undergone significant transformation, necessitating the implementation of the necessary protections. In this situation, the concept of organizational resilience becomes crucial.

Keywords: COVID-19; manufacturing; procurement; sales; organizational resilience

1. Introduction

The World Health Organization (WHO) declared the COVID-19 outbreak a pandemic in March 2021, with global confirmed cases exceeding 117 million and a death toll surpassing 2.6 million. The deployment of vaccines has led to a nearly 50% reduction in daily confirmed cases worldwide, with a more substantial 70% decrease observed in the United States. However, the emergence of new virus variants introduces uncertainties regarding achieving herd immunity. In the near future, a complete restoration of social and economic activities seems challenging, and the continuation of social distancing measures is anticipated to become a norm in society's "new normal".

The World Health Organization has issued a warning, indicating an increased likelihood of recurrent large-scale infectious disease outbreaks globally, potentially leading to a rise in major deadly diseases in the future, marking the onset of the "New Normal".

Moreover, alongside the economic crisis triggered by the COVID-19 pandemic,

nations worldwide have experienced significant contractions in economic activity. This decline has contributed to heightened price volatility in commodity markets. Price volatility, an inherent characteristic of commodity markets, displays variations among different commodities and evolves over time. Generally, the presence of low short-term elasticities in supply and demand exacerbates substantial price fluctuations in response to production shocks.

2. Literature review

This study examines the quantifiable effects of COVID-19 on manufacturing, procurement, and sales practices, acknowledging the significant alterations in the business landscape due to the pandemic.

3. Manufacturing

The "4M" concept in manufacturing management, encompassing Man (Operators), Machine (Mechanical equipment, tools, and molds), Material (Raw materials and spare parts), and Method (Engineering methods and process conditions), is crucial for product quality. Factors like human resources quality, operator skills, adherence to standard operating procedures (SOP), and total quality management (TQM) practices impact output quality. Machinery performance, maintenance, raw material supply chains, and collaboration between manufacturers also play vital roles. Material shortages can disrupt production, necessitating risk mitigation for continuity. Industry leadership requires advanced manufacturing processes, technical patents, and unique supervision mechanisms while maintaining production standards.

The 5M1E framework supplements the 4M analysis, providing a comprehensive understanding of production changes for competitive advantage. Thomas and Koontz (2011) introduced the 6M concept, adding Markets to the 5M framework for organizational goal achievement. Wardani's (2017) research on the medical system highlighted the impact of management resources on outpatient treatment quality through Man, Money, Machine, Materials, and Methods dimensions, with materials having the greatest influence. These frameworks were developed within Total Quality Management, emphasizing comprehensive inspection for quality enhancement. Lean Six Sigma has been applied to reduce manufacturing costs.

4. Procurement

Enterprises purchase raw materials or products that meet their quality and quantity requirements at competitive prices from appropriate suppliers. Suppliers are expected to deliver the items within a specified timeframe and offer both pre-sale and after-sale services. The procurement process, when effectively implemented, can help reduce procurement expenses. According to Ansaria and Heckel (1987), procurement expenses can be classified as "ordering costs", "price costs", "carrying costs", and "stock-out costs". Suppliers, time, pricing, quantity, and quality are the five major criteria that influence procurement—the so-called 5R procurement principles.

1) Right Vendor: Selecting the appropriate supplier is crucial for establishing sustainable and resilient supply chains. In addition to selecting suppliers based

on advanced technology and competitive pricing, it is essential to evaluate the manufacturer's reputation and reliability to establish a sustainable and enduring cooperative partnership. Furthermore, one strategy to maintain procurement stability is to diversify suppliers to reduce procurement risk.

2) Right Time: Buyers prioritize ensuring consistent supply at the appropriate time to guarantee product delivery. Many customers prioritize immediate delivery service when selecting suppliers because a shortage of raw materials could lead to lost production or a line closure while waiting for supply. It may impair the delivery time of customer orders, in addition to significantly increasing the expenses of manpower and replacement items. As a result, the shipping method must be adjusted, or compensation sought by citing a breach of contract.
3) Right Price: The cost of raw materials is a significant issue in manufacturing. Given the same level of quality, customers will choose producers with lower prices to maximize their profits. Furthermore, balancing quality and affordability is often the focus of large-scale acquisitions.
4) Right Quantity: The unit pricing and inventory management are determined by quantity procurement. Excess inventory is similar to a backlog of funds, putting strain on operations. As a result, flexible and efficient bulk purchasing, as well as preventing material shortages, are procedures in which purchasing people can use their professional bargaining position to control costs.
5) Right Quality: The quality of raw materials influences production quality and whether customers repurchase. High-quality procurement can reduce labor and material expenses associated with periodic inspections while also maintaining product quality. Repeat purchases are related with effective quality management.

Purchasing was previously seen as a part of the administrative procedure. The evolution of procurement strategies has been from an administrative to a strategic process in light of the globalization of supply networks in recent years. Ellram and Carr (1994) propose that the procurement strategy ought to be incorporated into the overarching corporate strategy. Procurement should take on more responsibility for strategic planning and implementation in light of global procurement trends, rapid technological change, and heightened competition. It should also define the four stages of the purchasing organization according to its level of strategic development, as delineated below.

Step 1: The procurement process starts here, passively, in response to inquiries from other company departments.

Stage 2: The procurement department is largely independent and dedicates a large amount of effort to formalizing the procurement process by putting in place formal supplier procedures, information-based information systems, and communication channels.

Step 3: the support phase, in which senior management acknowledges purchasing as a crucial business function.

Stage 4: the integration stage, in which the employees of the purchasing department play a critical role in the company's ability to compete. The purchasing department becomes a functional department within the organization, rather than just a facilitator.

According to Trent and Monczka (1998), the growing significance of suppliers is

a reflection of five major factors that impact the majority of industries:

1) The requirement to limit unit costs;
2) The requirement to control acquisition costs overall;
3) Supplier effect on buyers' ability to respond to ultimate customers due to concerns like delivery time.
4) Growing reliance on a small number of suppliers;
5) Buyer readiness to rely on suppliers to design and develop component systems;

These attributes enhance the standing of suppliers (Trent and Monczka, 1998) and motivate tight cooperation between suppliers and buyers to gain and maintain a competitive advantage.

5. Sales

Sales refers to the provision of goods or services to persons or organizations, and it is made up of a number of operations through which businesses transfer production results to consumers, create value, and serve customers. Because the primary goal of businesses is to make profit, the same holds true for the sales process. Businesses are dedicated to cost control in order to increase revenues. The following elements have the biggest impact on the company's profitability.

1) Transportation: refers to the process of delivering products from producers to consumers through transport and includes choosing the transport mode as well as its timing, route, cost, etc. Transport cost varies by mode (i.e., sea, land, or air) and market supply and demand. Generally speaking, high unit-price and timely goods will be shipped by air, while low-to-medium unit-price, bulky and non-urgent goods will be shipped by land or sea. Transportation costs are highly affected by the overall economic climate and global environmental factors. Song et al. (2005) conducted a cost-benefit analysis of the global container transportation network and proposed a simple formula to model the global container transportation network using a heuristic method. Their model is able to reproduce overall revenue, costs and container traffic for the transportation industry in general as well as for individual shipping lines and ports. They found that the cost of relocating empty containers accounts for 27% of the total operating cost of the world fleet and that overcapacity has been a significant problem for the maritime industry for many years.

Kamal et al. (2021) used daily data from NYSE-listed shipping companies to measure the short-term impact of the COVID-19 outbreak using an event research approach. They found that the news was initially classified as pessimistic; however, with certain policy responses, such as additional economic stimulus in the United States, shares in the maritime industry reacted highly positively. Such results are confirmed by an in-depth analysis of the financial performance of individual companies. It is obvious that in the context of COVID-19, the transportation industry is gradually changing from its prior operating conditions, in which supply has exceeded demand.

2) Revenue: is highly sensitive to product price and quantity, in addition to the overall profitability of the company. Accounts receivable recovery is one of the key factors in maintaining effective working capital, as rapid recovery can prevent a backlog of funds from developing. If such a situation is avoided, these funds can be

actively invested and potentially used to generate other income streams. All industries have faced challenges during the COVID-19 pandemic. Enterprises of all sizes are all seeking ways to increase revenues or reduce costs, which has almost become a matter of survival. Fitriasari (2020) conducted research on the survival of small and medium enterprises (SMEs) with the aim of formulating a business model that can be applied pandemics and found that the three important elements of business resilience are 1) superior product, 2) people behavior and process reliability, and 3) digital transformation. Achieving business goals and developing products or services to increase competitiveness requires the right digitization strategy. Proper digital infrastructure testing is required during periods of digital transformation.

3) Cost: consists of fixed, variable and miscellaneous costs. Fixed costs refer to those that do not change over time. For example, depreciation, plant rent, and management salaries are all fixed costs. Variable costs refer to those that change in proportion to production, such as raw materials, direct employee salaries, etc.

McMaster et al. (2020) analyzed the broad catalytic impact of the COVID-19 pandemic on the supply chains of multinational fashion companies through the lens of international business risk management. Notably, the pandemic has highlighted the problems inherent in supply chains with centralized production. The study found that while agile supply chain management was generally favored for its advantages in reducing costs and waste, this structure was limited by a lack of supply chain transparency and increased volatility in demand prior to the pandemic. Strong relationships solve this problem by facilitating information exchange. However, such a structure also results in increases in both inventory and inventory costs.

Shen and Fu (2020), Kumar et al. (2019, 2021, 2022, 2023) analyzed both revenue and costs in the energy industry and found that COVID-19 had a significantly negative impact on the performance of energy companies. When goodwill impairment was introduced as an adjustment variable, companies with such impairments were more affected by the pandemic. Coibion et al. (2020) surveyed more than 10,000 respondents to examine whether different times of local lockdowns had a causal effect on local households' spending and macroeconomic expectations. About 50 percent of survey participants said the coronavirus caused a loss of income and wealth, with average losses of $5293 and $33,482, respectively. Total consumer spending fell 31 percent, with travel and apparel seeing the biggest declines. Although many studies have confirmed that COVID-19 has had a negative impact on the overall economic environment, there is still an upward trend in operational performance in industries such as e-commerce, cross-border transportation, and medical vaccines. The global semiconductor industry has even experienced shortages in supply. However, the differences between industries, regions, and special genders are pronounced. Therefore, research on independent regions or specific industries is both representative and meaningful.

6. Research methodology

6.1. Architecture and hypotheses

According to the existing literature, this study considers Manufacturing (MFG) and Procurement (PUR) to be independent factors, Sales to be a dependent variable,

and Manufacturing (MFG) and Procurement (PUR) to be mutual variables. **Figure 1** depicts the research framework, which is separated into three parts.

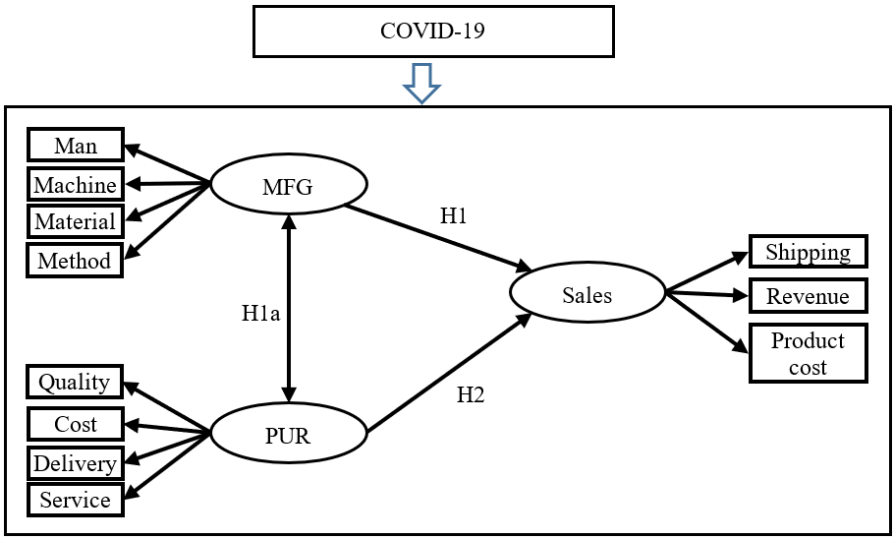

Figure 1. Research structure.

This study gathered relevant literature based on the aforementioned research goal and research framework to investigate the influence of COVID-19 on the connections between Manufacturing (MFG), Procurement (PUR), and Sales. The following are the study's hypotheses:

H1: Did manufacturing behavior significantly impact sales behavior during COVID-19?

H1a: Was there a significant interaction between Manufacturing and Procurement during COVID-19?

H2: Did procurement behavior significantly impact sales behavior during COVID-19?

6.2. Methodology

This study employs Structural Equation Modeling (SEM) as the statistical method to investigate the causal relationship between variables in the research model. IBM SPSS Amos 22.0 software is utilized for analysis and estimation using Maximum Likelihood (ML).

6.3. Object

This study utilized a questionnaire that was developed after conducting a literature review and consists of five questions using a measurement scale. Each item is rated on a five-point Likert-type scale, ranging from "no effect" to "very serious" (see Appendix). The questionnaire was administered to clients of SGS Taiwan certification.

Established in 1878, the SGS Group is a global leader in testing, certification, and inspection services, renowned for its commitment to quality and integrity. Originally registered as the General Inspection Notary Group in Geneva, Switzerland in 1919, the company now operates over 2600 branches and laboratories worldwide

with a workforce exceeding 100,000 employees.

SGS Taiwan Co., Ltd. was founded in May 1991 to expand the provision of professional testing and technical services. With over three decades of service in Taiwan, SGS currently has more than 3000 professionals. The company's head office is situated in New Taipei Industrial Park, New Taipei City and it boasts over 17 diversified laboratories throughout Taiwan.

7. Results

In our research, we employed various statistical methods to examine the validity of the research hypotheses proposed in this study. These methods include sample structure analysis, reliability and validity analysis, descriptive statistical analysis, adaptation of measurement models, and hypothesis verification analysis (specifically structural modeling). In the following section, we will analyze and interpret the findings of this study.

8. Research sample

A total of 4323 questionnaires were distributed, of which 311 were returned. Some researchers consider that a large sample size in needed for SEM analysis (e.g., $N = 200$; Boomsma and Hoogland, 2001; Hoogland and Boomsma, 1998; Kline, 2005). After the questionnaire was collected, a structural analysis of the sample was carried out to understand the characteristics and distribution of the sample as follows (**Table 1**).

Taiwan's industries are dominated by electronics/electrical machines (40.84%) and metals/machinery (20.90%), according to **Table 1**. The average values of the MFG → Man, PUR → Delivery, Sales → Revenue, and Sales → Product cost items are especially "serious". We circulated 4323 questionnaires and received 311 full responses. According to some researchers' recommendations (Boomsma and Hoogland, 2001; Hoogland and Boomsma, 1998; Kline, 2005), a sufficiently large sample size (e.g., $N = 200$) is required for structural equation modeling (SEM) analysis. After the questionnaires were gathered, a structural analysis was performed to analyze the sample's features and distribution. **Table 1** summarizes the findings.

According to **Table 1**, Taiwan's industries are predominantly composed of electronics/electrical machinery (40.84%) and metals/machinery (20.90%). Specifically, the average ratings for items such as MFG → Man, PUR → Delivery, Sales → Revenue, and Sales → Product cost indicate that these factors are perceived as "somewhat serious.".

Table 1. Sample structure analysis.

I/T	N/S	Ratio	C/R	MFG								PUR								Sales					
				Man		Machine		Material		Method		Quality		Cost		Delivery		Service		Shipping		Revenue		Product cost	
				AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.	AVG	Std.
1	7	2.25%	2.25%	3.04	0.77	2.68	0.76	3.29	1.02	2.68	0.84	2.75	0.76	3.57	0.66	3.57	0.98	3.04	0.86	3.43	1.18	4.06	0.67	3.04	0.77
2	0	0.00%	2.25%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	127	40.84%	43.09%	3.07	1.02	2.70	0.96	2.74	1.02	2.21	0.90	2.29	0.84	2.74	0.89	3.02	1.09	2.51	0.88	2.80	1.09	3.15	1.07	3.07	1.02
4	65	20.90%	63.99%	3.18	0.90	2.70	0.94	2.74	0.97	2.37	1.04	2.61	1.08	2.67	0.95	3.22	1.01	2.56	1.07	2.72	1.03	3.31	1.08	3.18	0.90
5	29	9.32%	73.31%	2.91	1.20	2.57	1.19	2.63	0.84	1.86	0.89	2.46	1.14	2.26	0.76	2.98	0.96	2.22	0.81	2.65	0.84	3.27	1.05	2.91	1.20
6	7	2.25%	75.56%	3.21	0.83	2.46	0.97	2.64	0.84	1.93	1.00	2.14	0.69	2.43	0.69	2.62	0.95	2.46	0.59	2.50	0.97	2.49	1.16	3.21	0.83
7	35	11.25%	86.82%	2.96	1.12	2.74	1.07	2.92	1.00	2.65	1.10	2.60	1.01	2.94	1.01	3.39	1.21	2.49	1.10	2.71	1.10	3.35	1.12	2.96	1.12
8	41	13.18%	100%	2.57	0.95	2.40	1.01	2.37	0.85	2.08	0.86	2.26	0.82	2.46	0.76	2.67	1.02	2.18	0.68	2.51	0.90	3.04	1.01	2.57	0.95

Note: (1) Industry Type: I/T: 1. Government, 2. Agriculture, fishery and animals, 3. Electronics and electrical machines, 4. Machinery and metals, 5. Services, 6. Information Industry, 7. Trading, 8. Other.

(2) Number of Sample: N/S, (3) Cumulative Ratio: C/R.

8.1. Model fit indices analysis

Due to unsatisfactory adaptation of the original model and its data, particularly after conducting the initial Confirmatory Factor Analysis (CFA), it was found that the MFG → Method and PUR → Cost factor loadings were both below 0.5, which is not ideal. To simplify the analysis, the variable "For lack of reliability" was subsequently removed from consideration (Hair et al., 2010).

In this study, the Modification Index (MI) provided by Amos 22.0 was utilized to conduct a modification test on the model. The MI represents the chi-square value that would decrease if a parameter estimate is added. After setting correlations and observing significant changes in MI values for certain items, such as "Man → Machine," "Material → Service," and "Machine → Delivery," researchers released residual covariance parameters and carried out three corrective measures in total. In the initial hypothetical model, the chi-square value was 140.304 (df = 24), while after the third correction, it reduced to 82.297 (df = 21). This indicates a drop of 58.007 or 41.34% in chi-square value. The revised overall model fit test after releasing these parameters is presented in **Table 2**.

Table 2 displaysthe fitness indexes for each model. After revising the model, all fitness indexes meet the criteria for good fit and are considered acceptable standards for the model, except for the chi-square degree of freedom ratio, AGFI, RMSEA, and PGFI values. This indicates that the proposed SEM model in this study exhibits a good fit. As a result, further evaluation of reliability and validity, as well as testing of the structural model, can proceed.

Table 2. The overall adaptation analysis of the model before and after correction.

Overall fit indexes	STD	Before model modified		After model modified	
		Numerical value	Result	Numerical value	Result
Absoltue fit indexes					
Likelihood-Ratio χ^2	$p \geq 0.05$	140.304***	-	82.297***	-
df		24		21	
χ^2/df	≤ 3	5.846	Bad	3.919	Acceptable
GFI	≥ 0.90	0.916	Acceptable	0.946	Good
AGFI	≥ 0.90	0.842	Acceptable	0.885	Acceptable
SRMR	≤ 0.08	0.045	Good	0.037	Good
RMSEA	≤ 0.08	0.125	Bad	0.097	Acceptable
Relative fit indexes					
NFI	≥ 0.90	0.921	Good	0.954	Good
NNFI	≥ 0.90	0.900	Good	0.940	Good
RFI	≥ 0.90	0.882	Acceptable	0.921	Good
IFI	≥ 0.90	0.934	Good	0.965	Good
CFI	≥ 0.90	0.934	Good	0.965	Good
Parimonious fit indexes					
PGFI	≥ 0.50	0.488	Acceptable	0.442	Acceptable
PNFI	≥ 0.50	0.614	Good	0.556	Good
PCFI	≥ 0.50	0.622	Good	0.563	Good

***$p < 0.001$.

8.2. Reliability and validity analysis of measurement models

Table 3 presents the convergent validity of the three scales. The standardized factor loadings (<λ>) for each level and its corresponding scale range from 0.572 to 0.918. While some dimensions have loadings below 0.7, they still exceed the practical significance threshold of 0.5 (Hair et al., 2010), indicating acceptable performance. Additionally, all other dimensions surpass the threshold of 0.70 (Bagozzi and Yi, 1988), demonstrating that these levels adequately reflect their underlying constructs.

The Construct Reliability (CR) of the latent variables ranges from 0.713 to 0.884, meeting the minimum requirement of 0.70 (Hair et al., 2010). The Average Variance Extraction (AVE) for the latent variables falls between 0.462 and 0.719, except for MFG which slightly falls below 0.5. However, both PUR and Sales exceed .50, suggesting that the observed variables have a stronger influence on these latent variables than measurement error does (Fornell and Larcker, 1981). Based on these findings, all three research tools exhibit good convergent validity.

Table 3. Latent variable construction reliability and mean variance extraction.

Latent variable	Observed Variable	Normalized loading λ,	*t*-value	CR	AVE
	Machine	0.588		0.713	0.462
MFG	Material	0.844	10.150***		
	Man	0.572	10.174***		
	Quality	0.682		0.814	0.596
PUR	Delivery	0.752	12.185***		
	Service	0.870	13.597***		
	Shipping	0.888		0.884	0.719
Sales	Revenue	0.725	15.559***		
	Product cost	0.918	23.939***		

Note: CR: Construct Reliability; AVE: Average Variation Extraction.
***$p < 0.001$.

8.3. Hypothesis verification (structural pattern)

The previous analysis confirms that the measurement model in this study demonstrates acceptable fit and good convergent validity. Therefore, in this section, we proceed to examine the path relationships in the structural model (**Figure 2**). The following table presents the estimation results of the proposed model, aiming to validate the research hypotheses.

Table 4 reveals that the path coefficient from "MFG" to "Sales" is not significant ($\beta = 0.102$, $p = 0.570$), suggesting no evidence of an influence from MFG on Sales. Thus, H1 is not supported.

On the other hand, there is a significant positive path coefficient from "PUR" to "Sales" ($\beta = 0.843$, $p < 0.001$), indicating that higher levels of PUR are associated with higher sales. Hence, H2 is supported.

Furthermore, there is a significantly positive correlation coefficient between "MFG" and "PUR" ($r = 0.899$, $p < 0.001$), indicating that higher levels of MFG correspond to higher levels of PUR.

Table 4. Parameter estimates for structural models.

Path	Unstandardized Coefficient	Standard Error	Normalized Coefficient	*t*	*p*
MFG → Sales	0.159	0.280	0.102	0.567	0.570
PUR → Sales	1.204	0.264	0.843	4.558***	<0.001
MFG ↔ PUR	0.339	0.047	0.899	7.183***	<0.001

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

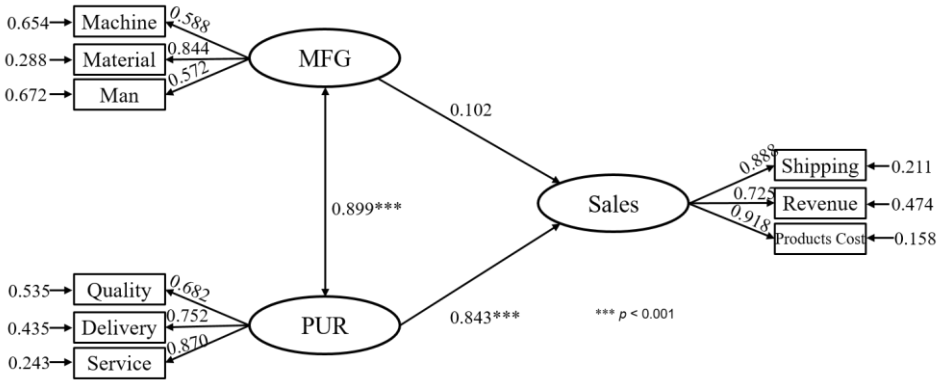

Figure 2. Structural pattern diagram.

9. Conclusion and discussion

This chapter includes a synthesis and comprehensive discussion of the research conclusions, proposes suggestions for future research inquiries, and discusses the limitations of the current research.

1) Conclusion

The objective of this study is to investigate the impact of COVID-19 on the relationships between manufacturing, procurement, and sales operations. **Table 5** presents the empirical research results and detailed outcomes of the study's research hypotheses. Subsequently, in line with the research purpose, an analysis will be conducted to determine if the research objectives are supported or not. This will be followed by a comparative analysis and discussion to further examine the findings.

Table 5. Summary of hypothesis testing results.

Hypothesis	Result
H1: Did manufacturing behavior significantly impact sales behavior during COVID-19?	Not supported
H1a: Was there a significant interaction between Manufacturing and Procurement during COVID-19?	Supported
H2: Did procurement behavior significantly impact sales behavior during COVID-19?	Supported

Source: Compiled by this study.

The results indicate that there is no significant impact of manufacturing on sales, and it is possible that there is a negative influence of manufacturing behavior on sales behavior.

The interaction between production and purchasing behavior is highly significant, suggesting that Taiwan's industries have experienced material shortages and delayed raw material deliveries during the COVID-19 pandemic.

There is a relationship between procurement and sales, with the latter demonstrating an increase in demand for shipments corresponding to an increase in procurement activities. suggesting that Taiwan's industries have experienced material shortages and delayed raw material deliveries during the COVID-19 pandemic.

There is a relationship between procurement and sales, with the latter demonstrating an increase in demand for shipments corresponding to an increase in procurement activities. Based on the aforementioned study findings, it is clear that Taiwan's industry was significantly impacted by production, purchasing patterns and sales acitivies during the COVID-19 pandemic, which led to changes in industry behavior patterns including work from home, virtual meetings, and other novel approaches.

2) Discussion and Management Implications

Organizations, businesses, and sectors have experienced extraordinary changes as a result of COVID-19 influence, and appropriate safeguards have had to be put in place. The idea of organizational resilience becomes essential in this context. "The ability to forecast, plan for, respond to, and adapt to constant changes in the environment and sudden operational disruptions, enabling an organization to survive and prosper" (Rosenberg, 2015) is the definition of organizational resilience as given by the ISO 65000:2014 standard. The agility, robustness, and risk management of supply chain systems are all improved by having a thorough grasp of organizational resilience (Subramani, 2004; Rai et al., 2012; Prajogo and Olhager, 2012; Singh et al., 2020; Huo et al., 2015). Furthermore, maintaining a strong infrastructure for information systems (IS) and information technology (IT) is essential to guaranteeing

10. Limitations

This study employs a quantitative methodology, utilizing a questionnaire for the survey. An interview provides a deeper understanding of the enterprises being examined, and it is impossible to increase the quantity and scope of investigations. The sole company that is included in the research scope is SGS Taiwan Ltd., which has successfully completed the certification process. Another disadvantage of this research is its limited representativeness.

Subsequent investigations may examine the effects of more infectious illnesses on industrial processes.

Author contributions: Conceptualization, PLH and BCYL; methodology, PLH and KHC; software, PLH; validation, PLH, KHC and BCYL; formal analysis, PLH; investigation, KHC; resources, PLH; data curation, PLH; writing—original draft preparation, PLH; writing—review and editing, BCYL; visualization, BCYL; supervision, PLH; project administration, KHC; funding acquisition, PLH. All authors have read and agreed to the published version of the manuscript.

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Appendix: Questionnaire

1. What has been the impact of COVID-19 on the company's manufacturing operations?			No effect	Slightly serious	Somewhat serious	Severe	Very serious
Items	Code	Content	1	2	3	4	5
(Man)	M1-1	Impact on personnel recruitment					
	M1-2	Impact on staff assignments (including overseas)					
	M1-3	Impact on personnel training (including overseas)					
	M1-4	Impact on personnel management (including overseas)					
(Machine)	M2-1	Impact on equipment maintenance					
	M2-2	Impact on the movement of equipment across factories (including overseas)					
	M2-3	Impact on new equipment purchases (including overseas purchases)					
	M2-4	Impact on procurement of equipment parts (including overseas)					
(Material)	M3-1	Impact on raw material procurement					
	M3-2	Impact on raw material transportation					
	M3-3	Impact on raw material acceptance					
	M3-4	Impact on communication with raw material suppliers					
(Method)	M4-1	Impact of SOP changes due to COVID-19?					
	M4-2	Affected by the statute of limitations at work?					
	M4-3	Affected by work standards?					
	M4-4	Confirm the impact of COVID-19 on job performance					
2. What has been the impact of COVID-19 on the company's purchasing operations?			No effect	Slightly serious	Somewhat serious	Severe	Very serious
Items	Code	Content	1	2	3	4	5
(Quality)	P-Q1	Purchasing quality requirements					
	P-Q2	Quality of products procured					
	P-Q3	Acceptance of products procured					
	P-Q4	Impact on quality of products procured					
(Cost)	P-C1	Impact on procurement cost					

	P-C2	Impact on procurement variable cost					
	P-C3	Impact on return loss					
(Delivery)	P-D1	Under the influence of COVID-19, the supplier's response to the delivery time will be affected?					
	P-D2	Under the influence of COVID-19, the impact on the delivery time of Procurement products?					
	P-D3	Under the influence of COVID-19, the delivery time of Procurement products is affected by transportation?					
(Service)	P-S1	Impact on after-sales service of products procured					
	P-S2	Impact on intractable disputes over products procured					
	P-S3	Impact on returns and exchanges of products procured					
	P-S4	Impact on procurement timeliness					
What has been the impact of COVID-19 on the company's sales operations?			No effect	Slightly serious	Somewhat serious	Severe	Very serious
Items	Code	Content	1	2	3	4	5
(Shipping)	S-S1	Impact on timeliness of product shipment					
	S-S2	Impact on shipping method					
	S-S3	Impact on shipping prices					
	S-S4	Impact on customers' ability to receive and accept goods					
(Revenue)	S-R1	Impact on the company's shipments?					
	S-R2	Impact on the company's turnover					
	S-R3	Impact on company profits					
	S-R4	Impact on product prices					
	S-R5	Impact on accounts receivable recovery					
(Product cost)	S-P1	Impact on product cost					
	S-P2	Impact on product variable costs					
	S-P3	Impact on company waste loss					
	S-P4	Impact on company property insurance premiums					