TEM Journal. Volume 13, Issue 4, pages 2875-2883, ISSN 2217-8309, DOI: 10.18421/TEM134-23, November 2024.

Enhancing Productivity: The Impact of Standardized Work Methods in the Shrimp Processing Industry

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***Abstract* - Shrimp production, a major global industry predominantly in Asia, faces efficiency challenges due to labor-intensive methods, labor shortages, and rising costs. This research develops standardized peeling methods to enhance productivity and examines their impact, considering employee age, experience, and shrimp size. Data were collected from employees categorized by age and experience. The study proposed and compared two peeling methods, Method A and Method B, with various sizes of shrimp. Productivity was measured, and factorial ANOVA was used to analyze the main effect of standardized peeling methods and interaction effects between peeling methods and various factors, including employee age, experience, and shrimp size. Results indicate that Method A significantly improves productivity. Employee experience emerged as a crucial factor, while age had a moderate effect. Minor interaction effects between peeling method and raw material size, as well as worker age, were insignificant.**

No interaction effect was observed between the method and worker experience. Method A consistently outperformed Method B and current practices. The study underscores the importance of standardized work methods and individual characteristics in driving productivity. Findings support the adoption of standardized methods, investment in training, cost management, and technological integration alongside regular review of work procedures, as key strategies for enhancing productivity in labor-intensive industries.

***Keywords* - Productivity, shrimp processing, standardized work method, shrimp peeling, labor-intensive industries.**

DOI: 10.18421/TEM134-23
https://doi.org/10.18421/TEM134-23

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Received: 03 June 2024.
Revised: 04 September 2024.
Accepted: 28 October 2024.
Published: 27 November 2024.

1. Introduction

Shrimp and shrimp products are widely consumed globally. Global shrimp production is projected to reach 7.28 million tons by 2025, with a compound annual growth rate (CAGR) of 6.1% from 2020 to 2025 [1]. According to the Food and Agriculture Organization of the United Nations, the major shrimp-producing countries are predominantly in Asia, contributing over eighty percent of global shrimp production [2]. Thailand ranks as the world's sixth-largest shrimp exporter, with exports totaling 147.3 billion tons in 2020 [3]. Despite the continuously rising demand, the shrimp export industry is experiencing a decline in production efficiency. This problem primarily stems from the industry's dependence on labor-intensive production methods.

Labor shortages and decreased workforce efficiency are significant contributing factors. Furthermore, the seafood industry faces escalating competition due to rising production costs and capacity constraints. These challenges pose substantial difficulties for operators, who consequently incur higher costs. To offset these expenses, operators may need to raise product prices, which could adversely affect the country's future competitiveness.

Thailand, which derives a substantial portion of its income from the export of food and agricultural products, encounters significant challenges in maintaining its competitiveness. Enhancing competitiveness and expanding export value are vital for sustaining and boosting the country's economic growth [4], [5]. In a context of steadily rising wages, improving production efficiency is a crucial strategy.

This study aims to enhance productivity in the frozen seafood manufacturing industry. Given the labor-intensive nature of this sector, the analysis centers on staff efficiency. The industry experiences high labor turnover and most companies lack standardized procedures for each stage of production. Consequently, workforce efficiency has progressively declined. To meet production targets, companies frequently hire additional workers at various stages of the manufacturing process, leading to increased production costs.

This study seeks to address the lack of standard procedures at each stage of the work process by exploring techniques for standardizing work methods. As previously mentioned, employees currently employ various techniques, leading to inconsistent outcomes. Consequently, this research aims to develop standardized procedures that enhance production efficiency, taking into account the characteristics of personnel and raw materials that may influence work methods. The ultimate objective is to improve organizational quality and operational efficiency.

This paper is structured as follows: The next section presents the literature review and the hypotheses under investigation. The "Methods" section outlines the research methodology employed in the study. The "Results and Discussion" section provides descriptive statistics, results of hypothesis testing, and a detailed discussion. Finally, the "Conclusions and Implications" section summarizes the findings and offers managerial implications.

2. Literature Review

Productivity has been defined as the ratio of output units produced to input units used to produce the outputs. Labor, raw materials, energy, machinery, capital, and other resources are examples of inputs [6]. There are several approaches for increasing productivity, including maintaining production while using fewer resources and increasing output while utilizing the same resources. Each approach from prior studies is detailed below.

Labor productivity is defined as the ratio of output units produced to working hours. To improve worker productivity, it is vital to determine the factors that influence productivity. Several factors affecting productivity have been identified in earlier studies.

Personal characteristics of employees, such as age, education level, and skills or job experience, have been identified as factors influencing productivity [7], [8], [9], [10], [11]. Furthermore, management has been identified as a factor influencing productivity. Management factors are such as the availability of tools or equipment used, the availability of raw materials, and supervisory monitoring [7], [8], [10], [12], [13]. Employee motivation, rewards, and punishments were identified as factors affecting employee productivity by Tam *et al*. [7], Hiyassat *et al*. [10], and Tam *et al*. [14]. They also took environmental and safety concerns into account as influencing factors.

Furthermore, other researchers have concentrated primarily on modifications in work methods or production lines/procedures in order to improve productivity. In these studies, the work-study method was employed along with lean manufacturing and work standardization [15], [16], [17], [18], [19]. Moreover, Pisuchpen and Chansangar [16] modified the production line using other approaches: line balancing and simulation models to compare different scenarios. Work standardization was considered one of the ways to improve overall productivity as it is defined as a set of specific work instructions that help workers perform their work efficiently [20]. As work standardization prevents workers from performing their work randomly, it reduces process variability. To achieve that, a work method study is required. Work-study is the investigation process used to get the best utilization of resources [21].

It consists of two parts: method study and work measurement to examine the activities, modify or simplify work or develop a new method, and study time required for each activity [22]. Several studies investigated the reduction in production time, which resulted in a productivity improvement by applying a work method study [17], [19], [23].

Recent studies have shown that peeling is a challenging step in shrimp processing. The attachment of the shell to the muscle makes the peeling difficult. For years, attempts have been made to improve the peel ability of shrimp by various methods to loosen the shell from the meat while maintaining the quality. Gringer *et al*. [24] proposed a method for measuring the strength of shell-muscle attachment of shrimp body and evaluating peeling efficiency and performance using a texture analyzer machine. Dang *et al*. [25] reviewed potential technologies for facilitating shrimp peelings, such as high pressure, microwave, ultrasound, and enzymes.

They discovered that these technologies could be used to loosen the shells from the meat, which helps increase the peel ability of shrimp.

However, high pressure, ultrasound, and enzymatic treatment may affect the properties and quality of the shrimp. In contrast, microwave technology has a significant problem regarding uneven energy distribution, which causes hot spots and non-treated areas. In terms of studies regarding the peeling machine, Zhao *et al*. [26] reviewed the technology development of the shrimp peeling machine.

They found more room for improvement, especially in the aspect of consistent performance, regardless of the different sizes of shrimp.

In the case company examined in this study, the primary product is cooked sushi shrimp, which is sold both domestically and internationally, with exports accounting for 87% of total sales. Data collected from the company indicate that manufacturing efficiency for sushi shrimp has decreased by 9% over the past two years, despite a yearly increase in international orders, which have risen by approximately 48% over the past three years. This trend is illustrated in Figure 1.

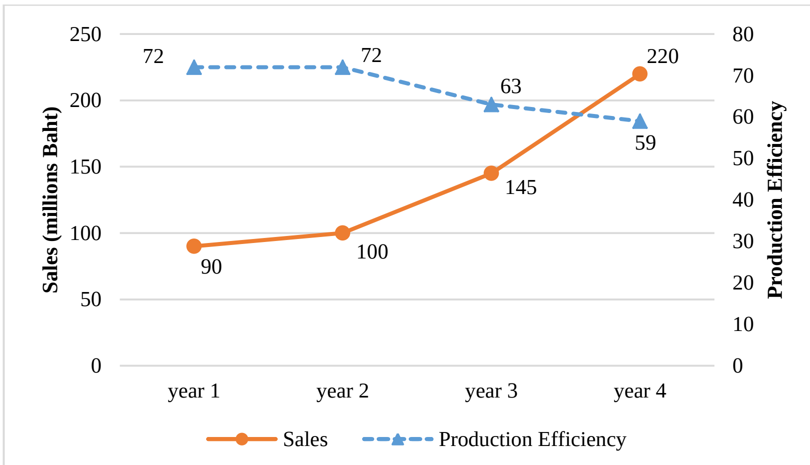

Figure 1. Sushi-shrimp product sales and production efficiency (pieces per person per hour)

The observed decline in productivity necessitates a comprehensive analysis of the production process, which has revealed a decrease in yields at nearly every stage. The production process for cooked sushi shrimp involves several steps: initially, raw shrimp is prepared, then stretched, and cooked. Following this, the shrimp is quickly chilled before undergoing hand-peeling. The heat treatment from cooking aids in partially loosening the shell from the muscle. Additionally, cooling the cooked shrimp under specific conditions prior to peeling reduces the temperature differential between the shell and meat, thereby enhancing peeling efficiency.

The company identified that the most substantial reduction in production yield, a 16 percent decrease, occurs during the shrimp peeling stage.

As cooked sushi shrimp is a ready-to-eat product, it necessitates high-quality processing and performance to ensure fully peeled shrimp. From the previous findings, current peeling machines do not consistently meet the required standards and lack the flexibility to accommodate varying shrimp sizes. Consequently, hand-peeling remains essential for processing this product, as it ensures better meat integrity and higher product quality.

Therefore, this study proposes and compares different peeling methods, evaluating their practical application under the specific conditions of cooked shrimp. Both skilled and unskilled employees, as well as shrimp of varying sizes, are considered to determine whether the proposed method is consistent and unaffected by shrimp size.

As depicted in Figure 2, the conceptual framework explores the impact of work methods on employee productivity, as well as the combined influence of employee characteristics, raw material attributes, and work methods on productivity. The framework encompasses two key dimensions of employee characteristics: age and work experience. In essence, the establishment of standardized work methods is expected to yield efficiency across varying employee and raw material profiles. Hence, the conceptual framework deliberately integrates these elements.

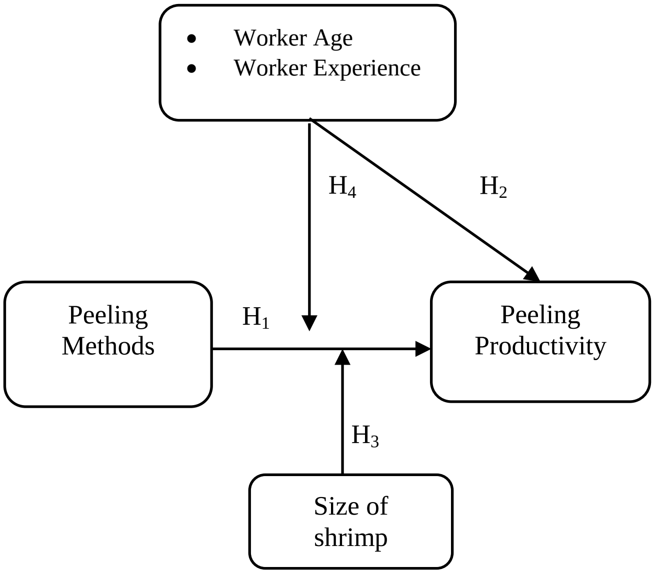

Figure 2. Conceptual framework

Based on the conceptual framework outlined, the following hypothesis was formulated for this study.

Hypothesis 1: The peeling method has a significant impact on peeling productivity.

Hypothesis 2: Employee personal characteristics: age and experience significantly impact peeling productivity.

Hypothesis 3: The effect of the peeling method on productivity does not depend on shrimp size.

Hypothesis 4: The effect of the peeling method on productivity does not depend on employees' characteristics.

3. Methods

Data were collected from 47 employees in the peeling department of the case company who were categorized by age and peeling experience as shown in Table 1.

Table 1. Employees categorized by personnel characteristics

Number of employees		Experience < 1 year	Experience ≥ 1 year	Total
Age	20-29 years old	14	7	21
	30-39 years old	7	5	12
	40-49 years old	4	10	14
	Total	25	22	47

The designed experiment concerns two peeling methods and two sizes of shrimp. Each employee is required to peel 50 shrimps for each method and each shrimp size. That implies that each employee is assigned to peel 200 shrimps.

Table 2 illustrates the data collection as described. Peeling time was collected from their daily reported worksheets, and peeling productivity was computed accordingly.

Table 2. Sample size

Total (n=9400)		Method A	Method B
Age	20-29 years old	2100	2100
	30-39 years old	1200	1200
	40-49 years old	1400	1400
Experience	< 1 year	2500	2500
	≥ 1 year	2200	2200
Size	small	2350	2350
	large	2350	2350

3.1. Measures

Peeling Productivity

Peeling productivity refers to the quantity of work accomplished by an employee within an hour. This metric was assessed by instructing staff to adhere to standardized procedures, recording the time taken by each employee to peel a shrimp, and subsequently calculating their productivity in terms of pieces per hour per person.

Peeling Method

A standardized peeling technique was formulated through an analysis of the methodologies employed by proficient employees.

Subsequently, a group discussion was conducted with these high-performing workers to distill two procedures exhibiting notable output rates, labeled as Method A and Method B. These methods were then adopted by all workers for further examination. The specific steps involved in the peeling process for each method are delineated below.

Method A:

1. Remove the carapace (headshell) from the side.
2. Peel off the shell, starting from the body and moving towards the flippers (uropods).
3. Cut off the pereopods (walking legs).
4. Scrape off the pleopods (swimming legs) from underneath the abdomen in a top-down direction.

Method B:

1. Peel off the shell, starting from the flippers (uropods) and moving towards the head.
2. Remove the carapace (head shell) from the side.
3. Cut off the pereopods (walking legs).
4. Scrape off the pleopods (swimming legs) from underneath the abdomen in a bottom-up direction.

3.2. Control Variables

In line with prior research findings, demographic factors presumed to impact employee productivity—specifically age and experience—were regarded as control variables. Age was categorized into three groups: 20-29 years, 30-39 years, and 40-49 years. Peeling experience was segmented into two groups: less than one year and one year or more. Furthermore, shrimp sizes were differentiated into two classifications: small (more than 60 pieces per kilogram) and large (60 pieces or fewer per kilogram).

3.3. Statistical Analysis

This experiment investigated the specific factors influencing employee peeling productivity. A Factorial ANOVA was used to examine the main and interaction effects on productivity.

4. Results and Discussion

A Multifactor ANOVA analysis was performed to assess peeling productivity utilizing the Statistical Package for the Social Sciences (SPSS).
The study examined four primary factors: employee age, experience, shrimp size, and peeling methods, alongside their interaction effects on peeling productivity. Descriptive statistics are detailed in Table 3.

Table 3. Means and standard deviations: Productivity

		Productivity	
		Mean	Std. Deviation
Age	20-29 years old	256.42	48.623
	30-39 years old	278.81	46.263
	40-49 years old	288.59	37.128
Experience	< 1 year	247.88	43.201
	≥ 1 year	298.8	35.115
Size	small	299.31	36.916
	large	244.12	39.304
Method	A	286.02	46.708
	B	257.41	42.895

Hypothesis 1 posits that there exists a discrepancy in peeling productivity between the two methods. To test this hypothesis, a t-test was conducted, revealing that method A yields higher productivity compared to method B (t=30.932, p = 0.000; see Table 3 for descriptive statistics). Additionally, a t-test was employed to determine whether method A significantly enhances productivity from the current practice, characterized by an average productivity of 259.06 with a standard deviation of 46.617. The test result confirms that method A indeed significantly improved productivity (t = 5.542, p = 0.000). Furthermore, this finding aligns with the ANOVA outcomes (Table 4), indicating that the effect of the peeling method on productivity is significant ($F_{(1,9390)}$ = 3516.254, p = 0.000, η^2=0.272). It states that the peeling method explains 27.2 percent of the variance in peeling productivity.

Table 4. ANOVA test

Test of between-subjects effects				
Dependent variable: Productivity				
Source of Variation	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1753670.44	3268.256	0.000	
Constant	673063039.67	1254364.81	0.000	
Age	299434.15	558.045	0.000	0.106
Experience	4765065.46	8880.491	0.000	0.486
Size	7158612.13	13341.26	0.000	0.587
Method	1886740.04	3516.25	0.000	0.272
Age * Method	7357.83	13.713	0.000	0.003
Experience * Method	85.73	0.160	0.689	0.000
Size * Method	19523.53	36.385	0.000	0.004

Hypothesis 2 addresses that demographic variables, worker age (Hypothesis 2a) and experience (Hypothesis 2b), directly affect peeling productivity. To test hypothesis 2a, ANOVA and multiple comparison tests.

The results show that workers of higher age tend to perform better (F=472.092, p-value =0.000). In addition, a t-test was performed to verify that experience affects productivity, yielding a t-value of -62.983 with a p-value of 0.000, which strongly supports Hypothesis 2b (see Table 3 for descriptive statistics). It is concluded that employees with more than 1-year experience can perform better than those with less experience.

Hypothesis 3 posits that there is no interaction between the peeling method and shrimp size on productivity.

Specially, it is expected that method A will always yield better performance than method B, regardless of shrimp size. To test this interaction effect, an ANOVA is run on productivity with the peeling method and shrimp size as independent variables (see Table 5 for descriptive statistics).

The analysis reveals significant effects of both peeling method and shrimp size, as well as an interaction effect between the two (Table 4). As stated earlier, the peeling method can explain the variance in the peeling productivity of 27.2 percent. The effect of shrimp size yields an effect size of 0.587, indicating that 58.7 percent of the variance in the peeling productivity was explained by the size of shrimp ($F_{(1,9390)}$ = 13341.263, p = 0.000, η^2= 0.587). Moreover, the interaction effect is significant ($F_{(1,9390)}$ = 36.385, p = 0.000, η^2= 0.004), indicating that the combined effect between method and shrimp size can explain the variance in the peeling productivity by about 0.4 percent. In the production of small-size shrimp, method A yields a larger difference in productivity than that of large-size shrimp. Figure 3 shows the productivity pattern across the peeling method and shrimp size groups.

Table 5. Means and standard deviations: Hypothesis 3

		Productivity	
		Mean	Std. Deviation
Small size	Method A	315.06	34.574
	Method B	283.57	32.165
Large size	Method A	256.99	38.494
	Method B	231.26	35.74

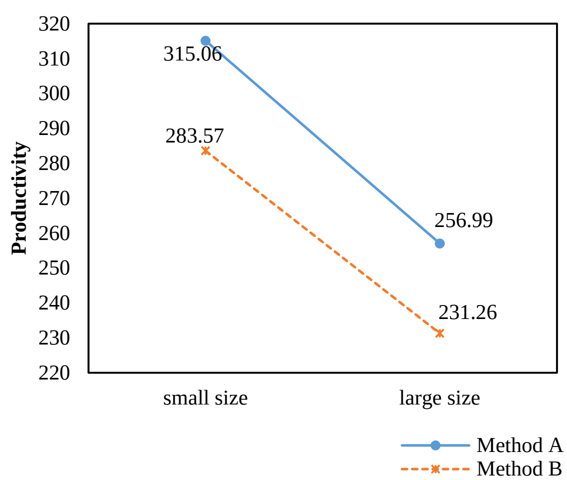

Figure 3. Peeling productivity: peeling method and shrimp size predictors

Hypothesis 4 posits that there is no interaction effect between experience and method (Hypothesis 4a) and age and method (Hypothesis 4b). It is hypothesized that peeling method A yields higher productivity than method B regardless of the employee's experience or age. Descriptive statistics are presented in Tables 6-7 and Figure 4.

Table 6. Means and standard deviations: Hypothesis 4a

		Productivity	
		Mean	Std. Deviation
Experience < 1 year	Method A	262.10	43.612
	Method B	233.67	37.780
Experience ≥ 1 year	Method A	313.21	33.315
	Method B	284.39	30.678

Table 7. Means and standard deviations: Hypothesis 4b

		Productivity	
		Mean	Std. Deviation
20-29 years old	Method A	269.76	49.094
	Method B	243.07	44.308
30-39 years old	Method A	295.21	44.356
	Method B	262.41	42.151
40-49 years old	Method A	302.55	35.812
	Method B	274.63	32.944

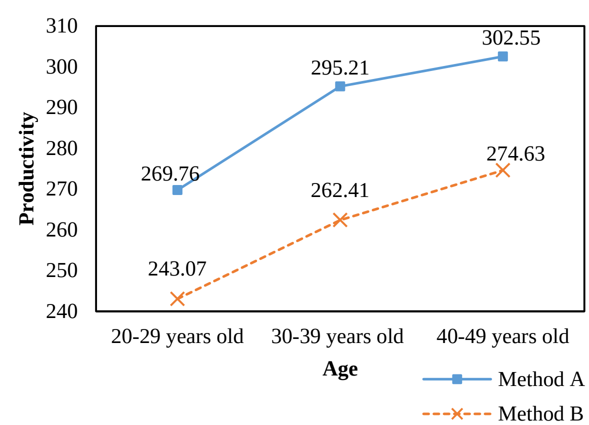

Figure 4. Peeling productivity: peeling method and worker age predictors

From ANOVA results, a main effect of worker experience was observed ($F_{(1,9390)}$ = 8880.491, p = 0.000, η^2 =0.486), a main effect of worker age ($F_{(2,9390)}$ = 558.045, p = 0.000, η^2= 0.106), an interaction effect between worker experience and peeling method ($F_{(1,9390)}$ = 0.160, p = 0.689, η^2 = 0.000), and an interaction effect between worker age and peeling method ($F_{(2,9390)}$ = 13.713, p = 0.000, η^2 = 0.003) (Table 4).

The test results indicate that 48.6 percent of the variance in peeling productivity is explained by worker experience, whereas 10.6 percent of that is explained by age. Regarding interaction effects, it was found that the effect of the peeling method differs depending on the worker's age. This is seen by the larger difference in productivity across worker groups of less than 30 years old than that of older age. However, this effect is only about 0.3 percent, which can explain the variance in productivity. Moreover, there is no combined effect between method and worker experience on productivity as the interaction effect is insignificant ($p = 0.689$). That is, the effect of the peeling method does not depend on worker experience.

This study employed theoretical frameworks to explain the impact of various factors on employee productivity within the labor-intensive company. The findings provide strong evidence for effects on productivity and confirm existing literature in three key dimensions. Firstly, individual factors, notably experience, exert influence on work efficiency within labor-intensive roles. Secondly, the standardization of work processes has been instrumental in improving managerial oversight and operational efficiency. Lastly, the experimental approach affords a more controlled evaluation of the efficacy of prescribed work methods.

The findings support the theory's assumption that productivity is driven by a combination of work methods and individual characteristics. The experimental method enabled qualification of each factor's effect. While previous studies have examined the main effects of these factors, the interaction between them has not been investigated. By employing experimental techniques, this study identifies these factors separately and understands their relative significance. The findings of this study highlight the considerable impact of work experience on work efficiency. According to Cohen [27], in terms of effect size categorization, the main effect of worker experience demonstrates a substantial effect size ($\eta^2 = 0.486$), whereas age exhibits a moderate effect size ($\eta^2 = 0.106$). This implies that work experience significantly outweighs age in influencing worker productivity.

The experimental method allowed for evaluating the impact of the proposed work methods while controlling for other variables. Previous research suggests that standardizing work methods can enhance productivity. Given the substantial effect size of the peeling method ($\eta^2 = 0.272$), the findings align with prior studies.

However, the developed work method aims to yield superior outcomes for workers of varying ages, experiences, and raw material sizes.

It was hypothesized that Method A would outperform alternative methods across all studied factors, although this hypothesis received partial support. The results indicate minimal interaction effects between method and worker age, as well as method and shrimp size ($\eta^2 = 0.003$, 0.004, respectively). Nonetheless, Method A consistently outperforms Method B and current practices.

5. Conclusions and Implications

This research investigated the influence of standardized work methods on productivity within the shrimp processing industry, with a particular focus on demographic factors such as employee age, experience, and shrimp size. The findings of this study are consistent with the underlying theoretical framework, indicating that performance is influenced by both standardized work methods and individual characteristics. That is, the results affirm that Method A substantially enhances productivity compared to alternative methods, accounting for 27.2% of the variance in peeling productivity. Moreover, employee experience emerged as a crucial determinant, explaining 48.6% of the variance in productivity.

Additionally, age exhibited a noteworthy influence, with older workers demonstrating higher levels of productivity.

Moreover, examining the interaction between the peeling method and various factors on productivity indicates that although there are minor combined effects between the method and raw material size, as well as between the method and worker age, these effects are considered insignificant. Additionally, no interaction effect is observed between the method and worker experience. This implies that selecting the appropriate peeling method is likely to yield substantial productivity enhancements with minimal interaction from other factors.

The findings of this study offer several managerial implications for enhancing productivity in labor-intensive industries such as shrimp processing.

1. **Implementation of Standardized Work Methods**: Empirical studies show that standardizing work methods can boost productivity. It shows that the work method designed in this study, Method A, can greatly improve productivity for any employee's attributes with no further investment expense. Managers should prioritize developing and implementing standardized methods tailored to the production process.

2. **Training and Development Programs**: Given the substantial impact of experience on productivity, companies should invest in comprehensive training programs to quickly elevate new hires to higher performance levels. This will ensure proficiency in job execution and maintaining high productivity standards across the workforce.

3. **Cost Management**: The need to add more personnel to balance the production process due to the lack of standard methods highlights the importance of cost management. By implementing effective standardized methods, companies can reduce the need for additional labor, thus controlling production costs and improving overall efficiency.

4. **Technological Integration and Procedure Review in Work Processes**: In response to technological advancements and challenges in hiring skilled workers, companies may consider incorporating new machinery, technologies, or innovations into their operations to enhance performance. Additionally, the frequent review and updating of procedures is considered critical to maintaining high productivity standards. Organizations can accomplish ongoing operational improvements by combining input from high-performing personnel and embracing advanced machinery and innovations in work processes.

In conclusion, this study demonstrates the critical role of standardized work methods, employee experience, and demographic factors in enhancing productivity. Establishing standardized work methods is instrumental in cultivating operational efficiency within organizations. Focusing on these aspects makes it feasible to enhance productivity, exercise cost control, and stay competitive, especially in labor-intensive industries.

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