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Performance evaluation of the supply chain system of a food product manufacturing system using a questionnaire-based approach

Olasumbo Makinde[a*], Tebogo Mowandi[a], Thomas Munyai[a], Michael Ayomoh[b]

[a]*Tshwane University of Technology, Staatsartillerie Rd, Pretoria West, Pretoria, 0001*

[b]*University of Pretoria, Lynnwoods Rd, Hatfield, Pretoria, 0083*

Abstract

Effective management of the end-to-end process of a food industry is vital for the achievement of the key strategic objectives of this organisation. However, various factors have limited the performance and productivity of the supply chain system of food industries; thus hindering an organisation from meeting its customers demand target. Hence; there is a need to appraise the performance of the supply chain system of a food industry with a view to identify factors limiting its performance and ensure continuous end-to-end process improvement. In light of this, this paper assesses the performance of the supply chain system of a food industry using a questionnaire-based approach. The structure of the questionnaire consists of myriad of questions that appraises the performance of various factors responsible for effective functioning and optimal flow of the supplier and production sections of the supply chain of a food industry based on the industry benchmark for these factors. The production operators responded to the appropriate sections of the questionnaire. The questionnaire result revealed that the overall performance of work stations 1, 3, 4 and 5 are below the organisation's target. Hence, the resolutions of various factors lowering the performance of these work stations were recommended as future studies. The questionnaire developed in this study serve as a template that could be used by supply chain managers to measure the performance of their supply chain systems, with a view to ensure continuous and sustainable end-to-end process improvement.

Keywords: Supply chain system; Questionnaire; Food industry; Assessment

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1. Introduction

According to Agus [1], supply chain is a conglomerate of facilities that are responsible for the: (i) ordering and purchase of raw materials, (ii) conversion of raw materials into semi-finished and finished products, and (iii) delivery of high quality finished products to the customers using a well-defined distribution system. In light of this, the management of this chain is vital for productivity improvement in various organisation. According to Syahira [2], supply chain management involves the coordination and integration of the various activities to ensure an optimal flow of raw materials through a manufacturing function all the way to the final user, in order to warrant customer satisfaction. Measuring the effectiveness and utilisation of the linkages that exist between the end-to-end processes of these aforementioned facilities is vital for continuous process improvement, required to exponentially improve the productivity of an organisation [3], [4]. According to Kazemkhanlou and Ahadi [5], on the one hand, the measurement of the supply chain system of an organization dictates the progression levels of that organization, while on the other hand it pinpoints the various factors that disrupts the optimal functioning of the supply chain system, and thereafter indicates the suitable actions that must be carried out in order to improve the product quality, process efficiencies and the overall performance of the supply chain of the organization [6]. According to Kusrini et al [7] the performance measurement used in assessing a supply chain system must be (i) derived from a systematic strategy, (ii) easy to understand, (iii) give accurate feedback, (iv) must be to controlled and manipulated by the user, (v) have specific goals, and (vi) must be relevant. On the other hand, it must be (i) clearly defined, (ii) provide just in time feedback, (iii) have explicit goals, (iv) premised based on clear and comprehensive data sources and formulas, and (v) it must be precise.

Various approaches are available in the literature for appraising the effectiveness of the linkages between the end-to-end processes of an organisation. Most of these Supply Chain Performance Measurement Systems (SCPMS) have on, the one hand, solely focused on either: (i) developing a blueprint or guideline/ frameworks (such as Map Model Frame- work [8], Balance Score Card [9], Performance Prism [10] and Supply Chain Operations Reference [5]), which highlight what needs to be measured and how to measure the performance of a supply chain system, or (ii) formulating some set of metrics/ performance attributes (such as time-based, non-financial and financial measures [11]) that need to be used to appraise the performance of a supply chain system of an organisation. On the other hand, literature on SCPMS have solely focused on establishing some set of measurement methods (such as Analytical Hierarchy Process [12], Analytical Network Process [13], Data Envelopment Analysis [14], Technique for Order Preference by Similarity to Ideal Solution TOPSIS [15], Fuzzy- Analytical Hierarchy Process [16] and Fuzzy- Analytical Network Process [17]), which clearly clarify how the appraisal of raw material suppliers need to be effectively carried out. However, to the best of the authors' knowledge, relatively few research works have focused on developing SCPMS which integrate all the aforementioned functions of the SCPMS or any two of these functions, in effectively appraising the overall performance or some sections of the supply chain system hypothesized by supply chain managers to be major contributors of low productivity; with a view to ensure continuous improvement of the chain. In light of this, this paper proposes a questionnaire-based approach, which indicate the conglomerate of facilities that need to be measured and the suitable metrics that must be used to measure the performance of internal customers and suppliers of a food production industry; considered as core productivity enablers in this environment, with a view to improve the overall supply chain performance of this organisation.

The rest of the paper are organized as follows. Section 2 presents the structure of the questionnaire that was used to assess the supply chain system of the food company. Section 3 presents and discusses the assessment results of the food industry company XYZ. The last section concludes based on the results obtained from the study.

2. Supply chain assessment questionnaire design

The purpose of the questionnaire was to appraise the utilisation and efficiency of various workstations and linkages that are available within the end-to-end production processes of a food industry. The content of the questionnaire was developed based on literature that indicated: (i) what must be measured in order to ascertain the performance of a supply chain systems and (ii) the key metrics that need to be considered in appraising the end-to-end processes of an organisation. The questionnaire developed in this study comprises of two sections, I and II. Section I investigate the demographic information of the workers, working at various work stations linked to the end-to end processes of this food production organisation. Section II ask about the performance of the various end-to-end processes of an

organisation with respect to various key metrics. Two Likert scales were used in the questionnaire. The first Likert scale of 1 to 2, with 1 being "Yes" and 2 being "No" and second Likert scale of 1 to 3, with 1 being "Not Done" , 2 being "Twice in Every Four Production Cycles" and 3 being "Every Production Cycle" were utilised in the questionnaire. In light of this, the myriads of questions tailored towards to evaluating the utilisation and efficiency of the work stations and linkages that are available within the end production processes of a food production organisation are highlighted as follows:

1) Is your workstation flexible to meet the fluctuating customer volumes?
2) Do you transport raw materials frequently from: (i) the raw materials stores to your workstation, as well as (ii) between workstations?
3) Do you have a demarcated area on your workstation to place raw materials before processing them?
4) Do you keep minimal raw materials quantities in your workstation?
5) Do you complete the Short Interval Controls sheets while operating at your workstation? (Q5).
6) Do you do problem solving and the root causes analysis for any breakdown experienced on your line?
7) Do you have Standard Operating Procedures on your workstation?
8) Do you frequently produce defect products on your workstation?
9) Are you trained to perform your tasks on your workstation?
10) Do you frequently adhere to the safety policies at your workstation when handling raw materials or WIP?
11) Do you frequently raise job cards for any breakdowns experienced on your workstation?
12) Do you frequently re-work products on your workstation?
13) Do you frequently track your shift production and performance?
14) Do you frequently achieve your quality targets on your shift?
15) Do you frequently get training to perform your tasks?
16) Do you frequently meet the hourly production rate or target true efficiency (TTE)?

The performance rating of the work stations used in the food production organisation, obtained based on the respondents reply to the myriads of the questions in the questionnaire are determined using equations (1) and (2).

$$PR = \frac{No.\,Yes\ answers}{Total\ no.of\ question} \text{ x } 100 \quad (1)$$

$$PR = \frac{No.responses\ satisfying\ acceptable\ threshold}{Total\ no.of\ questions} \text{ x } 100 \quad (2)$$

Table 1 indicates the company standards that could be used to assess the aforementioned key performance indicators of the production department of a food industry.

Table 1. Company standards for performance key performance indicators (KPI)

	Key Performance Indicators	Standard/Benchmark
	Production Function	
1.	Production plan flexibility	Availability of flexible production plan system
2.	Production process stoppages	Zero (0)
3.	Process input control management	High process input quality (i.e. Optimum operating temperature, pressure and water level of the machines)
4.	Defect resolution time	≤ 2 hour
5.	Raw materials handling strategy	Availability of the suitable raw materials handling system

	Key Performance Indicators	Standard/Benchmark
6.	Standard work Operating Procedures (SOPs) design strategy	Updated and displayed SOPs at the workstations
8.	Inadequate Problem solving techniques	Availability of problem solving tools
9	Production performance measurement strategy	Production performance monitoring system
10	Labor management and empowerment strategy	± 10 training modules per annum
11	Throughput	≥ 70% Overall Operations Efficiency
12	Overall Key Performance Compliance Threshold of a Work Station	≥ 75%

Potato chips production line, amidst other production lines was considered in this study because this line was hypothesized by the supply chain manager of the organisation as a low productivity and efficiency line, affecting the overall performance of the supply chain system of this organisation.

3. Results and discussion

The results of the questionnaire from the production department is discussed as follows. The results of the demographic information for the production department is depicted in Figure 1.

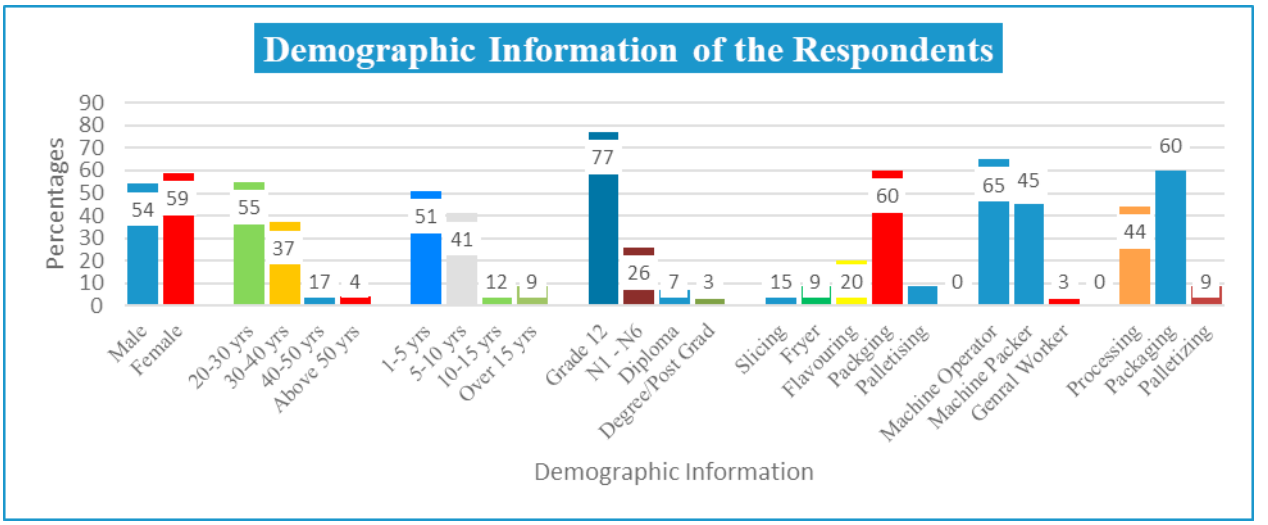

Fig. 1. Demographic information of the respondents

Based on Figure 1**,** a total number of 113 respondents from the Potato Chips production line participated in the study. The gender distribution indicated that the females (n=59), slights dominate the male (n=54) in the line. The age distribution indicated that the majority of respondents (n=55) are in the 20 – 30 years age group, while 51 of the majority of respondents have between 1 – 5 years working experience within the company. The study showed that the majority of the respondents (n=71) are qualified with a Grade 12 certificate, while only 4 have Degree/Post graduate qualification. The packaging workstation makes largest section in the line, with a majority (n=60) of the respondents, and 65 of the majority of the respondents are machine operators, followed by 45 of machine packers and 3 of general workers. The results of the descriptive analysis are discussed in the Tables 2 to 5.

Table 2. Participants' responses (for Q1 – Q4)

	Q1		Q2		Q3		Q4	
Workstation	Yes	No	Yes	No	Yes	No	Yes	No
Slicing (W1)		√		√		√		√
Fryer (W2)		√		√	√			√
Flavoring (W3)	√		√		√			√
Packaging (W4)	√		√		√		√	
Palletizing (W5)	√		√		√		√	
Total	3	2	3	2	4	1	2	3
5	60	40	60	40	80	20	40	60

All the respondents in three out of the five workstations (W3, W4, and W5), four out of five workstations (W2, W3, W4 and W5), and two out of five workstations (W4 and W4) reported that: (i) the production plan is flexible to meet the fluctuating volumes as per customer demands, (ii) they do experience delays due to transportation, (iii) they do have demarcated areas to store raw materials or WIP, as well as (iv) they do keep minimum raw materials at those areas (See Table 2). All the respondents in the remaining workstations responded otherwise for each of the aforementioned issues.

Table 3 Participants' responses (for Q5 – Q9)

	Q5		Q6		Q7		Q8		Q9	
Workstation	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Slicing (W1)	√		√		√		√		√	
Fryer (W2)	√		√		√		√		√	
Flavoring (W3)		√	√			√	√			√
Packaging (W4)	√			√	√			√		√
Palletizing (W5)		√		√		√	√		√	
Total	3	2	3	2	3	2				
5	60	40	60	40	60	40				

All the respondents in three out of the five workstations (W1, W2 and W4), three out of the five workstations (W1, W2, and W3), and three out of the five workstations (W1, W2 and W4) reported that: (i) they complete the Short Interval Control Sheets, (ii) they perform problem solving for breakdowns at their workstation, as well as (iii) have the standard operating procedures (SOP) at their workstations. All the respondents in the remaining workstations responded otherwise for each of the aforementioned issues (See Table 3). All the respondents in four out of the five workstations (W1, W2, W3, and W5) and three out of the five workstations (W1, W2, and W5) reported that: (i) they sometimes produce defects products, and (ii) they are trained to perform their duties at their workstations. All the respondents in the remaining workstations responded otherwise for each of the aforementioned issues (see Table 3).

Based on the aforementioned results, the Performance Rating (PR) of the various workstation W1, W2, W3, W4, and W5, in meeting the various key performance indicator targets related to questions 1 – 9, calculated using equation (1) are; 56%, 67%, 56%, 67%, and 67% respectively.

Hence, the various indicators lowering the overall rating of these workstation needs to be improved.

Table 4 Participants' responses (for Q10 – Q13)

	Q10			Q11			Q12			Q13		
	ND	TIFPC	EPC	ND	TIFPC	EPC	ND	TIFPC	EPC	ND	TIFPC	EPC
Slicing			√	√					√			√
Fryer			√	√					√			√
Flavoring			√			√	√					√
Packaging			√	√					√	√		
Palletizing			√	√			√				√	
Total	0	0	5	4	0	1	2	0	3	1	1	3
5	0	0	100	80	0	20	40	0	60	20	20	60

Legend: EPC is Every Production Cycle, TIFPC is Twice in Four Production Cycle and ND is Not Done

All the respondents in five workstations (W1, W2, W3, W4 and W5), three out of five workstation (W1, W2, and W4), as well as three out of the five workstation (W1, W2, W3) responded that (i) they do follow the safe working procedure, (ii) they do rework any products, as well as (iii) they do track their production performance at every production cycle for their shift. All the respondents in the remaining workstations responded otherwise for each of the aforementioned issues. Hence, all the respondents in four out of the five workstations (W1, W2, W4 and W5) responded that they do no raise any job cards for any breakdowns experienced at their workstation. Only the respondents in one workstation indicated otherwise on this issue. (See Table 4).

Table 5: Participants' responses (for Q14 – Q16)

	Q14			Q15			Q16		
	ND	TIFPC	EPC	ND	TIFPC	EPC	ND	TIFPC	EPC
Slicing		√			√			√	
Fryer			√		√			√	
Flavoring			√	√			√		
Packaging			√	√				√	
Palletizing			√	√			√		
Total	0	1	4	3	2	0	2	3	0
5	0	20	80	60	40	0	40	60	0

All the respondents in four out of the five workstations (W2, W3, W4, and W5), responded that they achieve their shift quality targets at every production cycle. All the respondents in three out of the five workstations (W1, W2 and W4) reported they do achieve their production targets twice in every four production cycle while the respondents in three out of the five workstations (W3, W4 and W5) reported that they do not get training for their roles and tasks they are supposed to perform. All the respondents in the remaining workstations responded otherwise for each of the aforementioned issues. (See Table 5).

In light of these aforementioned results, the Performance Rating (PR) of the various workstation W1, W2, W3, W4, and W5, in meeting the various key performance indicator targets related to questions 10 – 16, calculated using equation 2 are; 86%, 86%, 57%, 57%, and 43% respectively. In light of these aforementioned results, the Overall Performance Rating (OPR) of the work stations of this food organisation in meeting all the key performance indicator targets related to questions 1 – 16, calculated using equation (3) are; 71%, 77%, 57%, 62% and 55%

respectively.

$$OPR = \frac{PR_{Q_1-Q_9} + PR_{Q_{10}-Q_{16}}}{2} \quad (3)$$

The respondent opinions about the performance of the internal customers and suppliers of this food organisation as well as the linkages that exist between them, tallied with the once-off measurement made about the performance of these key players of the supply chain system of this organisation.

Hence, the prioritization of the various indicators (lowering the overall performance rating of the workstations) that should be resolved with a view to improve the overall performance of the supply chain system of this organisation need to be established using Hierarchical Structural Interaction Matrix (HSIM).

4. Conclusion

Continuous monitoring and measurement of various key indicators influencing the performance of the end-to-end processes of an organisation is essential for sustainable manufacturing. In light of this, a questionnaire, which highlight myriads of questions that could be used to measure the performance of a supply chain system of a food industry was developed in the study. The results of the study inferred that the overall performance of the work stations 1, 3, 4 and 5 in a food manufacturing organisation XYZ is below the overall key performance compliance threshold of the workstation expected in this organisation (i.e. at least 75%). To this effect, future studies should focus on the prioritization of the resolution of the low Key Performance Indicators (KPIs) that need to be improved in the affected work stations, with a view to increase the overall performance of the supply chain system of this food organisation using Hierarchical Structural Interaction Matrix (HSIM).

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