Integration between Production Planning, Quality and Sales: A Proposed Framework

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Abstract

Production Planning is a continuous process that aims to achieve particular products i at the right time in the future, which targets the best utilization of the available resources to satisfy the market demand. This study focuses on how production planning is to be integrated with quality control and sales. A myriad of variants of the problem has been addressed in literature, however this study will focus on two major variants observed in a brewing company located in Gauteng, South Africa. The first variant asks for integrating both production planning, quality control and sales process to obtain a more accurate and realistic production plan, whereas the second variant asks for addressing and analyzing the mutual influence between the three processes (production planning, sales and quality control) and the packaging and warehouse in the brewing company. To cope with these issues, a research framework is proposed in this paper. The aim of the proposed framework is to minimize the disparity between the planned production volume and the actual produced volume while considering the integration and the mutual influence between the aforementioned processes. The proposed framework is to be used as a starting point in developing a mathematical model that will tackle the aforementioned variants.

Keywords
Brewing process, Production planning, Quality, Packaging, Warehouse, Sales.

1. Introduction

In a survey published by Kirin institute of food and Lifestyle (Kirin, 2012) on the global beer production per country, the beer production went up to 3.7% from 2010 to 2011. This is its 27th consecutive year of growth. Looking at the global statistics, China has been the largest beer producing country in the world for the tenth year in a row, with an increased production of 10.9% more beer in 2011 than 2010. The United States is the second largest producer. Brazil comes third with a 3.4% growth in 2011 after reporting 18.2% annual increase in the previous year. The increasing trend of beer production shows that China, United States and Brazil have efficient and effective production planning and control methods.

Due to consistent failure in production variables such as production operations for the brewing company under study, well-defined and effective production management continuous to collapse. The production management has a sole objective which is to ensure that quality products are supplied in the required volume at the required time and at affordable cost. To achieve this, effective production planning and quality control is required **(**Cheng et al., 2018**)**. Features and characteristics of a product or services, which are relevant to its ability to satisfy a particular need are referred to as quality. Such features and characteristics may include physical dimensions, weight, hardness, color resistance etc **(**Cheng et al., 2018**)**. The quality features and characteristics of the brewing company in the study include alcohol, real extract, color, CO2, dissolved oxygen, PH and SO2. The satisfaction level of a good quality product possesses certain attributes, therefore in order to maintain the defined production goals and objectives, quality problems must be solved promptly with maximum attention.

The study at hand looks at the importance of production planning and quality in other to meet the customers' needs and demands. It also looks at the effects production planning and quality has on packaging and warehouse. The brewing company under study has been struggling to meet the customers' needs and demands off late due to a number of issues. Production plan can be changed depending on the constraints the brewing department is faced with. Unfortunately, the change is never suitable for the market. Changes done on the production plan compromises the market's demand.

1.1 Research Background

In the food industry, the brewing sector holds a strategic economic position with annual worldwide beer production exceeding 1.34 billion hector litres in 2002 (FAO, 2003). Beer is the fifth most consumed beverage in the world besides tea, carbonates, milk and coffee, and it continues to be a popular drink with an average consumption of 9.6 L/capita by population aged above 15 (OECD Health Data, 2005). When the economy is contracting or expanding, beer companies are attractive investment options. When the economy grows, beer consumption goes up as people tend to drink more whereas during recession beer is still consumed more because consumers are trying to beat stress and suffering (Hunkar, 2011).

Figure 1 presents the global beer market share in 2010. Anheuser-Busch InBev, which is based in Belgium, is the world's largest brewer by volume and owns about 200 beer brands. SABMiller PLC then was second with over 150 brands, including international brands. Third is Dutch beer giant Heineken, with more than 200 international, local and specialty beers and ciders. Then comes Denmark-based Carlsberg and China Resources Enterprise (Hunkar, 2011).

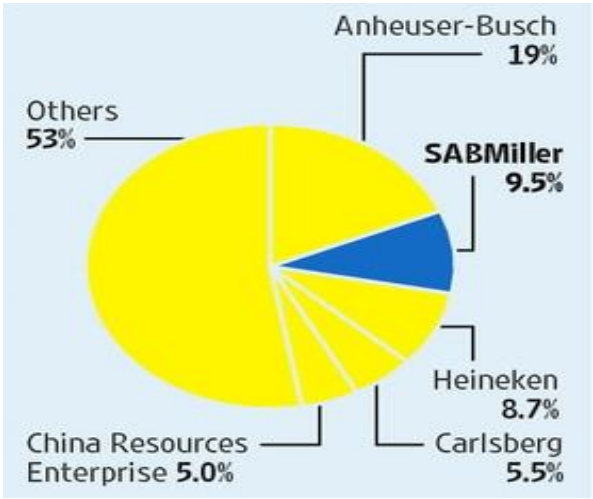

Figure 1. Global beer market share in 2010 (Hunkar, 2011)

1.2 Problem statement

There are a number of issues contributing to the impacts that brewing production planning and quality has on packaging and warehouse. Ideally, the resource planner gives the brewing department a plan, which states the number of brews that has to be done for each brand according to what the market will demand in two weeks' time. In most cases, the company does not meet the plan due to plant breakdowns, brew-house requiring to change brand to support other production areas, and produced brews not meeting quality parameters. The resource planner also provide a racking plan, which states the volume that has to be racked for each brand according to what the market will demand in 8 days' time. In most cases like in brew-house, the racking plan is not met due to breakdowns, quality issues and unavailability of storage vessels. The above-mentioned issues have an impact on downstream processes such as incapability to deliver the volume required by the market within the region, packaging brands not required by the market which end up stuck in the warehouse for months, and idling packaging or cutting down hours because there is no beer to package.

Figure 2 presents the difference between the volume demanded by the market, the committed volume and the actual volume racked by the cellars department for Brand-A beer. The volumes vary on a day to day basis and it is observed on day 3, 4 and 5 that the brewing department could not deliver the required volume, whereas the volume produced was more than the volume demanded by the market on day 1 and 2.

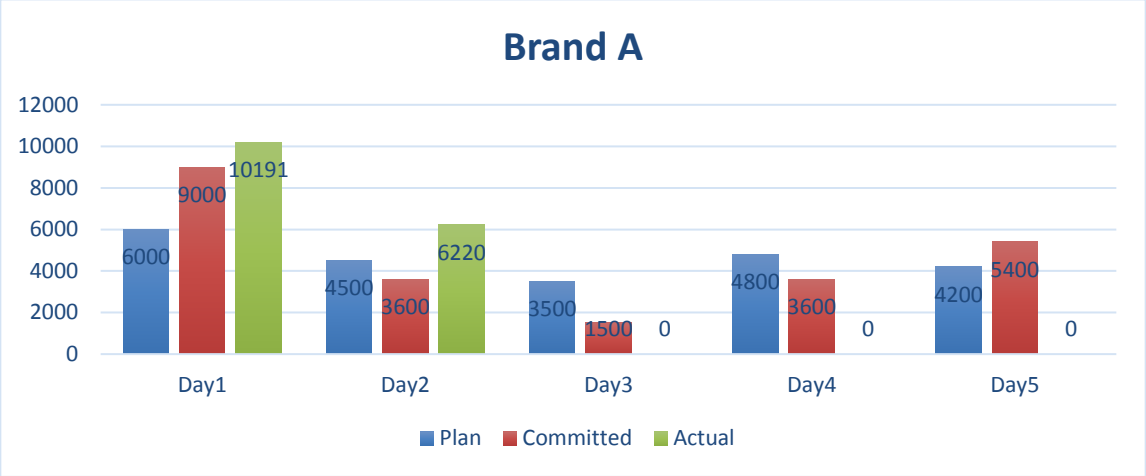

Figure 2. Brand-A planned, committed and actual volume in litres for a period of 5 days.

2. Literature review

The beer making industry has been around for years and the beer making process is the same throughout. Though beer making companies keep on optimizing their plants for efficiency to save costs and increase their capabilities, the idea of brewing is still the same. The research at hand looks at a stream of topics that prevent the brewing department from meeting their production plan.

2.1 Brewing Process Map

Figure 3 presents the brewing process from milling to distribution. After malt has been prepared, it is then transferred to the mill where it is crushed to make it easier for sugar extraction during mashing and also to separate the seed from the husk. The milled grain is mixed with hot water in a large vessel known as a mash-tun during the process called mashing (Fosters Group, 2006). In this vessel, the grain and water are mixed together to create a cereal mash. During this process, starch is converted into sugar that will be converted into alcohol(Oliver, 2011). The result of the mashing process is a sugar-rich liquid or "wort", which is then strained through the bottom of the mash-tun in a process known as lautering (Fosters Group, 2006). The wort is moved into a kettle where it is boiled with hops. This stage is where many chemical reactions take place, and where important decisions about the flavor, color, and aroma of the beer are made. After this stage, wort is moved to the whirlpool for cooling and addition of yeast prior to fermentation (Bamfort & Ward, 2014). During cooling, the wort is transferred to fermentation vessel where it will be kept until the end of the fermentation process. When the fermentation is complete, the brewer may rack the beer into a new tank, called a storage tank. Conditioning of the beer is the process in which the beer ages, the flavor becomes smoother, and flavors that are unwanted dissipate. After conditioning for several days, the beer may be filtered and force carbonated for bottling (Garret, 2011).

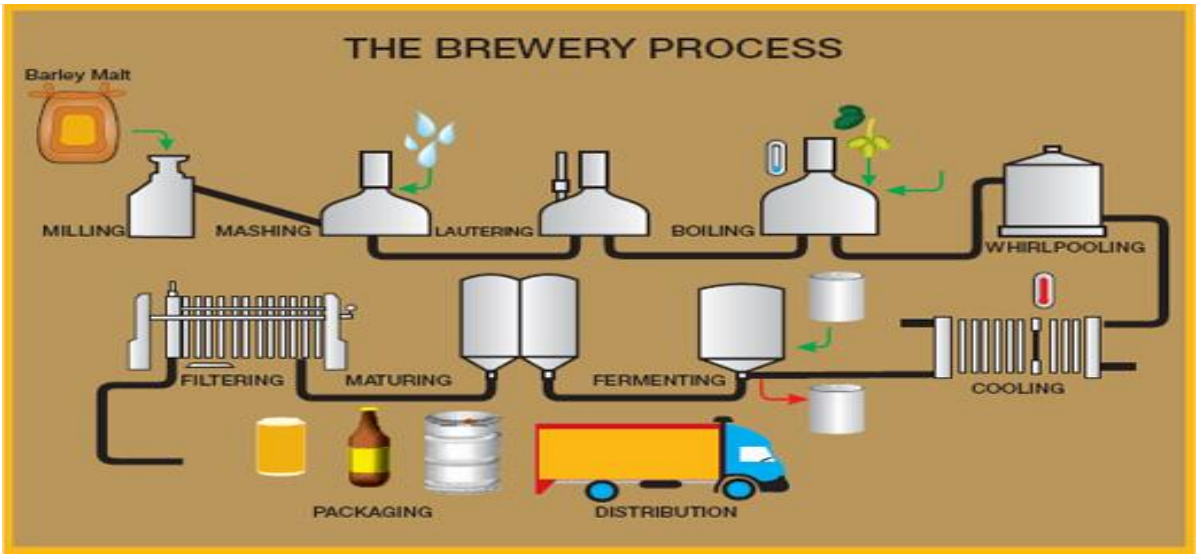

Figure 3. The brewing map (Eight-degree brewing)

2.2 Production Planning

Planning is a continuous process that aims to achieve particular products at some time in the future, which involves decisions or choices about alternative ways of using available resources (Silver et al., 1998). In some cases, wrong capacity assessment, internal bureaucracies, production schedule, idle time and other excess production requirements have broken the delivery schedules/ promises (Patrick & Emmanuel, 2001).

A study by Adebisi (2013) about the effects of production planning and budgeting on organizational productivity's objective presented a statistical correlation between some identified variables that may have direct impact on planning, budgeting and production in an industry, and how these variables can be adjusted for profit optimization.
The study was conducted to explain why Nigerian firms fail to follow the rule of production planning and control, and also to discover what manufacturing firms encounter in their attempt to carry out their production planning and control. He further explained that the determination of policy, the laying down of objectives and the general principles all serving as the basis on which operation is executed is the primary management responsibility arising from the planning element. This is required in relation to each of the major divisions. There has to be a continuous flow of information on workload, raw material availabilities and maintenance activities because a breakdown in communication between the shop floor and the controlling unit will delay product.

Adebisi (2013) analysed financial statements of the firms for a period of five years and questionnaires retrieved from the respondents. The study revealed that production planning has significant impacts on operational efficiency, enhanced equity capital and growth of Nigerian manufacturing industry. This finding implies that production planning significantly affects the Corporate Productivity Performance of firms.

Beer making industries use several strategies to manage their production plan. Jamalnia et al. (2017) proposed a novel decision model to aggregate production planning (APP) decision making problem based on mixed chase and level strategy under uncertainty where the market demand acts as the main source of uncertainty. This planning technique usually caters for one product or a family of similar products, i.e. with similarities in production process, skills required, raw materials needed, etc. despite small differences such that considering the problem from an aggregated viewpoint is still credible. Uncertainties are also incorporated into model due to instable state of real world industrial environments.

Jamalnia et al. (2017) used the APP process on carbonated soft drinks of three flavors cola, orange and lemonade as a family of products. The study considered a time horizon of 12 months, with 4 time periods where each time period reflected the seasonal oscillations of the product demands. They assumed the customer demand as the main source of uncertainty, which was presented in three levels: high demand, average demand and low demand with associated

probabilities. In the APP system, the forecasted demand acts as the driving force. Because seasonal demand patterns and unpredictability inherent in quantity and timing of received orders makes the whole APP system uncertain, utilizing a decision modelling tool that takes account of these uncertainties come highly recommended.

In order to meet the production plan and demand, there are a number of things the organization needs to take into consideration, such as machine preparation. According to Hopp & Spearman (2008), machine setups can be defined as all actions that have to be undertaken to prepare a machine or process for production. Prior to setting up the production equipment, production managers have to decide about whether a machine requires cleaning or maintenance, whether machine tools need to be changed, or whether the workers operating the production equipment should be replaced. In addition, production managers need to specify the settings of the production system for the next production cycle, which includes the clock frequency or production rate of the equipment.

According to Buzacott & Ozkarahan (1983) to achieve a desired production rate, the machines applied in producing a product can often be controlled in practice e.g. the processing speed of the machine can be adjusted, the amount of labor hours dedicated to the production process can be varied, or idle times can be inserted between task elements. According to a study conducted by Larsen (1997**),** the demand rate fluctuates over time, and when that happens the production rate needs to be adjusted to cope with these fluctuations. The authors showed that the appropriate response to an increased demand rate is a reduction of the production rate, which leads to reduced inventory build-up and consequently lower inventory carrying costs.

In addition to production planning and maintenance scheduling, the third aspect of production systems is quality control. Many researchers have investigated the hidden interactions and intersections between the three functions. However, most of the existing integrated models consider only two aspects at a time. Only few researches studied the simultaneous integration of these three aspects **(**Cheng et al., 2018**).**

2.3 Quality

Quality is also one of the aspects an organization has to pay attention to in order to meet the production plan and demand. When an organization does not get some of their quality aspects right in the process of making their products, it will be close to impossible for them to meet the demand. It takes time and effort to get the quality fixed so that the product can be packaged. Major quality problems include human error - all assignable cause of quality problems which result in variation of products can be classified as human error **(**Olukole, 2003). Dissatisfaction with remunerations, emotional problems, physical and health related problems etc. may be the main causes of human error. Fatigue and boredom during inspection may cause variation in quality of products.

The factors that may affect the quality of the final products include: (i) Quality of raw material - poor inspection during receiving, purchasing, storage and handling of materials may lead to inconsistent observation of products and this will directly affect the products, (ii) Environmental factors - poor lightening, high humidity, temperature, dust and other environmental factors that cannot be controlled have been reported to have pronounced negative impacts on quality of products, and (iii) Machines and tools - cheap maintenance, poor handling and servicing of tools, improper replacement of parts are major factors that can contribute to the defectiveness of a machine affecting the performance of the operators and the quality of products (Pang, 2003**).** Appropriate quality control practice through quality inspection can reduce these problems. The quality inspections may be in the form of detecting problems within production lines and processes thereby reducing scrap generation and providing information concerning the effectiveness of individual worker and a department, maintaining certain specified standards in products, meeting customers' specifications in order to minimize complaints and products return rate, eliminating products rework which do not meet standards **(**Pang, 2003). The companies that determine production planning manually take hours to achieve a satisfactory plan. There is often occurrence of unforeseen circumstances, events and change of information that makes it necessary to change the production during the production horizon. When this happens, it inconveniences the market demand **(**Cheng et al., 2018**)**.

3. Research Gap

There are various studies that look at production planning but none of them look at how it is integrated with quality and sales. A study by Jamalnia et al. (2017) proposed a novel decision model to aggregate production planning (APP) decision making problem based on mixed chase and level strategy under uncertainty where the market demand acts as the main source of uncertainty. The primary objective of the research was to find values of the production in regular shift and extra shift, backorder, inventory, subcontracting, workforce hired and laid off in regular shift and extra shift, product prices, etc. over the planning horizon for the company under study in the presence of uncertainty.

There is only one uncertainty mentioned in the study (market demand), however there is a possibility that the company might still fail to deliver due to machine breakdowns. The company may know the market's demand but still over produce just to keep production running. Quality also plays a major role. A batch of bad quality products can cause delays. All of these will lead to customer dissatisfaction and will eventually affect sales.

The brief literature review indicates that the production plan and demand has been given attention over the past years. Objectives have been outlined and issues that affect them have also been tackled. However, many organizations fail to follow the production plan and to meet the market's demand due to the constraints mentioned in the literature review. As much as organizations fail to meet the production plan due to constraints mentioned in the literature review, it is not mentioned in any of the studies how do production planning and quality has an impact on the packaging department and the warehouse (Inventory). Some organizations end up producing what is not needed by the market which will later stay idle in storage and warehouse taking up space. The brewing company under study is facing similar challenges, and there is a need to look into minimizing the variance between the actual products and the demanded products to avoid not meeting the market's demand and inventory build-up.

4. Proposed Research Framework

In this section, a proposed framework to tackle the aforementioned problems is presented. The proposed framework shows the interrelationships between production planning and other processes, i.e., quality control and sales. Furthermore, it shows the input parameters, variables and capacity constraints that needs to be considered while developing a production plan. Figure 4 shows that there are four input blocks to the production planning process. First, the market demand block shows the related input parameters and constraints such as the seasonal and random trends in demand. Also, it concerns with the expected demand for each product type. Second, the capacity planning block which guarantees the different capacities limits such as the human resources workforce, the production lines workforce, row material and the current inventory levels. Third, the sales block considers information related to the current and upcoming orders, the backorders and any changes or updates in the current ones. Fourth, the quality control block shares information related to the reword orders or the rejected production due to human errors, material defects, processing defects and/or production lines failures.

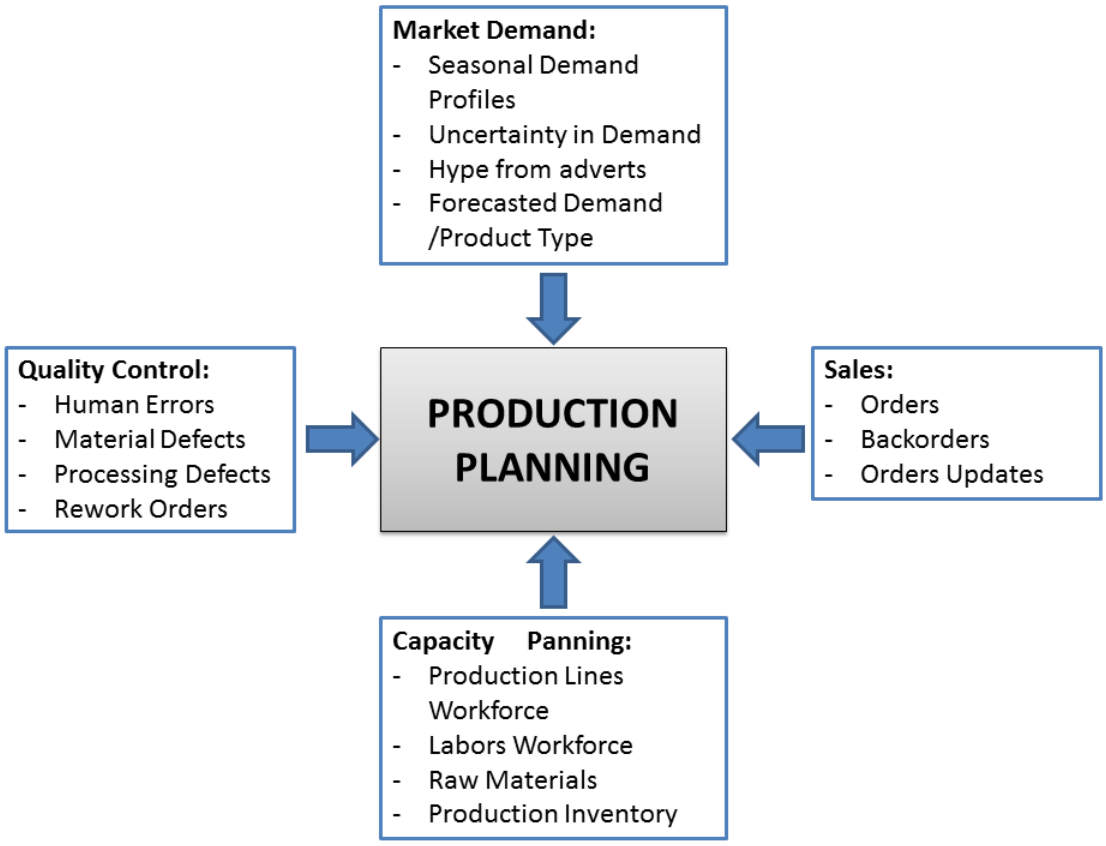

Figure 4. Proposed research framework

Furthermore, the continuous failure in meeting the production requirements have major impacts on the packaging department and warehouse. Those two departments will be considered in the proposed mathematical model. First, data from all related departments and processes will be collected. The data collection will include historical data from the brew-house, racking and packaging. The processing time during conversion of raw-materials to wort, wort to beer (fermentation), racking of beer, maturation and filtration will be collected along with the technical constraints encountered during all these processes. Second, extensive data analysis will be conducted (i.e. comparison between the existing data of planned vs actual volume) in order to get a clear idea of how long the problem has been going on for. Third, a mathematical formulation will be developed to model the interrelationships between all the blocks presented in figure 3. The main aim of the proposed mathematical model is to generate a more accurate and realistic production plan that considers the integration and interrelationships between these blocks and departments. Finally, results from the model will be statistically analyzed along with averages from the historical data.

5. Conclusion

Poor production planning decision making in the brewing company under study triggered a need for the research study on the topic. As a result of poor production planning decision, the working hours in the packaging department have been cut down which resulted in reduced salaries. The company needs to improve in sales forecasting, delivery and also with following the production plan. Quality as one of the major aspects that prevent the brewing department from meeting and following the production plan also needs to be looked into. Whilst the company prepares the production planning looking at what the market demand and capacity planning, production planning could go wrong due to quality and inventory build-up. The proposed frame work will use mathematical modelling to find balance between the committed volume and the actual volume and recommendations will come from the findings. The data collection is still in progress.

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Biography

Mamoletsi W Nkadimeng is currently a fulltime Master degree student at the University of Johannesburg. Ms Nkadimeng holds a diploma in Chemical engineering from Vaal University of Technology and a B.tech in Operations Management from Vaal University Of Technology. She is currently employed by AbInbev as a process Operator with 3years experience.

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