The Application of Business Intelligence and Analytics to Drive Better Business Outcomes in BSSB: A Small Tissue Paper Converting Establishment

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Abstract - BSSB faces many uncertainties in its manufacturing, such as production targets, rejects and parent rolls' sources. Exposing business intelligence and analytics to BSSB will assist them in making wise choices and decisions. This study attempt to establish an output benchmark, analyse and suggest the manufacturing rejects rate and determine the best source of parent rolls. The definition of BSSB is a tissue paper converting company that has been in operation for four years. This study indirectly promotes sustainable development goals related to decent work, economic growth and innovation, and creating new jobs and business opportunities. The hypotheses tested the elements impacting output and rejects, such as basis weight (gsm), the TAPPI forecasted calculation (TFC) and weight. The chosen method is the CRISP-DM. Stages of CRISP-DM involved business understanding, data understanding, and data preparation divided into data cleaning, data verification, data exploration and selection, data transformation and construction. The data mining process included selecting the test models under classifications and clustering. Based on the test results, weight, actual output (ACTL), basis weight, and the TFC have positive relationships. The results that portrayed BSSB manufacturing operations as "*superbly efficient*" was inaccurate. BSSB needs to rectify its production to ensure the finished product meets its specifications. It should implement a rejection rate of 3% while improving its production and collecting new data. In addition, the source of parent rolls should be from batches named AA, BB, CC and DD. The result of output consistency, basis weight, and productivity were the criteria used to formulate recommendations. Also included were suggestions for a specific data collection and recording area to facilitate further analysis. Business intelligence and analytics may have discovered the facts about the production of BSSB, but the decision to improve and implement lies at their management discretion.

Keywords— Business intelligence, data analytics, manufacturing, production

I. INTRODUCTION

A. Background

Today, manufacturing activities have become more complex. New inventions, modern technologies and automation processes are transforming manufacturing activities. Not all manufacturing processes are suitable to be automated. Even though it is automated, human factors still play a significant role in the activities.

Some manufacturing companies involuntarily adopt new technologies and automation in their processes. Many issues forced them into it, and one of the issues would be the cost of legally employing human operators. In some locations, the cost of labour has increased significantly. Some companies seek new opportunities and take the bold initiative to relocate their manufacturing operations to a country with lower employment and operating costs.

The modern approach to business management and decision-making has also changed. Many businesses gradually started to use business intelligence and analytics tools, which will open a path for better business outcomes by minimising assumptions and establishing facts for deciding. It will eventually contribute to a better business outcome. This study will cover a preliminary application of business intelligence and analytics to a company known as BSSB. The primary business activities of BSSB are manufacturing (converting) and trading tissue paper.

B. Research Objectives

The research objectives are :

- To establish forecast output using TFC and compare against ACTL for guidelines and control measures.
- To analyse the BSSB production rejection rate based on TFC versus ACTL and set the standard accordingly.
- To determine the best parent roll source by comparing the parent rolls' performance in the production.

C. Research Questions

The research questions are:

- How to establish guidelines or control measures for BSSB production?
- What is the acceptable production rejection rate?
- How to identify the better source of parent rolls from the two sources?

D. Research Hypotheses

The basis of the hypotheses is from BSSB's current operation and processes. The product input is in weight, and the output is in sheet count. The hypotheses tests include the test of the relationship between weight, ACTL, and forecast output. The hypotheses are:

H10 Basis weight (grammage of paper per square meter/gsm), size of the finished product, and sheet count have no relation to determining the output

H11 Basis weight (grammage of paper per square meter/gsm), size of the finished product, and sheet count are the elements in determining the output

H20 The TFC is not an element for determining the rejection rate.

H21 The TFC is one of the elements for determining the rejection rate.

H30 Basis weight (gsm) has no impact on the rejection rate

H31 Basis weight (gsm) has an impact on the rejection rate.

H40 Basis weight (gsm) has no effect in determining output results

H41 Basis weight (gsm) has a significant effect in determining output results

H50 Weight has no impact on rejection

H51 Weight has an impact on rejection.

E. Significance of the Study

BSSB will be implementing business intelligence and analytics for the first time. Their confidence and expectation may not be high, but they are eager to know the outcome. It would be the initial motivation to encourage BSSB not to ignore their data. Currently, BSSB data may not be meaningful to their management, and their perceptions may change when the dataset is in an understandable format. It will allow a better understanding of its manufacturing history. If there are any irregularities, the data may explain why it happens. All the mentioned processes will be descriptive and diagnostic analyses. Perhaps, with enough data, predictive and prescriptive analytics are the next step. Hopefully, it will assist BSSB in many aspects of its operation and business.

II. LITERATURE REVIEW

A. Brief Industry Background

Digital technologies have changed the pulp and paper industry landscape. The impact results in the physical newspaper no longer trending as many people nowadays read the news via their smartphones, computer and related gadgets.

Unlike newspaper paper, the case is different for tissue paper. According to [1], Euromonitor 2017 reported a constant growth of 2.6% annually for ten years up to 2015 of tissue paper and packaging product production globally. It is equivalent to 32.8 million tons and gives a market value of $72.8 billion. While [2] wrote that tissue paper is very competitive and worth USD100 billion globally. Even though the tissue paper industry may portray a relatively viable business, the Covid-19 pandemic may change the business landscape. It may increase or decrease. Unfortunately, the latest statistics were unable to find during this study. It shall be a new area of research to know the impact of the technology and the covid-19 pandemic on the pulp and paper industry.

B. Production Improvement Method

When discussing manufacturing processes usually involves the production improvement concepts or methods, and there are many. Examples of the production improvement concepts are Lean, Six Sigma, Kaizen, 5S, Six Big Losses and many others. Even though this study applies none of these methods directly, let us briefly explore to get a general understanding.

1) Lean Manufacturing: Lean manufacturing concepts evolved from Japanese industries. It started with Toyota production. As suggested by many authors, they considered lean manufacturing a technique to reduce waste. According to [3], lean maximises the product's value by minimising waste. It is also understood, supported and presented by [4]. Their research elaborated that the key objective of lean was to reduce waste. It reduces the need for huge inventories and produces a high-quality product at the lowest cost by integrating quality control decisions into the manufacturing process.

Reference [5] explained that lean manufacturing uses less of everything, less human effort, less space, less investment in tools, and less time than mass production. According to their understanding of the concept, many companies practise lean manufacturing and do not implement lean totally. They also highlighted those seven dimensions that contribute to leanness measurement, such as :

- Manufacturing process and equipment: To respect quality standards
- Planning and scheduling: Synchronising production and demand
- Visual information system: To simplify information flow to assist decision making
- Supplier relationship: Improving integration between supplier and buyer

- Customer relationship: Improving services such as prompt deliveries, reliability, etcetera,
- Workforce: To get all the employees to be involved in the quality improvements program
- Product development and technology: To improve the product may be in terms of product structure or materials and innovate product design practices and methodologies.

Again, reference [5] also explained that waste in lean manufacturing comprises eight elements:

- Overproduction waste
- Waiting waste
- Unnecessary motion waste
- Transportation waste
- Processing waste
- Inventory waste
- Defects waste
- Waste of underutilised people

In summary, lean manufacturing allows companies to be more flexible with fewer processes and eliminate unnecessary business operations. In addition, it could be more responsive to customers' demand or current trending and hence could offer a wide range of products with high quality, cheaper and fast turnaround time.

2) Six Sigma: According to [6], Six Sigma is a management philosophy to reduce variation in achieving business objectives. It is an approach to reducing or eliminating defects or rejects. It is a data-driven methodology for process improvement and decision-making. In another definition by [7], Six Sigma looks for the root cause of the problem by analysing data and statistics. It is a philosophy and method to improve quality. Some may call the Six Sigma campaign by a different name, for example, "*Operation Excellence*", "*Zero Defects*", or "*Customer Perfection*". The approach of analysing data and digging to the roots looks similar to business intelligence and analytics.

What are the Six Sigma improvement programs or elements? It has two;

a. Define – Measure – Analyse – Improve – Control (DMAIC)

- Define: defining the problem or room for process improvement
- Measure: measure the current performance
- Analyse: analysing the problem by going to the root to know the cause
- Improve: eliminate or improve the root cause and improve the performance
- Control: to ensure and maintain the improved performance

Fig. 1 Six Sigma diagram scheme concept DMAIC

b. *Define – Measure – Analyse – Design – Verify (DMADV)*.

Most of this method is applied when developing new products or services. The differences are the last two processes:

- Design: Output from the newly improved manufacturing process is tested on a group of customers to get their feedback.
- Verify: As the new product or services start in the market, the changes will be ongoing according to customers' feedback.

Fig. 2 Six Sigma diagram scheme concept DMADV image

Six Sigma DMAIC is more suitable for production improvement, while Six Sigma DMADV is used to create a new product or adjust the product to suit customers' needs. Six Sigma has disadvantages too. Some of the drawbacks highlighted by [8] were:

- May not contribute towards cost savings. When product quality improves, it may generate capital expenses and overhead costs.
- Data gathering and analysis may take time, translating this into higher costs.
- Implementing Six Sigma requires skilled personnel.

3) Continuous Improvement / Kaizen: Kaizen is also known as Continuous Improvement. It is a strategy whereby all employees are involved in business and manufacturing process improvement. Reference [3] stated that Kaizen or Continuous Improvement, in a simple explanation, is an initiative to expand and grow success and minimise failures. Continuous Improvement is part of the lean technique.

According to [9], Kaizen implementation uses the PDCA cycle, also known as the Deming or Shewhart cycle, as shown below:

- Plan: in this stage, the activity is to define the goals and the way to achieve it
- Do: this is the implementing stage of the plan
- Check: results from the implementation are to analyse, evaluate and identify room for improvement
- Act: this is the adjustment stage from the weaknesses or flaws found in the previous stages

Fig. 3 PDCA diagram

Reference [9] highlighted that the PDCA concept has seven quality control tools. It is easy to implement for the majority of industries. Those seven quality control tools were:

- Check Sheet: a tool that collects data on rejection or defect. It is a starting tool.
- Histogram: One of the tools for data visualisation and presentation.
- Pareto Chart: With the data in graphical form, much easier to focus on any defect that gives the highest. These tools are also called data analysis tools.
- Cause and effect diagram: After identifying the major problems, it uses the Ishikawa or fishbone diagram. It will consider many factors, for instance, operator, machine, input material, etcetera.
- Control Chart: To take action when discovering the root of the problem. After implementing the solution, it should see whether there is any difference and if improved, it should be maintained. This chart should be the control for the process of rejection.
- Flow Chart: It is a tool to overview the process structure or organisation hierarchy
- Scatter/Dot diagram: Finding the negative or positive relationship between two variables

4) The Six Big Losses: Seiichi Nakajima developed the Six Big Losses in 1971. It came from TPM (Total Productive Maintenance). Fig. 4 shows the six steps of the Six Big Losses. Comparing those steps to this study, many of the steps occurred in BSSB's production. For instance, the breakdown of their machine because of converting web broken.

Reference [10] analysed and highlighted minor stops and how they are "*part of their everyday life*" for manufacturing activities. This phenomenon must change, as many minor stops will eventually result in significant losses. Their research focused on TPM and used many methods, including the Six Big Losses.

Overall Equipment Effectiveness	Recommended Six Big Losses	Traditional Six Big Losses
Availability Loss	Unplanned Stops	Equipment Failure
	Planned Stops	Setup and Adjustments
Performance Loss	Small Stops	Idling and Minor Stops
	Slow Cycles	Reduced Speed
Quality Loss	Production Rejects	Process Defects
	Startup Rejects	Reduced Yield
OEE	Fully Productive Time	Valuable Operating Time

Fig. 4 *"Recommended names and definitions for the Six Big Losses simplify and strengthen the alignment to OEE – and ensure that all losses are covered"*

This section's idea is to expose available and practice production improvement concepts. Some combine or embed one method into another, such as Lean Six Sigma, the lean method with continuous improvement, or the Kaizen technique. Regardless of the approaches, concepts, ideologies, elements, and methods used, all objectives are the same: improvement, waste reduction, cost reduction, productivity, customer needs, etc.

The difference in implementation amongst companies is that they use and adapt to a suitable method according to their circumstance, culture, and skills and may not follow the complete process [5].

C. Tissue Paper Converting

The tissue paper converting process is as complex as a paper mill and pulp mill in its way. Tissue paper is used daily for hygiene-related purposes as it is a special and unique paper product with extra absorbency, durability, and softness depending on its function [11]. For example, the texture of napkins and hand towels would differ from the toilet and facial tissue. It also depends on the need of end-users. Numerous factors affect the softness, feel, and performance of tissue paper, including the fibre type, the chemicals used, creping, and the conversion process [11]. This statement is in line with [12], whereby the raw stock, dilution and chemicals used in stock preparation before transferring to a papermaking machine will determine the property of the paper produced.

By embossing tissue paper, the calliper increases, and the stiffness of the finished product decreases. When combined

with other factors, like the pulling strength of the machine, this could affect the basis weight of the tissue paper (gsm) [6].

D. Output Forecasting

Forecasting is a crucial component of the overall business operation planning in the manufacturing industry and helps the management anticipate many things, including their financial needs. An interesting statement in the research by [13] stated that:

"*However, forecasting factory productivity is a challenging task because productivity is subject to significant uncertainty, primarily caused by inconsistent human-assisted operations*."

According to [14], their study results acknowledge that forecasting is a significant planning input that could lead to business success in all companies. In the meantime, reference [15] emphasised that planning and forecasting are the foundations for logical decision-making.

This study will not focus on forecasting output relating to the human factors as highlighted by [13] due to insufficient data and the situation of the COVID-19 pandemic. However, this study makes "*the forecast*" using the Technical Association of the Pulp and Paper Industry (TAPPI) formula and will be simplified. The forecast output quantity can be calculated based on the weight of the parent rolls, the product's dimensions, the gsm, and the number of sheets. Then the quantity from the mathematical calculation will be compared to the actual quantity produced in the production. The result of the comparison will be analysed. Also, the calculation result will be the guide or target output for the production. It could be a preliminary platform to expand to others. While it looks easy, there may be hidden facts that data analytics may uncover.

According to ISO/TC6, the measurement units should follow the International System of Units (SI or SI metric units). Technical Association of the Pulp and Paper Industry (TAPPI) has established a standard method to calculate the basis weight (gsm) of paper and paperboard – T410 (om-13), and it is identical to the testing method by EN Standard - EN 536 (2013) and ISO Standard - ISO 536 (2012) [16].

The calculation methods will first identify:

- the size of the finished product, length and width in meter,
- the quantity of finished product in its standard packaging specification, the number of sheets or sheet count,
- the gsm or basis weight of the parent roll loaded onto the converting machine; for example, 36gsm.

Based on the TAPPI methods, below is the simplified formula to calculate the weight for the finished product.

$$\frac{\text{Length X Width X Gsm X Number of Sheet}}{1000} = \text{Weight of the finished product in Kg} \quad (1)$$

For example;
Length = 180 mm Width = 210 mm
Gsm = 45 gsm Number of sheets = 4000

First, to convert millimetres into meter; therefore;
Length = 0.18 m Width = 0.21 m

0.18 X 0.21 X 45 X 4000 = 6,804
and this is in grams,

To convert into kilogram; 6,804 / 1000 = 6.804 kg.

Therefore, the weight of 4,000 sheets of 45 gsm paper with 180 mm length and 210 mm width is 6.804 kg. Then, it is to divide the parent roll weight by the weight of the finished product to get the forecasted output. This method will act as a guide.

Important Note: *Not included in the calculation of the weight of the finished product per kilogram is reject allocation. Meaning that the results from the calculation will be the maximum output of the parent roll based on its weight with no rejects. Assuming other factors remain the same.*

E. Rejection/Waste/Production

Most production improvement concepts focus on waste, rejection, or production loss. Many people will think rejects are deformed or do not meet the standards, and the focus will be on the product. In the Six Big Losses method, waste is a holistic approach not limited to the product. It means there is another type of waste besides product or material rejection.

A study by [17] highlighted that the rejection occurred in a few stages. It started in the preparation stage and log rejecter stage. The parent rolls from the supplier also caused rejects. For example, the parent roll rewinding is loose. When this happens, preparing the parent roll will need more time and materials before converting machines.

A log rejecter is an accumulator machine that collects output from converting machine and queuing for the packaging machine. In this stage, technical constraints of the log rejecter, log saw (log cutting machine), packaging machine, and the packaging equipment contribute towards rejects, covering 85% of total material waste [17]. Fig. 5 illustrates technical machine drawings in order to help understand the process.

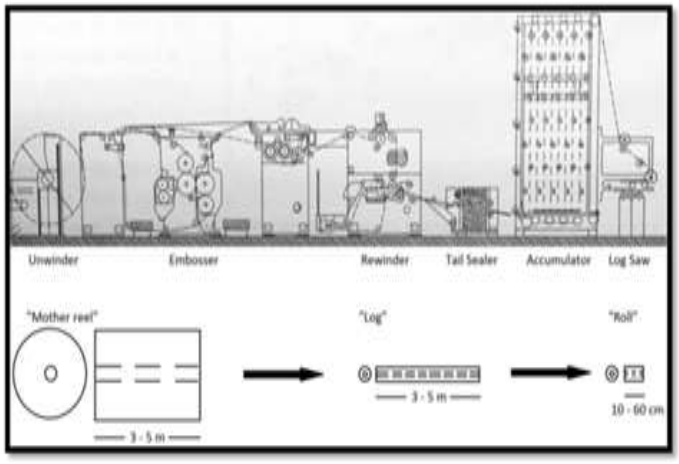

Fig. 5 Tissue paper converting process

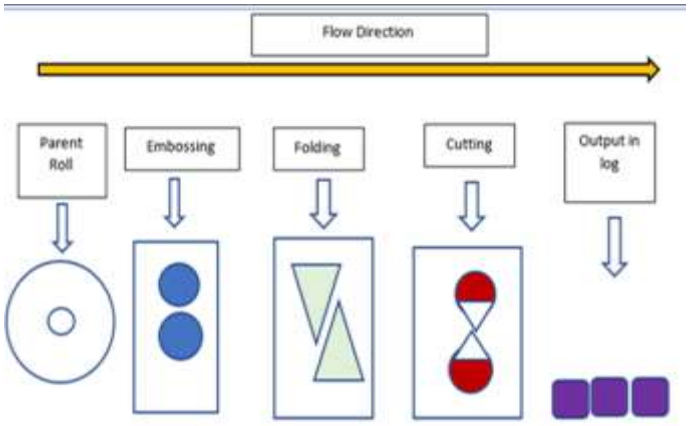

Fig. 6 BSSB machine process flow

Compared to the BSSB Machine process flow, in Fig. 6, the starting is the same; it started with the loading of the parent roll. Then it will go through embossing. The following process is different from the machine in Fig. 5 producing roll products, whereas Fig. 6 produces the folded product.

Each converting machine has a specific task, either roll or fold. The roll or fold process may differ in some parts of the machines. The front and other sections would be the same. 85 % of material waste will be generated at the conversion point, log accumulator or rejector, packaging equipment, etc.,[17]. It may appear to be similar to BSSB in some ways.

As mentioned earlier, reference [17] split rejects into two categories. The first category includes rejection that can be avoided or reduced. The second type of rejection is non-preventable and non-reducible. Now let us compare which sections are similar to BSSB converting process. Please refer to Table I and Table II.

TABLE I

GROUP A – REJECTION COULD BE PREVENTED

Category by Pejic, (2016)	BSSB Process	Remarks
Paper machine web brake waste	Applicable	Parent rolls from the supplier will have joins. Sometimes one (1) join and sometimes two (2).
Converting machine web brake waste	Applicable	During the machine running, sometimes web brake
Tail seal logs waste	Not Applicable	Not Applicable
Dropped rolls in log saw separator.	Not Applicable	Not Applicable
Roll waste between log saw and packaging machine.	Applicable	Rejection sometimes because of size depending on the parent roll width and the finished product size
Roll waste between packaging machine and palletising/sack machine.	Not Applicable	Not Applicable
Roll waste between sack machine and palletising.	Not Applicable	Not Applicable
Palletising waste.	Not Applicable	Not Applicable

TABLE III

GROUP B – REJECTION COULD NOT BE PREVENTED

Category by Pejic, (2016)	BSSB Process	Remarks
Mother reel preparation waste.	Applicable	The opening of the parent roll needs to join or fed to the machine
End of mother reel waste.	Applicable	Nil

Rejected logs waste.	Applicable	Nil
Trim cookies waste.	Applicable	Nil

It is not advisable to rule out parent rolls technical facts. The facts on technical shall include the machine direction (MD) and cross direction (CD) tensile strength. According to [11], the finished product depends on the parent roll loaded onto the machine. It already has certain specifications, but the process of converting may change or alter specifications based on converting conditions.

The different application methods of embossing changed the characteristics of the tissue paper in terms of softness and texture, even though using the same parent roll. The embossing process increased the calliper and reduced the stiffness [18].

At converting machine, if the paper turns softer with "deep holes" in embossing, it may affect the machine runnability. As a result, there are possibilities of having a minor machine stop. It will depend on the converting machine adjustment and conditions. This study will not discuss it further on this issue.

Besides machines and processes, another element is the human factor. What about the operators operating the machines or human factors?

Training could help in minimising rejects [10],[17]. While according to [19], two factors of humans affect production; stress and the skills or capabilities of the operator. Many books are written about human factors regarding work, as humans are complex. In [20], their research conclusion highlighted five factors that contributed to the success of lean implementation. It is not advisable to rule out parent rolls technical facts. The facts on technical shall include the machine direction (MD) and cross direction (CD) tensile strength. According to [11], the finished product depends on the parent roll loaded onto the machine. It already has certain specifications, but the process of converting may change or alter specifications based on converting conditions. Those were:

- Leadership and management of the company which fully committed to the program,
- Communication between all levels,
- The company's financial capability,
- Employees' skills and expertise, and
- The organisational culture

Four out of five factors are directly associated with humans. Reference [21] emphasised that the participation of every employee in the program and proper training are needed to make it successful.

Each plays a role, and without good leadership and management to lead the way, the program would be a failure. The last factor highlighted by [20] is interesting. It relates to the working environment. If the employees are happy, it will translate into productivity and performance.

Although stated earlier that this study would not focus on forecasting related to human factors, it is undeniable that it is essential. Perhaps another study will be conducted to extend this study, focusing more on human factors.

F. Why Business Intelligence and Analytics

Why business intelligence and analytics in manufacturing or business? Why do business intelligence and analytics matter to the manufacturing improvement process and tissue paper conversion? What can it do? Let us briefly explore and address the concerns in this section.

A study by [22] examined and compared the usage of operational business intelligence (OpBI) and manufacturing execution systems (MES). They found out that the OpBI covered more comprehensive compared to MES. They concluded that both tools complement each other, OpBI giving a better overall scope of the business, including manufacturing.

An interesting quote in an article by [23]; "*Business intelligence isn't business espionage. It's simply knowledge and foreknowledge of the external environment. It's the collection of intelligence from human sources – not just published information – that sets a world-class business intelligence system apart. You don't need Machiavellian tactics to acquire competitive information. In fact, most of what you need is already inside your company….*"

The above statement asked us to look inside our organisation before taking it further. Following the concept of discovering in own operations, before diving deeper, first is to look within the BSSB production and understand what is happening. The descriptive analysis could help BSSB distinguish between facts and assumptions, but be ready; what they know or assume and what their dataset tells may not be the same.

Reference [24] highlighted that integrating operational and historical data and business intelligence (BI) could improve information value and quality. It helps the management to understand and decide.

Most manufacturing or production improvement methods use data to analyse and evaluate the situation. Therefore, it is not wrong to claim that data analytics, a subset of business intelligence, has been used for some time under many names.

Upon having a comprehensive understanding, BSSB can plan their action wisely. Moreover, from the facts discovered, they could further explore or perhaps plan their business strategies in terms of market, finance and operations to remain competitive and relevant. Maybe business intelligence and analytics are too complicated by the name, making many businesses hesitate to know or explore business intelligence and analytics.

III. METHODOLOGY

The methodology chosen for this study is CRISP-DM. In brief, CRSIP-DM has six steps:

- Business Understanding
- Data Understanding
- Data Preparation
- Methodology
- Evaluation
- Deployment

The earlier section in the literature review briefly explained the business understanding. It was a general overview of the industry. In addition, the manufacturing or production improvement process has given us some understanding of the manufacturing operations.

The data understanding process began with identifying the data source, followed by data collection, reconciliation, and description. The dataset then went through the data preparation process, which provides data cleaning, quality verification, exploration, selection, transformation, and construction.

The preliminary exploration of the BSSB dataset will use a data mining method, namely classification and clustering. The models selected were Naïve Bayes, Support Vector, Machine (SVM), Linear Regression, Tree and Simple-K-Means. The model will apply two testing condition parameters which are 20% of the dataset will treat as training data and 10-fold-cross validation.

At this beginning stage, a descriptive analysis such as mode, median, minimum and maximum will help understand the historical summary of BSSB production. If further understanding is needed, the test may expand. Fig. 7 below illustrates the flow of the research process. It includes the selected models and possibilities for additional testing.

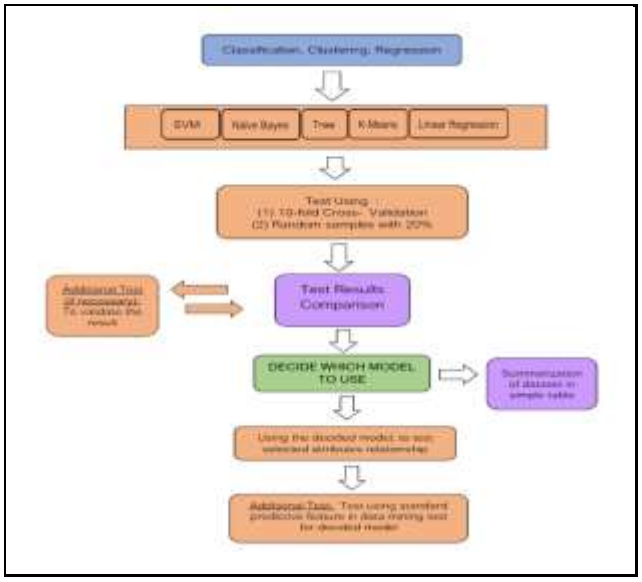

Fig. 7 Research Process

IV. RESULTS

Let us examine the relationship between chosen attributes using Naïve Bayes. Scatter Plot is used to view the results. Underneath is the selected attributes and the combination for the relationship test:

- Weight and ACTL,
- TFC and ACTL
- Basis weight (gsm) and ACTL

Fig. 8 reflected the positive relationship between weight vs ACTL attributes. The colours blue, green and yellow are showing instances. A point inside the "*red*" circle represents the lightest weight, while the "*black*" circle represents the heaviest. The heavier, the more quantity produced. Below is the summary.

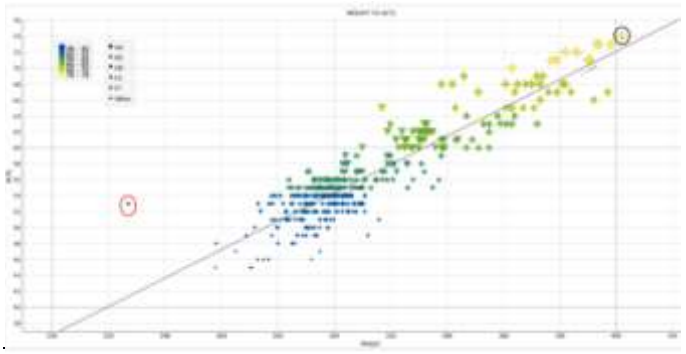

Fig. 8 Weight vs ACTL

TABLE IIIII
SUMMARY OF FIG. 8

	WEIGHT	ACTL	TFC	GSM	BATCH
Lightest weight (RED Circle)	227	53	42	36	CC
Heaviest weight (BLACK Circle)	402	74	68	38.9	EE
Regression line "r" value = 0.91					

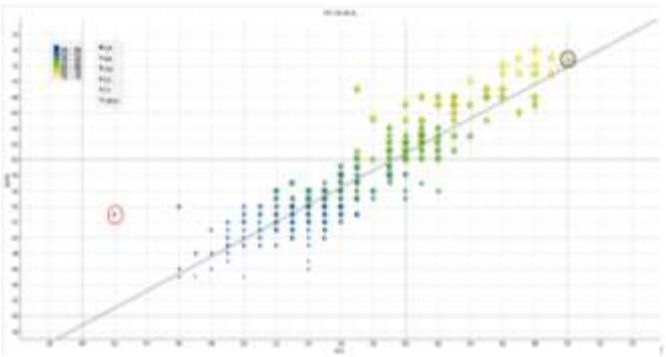

Fig. 9 TFC vs ACTL

TABLE IVV
SUMMARY OF FIG. 9

	WEIGHT	ACTL	TFC	GSM	BATCH
Lowest TFC (RED Circle)	227	53	42	36	CC
Highest TFC (BLACK Circle)	398	73	70	37.4	FF
Regression line "r" value = 0.9					

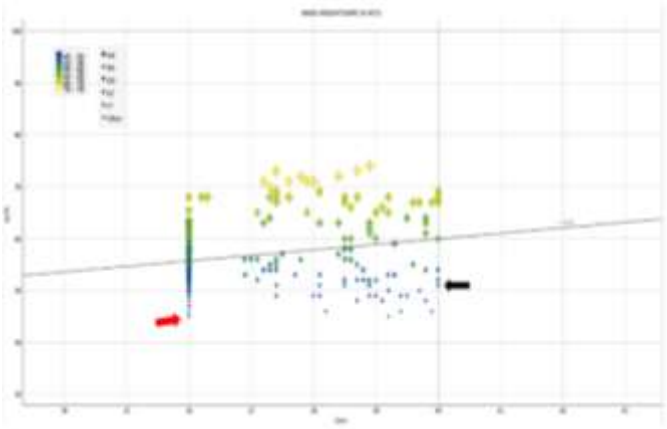

Fig. 10 Basis weight (gsm) vs ACTL

TABLE V
SUMMARY OF FIG. 10

	WEIGHT	ACTL	TFC	GSM	BATCH
Lowest gsm Lowest Output (RED Arrow)	258	45	47	36	DD
Highest gsm Lowest Output (BLACK Arrow)	295	51	49	40	FF
Regression line "r" value = 0.23					

In concluding the investigation on the relationship, all the above findings revealed a positive relationship between ACTL and three other attributes: weight, TFC and basis weight (gsm). Comparing the regression line (r-value) for basis weight (gsm) may not be as steeper (positive) as the other two. However, it would be enough to recognise the relationship as positive.

In exploring the descriptive analysis of the BSSB dataset, their dataset results reveal that:

- the relationship between ACTL, basis weight, the TFC and weight were positive. Increased or decreased value will affect the output.
- BSSB production runs with no target output or benchmark for all batches of parent rolls. BSSB does not know their performance.
- Some of the parent rolls produced more than or equal to the mathematical calculation presented by the TFC. At one glance, this reflects that BSSB production is "*superbly efficient*". Is it?
- Parent rolls of batches named AA, BB, CC and DD were from the same source and parent rolls EE, and FF were from another source. Even though they were from the same source, they have shown some differences between each batch in weight, output and basis weight. The differences were minimal.
- The parent rolls' weights were the same, but the ACTL output differed. The differences may not be significant, but it shows the difficulty of achieving the same.
- The basis weight has influenced the ACTL. The batch of parent rolls named AA, BB, CC and DD have provided one value of basis weight (at 36 gsm) for all compared to EE and FF. The prediction test has proven that basis weight could not be "*exactly*" at one value. If not possible to be exact at one value, then the range and consistencies are vital. Inconsistent parent rolls may affect the output and the production process.
- The parent rolls' basis weight was proven reasonably consistent, so, basis weight shall be excluded as one factor that puts BSSB's production in question.
- It would be difficult to determine their exact level of rejection because of the many directions of tolerances allowed in the industry practices for the product. Also, there is no data on the physical rejects.

V. DISCUSSION AND CONCLUSION

A. *Discussion*

Before discussing further, CRISP-DM has set the steps from the beginning to understand the business, including the manufacturing processes. Understanding the businesses and processes made data understanding easier and led to better analysis.

The discovery that the total average ACTL is more than the TFC has led to many assumptions. Let us begin with the impression of the "superbly efficient" performance by BSSB production, whether it was valid.

According to [17], there are two types of rejection and summarised below:

- rejection could be prevented: includes web brake waste in the paper machine, converting machine web brake waste, tail seal logs waste, dropped rolls in log saw separator, roll waste between log saw and packaging machine,
- Rejection could not be prevented: includes mother reel preparation waste, end of mother reel waste, rejected logs waste, etc.

It means that there are rejections in manufacturing, and some parts are unavoidable. BSSB operation is not well organised, which explains why BSSB production is "*superbly efficient*" without rejection. This conclusion is fair after considering all the facts presented earlier.

The key factors affecting the output are the size (length and width), basis weight, sheet count and weight. This study has adequately explored and examined basis weight from the dataset and tried the prediction feature in the data mining. Comparing the parent rolls consistency, batches AA, BB, CC, and DD were more consistent than batches named EE and FF. When basis weight is stable and consistent, the other possibilities that affected the output results to be "superbly efficient" would be the measurement, sheet count and weight. For example, the finished product weight is lighter if the size is shorter or less in sheet count. Therefore, having a lighter weight allows ACTL to exceed the TFC. It is another explanation of why BSSB production is "*superbly efficient*".

When ACTL is higher than the TFC, it is favourable to BSSB in terms of cost and productivity. On the other hand, it reflects that BSSB production is not quite right. As it may affect the product quality, thus it may also affect BSSB overall.

Even though there is an industry tolerance, exercising the tolerances to escape mistakes could jeopardise BSSB's reputation as a reliable and trusted manufacturer. Moreover, it will involve business ethics. Therefore, BSSB should maintain product consistency according to its committed specifications and quality. Should there be any setback, it must be within the industry's acceptable tolerance level.

Now, the research questions need to be answered and below are the explanations.

1) How to establish guidelines or control measures for BSSB production?

Based on earlier facts and discussions, TFC should be the guidelines or control measures for BSSB production. A Linear Regression prediction model could be the countercheck mechanism for consistency in parent rolls. It could allow BSSB to recognise each batch's range, basis weight consistency, and output performance. It could be important feedback to the parent rolls' supplier. The supplier could progressively improve their quality and supply to BSSB with more consistent parent rolls in terms of weight and basis weight.

2) *What is the acceptable production rejection rate?*

Setting an acceptable rejection rate for BSSB production is a challenging task. For benchmarking, BSSB could temporarily accept the lowest percentage of ACTL - TFC at -2.78% or rounded as 3%. It is a practical suggestion while BSSB rectifies their production. As an additional suggestion, a new data collection of the physical rejection for the machine setting before starting and ending each parent roll will lead to more accurate benchmarking.

Basis weight should be one of the inputs to determining the rejection rate. It relates to the consistencies of the parent rolls. Besides, the same amount of physical rejection for a higher basis weight will be heavier than the lower basis weight, even though the percentage may be the same. As a holistic approach, BSSB should consider having a more aggressive and effective quality checking method. It should begin from accepting the parent roll to the end product.

3) *How to identify the better source of parent rolls from the two sources?*

One factor that ought to consider in identifying the better source of parent roll would be consistency. ACTL should not be the mere factor determining the better source of parent rolls, as it could be misleading.

The predictive analysis on the basis weight and ACTL have revealed the consistencies of each batch of parent rolls. In addition, it proved that slight changes produced different results. For instance, the same parent roll weight with the minor difference in basis weight gives different output results. Adding to the parent rolls' consistency, parent rolls for the source of AA, BB, and DD showed a better outcome in average daily output. Therefore, based on:

- basis weight consistency,
- average daily output,

the suggestion is for BSSB to buy the parent rolls from the source of AA, BB, CC and DD. Having less total weight and producing better output translates into less material cost. It also means that having a lower basis weight and consistent production output would lead to a better product cost. Comprehensive analysis with new data might discover many facts concerning yield and productivity. BSSB should give this a serious thought.

After examining, Table III below explains the findings of the research hypotheses. How will all the previous results and discoveries help improve their business? It may help in many ways, and the explanations are in the later paragraphs.

BSSB should investigate their production and their end product. The preliminary process of descriptive analysis has partly become a BSSB quality checker. The high output does not mean it is excellent. It could deceive from recognising

the accurate performance. With this, BSSB could determine the checklist before and after each roll ran on the machine. BSSB could explore preventive maintenance on their machinery, provided they could collect and record the necessary data. Quoted by [25] in the journal, "*…Measurement acts like a data collection system that gives useful information about a particular situation or activity…*" but when too much data to collect and record, that activity could be a distraction from the actual focus, reduced efficiencies and increased unnecessary workload.

TABLE VI
FINDING OF HYPOTHESIS

H	HYPOTHESES STATEMENT	RESULT
$H1_1$	Basis weight (grammage of paper per square meter/gsm), size of the finished product, sheet count are the elements in determining the output.	ACCEPT. There is enough evidence to support the $H1_1$ as per the TAPPI calculation method.
$H2_1$	The TAPPI forecasted calculation (TFC) is one of the elements in determining the rejection rate.	ACCEPT. There is enough evidence to support the $H2_1$ as one of the elements in determining the rejects. The result of the calculation was the benchmark for comparing against the ACTL.
$H31$	Basis weight has an impact on the rejection rate.	REJECT. There is enough evidence to support the $H31$ that basis weight has no impact on the rejection rate. Basis weight impacts the rejection weight, as proven in the relationship test with the weight **but not the rate**.
$H4_1$	Basis weight has a significant effect on determining output results.	ACCEPT. There is enough evidence to support the H41's significant effect in determining output results. The relationship test between basis weight and ACTL resulted in positive. Consistent basis weight would lead to a consistent output, machine efficiencies, etc. The lower the basis weight, the lighter the finished product, which will also affect the product cost.
H51	Weight has an impact on rejection.	ACCEPT. There is enough evidence to support the H51 giving impact on rejects. The relationship test between weight, ACTL and basis weight (gsm) resulted positive. It means the heavier the weight, the higher ACTL. Therefore, the higher the reject, the heavier the weight.

B. *Conclusion*

The conclusions of BSSB preliminary data analytics favour BSSB by:

- Discovering facts about their production despite being "*superbly efficient* ".
- Creating awareness of the possibility that their final product deviates from its original specifications. It would be crucial to correct this before their customers find out, as this may have serious ramifications.
- Establishing temporary measures and guidelines to benchmark and control BSSB production
- Establishing facts on parent roll consistency. It will help BSSB decide on their parent roll source.

Adding to the abovementioned, let us briefly explore the possible impact on BSSB. With the consistency of the parent rolls:

BSSB could have better production planning. It includes workforce planning, such as overtime, inventory planning, and many others.

- BSSB could have better sales and market planning. For instance, they will know the maximum capacity to sell. It also allows the sales personnel to commit reasonable delivery lead-time to the customer.
- BSSB could have better working capital planning and cash flow cycle. For instance, they will know when to prepare capital for material purchase, determine raw material re-order level and many other related matters.
- BSSB could have better control over product costing. They could advise sales and marketing on attractive and competitive pricing. It also allows them to plan their marketing.

Implementing business intelligence and analytics could perhaps discover more facts with additional data. Hence, it may lead to a more significant impact on BSSB business.

VI. LIMITATIONS AND RECOMMENDATIONS

A. *Limitations*

This study has limitations. The limitation is the data. For example, the records of overtime are not available. In another example, the date and details of days unable to

work due to restrictions of Covid-19 were not recorded. Without the data, the productivity analysis could not be in-depth as this would be misleading. The machine efficiency analysis also could not be carry-out. The recommendations and suggestions made were solely based on the dataset. Other considerations, especially financial factors, were not included. Nevertheless, this study managed to produce results that could benefit BSSB.

The facts discovered may motivate BSSB to adapt business intelligence and analytics to their business. It could be a holistic approach combining their sales, accounting and manufacturing.

Business intelligence and analytics may not be the ultimate thing, but the facts and knowledge discovered and gathered from the process are priceless. Assumptions may lead to a less accurate decision. Business intelligence and analytics shall reduce many assumptions. It will elevate and improve the way in decision-making. Eventually, it will also lead to better business outcomes.

Some discovered facts may be unfavourable to BSSB, but those were the facts. If they disregard or do not use it wisely to their advantage, then the business intelligence and analytics facts discovery would add up to the statistics of the consumption gap.

B. *Recommendations*

Based on the results and conclusions, the recommendations are in two parts. The first part of the recommendations is:

- to establish a production benchmark based on TFC for each parent roll
- to establish a temporary reject rate at 3% until BSSB rectifies its production and the proposed data available for further analysis
- to choose the supplier of parent rolls AA, BB, CC and DD and monitor the consistency

The second part of the recommendation involves conducting new data collection. Below are the suggested areas for data collection:

- Time Taken to complete each roll
- Number of stops and how long
- Weighing physical rejection of starting set-up
- To weigh physical rejection of each roll completed
- Any major production stop or breakdown and why

Last, BSSB should plan and structure an official recording mechanism such as report forms for its operational activities. By having the reports, the data collection could be faster and better. On the other hand, they should balance the workload as too much data collection could cause neglect of the primary focus of the operations.

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