CHAPTER 2

THEORITICAL FOUNDATION

2.1 Supply Chain Management

Supply chain management is the handling of the entire production flow of a good or service — starting from the raw components all the way to delivering the final product to the consumer [7]. According to cio.com [8], supply chain management consists of planning, sourcing, making, delivering, and returning as can be seen in figure 1. This research, however, is trying to find a way to improve the planning part. The planning step is the step where the company plan and manage all the resources to make sure the supply meets the customer’s request and at the same time is efficient, effective, delivers value to customer and meets company’s goals.

Figure 2. 1 Supply Chain Management Process [7]
2.2 Restaurant Inventory Management

In restaurant cases, there’s also restaurant inventory management. Restaurant inventory management is the process of tracking ingredients in and out of the restaurant [9]. This process regulate the number of menu ordered, everything that came out the kitchen, and the amount of ingredients left afterward. It also includes the product allocation between stores. This process is a bit tricky to do especially since ingredients will go stale over time. Although nowadays there are a lot of inventory system that can help businesses track their inventory automatically, there are still some processes that still can’t be overcome with system and needs to be done manually. For example, POS system might be able count the number of menus ordered and the amount of ingredients used. However, the system might not be able to include losses from ingredients waste, incorrect preparation, spoilage. To be able to manage the inventory accurately, the restaurant needs to compare the physical stock manually with the amount of inventory in the POS system. This is the reason why it is hard for the restaurant, or any business in general to accurately keep track of the inventory. If the inventory itself can’t be kept track of, it will also be hard for the business to analysis or forecast the current and upcoming demand. Being able to manage the inventory properly is extremely important because it is critical for daily financial health of the business. It also let the business to plan strategy accordingly, including demand forecasting. Food cost is also one of the biggest budget items in the restaurant. This mean if the restaurant is able to gain full control of the food budget, it would be able to increase its the profit as well. According to assetinfinity.com [10], proper restaurant inventory management can be achieved by having features such as:

- Cloud-based system
- Instant billing
- Stock management
- Raw material management
- Recipe management costing
- Menu updates
- Central kitchen management
- Roles and permission
- Analytics and reporting
- Shelf-life management
- Marketing and CRM module
- Centralization
- Scalability
- Integrations
- Ease of use
- Quick Support
- Theft Control
- Security
- Mobility
- Payment integration

As can be seen in the figure below
This thesis describes more closely at a few features mentioned above and provides predictive solutions using machine learning algorithms.

2.2.1 Raw Material Management

Another important feature for restaurant inventory management system. Similar to stock management, raw material management also help restaurant keep track of the fresh ingredients, especially the biodegradable ingredients. This feature will alert the restaurant whenever a certain raw material reach reorder point set before hand by the restaurant

2.2.2 Recipe Management and Costing

This feature is a prerequisite for the restaurant to be able to control food cost efficiently. Recipe management and costing point out the importance of standardization of recipe, which require the restaurant staff to prepare a menu using the exact required amount of ingredient as stated in the recipe. This helps the restaurant
to check and reduce food cost. This also help the restaurant to easily know how long the remaining ingredients in the inventory restaurant will last. Recipe management also lower the chance of ingredient stealing happening in the company. In bigger chains, this feature help the restaurant to keep the consistency of the taste of the dishes as well because the recipe is the same.

2.2.3 Analytics and Reporting

Analytics and reporting is a crucial feature for not only restaurant but also business in general. Some software provide this feature which allow the restaurant owner to check the simplified report of the past month or even past year. This is also what the researcher mentioned at the beginning, utilization of data. This feature provide data from different aspects such as sales, inventory movement, etc to give insight to company stakeholder. This will allow the company stakeholder to understand the trend and plan properly for the future.

2.2.4 Shelf-Life Management

Shelf life is the amount of time each item or ingredient can stay in the inventory before they start degrading. Shelf-life management is important to help the restaurant to be aware of how long the ingredient can still last. This will allow the restaurant to plan accordingly to get rid of the ingredients before they are completely spoiled and become unusable. This prevents food wastage and lower food quality due to degraded ingredients.
2.3 What is Data Science

Data science is the domain of study that deals with vast volumes of data using modern tools and techniques to find unseen patterns, derive meaningful information, and make business decisions [11]. Data science uses complicated machine learning formula to do prediction. The data used for analysis can be from multiple sources and present in various formats. The sources in this case would be restaurant’s past data of inventory turnover. For example, when is the peak time of the restaurant? Which menu get ordered the most, what is the ingredients used to create the menu? Which ingredient usually get disposed due to expiration and other reasons? Etc. The data will then need to be processed before it can be useful to the company.

2.4 Machine Learning

Machine learning, as explained above is the machine’s ability to learn something new, by itself. This is the core of the data science. [12] Some examples of machine learning is video recommendation algorithm in video platform such as Youtube. The *machine* or the system in the video platform learns what type of video do you like to watch, which genre, how long the duration is, which country is the video from, what is it related to, etc. After learning the behaviour of your watch history, the system will then suggest you a similar video in order to keep you engaged and keep watching video in their site. The illustration of machine learning can also be seen from the figure below:
2.5 Machine Learning Tasks

Machine learning tasks are usually categorized into:

2.5.1 Classification

Classification is a process of categorizing a given set of data into classes. It can be performed on both structured or unstructured data [13]. The process of this algorithm start by predicting which class / category the new data fall into. A simple example of classification we are all familiar with can be seen in the figure below.
Classifying mail into spam and non-spam is a feature almost every mail software has now. Nowadays, some software also provide this feature for call. The AI will detect whether the caller is a suspected scam or telemarketer.

2.5.2 Association

Association, as its name suggest is a rule based machine learning and data mining technique that finds important relations between variables or features in a data set [15]. Association rule finds out the relation between variables that we might not realize. The example of this algorithm is someone who buy diapers in a retail store tends to buy milk as well. This type of information is beneficial and might be proven useful for stores’ campaign.
2.5.3 Clustering

Clustering is a technique that involves putting data into a related group, without knowing beforehand the group definition [16]. The example of this technique is a retail store that sells man suit. Out of the 100 branches of this retail store, 99 branches successfully sells the product. With the help of clustering technique, it is found out that all the 99 branches use the television to promote their product while the one who is unsuccessful use the radio.
2.5.4 Regression / Prediction

Regression is a supervised learning technique which helps in finding the correlation between variables and enables us to predict the continuous output variable based on the one or more predictor variables. [17].

An attribute is a property or characteristic of an object [18]. E.g hair colour of a person, current temperature, etc. Current temperature is also the example of continuous attributes. Continuous attribute is technically consisted of infinite number of steps. For example, temperature can be 34.1°C, 34.2°C, 34.3°C, etc. Regression is the method that is usually used to predict this type of data. In this study, the problem the researcher is trying to solve, which is to find the optimum number of fresh ingredients the restaurant should order, is also a continuous attribute. This make regression the perfect method to be used in this research. Aside from the optimum number of the ingredients, the researcher will also use this method to predict the number of upcoming visitors.

2.6 Machine Learning Algorithms

Generally, there are 3 types of machine learning algorithms which are supervised learning, unsupervised learning, and reinforcement learning. [19] Regression is included into the supervised learning category. Supervised learning category is the algorithm where the machine learns the past data pattern and use it to predict the future. The researcher will first gather the dataset from a source. The source can be from internet, real data from real business, or created by the researcher which is also called synthetic data. The data set will then be separated into training set and test set. The machine or A.I will first learn from the past data set or training set and try to predict the outcome. Later on we are going to check whether the data is correct
based on the test set. The process will be repeated until the machine gain reach enough accuracy the researcher desires. The general formula for supervised learning algorithm is \( Y = f(X) \). [20] Where \( Y \) is equal to output variable and \( X \) is equal to input variable. Aside from regression, other examples of supervised learning are decision tree, random forest, KKN, logistic regression, etc.

### 2.6.1 Random Tree

One of the supervised algorithms is called random tree. Random Tree is a supervised Classifier; it is an ensemble learning algorithm that generates many individual learners. It employs a bagging idea to produce a random set of data for constructing a decision tree. In standard tree each node is split using the best split among all variables [21]. This algorithm will be used by the researcher later on as one of the comparisons.

### 2.6.2 Random Forest

Another algorithm that will be used later on is random forest. According to builtin.com [22], Random forest is the combination of decision tree merged for a more accurate and consistent prediction. Decision tree itself is an algorithm where a diagram or chart used to determine a course of action or show a statistical probability. [23]

### 2.6.3 Linear Regression

Linear regression attempts to model the relationship between two variables by fitting a linear equation to observed data. One variable is considered to be an explanatory variable, and the other is considered to be a dependent variable. [24] For example, weight of a person might be related to their height.

### 2.6.4 Multilayer Perceptron

Multilayer perceptron or also known as neural networks, are a set of algorithms that are designed to function similarly to human brain, used to recognize pattern.
Neural networks mostly help in clustering and classifying data. They act as a clustering and classification layer on top of the data that are stored and managed. [25]

2.6.5 M5P

M5P is Reform of Quinlan's M5 algorithm for tempting trees of regression models. M5P combines a conservative decision tree with the possibility of linear regression functions at the nodes. [26]