

# Application of Lean Six Sigma to Improve The Food Bank Singapore's Vending Machine Replenishment Process – A Case Study

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## Abstract

Lean Six Sigma is a well-established and widely adopted process excellence methodology across various industries. It is known for its step-by-step approach to process improvement using the DMAIC framework while encompassing various lean tools at different stages. Its applicability in non-profit organisations has produced positive results in increasing the effectiveness and efficiency of operations. However, the research on the application of Lean Six Sigma is limited within Food Banks globally as most Food Banks adopt the lean approach towards process improvement. Therefore, through a case study of The Food Bank Singapore, this research aimed to discover the feasibility of Lean Six Sigma in improving the packing and replenishing of The Food Bank Singapore's vending machines, also known as The Food Pantry 2.0. The applicability of Lean Six Sigma in a Food Bank was shown through a reduction in packing time with less manpower involved at the warehouse. Applying the VOC, the customers' food preferences was fulfilled along with a significant decrease in food wastage at the vending machines. However, it is recommended for the process to be continuously monitored and refined to facilitate the expansion of The Food Pantry 2.0.

## Keywords

Lean Six Sigma, DMAIC, 5S, Food Banking, Food Pantry 2.0

## 1. Introduction

Lean Six Sigma (LSS) is a step-by-step process to eliminate waste and to reduce variation through the stages of Define, Measure, Analyse, Improve and Control (DMAIC) (Salah et al. 2010). Major business organisations adopt LSS to refine their business process, to achieve customer satisfaction and improve their financial status (Salah et al. 2010). Although it is in the nature of profit-making organisations to lower their operating costs and increase their efficiency, non-profit organisations are also adopting a similar approach as they possess limited resources in terms of capital, manpower and technology (Glover et al. 2014, Pieńkowski 2016).

This research explored the applicability of LSS in a non-profit organization, The Food Bank Singapore (FBSG). According to the Global Food Security Index (2019), Singapore is ranked as the most food-secure country out of 113 countries. Nagpaul et al. (2020) revealed that 10.4 percent of Singaporean households experience food insecurity at least once a year. Founded in 2012, The Food Bank Singapore aims to eradicate hunger and all forms of food insecurity in Singapore by 2025, by serving as the main body for coordinating all food donations and distributions throughout the nation (Nagpaul et al. 2020). With the drive towards contactless and automated self-collections of food donations, The Food Pantry 2.0 – food vending machines initiative was launched in October 2019 with the pilot site in Toa Payoh estate. The three vending machines at the pilot site dispense food bundles that contain mainly food items with shelf-life of less than two months (Foodbank 2020). Currently, FBSG is working towards installing 100 machines within housing estates in Singapore (Foodbank 2020).

This study examines the replenishment processes involved in operating the three vending machines at the pilot site in Toa Payoh. A thorough review of the food packing process for replenishing the vending machines at the pilot site at FBSG's warehouse was conducted. The aim was to streamline and improve the existing packing and replenishing process at the warehouse before additional machines are launched at the other locations towards the end of 2020.

## 1.1 Objectives

In this study, we seek to apply LSS to improve FBSG's vending machine replenishment process and outlined the following research objectives:

- To understand the Voice of Customer (VOC) and map out the AS-IS process of replenishing the vending machines through defining the Suppliers, Input, Process, Output, Customers (SIPOC).
- To measure and analyse the food packing process for replenishing the vending machines using the Spaghetti Diagram and Process Value and Time Analysis (PVT) Tool.
- To improve on the AS-IS process and sustain the TO-BE process using the 5S methodology.

## 2. Literature Review

Lean Six Sigma is a well-developed and commonly used methodology across organizations for process improvement (Snee 2010, Antony 2015). Organisations adopting the LSS methodology aims to eliminate waste, decrease variability while improving the process performance (Cheng and Chang 2012, E.V. et al. 2019). According to George (2002), the LSS methodology has proven its effectiveness in the manufacturing and services industry as a well-established performance excellence methodology since its establishment. Within the LSS methodology, the DMAIC structure of Six Sigma links the lean tools and techniques at each stage of the improvement process (George 2002, Snee 2010). The framework guides the selection of project, measurement and analysis of the data collected, before optimising and sustaining the process (Salah et al. 2010).

Over the past decade, several non-profit organisations have also successfully applied LSS and DMAIC as the framework that encompasses lean tools in a warehouse setting: Implementation of LSS in the Assistive Devices Service Center (Cheng and Chang 2012) and Applying LSS in GRID Alternatives Warehouse (Leon 2016). Cheng and Chang (2012) achieved a reduction in production time through reorganising the storage racks and similarly Leon (2016) achieved a reduction in the time taken for loading and unloading of components after a build was completed. Similarly, Food Banks operate in a warehouse setting but the use of LSS for process improvement is not thoroughly researched in this environment. Therefore, this research aims to contribute to the current pool of knowledge in the applicability of LSS in non-profit organisations – The Food Bank.

Common benefits of the lean approach include refining the current process, better use of manpower and physical spaces, reducing errors, freeing up capacity, increased production rate and faster delivery times (Martin 2018). Using the lean approach, Glover et al. (2014) refined the work process of The Greater Boston Food Bank to achieve a reduction in lead time for order picking and order fulfillment. Over at The Wrocław Food Bank, Pieńkowski (2016) observed a reduction in process time, faster inventory turns and better utilisation of storage spaces.

Although The Greater Boston Food Bank and The Wrocław Food Bank were able to achieve most of their objectives through the lean approach, there is a lack of emphasis in the application of Six Sigma within Food Banks. Salah et al. (2010), recommended the integration of lean and Six Sigma where both methodologies support each other. The benefit of using DMAIC as the core framework is known to speed up process improvement by deploying the suitable lean tools in different stages through a holistic process improvement approach (Salah et al. 2010). In response, Pieńkowski (2016) reported on the application of an adapted DMAIC approach and a 5-step lean management process and the use of Value Stream Mapping (VSM) for improving the warehouse processes of the Wrocław Food Bank.

## 3. Methods

As the extant literature is insufficient for the researchers to draw reference for this project, the uniqueness of this research requires the researchers' participation to document relevant findings for process improvement. Therefore, an action research approach was adopted as the researchers sought to examine the AS-IS processes on-site in order to

develop feasible solutions for solving real world organisational issues via the engagement and participation of the problem-solving process (Saunders et al. 2016). This action research approach entails the participation of the first author and close cooperation of the researchers with the employees of FBSG in order to prescribe workable solutions to tackle the inefficiencies in the current packing and replenishing processes in FBSG's warehouse.

Furthermore, the case study approach provides a comprehensive examination into a real-life issue to comprehend the relationship between the subject of the case and the circumstances related to the case (Saunders et al. 2016). In this action research study, we closely examined the current processes in the studied case with a view to eradicate waste or non-value adding activities through the application of LSS for process improvement in a non-profit organisation – The Food Bank Singapore.

#### **4. Data Collection**

Case Study - The Food Bank Singapore was founded in 2012 with the objective to eradicate hunger and food insecurity in Singapore by 2025 (Nagpaul et al. 2020). The Food Pantry 2.0 was initially launched in Toa Payoh as a pilot test site with a setup of three vending machines and it has since expanded to four additional locations island-wide in Singapore.

Literature reviews were conducted to obtain an understanding of the process improvements that were implemented in various Food Banks using the lean approach and thereafter, the applicability of LSS in non-profit organisations. Using the action research approach, primary data was manually collected through observing and participating in the food packing process in FBSG's warehouse and replenishing the vending machines at Toa Payoh. Key metrics of the data collection process include (1) the time taken to complete each activity in the overall process to replenish the vending machines and (2) the type and quantity of expired food and food that will expire before the next round of replenishment which was collected twice per week over four weeks.

To understand the Voice of Customer (VOC), the primary researcher identified himself as a volunteer of FBSG and initiated informal interviews with the customers of the vending machines to understand their dietary needs and preferences. The informal interview was administered to 10 interviewees in the form of a casual conversation in Toa Payoh where the vending machines are located.

#### **5. Results and Discussion**

##### **5.1 Define Phase**

The SIPOC process map in Table 1 shows that there are three essential inputs required to initiate the packing process which are: (1) Food items; (2) Information and (3) Manpower. Combining the three factors using the AS-IS process, there are two outputs to be achieved. The first output is to produce boxes of food that are packed with sufficient food to enable the replenishment of the vending machines. The second output is to utilise the food items to restock the vending machines to its maximum capacity.

Using the VOC, conversations were initiated with the customers who were waiting for the vending machines to be restocked. A total of 10 customers were interviewed. The customers were elderly who identified themselves as residents living nearby. All of them indicated strong preference for white rice, vermicelli, breakfast cereals, cream crackers, instant 3 in 1 coffee, carton milk and milo powder. Furthermore, 3 out of 10 indicated that they would also look for canned food, cooking oil and condiments such as salt, sugar and soya sauces which can be used to prepare cooked meals. However, only 1 out of 10 indicated that she occasionally buys snacks from the vending machines. Therefore, the VOC reaffirmed the data collected on the type of expired food and food that will expire before the next replenishment which were mainly snacks and biscuits.

Table 1. SIPOC Process Map

<b>SIPOC: The Food Bank Singapore's Vending Machines Replenishment Process</b>				
<b>S</b>	<b>I</b>	<b>P</b>	<b>O</b>	<b>C</b>
Suppliers	Inputs	Process	Outputs	Customers
The manager who is in-charge of receiving the food donations, checking of expiry dates, sorting and shelving the food items.	Provides food items with less than two months of shelf-life. Possess the authority to provide additional food items upon request.	Refer to the AS-IS process map in Figure 1.	At The Food Bank Singapore's warehouse: Boxes of food items that are sealed and labelled correctly with the date of replenishment and location.	Holders of The Bank Card (Beneficiaries) who can redeem each food bundle from the vending machines at two credits per bundle.
The supervisor who leads the vending machines initiative and has access to information regarding the vending machines.	Provides information on the remaining capacity of the vending machines to determine the amount of food items to pack for replenishing the vending machines.		At Toa Payoh where the vending machines are located: Replenish the vending machines to its maximum capacity using the boxes of food items.	General public who can purchase the food bundles at \$2 per bundle.
Volunteers who sign up for volunteering sessions at The Food Bank Singapore's warehouse.	Provides labour to aid the supervisor in activities such as checking the expiry date of the food donations received, shelving the food items and packing the food items to be distributed.			

The SIPOC mandates the understanding of the initial end-to-end process of replenishing the vending machines which is shown in Figure 1. The emphasis is on the warehouse activities rather than the actual conduct of the replenishment activities at the site where the vending machines are located. The vending machines are replenished twice weekly, on Tuesdays and Fridays. Therefore, the packing of food at the warehouse was conducted on Thursdays. The supervisor will check the number of empty cubbies via remote access to the vending machines on Tuesdays and Thursdays to determine the quantity to pack for replenishments on Tuesdays and Fridays respectively. Documenting the information of the food items is less tedious at this stage as the vending machines are only located at a single location in Toa Payoh.

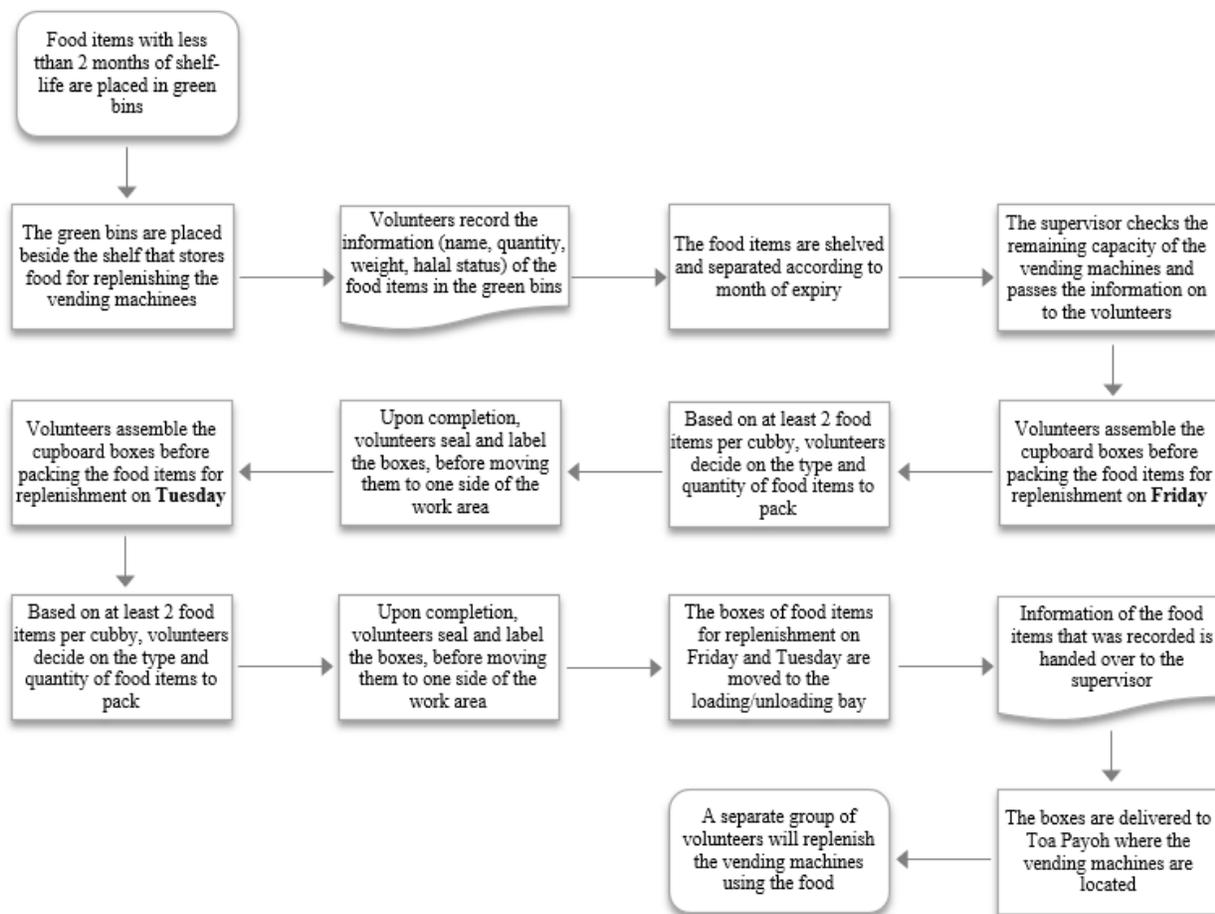


Figure 1. AS-IS Process Map

## 5.2 Measure and Analyse Phase

Based on the AS-IS process map, the spaghetti diagram in Figure 2 was developed to visualise the flow of human (volunteers) and material (food items) within The Food Bank Singapore’s warehouse. According to Table 2, a total of 27 steps were required to complete the initial packing process, starting from recording the information of the food items inside the green bins until the boxes of food that were sealed and labelled are moved to the loading/unloading bay for delivery and returning of the pallet jack to its original location. There was a congestion between the packing area and the food storage shelf where the stationery holder was located because of the need to retrieve and return the stationery for assembling, sealing and labelling the boxes. As there was no demarcation of the packing area, volunteers who were helping out with other activities within the warehouse often extend their usage of the space and the volunteers packing the food to replenish the vending machines are left with limited space.

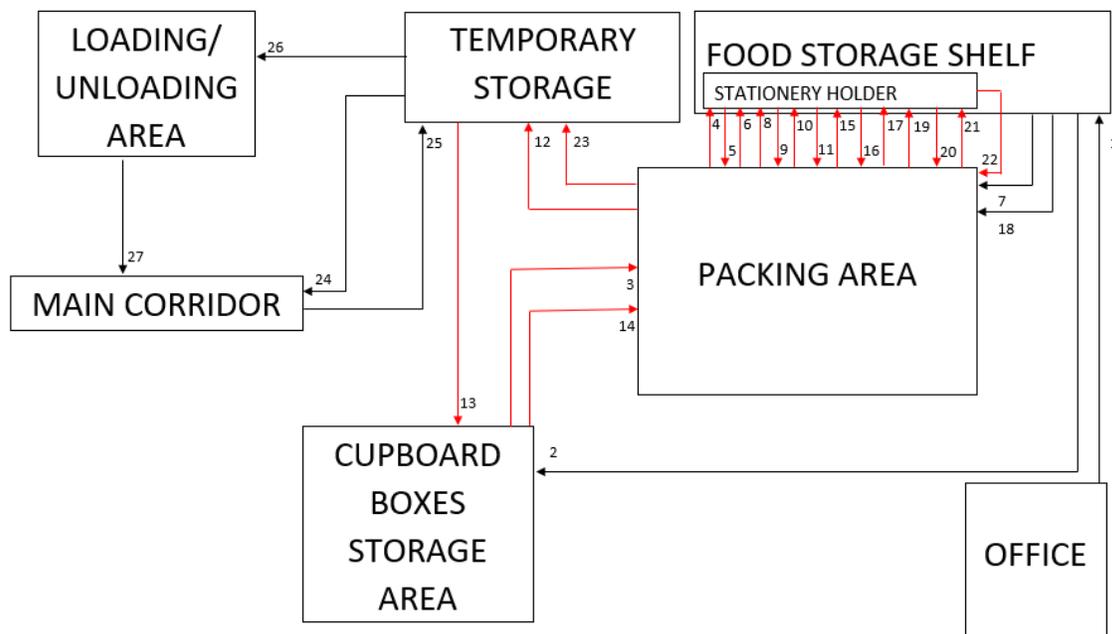


Figure 2. Spaghetti Diagram

Table 2. Sequence of activities in the Spaghetti Diagram

Mapping of the AS-IS process map into a Spaghetti Diagram	
1.	Record the information of the food items in the green bins and shelve all the food items
2.	Proceed to the cupboard boxes storage area
3.	Select and bring the cupboard boxes to the packing area
4.	Proceed to the stationery holder
5.	Retrieve the pen knife and scotch tape to assemble the boxes at the packing area
6.	Return the pen knife and scotch tape into the stationery holder
7.	Pack the food items from the shelf into the boxes at the packing area for Friday's replenishment
8.	Proceed to the stationery holder
9.	Retrieve the pen knife, scotch tape and marker to seal and label the boxes at the packing area
10.	Return the pen knife, scotch tape and marker into the stationery holder
11.	Proceed back to the packing area
12.	Move the sealed and labelled boxes to the temporary storage area
13.	Proceed to the cupboard boxes storage area
14.	Select and bring the cupboard boxes to the packing area
15.	Proceed to the stationery holder
16.	Retrieve the pen knife and scotch tape to assemble the boxes at the packing area
17.	Return the pen knife and scotch tape into the stationery holder
18.	Pack the food items from the shelf into the boxes at the packing area for Tuesday's replenishment
19.	Proceed to the stationery holder
20.	Retrieve the pen knife, scotch tape and marker to seal and label the boxes at the packing area
21.	Return the pen knife, scotch tape and marker into the stationery holder
22.	Proceed back to the packing area
23.	Move the sealed and labelled boxes to the temporary storage area
24.	Retrieve the pallet jack from the main corridor
25.	Bring the pallet jack to the temporary storage area and load up the sealed and labelled boxes
26.	Move the sealed and labelled boxes to the loading/unloading bay
27.	Return the pallet jack to the main corridor

The activities that were performed in the AS-IS process were analysed using the PVTA tool shown in Table 3 to determine the importance of each activity and the time taken to complete each activity. Each activity can be classified as either Value Adding (VA), Non-Value-Adding-required (NVA-r) or Non-Value-Adding (NVA) which is considered as a waste activity. According to the results in the PVTA table, the initial step of recording the information of the food items in the green bins took 8 minutes 30 seconds. This process was slow and inefficient because the volunteers had to locate the information of each food item on the packaging such as the weight and *halal* status before matching the food item to its correct category using the reference material that was provided by the manager. Furthermore, all the information was recorded using pen and paper which slowed down the whole process. The 2<sup>nd</sup> step of shelving the food items after it was recorded was deemed as NVA because most of the same food items were packed into the cupboard boxes soon after they were assembled. Moving the sealed and labelled boxes to the temporary storage area was also deemed as NVA because this step could be avoided if sufficient packing area was allocated for the volunteers. Although packing of the food into the boxes was considered as VA, there was a significant wait time because the volunteers need to decide on the type and quantity of food items to pack which also slowed down the whole process.

Table 3. Process Value and Time Analysis table

<b>Process Value and Time Analysis</b>					
<b>Name:</b> Volunteers 'A', 'J' & 'S'		<b>Process Name:</b> Packing of food at The Food Bank Singapore's warehouse to replenish the vending machines			
<b>Date:</b> 23 July 2020		<b>Time Measured:</b> Minutes			
<b>No.</b>	<b>Process Step</b>	<b>Step Label (VA, NVA, NVAr)</b>	<b>Value Added Process Time</b>	<b>NVA &amp; NVA-Required Process Time</b>	<b>NVA – Wait Time</b>
1.	Record the information of all the food items in the green bins	NVAr		8.5	
2.	Shelve the food items, separated by expiry date	NVA		8.5	
3.	The supervisor remotely accesses the vending machines to check the number of empty cubbies	NVAr		3	
4.	Proceed to the cupboard boxes storage area	NVAr		0.083	
5.	Select and bring the cupboard boxes to the packing area	NVAr		1.667	
6.	Retrieve the pen knife and scotch tape from the stationery holder	NVAr		0.05	
7.	Assemble the boxes at the packing area	NVAr		1.133	
8.	Return the pen knife and scotch tape into the stationery holder	NVAr		0.05	
9.	Pack the food items from the shelf into the boxes at the packing area for Friday's replenishment	VA	8.5		5.183
10.	Proceed to the stationery holder and retrieve the pen knife, scotch tape and marker	NVAr		0.05	
11.	Seal and label the boxes at the packing area	NVAr		1	
12.	Return the pen knife, scotch tape and marker into the stationery holder	NVAr		0.05	
13.	Move the sealed and labelled boxes to the temporary storage area	NVA		0.5	

14.	Proceed to the cupboard boxes storage area	NVAr		1.667	
15.	Select and bring the cupboard boxes to the packing area	NVAr		0.083	
16.	Retrieve the pen knife and scotch tape from the stationery holder	NVAr		0.05	
17.	Assemble the boxes at the packing area	NVAr		1.133	
18.	Return the pen knife and scotch tape into the stationery holder	NVAr		0.05	
19.	Pack the food items from the shelf into the boxes at the packing area for Tuesday's replenishment	VA	9		4.383
20.	Proceed to the stationery holder and retrieve the pen knife, scotch tape and marker	NVAr		0.05	
21.	Seal and label the boxes at the packing area	NVAr		1	
22.	Return the pen knife, scotch tape and marker into the stationery holder	NVAr		0.05	
23.	Move the sealed and labelled boxes to the temporary storage area	NVA		0.5	
24.	Retrieve the pallet jack from the main corridor	NVAr		0.5	
25.	Bring the pallet jack to the temporary storage area and load up the sealed and labelled boxes	NVAr		0.767	
26.	Move the sealed and labelled boxes to the loading/unloading bay	NVAr		3	
27.	Return the pallet jack to the main corridor	NVAr		1	
				<b>Time</b>	<b>% of total</b>
Total Value-Added Process Time				17.5	28.46
Total Non-Value-Added & Non-Value-Added-r Process Time				34.433	55.99
Non-Value-Added – Wait Time				9.567	15.56
Total Lead Time				61.5	100

### 5.3 Improvement and Control Phase

After analysing the data using the Spaghetti Diagram and PVRTA, the primary researcher and the relevant stakeholders brainstormed for ideas to achieve the TO-BE process during the improvement phase. Thereafter, the 5S methodology was deployed to encompass the new process and sustain the improvements made.

As part of the brain-storming process, a method of bundling the food was developed based on the VOC that was obtained from interviewing the customers. This method was developed together with the supervisor who is in-charge of the vending machines. Based on two food items per cubby, the 1<sup>st</sup> item (known as the 'base') will be selected from one of following broad categories: (1) staples, (2) canned food, (3) beverages or (4) condiments. The 2<sup>nd</sup> item (known as the 'filler') will be selected from one of the following broad categories: (5) snacks or (6) food with shelf-life of less than two months. The food from the 5 categories will have a shelf-life of more than two months which are requested from the manager who is the overall in-charge of the warehouse. Based on the six broad categories, a packing list was created to streamline the packing process. The packing list requires the supervisor to input the number of empty cubbies to generate the breakdown in quantity of food in each broad category with the exception of food that has less than two months of shelf-life. Additionally, the packing list guides the volunteers in packing the food which eliminates

the time wasted in deciding the type and quantity of food to pack. To simplify the requirements across all the different sites, a standard quantity will be provided for each round of replenishment.

As mentioned earlier, the volunteers had to record the food items in found in the green bins using pen and paper which was deemed slow and inefficient. Therefore, a “check-out form” was created to streamline the information recording process. The form requires the volunteers to select the food item type, weight range and *halal* status using a dropdown list before keying in the quantity under the column(s) that indicate the different sites where the vending machines are located. The information recording process is digitalised to reduce the rate of errors in recording information using pen and paper. Additionally, this is to facilitate the increase in number of sites where the vending machines will be located as the information recording gets more tedious when the number of sites increases.

#### Step 1: Sort

The decluttering of the workplace began with the removal of unnecessary items such as: (1) non-food items, (2) empty green bins, (3) woven fabric bags and (4) food items left in front of the shelf but not allocated for replenishing the vending machines, e.g. food for animal shelter.

#### Step 2: Straighten

All the non-food items were neatly stacked at one end of the shelf. Non-food items are required because one of the new locations, Tuas, had requested for the provision of toiletries as an option in the vending machines. The racks on the shelf was rearranged according to the flow of the packing list, assigning each rack to one of the five broad categories. Each layer was assigned a category, starting from the rack on the left (bottom to top): (1) staples, (2) canned food and (3) beverages and on the right (bottom to top): (1) condiments, (2) biscuits/snacks. The area below the condiments contains unopened boxes of food that could not fit into the racks. All the volunteers volunteering in The Food Bank Singapore warehouse will place their personal belongings in the cabinet that was located in the corner of the warehouse. The cabinet was located on the right of the shelf and the packing process was disrupted whenever any volunteer needs to access the cabinet to retrieve his/her belongings. There was also a table in the warehouse that was not efficiently utilised. Volunteers who were recording the information of the food items found in the green bins had to do it on the ground or on a make-shift desk that was made out of boxes. Therefore, the position of the cabinet and table was interchanged.

#### Step 3: Shine

The supervisor and the volunteers cleaned and tidied up the area after the shifting of the cabinet and table was completed. A comparison of the workplace condition before and after applying the first three steps of the 5S methodology is shown in Table 4. The final condition of the work place is show in Figure 3.

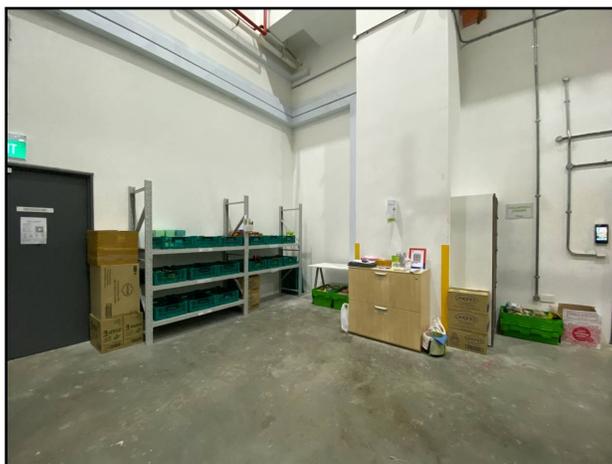


Figure 3. Condition of the work place after completing the first three steps of the 5S methodology

Table 4. Comparing the condition of the work place before and after the 5S methodology was deployed

	Before		After	
A		The right shelf contained a mixture of food and non-food items. The green baskets on the racks were not arranged according to the workflow. Access to the shelf was blocked by the boxes on the floor.		Non-food items were removed. The racks were arranged according to the five categories used for the bundling process. Boxes blocking the front of shelf were removed.
B		The corner beside the right shelf contained food and non-food items, and items that were not required for packing and replenishing the vending machines.		The mess at the corner was cleared and only non-food items were placed there. Food items that belong to the vending machines were placed on the shelf.
C		Volunteers who were volunteering in other areas of the warehouse disrupted the packing process whenever they require access to the cabinet to retrieve their personal belongings.		The cabinet was shifted away and replaced with a table. Volunteers now have a proper space to fill up the check-out form instead of doing it on the floor or on top of the cupboard boxes.
D		The table mentioned in "C" was originally placed in this corner. The corner was a temporary storage area for miscellaneous items when the employees could not decide where to store those items.		The cabinet mentioned in "C" was placed at the position where the table was previously located, to prevent any disruption to the packing process. The mess on the floor was also cleared up.

#### Step 4: Standardise

The process starts with the supervisor who will determine the frequency of replenishments across all the different sites where the vending machines are located. A fixed quantity of food items will be provided for each round of replenishment which is sufficient to either replenish 40 or 80 empty cubbies. The frequency of replenishment will be based on the agreement between the supervisor and the business owners who have adopted the vending machines. If the food items are insufficient to meet the packing requirements, a request will be made to the manager for additional food items to be transferred to the packing area. The food items are packed straight into the boxes and only surpluses are stored on the shelf at the end of the whole process.

The improved process which starts from selecting and assembling the cupboard boxes until the boxes are sealed and labelled took between 36-43 minutes in three separate trial runs with two volunteers as shown in Table 5. The 3<sup>rd</sup> run produced the best result with a reduction of 20 minutes in packing time through two volunteers compared to the initial process of 56.232 minutes with three volunteers. Although there were two volunteers involved in the process, the physical activities such as selecting and assembling the cupboard boxes, packing the food, and sealing and labelling the boxes were done by only one volunteer. The other volunteer was only responsible for recording the information of the food via the check-out form while the food was packed into the cupboard boxes. A temporary packing area was also demarcated using cupboard boxes to avoid moving the sealed and labelled boxes to a temporary storage area. With these improvements, NVA activities such as shelving the food, checking the no. of empty cubbies and moving the sealed and labelled cupboard boxes to a temporary storage area were avoided. However, it was observed that packing of the 2<sup>nd</sup> item (filler) took longer than the 1<sup>st</sup> item (base) across the three runs. The food items used as the filler were mainly food with less than two months of shelf-life. Therefore, depending on the variety, commonality and number of different food items that has less than two months of shelf-life, more time was required to enter the information into the check-out form.

Table 5. Comparison of the time spent on each activity between the initial and improved process

Activity	Total time taken to complete each activity in the packing process (minutes)			
	Initial Process	Trial Run 1	Trial Run 2	Trial Run 3
Record the food information	8.5	-	-	-
Shelve the food	8.5	-	-	-
Check the no. of empty cubbies	3	-	-	-
Select the cupboard boxes	3.5	2	3	1
Assemble the cupboard boxes	2.466	3	3	2
Pack for day 1 replenishment/1 <sup>st</sup> item (base)	13.683	15	14	15
Pack for day 2 replenishment/2 <sup>nd</sup> item (filler)	13.383	20	17	15
Seal and label the cupboard boxes	2.2	3	5	3
Move cupboard boxes to temporary storage area	1	-	-	-
Total:	<b>56.232</b>	43	42	<b>36</b>
% improvement:	-	23.53%	25.31%	<b>35.98%</b>

#### Step 5: Sustain

The necessary documentation such as the packing list and check-out form is handed over to the supervisor to sustain the improved process of packing the food to replenish the vending machines. Following the TO-BE process shown in Figure 4, the supervisor experienced the whole packing process a couple of times to familiarise herself, as she works to develop a set of instructions that guide new volunteers through the whole process.

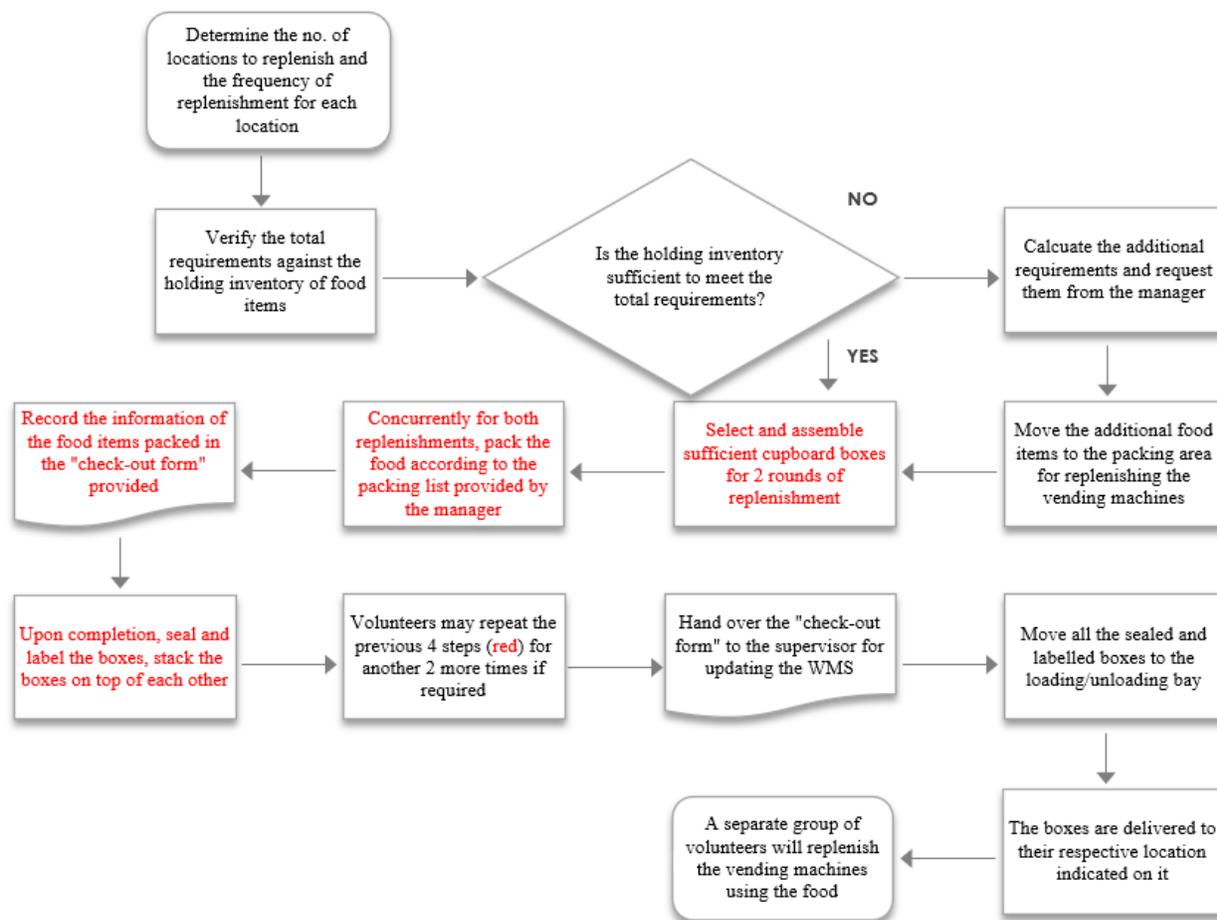


Figure 4. TO-BE process map

## 6. Conclusion

This research featured the application of LSS in a non-profit organisation – The Food Bank Singapore. Although non-profit organisations face limited funding for manpower and technology as well as having to rely on volunteers to execute most of the laborious activities, the avenue to streamline and reduce operations process variations through the use of LSS methodologies is enormous. The DMAIC framework provided a structured step-by-step problem-solving approach for improving the packing and replenishing process of the vending machines in FBSG’s warehouse through the use of various lean tools. The VOC provided a thorough understanding into the food preferences of the vending machines’ customers, thereby enabling FBSG to better match the food bundles to the customers’ preferences. Additionally, the Spaghetti Diagram and PVTA allowed the researchers to identify areas of inefficiencies in the packing and replenishing process before applying the 5S methodology to streamline the initial process and develop a systematic process. The application of LSS proved to be effective as the new packing process achieved almost a 36% reduction in packing time with two volunteers instead of three volunteers in the initial process. Additionally, the supervisor has more control in the new process compared to the initial process where the volunteers had to make most of the decisions.

## 7. Limitations and Recommendations

The results were limited based on a single pilot test site – The Food Pantry 2.0 at Toa Payoh, where only the VOC and the profile of the customers residing within that area were obtained. As the expansion of The Food Pantry 2.0 is still on-going after this research was concluded, further research can be considered in the following areas:

- Formulate a packing and replenishment schedule to integrate all the vending machines across different sites.

- Explore the integration of the packing and replenishing activities for the vending machines as part of the overall warehouse activities.
- Explore the implementation of barcode technology to streamline the information flow.

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## References

- Antony, J., Challenges in the deployment of LSS in the higher education sector: Viewpoints from leading academics and practitioners, *International Journal of Productivity and Performance Management*, vol. 64, no. 6, pp. 893-899, 2015.
- Cheng, C., Chang, P., Implementation of the Lean Six Sigma framework in non-profit organisations: A case study, *Total Quality Management*, vol. 23, no. 4, pp. 431-447, 2012.
- E.V., G., Antony, J., Sunder, V., Application of Lean Six Sigma in IT support services – a case study, *The TQM Journal*, vol. 31, no. 3, pp. 417-435, 2019.
- Foodbank, food pantry – The Food Bank Singapore, Available: <https://foodbank.sg/our-big-projects/food-pantry>, Dec 12, 2020.
- George, M., *Lean Six Sigma: Combining Six Sigma Quality with Lean Speed*, McGraw-Hill, 2002.
- Glover, W., Poopunsri, T., Hurley, R., Applying Lean to Non-Profit Organizations: A Food Bank Case Study, *Proceeding of the 2014 Industrial and Systems Engineering Research Conference*, Montréal, Canada, May 31 – June 3, 2014.
- Leon, J., Adapting Lean Six Sigma for a Non-Profit Organization, 2016.
- Mark, S., Lewis, P., Thornhill, A., *Research Methods for Business Students*, 7<sup>th</sup> Edition, Pearson, 2016.
- Martin, J., *Lean Six Sigma for Supply Chain Management: A 10-Step Solution Process*, 2<sup>nd</sup> Edition, McGraw-Hill Education, 2018.
- Nagpaul, T., Sidhu, D., Chen, J., The hunger report: An in-depth look at food insecurity in Singapore, 2020.
- Pieńkowski, M., Implementation of Lean Management in Non-Governmental Organisations. Wrocław Food Bank Case Study, *International Journal of Contemporary Management*, vol. 15, no. 1, pp. 107-130, 2016.
- Salah, S., Rahim, A., and Carretero, J., The integration of Six Sigma and lean management, *International Journal of Lean Six Sigma*, vol. 1, no. 3, pp. 249-274, 2010.
- Snee, R., Lean Six Sigma – getting better all the time, *International Journal of Lean Six Sigma*, vol. 1, no. 1, pp. 9-29, 2010.
- The Economist Group, Global Food Security Index (GFSI), Available: <https://foodsecurityindex.eiu.com/index>, Dec 12, 2020.

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