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The Toyota Production System (TPS) in a Non-Traditional Manufacturing Environment: The Role of Standardization in the Fast-Food industry

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THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Manufacturing Systems Engineering
at the University of Kentucky

By

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ABSTRACT OF THESIS

The Toyota Production System (TPS), also known as Lean Manufacturing (LM), was founded in the automotive industry and has contributed to Toyota's decades of success. This has brought much attention to TPS and how this system may be implemented in other industries. Focusing on the TPS foundational element of standardization, this study examines the impact of target cycle time (TCT) on process fluctuation in a fast-food environment. To observe the effects of TCT, team members within 3 production lines were timed. Times were measured before and after the addition of a TCT to the Standardized Work (STW) in place. It was found that fluctuation was reduced by an overall average of 9 seconds per process after the addition of TCT to STW, suggesting that the addition of a TCT to STW may reduce process fluctuation within the production line.

Additionally, the relationship between standardization and the flexibility of the standardized system within the restaurant was examined in dynamic market conditions, specifically during the COVID-19 pandemic. When the sales percentage change in 2019 was compared to 2020 and a local competitor, the restaurant showed an overall increase. This growth may suggest a relationship between standardization and system flexibility.

KEYWORDS: TPS, Standardization, Target Cycle Time, Fluctuation, Flexibility, Lean Manufacturing.

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04/29/2022

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DEDICATION

I dedicate the work done for this master's thesis to my family and friends both in South Africa and in Kentucky. A special mention to my parents for their sacrifice, providing me with all the tools needed to follow my dreams. Their support and guidance throughout my journey have been an absolute blessing and I am forever grateful. To my sisters, brothers-in-law, and niece and nephews, our interactions although from afar mean more than you will ever know, I thank you for those special moments that always turned into a source of motivation. Liana, I dedicate this to our future and the successes to come thank you for your undivided support and patience with me throughout this process.

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CHAPTER 1. INTRODUCTION

The Toyota Production System (TPS) also known by many as lean manufacturing (LM), is a production system based on the philosophy of the complete elimination of waste and the respect for people ("Toyota Motor Corporation Official Global Website,"). TPS tracks back to Sakichi Toyoda (1867-1930), the inventor of the automatic loom and the father of the Japanese industrial revolution (Saito, Kozo, & Cho, 2012) ("Toyota Motor Corporation Official Global Website,"). Sakichi's son Kiichiro Toyoda established the Toyota Motor Corporation in 1937 upon traveling to Europe and the United States witnessing first-hand the rise of the automobile industry. Post-World War II, eight years later Kiichiro needed to rebuild the company using limited resources and capital. This is where TPS began.

Waste intertwines and accumulates through what is known as the 7 wastes: overproduction, excess inventory, defects, overprocessing, motion, waiting, and transport (Mungu et al., 2011) (McBride, 2003). The automatic loom created by Sakichi eliminated waste by automating the capability of the machine to stop before defects occurred and removed the need for wasteful practices such as needing a worker to constantly watch the machine ("Toyota Motor Corporation Official Global Website,"). This invention proved to successfully improve productivity and work efficiency via the removal of waste. This led to the first pillar of the TPS House **Figure 1.** known as Jidoka. Jidoka is based on respect for people, a fundamental philosophy within TPS. The word can be translated in TPS terms as "automation with human element". This refers to built-in quality within the work environment whilst freeing up the worker to be able to do more meaningful and full work, which improves the efficiency of both the system and the worker (Saito et al., 2012).

Kiichiro needed the time between production and payment to be swift and therefore production only made what was needed, when needed, and in the correct amount needed, the idea of Just-In-Time (JIT) production was born (Saito et al., 2012). JIT and the start of TPS was therefore realized through the philosophy of waste elimination ("Toyota Motor Corporation Official Global Website,"). JIT is the second pillar of the TPS House **Figure 1.** Again, JIT is producing what is needed only when it is needed and only in the amount that is needed. The idea of JIT is to therefore reduce cost and lead time to the customer, as well as to expose any waste in the system, which could then be removed via problem-solving activities (Saito et al., 2012) (Ohno, 1988). Upon highlighting two main ideas developed in the early stages of TPS, there were several other pioneers and contributors to the development and realization of TPS. These pioneers all encompassed the principles and philosophies set out by the corporation, the elimination of waste, the respect for people, and customer-first thinking (Saito et al., 2012).

TPS has been studied for decades. The benefits and short fallings of this production system, and the struggles of successfully implementing the systems related to TPS have been publicized. These struggles are especially noted in variable demand environments and small and medium-sized enterprises (SMEs) (Pearce, Pons, & Neitzert, 2018). Originating within the automobile industry TPS in recent years has been proven successful outside of the automobile industry and further outside of the production environment (Lopes, Freitas, & Sousa, 2015). This leads to the introduction of this study; a study of the TPS implementation within Stryker Standard (SS) an SME, that operates within the fast-food industry.

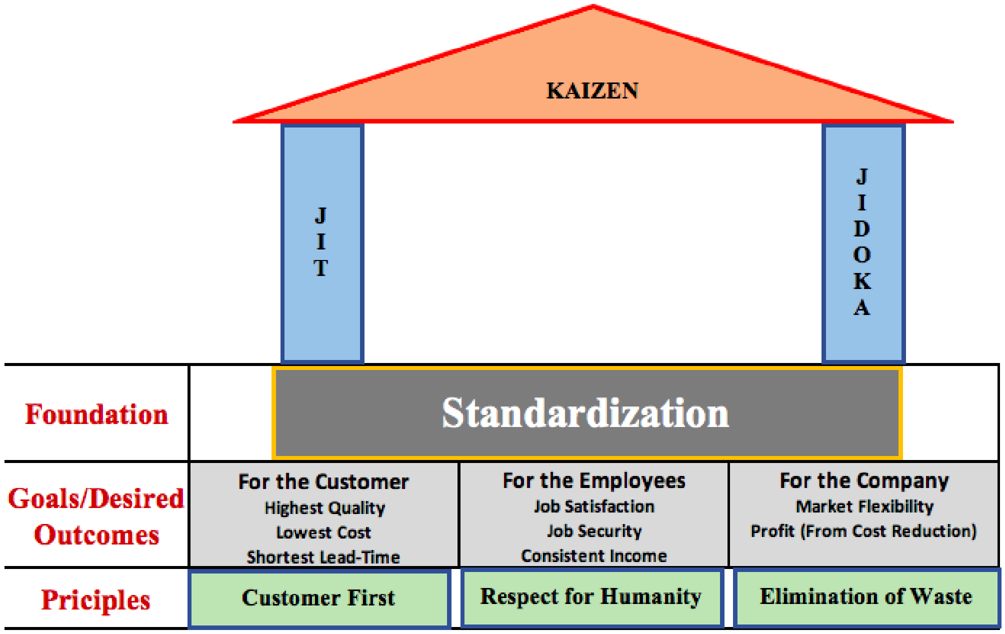

Figure 1: The TPS House (with permission from the University of Kentucky Lean Systems Program, 2022).

This study will be focused on the TPS idea of standardization, the foundation of TPS as seen in **Figure 1**. The idea of standardization encompasses all things related to TPS whether it be operational implementation or philosophical implementation. TPS studies have showcased both great upside potential in growth and development as well as some failures in implementation, therefore, raising questions about the effectiveness of TPS (Pearce et al., 2018) (Womack & Jones, 1997) (P Hines, Found, Griffiths, & Harrison, 2008). This study will showcase the exploration of the implementation of TPS tools within a standardized environment and further showcase the effects of equipping standardized work (STW) with a timestamp. These timestamps are derived from the idea of takt time found in traditional manufacturing environments, which in this case will be referred to as and used interchangeably with target cycle time (TCT) explained in the upcoming chapters.

CHAPTER 2. BACKGROUND

The research and data collection for this study was obtained through observations within Stryker Standard LLC (SS). SS oversees the operation of two Chick-fil-A (CFA) free-standing restaurants. The operator of SS, Jeff Stryker has been involved with the LM department at the University of Kentucky (UK) for more than a decade. The concepts taught by UK coincide with the teachings of TPS and therefore SS has interpreted most of these teachings as such. SS has shown great success in their lean journey through building a continuous improvement culture of one system, one voice that is foundationally built on standardization.

UK has labeled their LM teachings as "True Lean", a synonym for TPS. Many Toyota retirees are involved in the teachings offered by UK, which contributes to the first-hand nature of the teachings and references made to TPS (Maginnis, Cooper, & Parsley, 2021). There is a need to standardize the definition of TPS, UK True Lean defines it as: "The group by themselves, using systematic problem solving to improve the work they do, towards the achievement of the company's targets and goals, when and only when the company culture is the reason the improvement occurs." (Kreafle, 2018) (UK IR4TD, 2020).

As mentioned, SS has been in the pursuit of lean for many years and has come to a comfortable place concerning systems, efficiency, quality, and overall productivity. The question then arises, what is next? The following study dives into not only the importance but the necessity of standardization within any industry or organization in the pursuit of TPS. No matter where the organization may be in its lean journey, this study presents tools and practices to start as well as a way to improve an already implemented TPS system.

The study focuses on the “Hot-Line” (HL) within the layout of SS, the HL is essentially made up of three separate production lines producing a variety of products within the kitchen area. **Figure 2.** Shows the layout of the HL and the three production lines. It is important to note that for the study each production line will have its own TCT as the calculation is based on the amount of product moving through each line. Each production line has a product mix ranging from 3-to 18 variations of the product that move through them. With the execution of work elements being done in seconds and the amount of variety within each line, standardization plays a huge role in calming the environment down. This also gives the team members (TM) the ability to follow STW reducing any mental burden that may be associated with high variety production in a fast-paced environment.

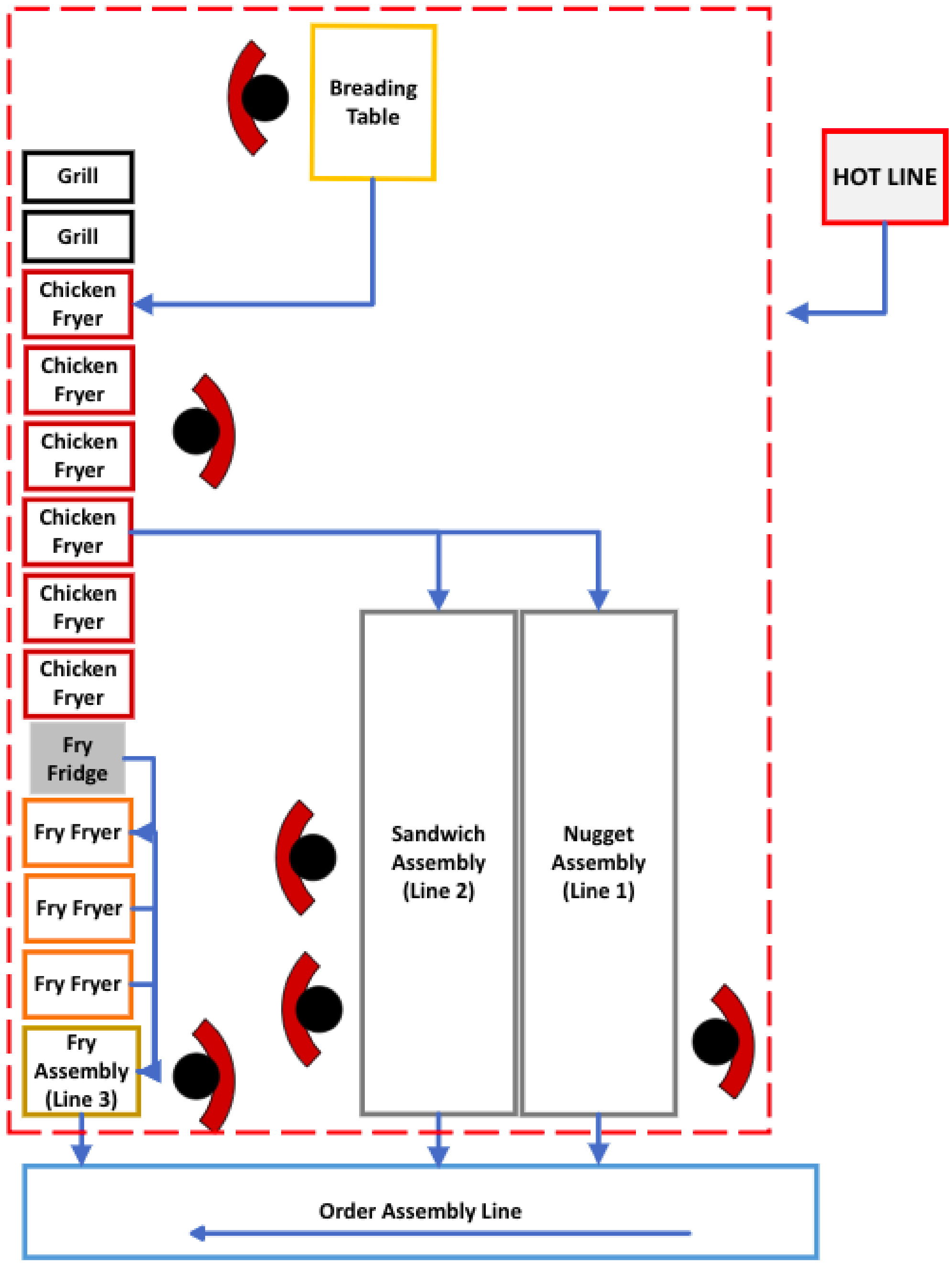

Figure 2: The HL layout shows material flow through each production line. ....(Line 1 – Nugget Assembly, Line 2 – Sandwich Assembly, Line 3 – Fry Assembly)

There is a common theme throughout the study, where all the roles and activities done within the restaurant and specifically on the HL have been derived from standardizing the process, the work elements at each station, and the roles and responsibilities of each TM.

CHAPTER 3. LITERATURE REVIEW

This section explores previous literature that pertains to the implementation of TPS tools within SMEs and the fast-food industry. Research about the success and/or failure of TPS, standardization, takt time, and the implementation thereof will be highlighted. There are few examples of published literature relating to the food industry (Dora, van Goubergen, Kumar, Molnar, & Gellynck, 2014) (Marodin & Saurin, 2013). There are even fewer published resources relating to the fast-food industry, which shows low adoption of LM within the entire food industry (Lopes et al., 2015). This may be due to the large batch processes already within the food and beverage industries as well as the high regulatory nature of the industry, the huge supply chain operations needed, and the fact that consumers are easily tempted by new products leading to more frequent changes in production (Freudenberg, 2005) (Heymans, 2015) (Dudbridge & Wiley, 2011). The studies that do relate to the food industry show promise in the internal adoption of LM for all involved and that LM may have an interesting potential within the food industry (Lopes et al., 2015) (Simons & Zokaei, 2005) (Floyd, 2017). TPS within the fast-food industry has little public exposure, Floyd writes about a successful TPS implementation within Panera. TPS was used to significantly reduce the wait time to order and simplify kitchen displays to increase order customization accuracy (Floyd, 2017).

Many writings on TPS highlight the realization of waste elimination, JIT, Jidoka, and continuous improvement (CI) however, standardization is rarely highlighted as the main tool needed to implement TPS. Bhamu and Singh Sangwan, highlight in their extensive literature review, the need to standardize the definition of TPS as well as synthesize TPS objectives to converge to a few critical objectives (Bhamu & Sangwan, 2014). Further, there is slow adoption of TPS in variable demand scenarios due to the lack of standard TPS implementation processes/frameworks and an apparent lack of flexibility (Peter Hines, Holwe, & Rich, 2004) (Boyle & Scherrer-Rathje, 2009) (Bhamu & Sangwan, 2014). With that being said, frameworks for supporting high variety low volume (HVLV) manufacturing environments adopting takt time for improvements have been introduced (Øystese, 2019). However, it has been noted that takt time is more applicable within a homogenous manufacturing mix and that a number of the concepts in the framework are not universally applicable to all HVLV manufacturing environments (Øystese, 2019). Takt time can be applied to a significant part of the manufacturing process and can increase efficiency with respect to lead time reliability and the productivity of the system (Ricondo Iriondo, Serrano Lasa, & De Castro Vila, 2016).

It has been suggested that the real problem with achieving TPS success is not management's failure to commit but rather their ignorance of what exactly they should be committing to. This led to the idea of a lack of knowledge being the problem in trying to successfully implement TPS (Pearce et al., 2018). The success factors need to be more explicit with the inclusion of the expected commitment of management (Pearce et al., 2018) Management knowledge is vital, particularly in the SME environment due to the potential resource constraints. The commitment and knowledge of management can affect the implementation of TPS both positively and negatively (Worley & Doolen, 2006). The positive effects pertain to the structure and size, which promote communication and flexibility (Pearce et al., 2018). Whereas the negative effects pertain to the complexity of processes due to the size and resource constraints of SMEs (Goodyer, Grigg, Shekar, & Murti, 2011). There seems to be some contradiction within the literature regarding the relationship between SMEs and TPS. Some sources argue that SMEs are flexible enough to sustain TPS implementation with the full support of management, while others state the complexity of SME processes and resource constraints make TPS implementation a tough task (Pearce et al., 2018) (Goodyer et al., 2011) (Lopes et al., 2015).

Internal TPS practices and engaging TM who do the work in problem-solving can provide a positive and significant improvement to operational performance using quality, delivery, flexibility, and cost as measurables (Maginnis et al., 2021) (UK IR4TD, 2020). TPS has also been associated with failure and is said to not be sustainable outside the conventional manufacturing setting such as the service industry (Chavez, Gimenez, Fynes, Wiengarten, & Yu, 2013) (Schröders & Cruz-Machado, 2015).

Another element used widely in TPS and plays an important role in visualizing the system is key performance indicators (KPIs). In this study, KPIs will be explored at the process level in the form of cycle time (CT). KPIs foster CI by providing management with data that allows them to assess performance, reallocate resources if needed and use data to guide strategies instead of opinions (Bentley, Blake, Shackell, & Trafford, 2020). It then becomes vital that KPIs are aligned with the true goal of the system, which eliminates any biased behavior (Manheim, 2018)(Bentley et al., 2020). Campbell's Law states; that what can be interpreted as too much focus on KPIs can lead to a lot of focus on how to corrupt the process the KPI is intended to measure instead of improving the performance of the process (Bentley et al., 2020) (Manheim, 2018).

From the above review, it can be easily seen that there is a definite variability in published works regarding TPS implementation success. There is a need for further research on TPS implementation in industries outside of manufacturing and production.

This study aims to contribute to the literature found above by answering the questions found in the next chapter.

CHAPTER 4. PURPOSE

4.1) Research Questions

The research questions for this study are:

1. How does the addition of a TCT to STW impact process fluctuation?
2. Does standardization have an impact on the flexibility of a system and its response to dynamic market conditions and unforeseen events such as COVID-19?

4.2) Hypothesis

1. The addition of a TCT to STW will impact the performance of the production line by reducing process fluctuation.
2. Standardization increases the flexibility of the system, minimizing the effects of changing market conditions.

4.3) Objectives

The objectives of this study are therefore to test:

a) The effectiveness of implementing STW that details a TCT in a standardized system within the fast-food industry.

b) The potential relationship between standardization and flexibility in a lean system during and throughout unforeseen dynamic environments.

4.4) Purpose

The purpose of this study is to aid in fulfilling a business need set out by SS to maximize sales capacity through reducing process fluctuation on the HL, to provide evidence of the relationship between standardization and flexibility, and to contribute to the literature from the previous chapter by providing work done in an industry that seems to need more attention. The effect of adding takt time to STW in a non-traditional, non-homogenous manufacturing setting can aid in showcasing that the concept of takt time may be universally applied. Standardization will be highlighted as the main idea needed for any type of TPS implementation as well as exploring the attainability of TPS within an SME setting through standardization, TM engagement, and management support. An LM definition has been proposed in the introduction as well.

To expand on the purpose of this study, the STW with the addition of a TCT can create more clarity on operational goals set out by the corporation and aid leadership as well as TM in the training process. This displays that TPS can be successfully implemented in a non-traditional manufacturing environment through the commitment to standardization. SS has standards outlined by their corporation that detail procedurally how to do the individual processes, however, these standards do not detail how to execute the entire operation. Individual process standards are set up as a how-to guide, with procedure guidelines and safety practices being highlighted. Although there is no specified amount of time each process should take relative to the amount of sales volume being done per operation, these standards are clearly defined and display the best practices to ensure the safety and quality of both TM and product.

In traditional manufacturing settings, takt time is associated with processes on the production line based on customer demand. However, in this case, customer demand is unknown on a day-to-day basis as the corporation has only the backing of projection-based sales predictions for a given day to guide it. Therefore, the nature and pace of this industry make it difficult to capture KPIs at a TM and process level. By adding the element of time to STW, the leadership team can measure how well their team is trained, what areas may be problematic due to high fluctuation, as well as how obtainable their goals and the goals set out by their corporation are.

TPS within Toyota has shown resilience throughout the years and this resilient nature will be explored within SS and what evidence there is to show how standardization aided in minimizing the effects of the unforeseen event that shook the globe, COVID-19. The purpose here would be to explore standardization and its role in creating stability and flexibility within systems that are foundationally built on standardization. Further, how this may enable them to deal with unforeseen dynamic environments and ever-changing market conditions.

CHAPTER 5. STUDY DESIGN

5.1) Methods & Methodology

The study included the collection of observed data samples in the HL for both the initial and experimental conditions, which were then analyzed. Standardization tools in place were modified to fit the needs of the study. These modifications included more detail to the document aiding in the CI nature of the standardized work element sheet (SWES) document itself.

Initial condition – the initial condition was captured via observation of the current state within SS, approximately 1120 data points were collected. TM were timed completing their activities on the HL with no incentives to capture as ‘real/normal’ working environment as possible. This was done to get the most accurate reading of the current processing time for each position under observation. Times were captured on a time measurement sheet (**Figure 3.**) and were then analyzed and used to produce work balance charts. These charts indicated the lowest normal cycle time (LNCT), fluctuation, average CT, and periodic work where appropriate as seen in **Figure 8.**

Experimental condition – the experimental condition was also captured via observation of TM completing their activities on the HL, approximately 90 data points were collected. However, the TM was made aware of the TCT in their specific position. TM were again encouraged to complete their work as ‘normal’ as possible for the integrity of the data collection. The experiment here was to see the effects of knowing the time expectation associated with the work in the various positions of the HL. This time will be attached to the STW of each position in the HL having the goal of minimizing fluctuation in the line and training TM to meet the TCT and that be the measure of future training capability.

The STW has been implemented in the system however up until this study the STW has not referenced a time in which the process should be completed. The reason for this was simply that the need was not there due to other prioritized problems being solved. SS has now come to a place where standardization is their foundation of systematic improvements and therefore has now seen the need to further improve their system via the elimination of waste, in this case focusing on high variability fluctuation in tasks on the HL. SS has a service time of 60 seconds which proves as a difficult task in high volume sales hours even with standardization in place. The goal of this study is to get another step closer to reaching that target set out by the corporation. Currently, none of the individual processes have a TCT associated with them besides the 60-second service time, which should be noted as an outcome/result-orientated goal with no detailed foundational implementation plan to meet that outcome. The methodology was carried out at each of the 6 roles that make up the HL (the modeled area) where data was collected and then analyzed. Once the results were known the methodology was repeated with changes as mentioned in the experimental condition and these results were then analyzed and compared to the first iteration in the initial condition.

5.2) Approach

Data samples were collected via observation of 6 roles on the HL. The work elements were timed initially at random with any TM at the workstation. These times were set up to start and stop at designated positions enforcing standard conditions for consistent data collection. **Figure 3**. Showcases the sheet used to capture the timed work elements in each role. Times were taken for 6 roles with several different team members working in each role. Each work element was timed and then added to calculate the total processing time of each position. The lowest normal cycle time (LNCT) relates to the lowest time observed of the entire process and not just the addition of the lowest time per element. The 'normal' refers to work that followed standards set out by the standardized work (STW), therefore cycles that included abnormalities and practices outside of standard were not included in the calculation. From these data points work balance charts were used to analyze the data and recommendations were made, which will be displayed in the upcoming sections.

12 Cycle Time Measurment Sheet

Process Name:	Process Time Measurement Sheet	Date:		Prepared by:
		Shift:	Takt Time:	

Seq #	Station Tasks/Work Elements	Product Type															
		Start/Stop Points	Timing Cycles												Adjusted Element Time (used of STW charts)		
			1	2	3	4	5	6	7	8	9	10	11	12			
1																	
2																	
3																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
Total Process Time Measurement			0	0	0	0	0	0	0	0	0	0	0	0			
Periodic and Fluctuation Comments															Sum of *Adjusted Element Times* = CT (lowest Normal *Total Process Time Measurment*)		

Figure 3: Time Measurement Sheet used for data collection

5.3) Takt Time

On the topic of standardization, other TPS tools and philosophies can be introduced. In this study, the introduction of takt time is explored. Takt time plays an important role in this study and will be described in this section. Takt time can be applied to a significant part of manufacturing processes and has an implied increase in efficiency relating to the reliability of lead time, productivity increases, management simplification, and continuous improvement culture (Ricondo Iriondo et al., 2016). Having the goal of increased flow via waste elimination, takt time can be regarded as the direct link between the customer and the production system (Fiallo, M & Howell, 2012). Another benefit of takt time which this study is based on exploring within the fast-food industry is the reduction of process fluctuation variability (Yassine, Bacha, Fayek, & Hamzeh, 2014). Traditionally, in conventional manufacturing environments, takt time is calculated as the division of the effective operating time by the number of products required by the customer (Hamed & Soliman, 2020). It is essentially the time set for the supply of a process derived from the customer demand (Yassine et al., 2014). **Figure 4** shows the equation used to calculate takt time in traditional manufacturing settings.

$$\textbf{Takt Time} = \frac{\textbf{Total Time Available}}{\textbf{Total Customer Demand}}$$

Figure 4: Takt Time calculation

It is important to note that in this study takt time is not used by definition and will be referred to and used interchangeably with target cycle time (TCT). The reason for this is due to the unique nature of the fast-food industry. The fast-food industry is an unconventional manufacturing industry in the sense that there is no preset demand or daily quota that can knowingly be met. Instead, demand varies on a daily basis. Essentially the order is paid for first and within a matter of seconds/minutes, the order is fulfilled. In most other manufacturing industries orders are placed with a potential deposit and only once the order is fulfilled with a much greater lead time it is then paid for in full. Therefore, it would not be possible to calculate takt time by definition as the customer demand is unknown, this leads to the explanation of TCT in this case.

The TCT was calculated as seen in **Figure 5.** This calculation was derived from the total sales of a high selling day with the assumption of the current demand being able to meet that number of sales on any given day. The reason for this was to derive a TCT that would reflect not only a daily sales goal that has been met before but also a day of high productivity. This in turn would lead to the TCT being lower and therefore TM would need to be competent in each role to perform at the required level to meet the sales target. This presents a new creative way to apply and implement the concept of takt time within an environment outside the scope of where takt time originated, the automobile manufacturing industry. The nature of this use displays the flexible nature of TPS implementation, with possibilities throughout the industry. Once again takt time is based upon standardization within the system and would not be possible without it, emphasizing the importance of having a foundation of standardization for any implementation relating to TPS.

*** Total Available Time (Lunch/Dinner items):**

$t_{Total} 10{:}30\ am\ - 10pm = 11.5\ hrs$
$t_{Total} = 11.5\ hrs \times 3600 = 41400\ s$

*** Total Sales within Total Available Time:**

$S_{Total} = \$39{,}982.06$

*** 3 Production Lines with a unique varrying product mix moving through each:**

$Line_1 Nuggets$ Customer Demand(Amount Sold) $CD_3 = 2379$

$Line_2 Sandwiches$ Customer Demand(Amount Sold) $CD_2 = 2426$

$Line_3 Fries$ Customer Demand(Amount Sold) $CD_1 = 2556$

*** Target Cycle Time (TCT)/Takt Time for Each Production Line:**

$$TCT\ Line_1 = \frac{t_{Total}}{CD_1} = \frac{41400\ s}{2556} = 16\ {}^{s}/_{product}$$

$$TCT\ Line_2 = \frac{41400\ s}{2426} = 17\ {}^{s}/_{product}$$

$$TCT\ Line_3 = \frac{41400\ s}{2379} = 17\ {}^{s}/_{product}$$

Figure 5: TCT calculations for each production line.

5.4) Standardized Work

This section will explore standardized work (STW), the tools used to implement STW, and the contribution STW has to the stability of a TPS system. STW refers to the most recent up-to-date documentation of the most efficient way to complete work elements that make up a single process/job (UK IR4TD, 2020). For workstations, STW is the vital component that allows TM to concentrate on the standards and quality measures set within their workstation that contribute to the performance of the entire system. SS has STW for every job and task in the restaurant documented on a standard work element sheet (SWES). SWES documents are used for training and are updated in the event of any new rollouts, equipment changes, and/or problem-solving activities that led to an improvement within the process. **Figure 6.** shows an example of an STW document template utilized by SS.

Revision Date:	Element #:	Name:	Item/ Name of SWES		Role: Start Point: 1st touch point	Stop Point: Last touch point
Created By: / Created Date: / Revised By:	Manager/ Lead: / Takt Time:			Company/ Store:	Cycle Time:	

1 2 3 4 5

Symbol Legend:	Safety ✚	Quality ★	Productivity ➡	Knack K	
Step	**Work Content (What?)**	**Pathway**	**Symbol**	**Key Point(s): (How?)**	**Reason: (Why?)**
1	What 1	Pathway Reference Here	✚	a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
2	What 2		★	a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
3	What 3		➡	a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
4	What 4		K	a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
5	What 5			a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
6	What 6			a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
7	What 7			a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?
8	What 8			a. Detail of how to do the what, tools or knacks we use to complete the what	a. Why do we do it that way? Safety? Presentation? Taste? Productivity? Quality? Cost?

Figure 6: SWES document template (with permission from, (Stryker, 2022)).

Created Date: 1/31/2020	Element #: 9	Name: [redacted]	Role: Fries Start Point:	Stop Point:
Created By: [redacted] Revised By: [redacted]	Manager/Lead:	Store: Turfland	Grab fry bag from [redacted]	finished product in chute
Takt Time:				

Legend: ➡ Productivity	✚ Safety	★ Quality	K Knack		
Step	**Work Content (What?)**	**Pathway**	**Symbol**	**Key Point(s): (How?)**	**Reason: (Why?)**
1	Prepare basket for use		★	a. Remove basket from hot oil and hang basket on front of fryer	a. Basket [redacted] in use, to keep the [redacted]
2	Dr [redacted] affle Potato Fries into basket to be cooked		➡	a. Remove 1 bag of fries [redacted]	a. One piece flow; Fries could become soggy if left out
			★	b. Fill basket(s) to appropriate fill line, drop basket into oil immediately.	b. Fries could become soggy if left over hot fryer
			★	c. If any fries fall into oil, they should be removed with skimmer at end of cooking cycle	c. Fries will burn and reduce oil life, if not removed
3	Lower basket of fries into oil and start timer		✚	a. Lift basket and lower into hot oil, slowly and carefully	a. Avoid splattering oil and prevent burns
			★	b. Gently shake basket(s) of fries and start timer for cooking cycle (WF)	b. Ensures fries separate and cook evenly
	Transfer cooked Waffle		★	a. When time is up, lift basket o [redacted] seconds	a. Drains excess oil and ensure fries are cooked properly

Figure 7: Example of an actual SWES document used (with permission from (Stryker, 2022)).

SWES documents are vital in fully describing what is expected of the TM in each position and having enough detail for TM to complete the job with little or no issues. The addition of TCT to the SWES is an additional detail used for the TM as a guideline and can be related to an individual/process KPI. Further, TCT can be used for leadership to easily audit the TM competency level within each role. STW creates an environment where abnormalities are easily noticed and can therefore be resolved quickly with minimal effect on the system's operation at the specific time an abnormality may occur. Abnormal work (abnormalities) refers to an event that occurs which veers the TM away from the standard as noted in the SWES. This type of work should not be dealt with by the TM but instead, a leader should be made aware of the abnormal occurrence, and they would then deal with the abnormality. In a fast-paced environment such as the fast-food industry, abnormalities are mainly dealt with by the implementation of temporary countermeasures (quick fixes). These countermeasures enable the process to continue for the time being until a problem-solving activity can be done where the root cause can be identified, and the abnormality can be resolved.

CHAPTER 6. RESULTS AND DISCUSSION

6.1) Results

This section details and presents the results relating to the first research question posed, these results are based on the analysis of the collected data via observations described above. The main plots that will be analyzed are work balance charts that relate to the workstations and roles on the HL. Work balance charts were chosen as they are highly effective at showing the relationship between takt time/TCT and cycle time (CT) and they are equally effective at highlighting bottleneck processes, high fluctuation processes, and work balance improvement opportunities. These charts were used to visualize the fluctuation within each process and how that fluctuation relates to the calculated TCT. By identifying areas with high fluctuation, improvement opportunities are identified. High fluctuation aids in presenting areas where standards are being neglected or missed, or they may not be obtainable currently in that area due to the occurrence of other abnormalities. Therefore, problem areas and/or waste can be easily identified by analyzing fluctuation. This can then lead to a problem-solving activity or root cause analysis where the realization of an abnormality and/or wasteful activity can be identified and resolved.

The ideal target state of a work balance chart showcases takt time to be equal to CT and fluctuation to be 10% of CT. As seen in this analysis, cycle time is below the TCT in some cases. This is an indication that wasteful activities/overproduction may be occurring or that there is an opportunity to increase the capacity of a given process. Bearing that in mind, it is important to note that many activities within the STW were not captured on the work balance charts. Some charts show CT being less than the TCT however the fluctuation in most cases goes beyond the TCT. This leads to further evidence that there are abnormalities and/or wasteful activities that are still within the system. When pursuing TPS, the ideal state is there to guide the continuous improvement efforts and can be generalized as, zero defects, single-piece plow, pull system, lead time, value-added processes, and human factors (Farmer, 2015). As there will always be abnormalities and/or waste in the system, the goal is to easily notice and deal with the abnormalities and waste efficiently and effectively in a way that minimizes the effects on the system as well as the customer.

The following figures (**Figures 9 – 13)** show the comparison between the initial condition (on the left) and the experimental condition (on the right). The points that will be highlighted include the reduction in fluctuation, if any, and any changes in the CT for each process on the HL. Again, the initial condition was captured without any incentive and during regular cycles of work that the TM would have already been doing for the given day. The experimental condition was captured in a controlled setting where the TM was made aware of the TCT before doing their work. It was made clear that the TCT should be met and TM should complete their work elements as "normal" as possible while meeting all of the standards set out by the SWES. **Figure 8.** Shows the key for the work balance charts and the work balance chart elements that will be analyzed throughout this section.

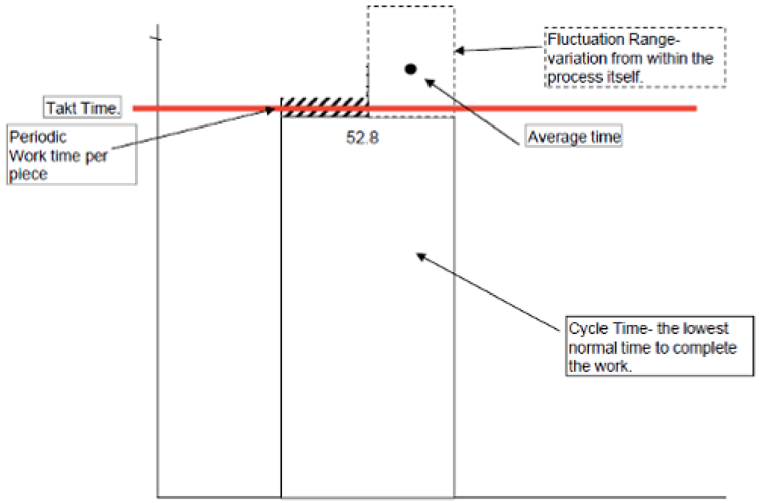

Figure 8: Work balance chart KEY (with permission from the University of Kentucky Lean Systems Program, 2022).

In this study, the red line refers to the TCT calculated for each production line and process. The base rectangle represents the LNCT per process as discussed previously, the broken line border represents the fluctuation, which will be the main focus. The average CT is represented by the solid black dot and periodic work is represented by small solid bordered rectangles (periodic work refers to the amount of time it takes to complete the periodic work divided by the frequency the work occurs or must be completed).

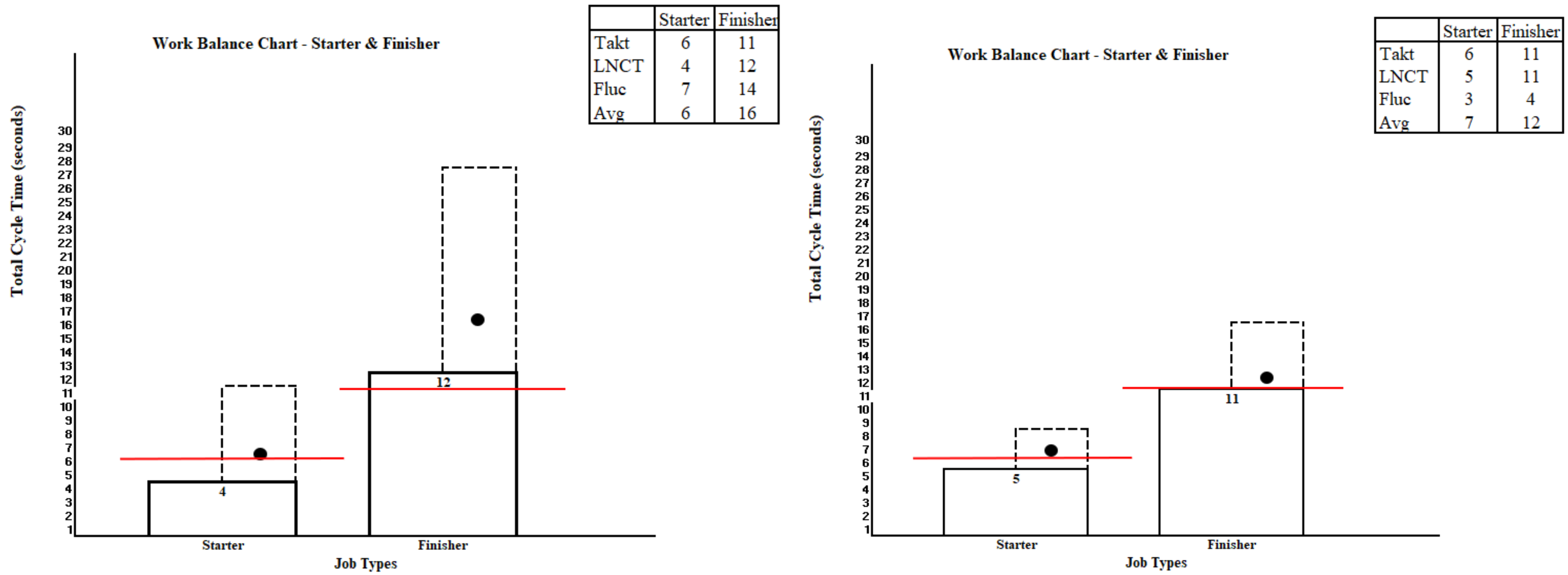

Figure 9: The comparison between the initial condition (left) and experimental condition (right) for the Starter and Finisher roles on the HL.

The Starter and Finisher role is displayed above, drawing attention to the difference in fluctuation between the initial condition and the experimental condition. The difference here results in a 4 and 10-second gain for each process. Again, the ideal state for work balance charts show the TCT equal to the CT and process fluctuation at 10% of CT. Notice the experimental condition for the finisher role is moving toward the ideal state.

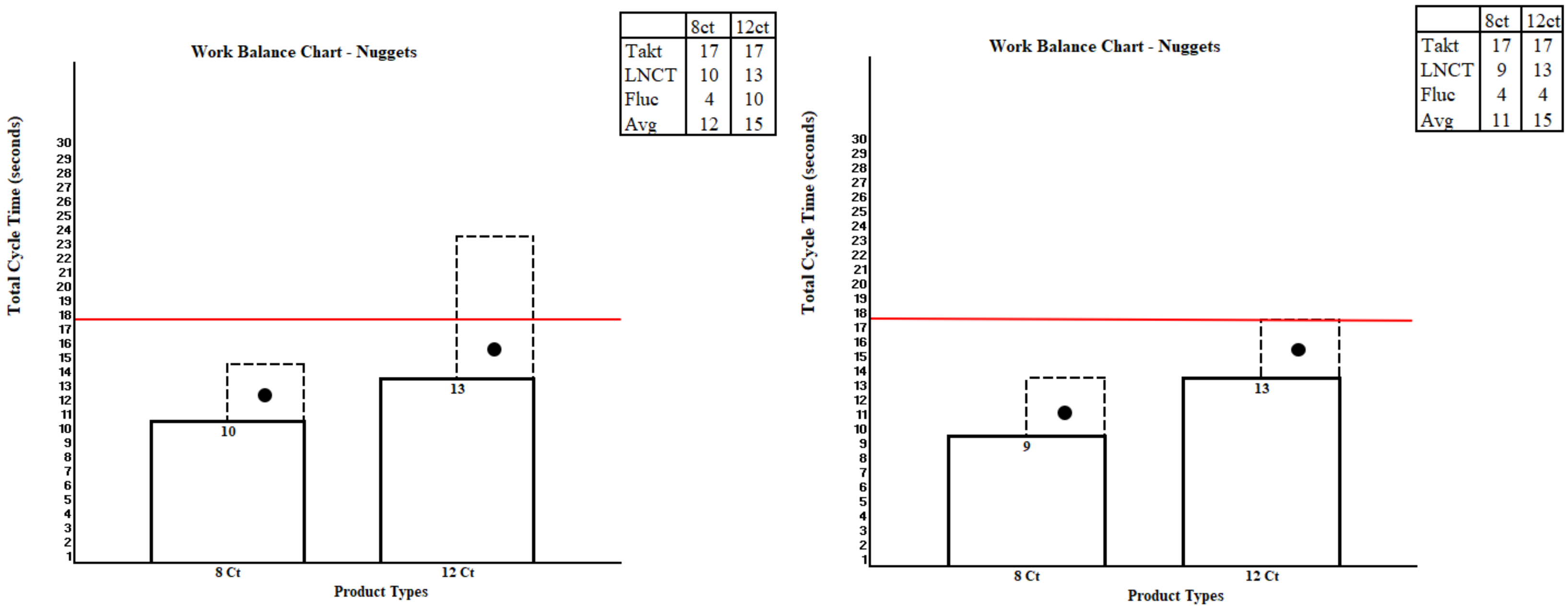

Figure 10: The comparison between the initial condition and experimental condition for the Nuggets role on the HL focusing on high volume products, the 8ct and 12ct nuggets.

The Nuggets role is displayed above, again drawing attention to the difference in fluctuation between the initial condition and the experimental condition. The differences seen here result in an overall 4-second gain for this role. Noticing here the CT is lower than the TCT in every case, pointing to the potential of possible waste or increased capacity in the nugget production line.

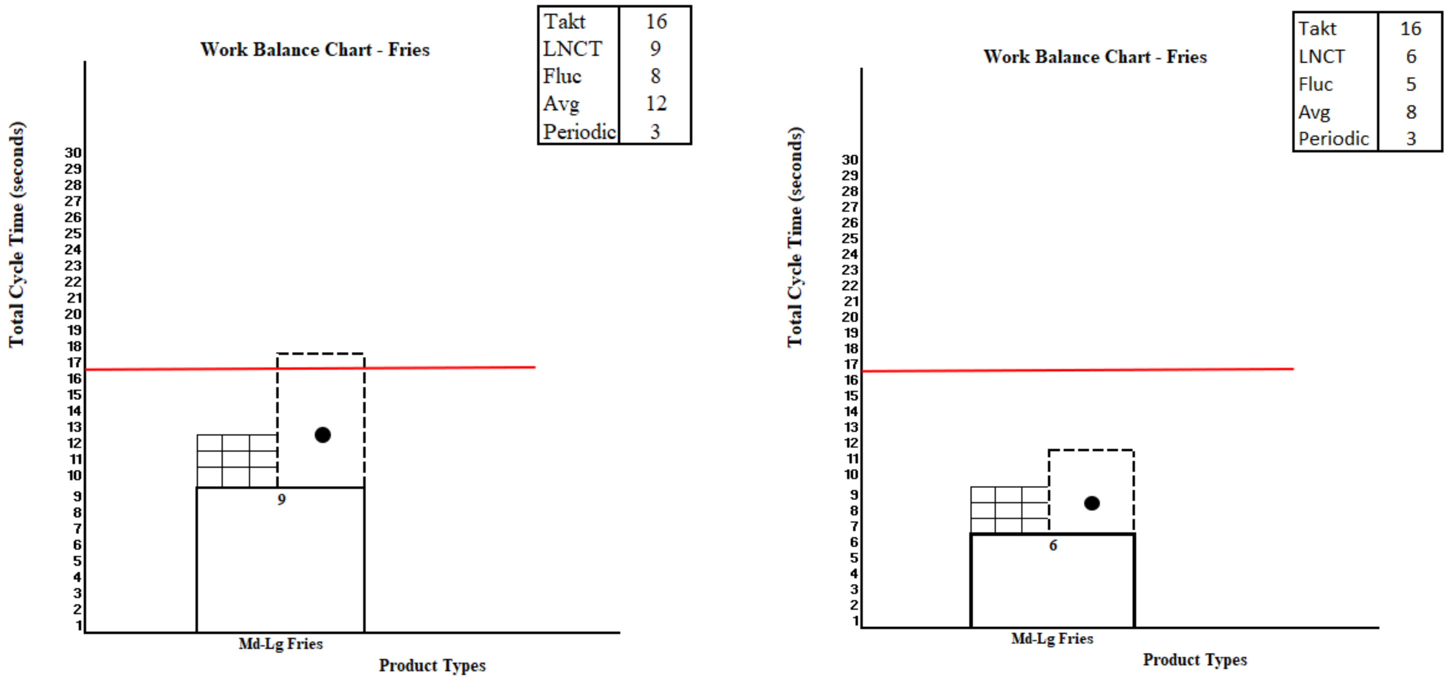

Figure 11: The comparison between the initial condition and experimental condition for the Fries role on the HL.

The Fry role is displayed above, again drawing attention to the difference in fluctuation between the initial condition and the experimental condition. The differences seen here result in an overall 3-second gain in reduced fluctuation for this role. Noticing here the CT reduction in the experimental condition, this line is unique as fries are the only product being produced in this line therefore the possibilities of waste surrounding this process are reduced however this does show us a capacity for increased volume.

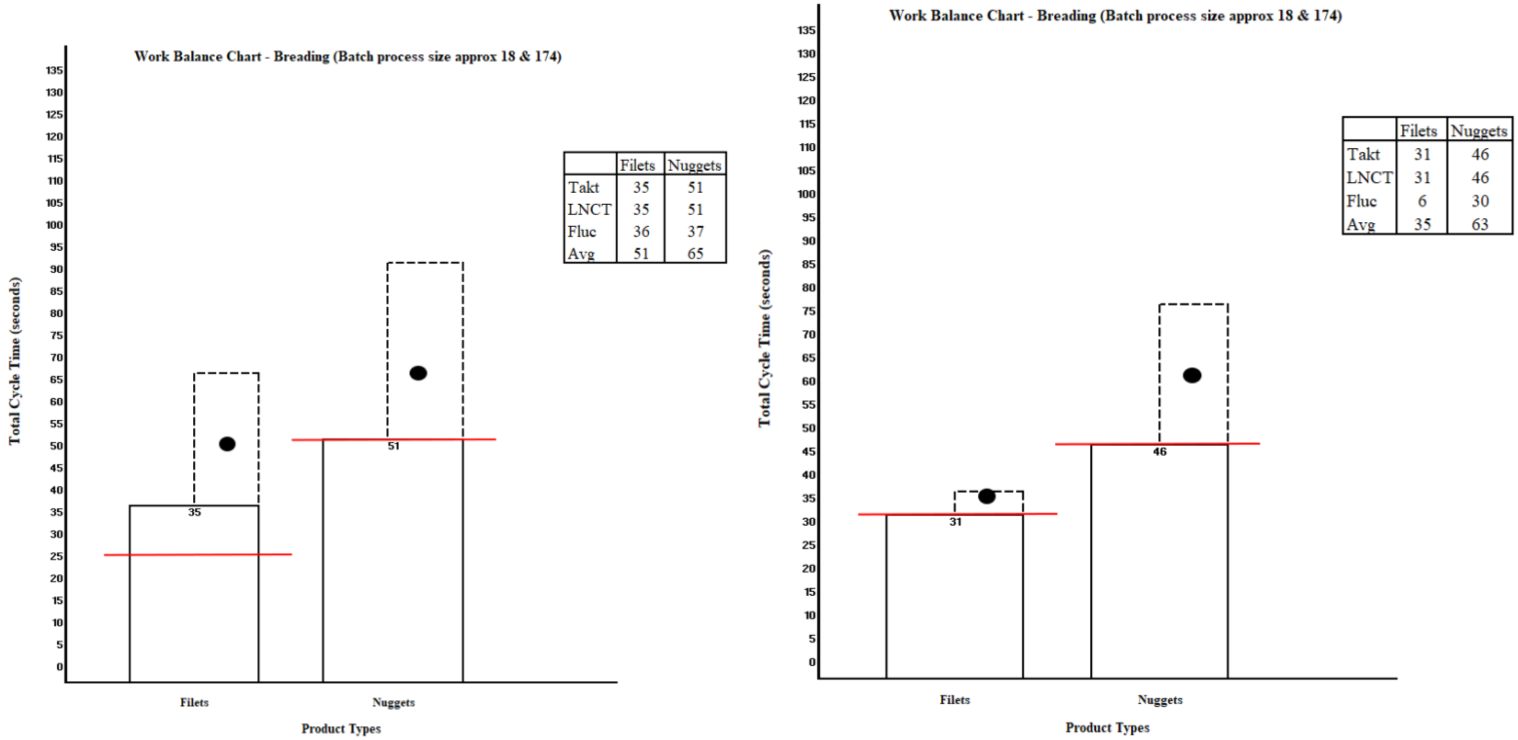

Figure 12: The comparison between the initial condition and experimental condition for the Breading role at the start of the HL again focusing on the high-volume products, filets, and nuggets.

For the next two roles, Breading and Machines it is important to note that firstly the scale is 5 times that of the previous charts and the reason for this pertains to the second important note, that these processes are batch processes. Each batch represented in the results averages around 18 seconds when analyzing filets and 174 seconds when analyzing nuggets.

Notice the larger amounts of fluctuation associated with these processes and the impact of TCT when comparing the two conditions. For Breading, we can see a 30 and 7-second reduction in fluctuation.

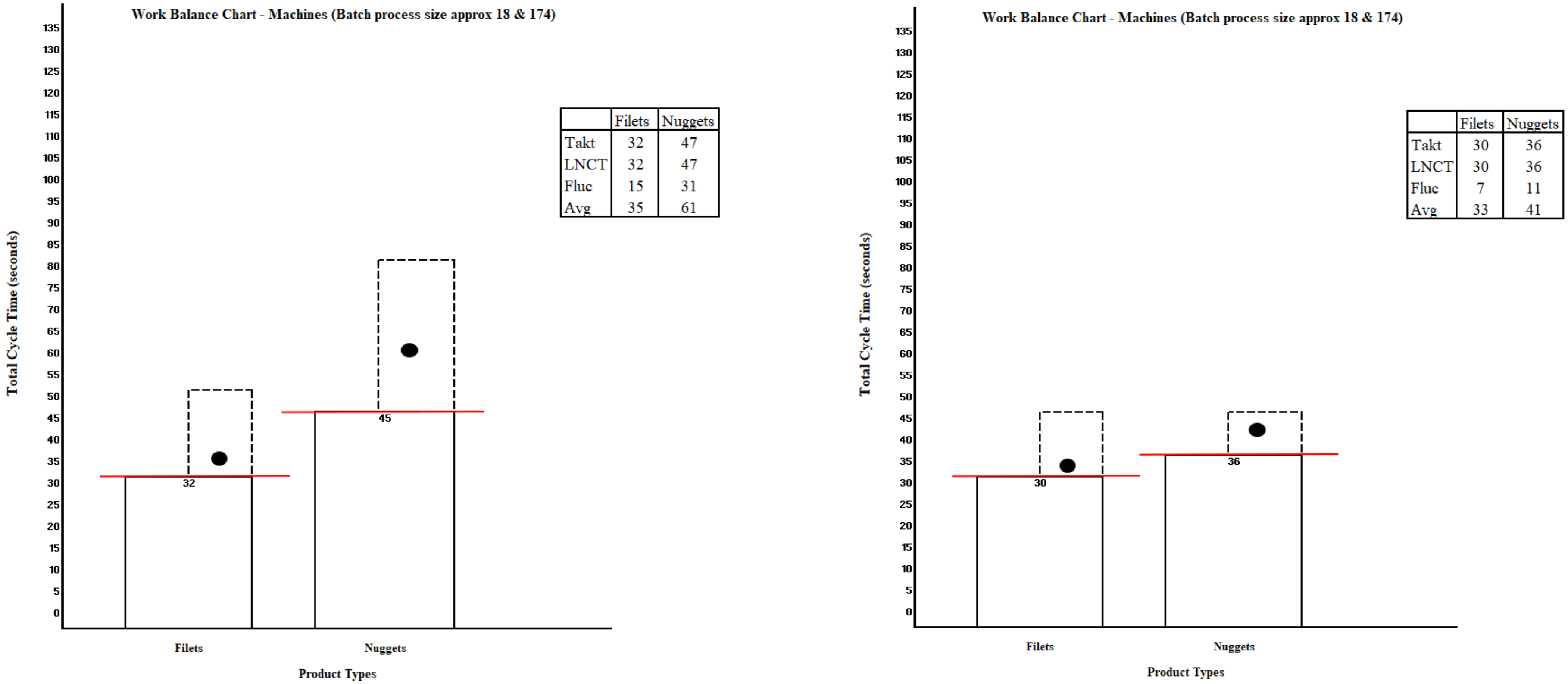

Figure 13: The comparison between the initial condition and experimental condition for the Machines role on the HL.

The Machines role is displayed above, again drawing attention to the difference in fluctuation between the initial condition and the experimental condition. The differences seen here result in an overall 28 seconds gain from reduced fluctuation for this role.

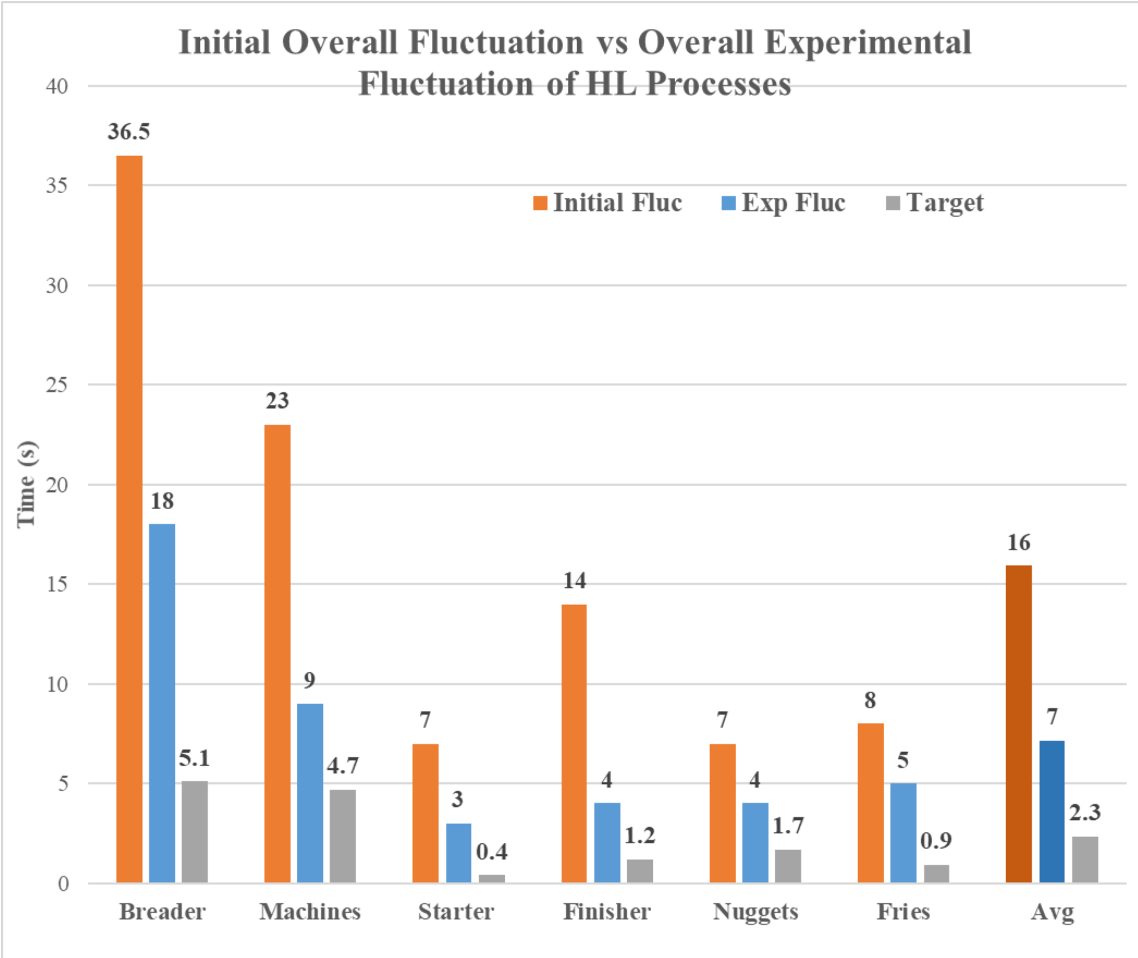

Figure 14: Overall Fluctuation comparison for each role.

Figure 14. Displays the differences in fluctuation per process of the initial, experimental, and target (10% CT) conditions. The average (Avg) bars on the right of the plot represent the average overall fluctuation per process. Notice the difference here of 9 seconds between the average initial fluctuation per process versus the experimental fluctuation per process.

6.2) Discussion

This section will explore what the results in the previous section mean, what they represent and what significance they may have concerning SS and the fast-food industry.

As seen above there were differences in fluctuation between the initial condition and the experimental condition. These results suggest that giving TM a TCT to meet in their specific role may reduce process fluctuation and variability seen in that specific role throughout the day. The reduction in fluctuation represents that the process was done at a more consistent rate whereby the range of values from the LNCT to the longest CT in the experimental condition was lower than the range of values from the LNCT to the longest CT in the initial condition.

The results presented relate to the first research question of how the addition of a TCT to STW may impact process fluctuation and production line performance. As seen from the results the impact of adding a TCT to STW led to an average overall reduction in process fluctuation of 9 seconds per process. When relating that back to the business's need of maximizing sales capacity, **Table 1** shows the potential gain this reduced fluctuation could have. The table details the LNCT, the initial average CT, and the experimental average CT. The average CT was used as fluctuation feeds into that value, the higher the average the more fluctuation within the process. The product mix of a current average day was used to get the average amount of product each process sees. Using the amount of product and the CT, a total processing time per day was calculated and compared. Any difference between the initial and experimental total processing time was used to calculate the potential gain of the process. This was done by dividing the total processing time difference by the experimental average CT to get an idea of how much potential product could be made and sold assuming the demand is there. The amount of product was then multiplied by the dollar value of each specific product leading to the total potential gain of each process. It is important to note that for the batch processes the potential gain is in terms of batches and therefore was related to product volume through multiplying the gain in batches by the batch size and then diving that by the amount of product sold if needed as in the case for nuggets. **Figure 15.** Shows the breakdown of each process's contribution to the overall total potential gain of $13,542.25 per day.

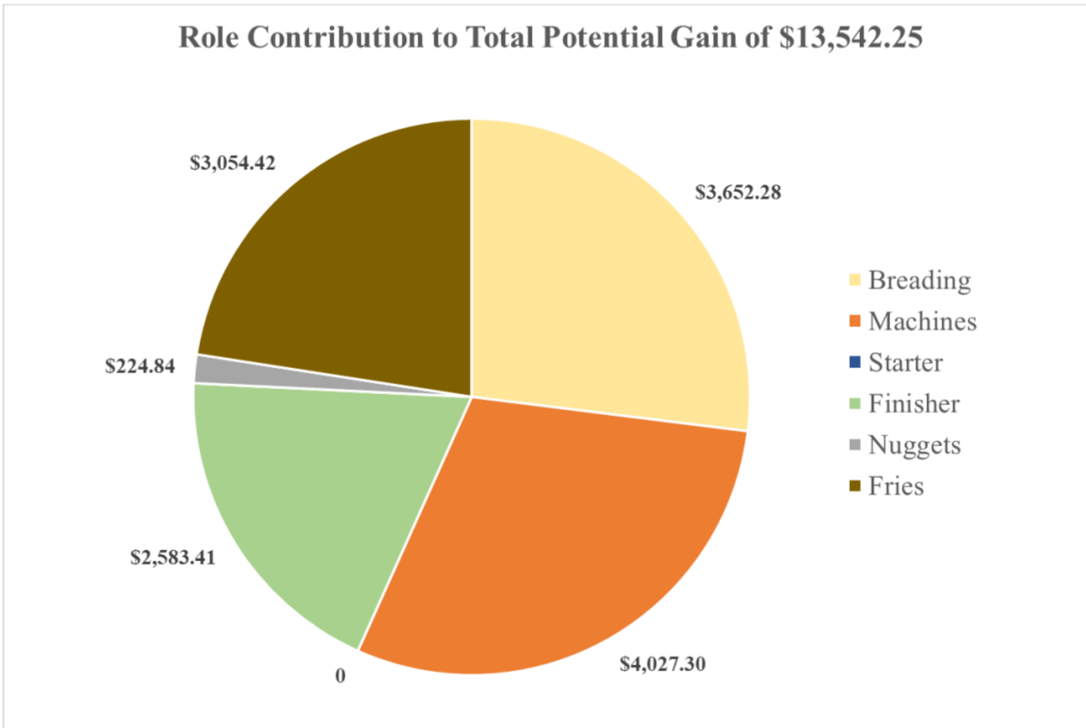

Figure 15: Total Potential Gain from Reduced Fluctuation.

Table 1: Potential financial gain from an overall reduction in fluctuation

Breading Role:		**Cycles/Batches (AVG 18 filets)**	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Breaded Filets	1642					**$ amount per unit (filet)**
LNCT	35	91	3185		**Theoretical gain in Production (# of bacthes)**	**$4.45**
Initial AVG CT	51		4679			**$ amount in gain**
Exp AVG CT	35		3185	1494	42.7	**$3,418.94**
		Batch (1bag/approx.174 nuggets)	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Breaded Nuggets	13224					**$ amount per unit (12ct)**
LNCT	51	76	3876		**Theoretical gain in Production (# of bags)**	**$6.67 (12)**
Initial AVG CT	65		4940			**$ amount in gain**
Exp AVG CT	63		4788	152	2.4	**$233.34**
Machines Role:		**Batch (18 filets)**	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Breaded Filets	1642					**$ amount per unit (filet)**
LNCT	32	91	2912		**PotentialProduction (# of bacthes)**	**$4.45**
Initial AVG CT	35		3185			**$ amount in gain**
Exp AVG CT	33		3003	182	6	**$441.76**
		Batch (1bag/174 nuggets)	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Breaded Nuggets	13224					**$ amount per unit (12ct)**
LNCT	47	76	3572		**Potential gain in Production (# of bacthes)**	**$6.67 (12ct)**
Initial AVG CT	61		4636			**$ amount in gain**
Exp AVG CT	41		3116	1520	37	**$3,585.53**
Starter Role:		**1-piece-flow**	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Breaded Filets	1642					
LNCT	4	1642	6568		**No Gain**	
Initial AVG CT	6		9852			
Exp AVG CT	7		11494	-1642		
Finisher Role:		**1-piece-flow**	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Breaded Filets	1642					**$ amount per unit (sandwich)**
LNCT	12	1642	19704		**Potential gain in Production (# of sandwiches)**	**$4.72**
Initial AVG CT	16		26272			**$ amount in gain**
Exp AVG CT	12		19704	6568	547	**$2,583.41**
Nuggets Role:		**1-piece-flow**	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of 8ct Nuggets	524					**$ amount per unit (8ct)**
LNCT	10	524	5240		**Potential gain in Production (# of 8ct)**	**$4.72**
Initial AVG CT	12		6288			**$ amount in gain**
Exp AVG CT	11		5764	524	48	**$224.84**
		1-piece-flow	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of 12ct Nuggets	416					
LNCT	13	416	5408		**No Gain**	
Initial AVG CT	15		6240			
Exp AVG CT	15		6240	0		
Fries Role:		**1-piece-flow**	**Total Process Time (s)**	**Second Savings (s) Initial - Exp Process time**		
# of Fries (md, lg)	2556					**$ amount per unit (md fry)**
LNCT	9	2556	23004		**Theoretical gain in Production (# of fries md, lg)**	**$2.39**
Initial AVG CT	12		30672			**$ amount in gain**
Exp AVG CT	8		20448	10224	1278	**$3,054.42**
					Theretical Total Savings	**$13,542.25**

6.3) Flexibility and Standardization

The next part of the discussion will explore and present evidence that may show a relationship between standardization and flexibility within SS. The evidence explores how standardization was able to minimize the effect of ever-changing market conditions and unforeseen events such as COVID-19.

In manufacturing flexibility is associated with balance and the ability to easily flex to issues and/or bottlenecks. One of the great developments that standardization has made possible in SS is the ability to have a cross-trained workforce. The benefits of having multiple people able to fulfill different roles throughout the working day are endless. This eliminates the need to rely on a single person's skill set to complete a job but rather creates flexibility where multiple people can acquire multiple skill sets and fulfill different jobs throughout the workplace. This played a significant role amid the COVID-19 pandemic when multiple people at a time were unable to work due to exposure and contraction of the virus. SS has made cross-training a priority since day one, employees are hired with the knowledge that they will be expected to know and will be trained in multiple roles within the workplace. Previously TM were trained and able to work in a role without any assistance once the trainer thought they were meeting standards. This brings up another unique part of this study where training and the tracking of training using time-stamped standard work and tracking (SWAT) documents were implemented.

A TM competency level was reliant on a judgment call from leadership where standards could easily be missed or neglected by the TM due to the possible overload of information during on-the-job training in the fast-paced environment. Having implemented the TCT as another standard to meet, not only creates an easier way to audit

TM for leadership but also holds the TM accountable in their training. Accountability in training comes into play when leadership has the resources to easily audit using a measurable metric such as time. If the TCT is not being met, leadership has a signal to observe the process more closely to see what the problem may be. This holds for the reverse where TM may be undercutting the TCT, and leadership once again has a signal to observe more closely. The difficulty within the implementation of standardization is not having clarity on where and how standards are not being followed at a process level. If continuous improvement is based upon standardization abnormalities in the process can be easily identified but the difficulty still lies in obtaining measurable data to drive decision making and problem-solving.

To get a measure of the current state of training in SS, a training matrix was developed. This matrix can be more clearly described as a flexibility index where the percent trained relates to the probability of a TM being capable of fulfilling any specific role within SS at any given time. The matrix was created to start with TM self-auditing, the reason for this was to get an idea of where TM ranked themselves in their ability as well as to provide a place for management to start the auditing process of TM capability. **Figures 16-17.** Show the actual training matrix used within SS and the SWAT document used as an auditing tool by leadership, which correlates to the example SWES presented earlier in the paper. Notice the work elements on the SWAT across the top row correlate with those along the first column in the SWES document. The black and blue fill on the left side of the figures represent the TM.

	Roles	MA	HL	PL	Stocker	HK	Breader	Machines	Starter	Finisher	Nuggets	Fries	Prep	Produce Bustin	Cash	Drinks (DT)	Drinks 2	Mobile Drinks	Expeditor	Ex. Lane	Dinning room	Hospitality	Anchor (Host)	IPOS	Biscuits	Bkfast Finisher	Bkfast Starter	Minis	Hashbrowns	Griddle	Average	% Trained
5	[redacted]	6	6	6	6	6	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	1	2	3	6	6	5.45	91%
6		6	6	1	6	6	0	0	2	2	3	3	4	5	6	6	6	6	6	6	6	6	6	6	3	0	0	2	6	6	4.17	70%
7																															0	0%
8		6	5	6	6	6	5	5	6	6	6	6	6	5	6	5	5	5	6	6	6	6	6	6	0	4	4	3	6	5	5.28	88%
10		6	6	6	6	6	5	0	6	6	6	6	6	6	6	6	6	6	6	0	6	6	6	6	0	0	0	0	0	0	4.31	72%
11		6	6	6	6	6	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	5.93	99%
12																															0	0%
13		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	3	5	5	6	6	5.62	94%
14		5	6	3	6	6	2	6	6	6	6	6	6	2	6	6	6	6	6	6	6	6	6	6	6	5	5	6	6	6	5.52	92%
15		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	6	6	6	6	6	0	0	0	0	0	4.76	79%
17		4	5	6	6	6	5	6	6	6	6	6	6	3	6	6	5	6	6	5	6	6	6	6	0	0	0	2	0	0	4.52	75%
18		3	5	3	6	6	3	6	4	3	3	4	3	1	6	6	6	6	5	6	6	6	5		1	0	1	2	5	6	4.18	67%
19		6	6	4	6	6	6	6	6	6	6	6	4	3	6	5	5	5	6	6	6	6	6	6	6	6	6	5	6	6	5.62	94%
20		4	6	3	6	5	4	6	6	5	4	4	3	0	6	4	5	3	6	5	6	6	6	6	3	3	2	1	6	6	4.48	75%
21		0	6	6	6	6	6	5	6	6	6	6	6		6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	0	4.46	72%
22		0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	2	2	2	6	6	5.17	86%
23		0	6	5	5	6	2	5	6	6	6	5	6	6	6	6	6	6	6	6	6	6	6	6	0	0	0	1	2	0	4.38	73%
24		0	0	6	4	3	4	6	6	6	6	6	6	6	0	3	3	3	3	0	2	0	0	0	5	6		5	6	6	3.61	58%
25		0	6	3	6	6	1	5	6	6	5	6	6	6	6	6	6	6	6	6	6	6	6	6	0	6	6	4	6	6	5.17	86%
26																															0	0%
27		0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	0	4.55	76%
28		0	5	6	6	6	6	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	0	4.45	74%
29		0	4	3	5	2	0	2	4	4	5	4	3	2	6	6	6	6	6	4	4	3	6	6	3	3	4	4	6	6	4.03	67%
30		0	6	4	4	6	6	6	5	5	5	6	6	1	6	6	6	6	6	6	6	6	6	6	6	5	5	5	6	6	5.28	88%
32																															0	0%
33			0	0	0	4	0	0	0	0	0	0	0	0	1	2	4	4	4	4	3	0	4	0	0	0	0	0	0	0	1.07	18%
34		0	0	0	1	3	0	0	0	0	0	0	0	0	6	5	5	6	5	5	4	0	5	6	0	0	0	0	0	0	1.76	30%
35		0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	4	4	5	0	0	3	4	0	0	0	0	0	0	0.93	16%
36																															0	0%
37																															0	0%
38																															0	0%
39																															0	0%
40																															0	0%
41																															0	0%
42		1	2	3	2	2	5	5	5	5	5	5	2	3	1	2	2	3	2	2	2	3	2	2	3	5	5	4	5	5	3.21	55%
44		0	5	0	5	5	2	6	5	5	5	5	6	5	6	5	5	5	6	6	6	6	6	6	5	5	5	5	6	6	4.93	85%
45		0	0	0	3	5	0	4	0	0	3	2	0	0	5	3	3	3	4	5	4	5	5	5	0	0	0	0	2	4	2.24	39%
46		0	0	0	0	0	3	3	0	0	5	5	4	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	5	1.21	21%
47		4		5				4	5	5	5	4	5	4											3	5	5	5	5	5	4.60	41%
48																															0	0%
49		0	5	5			5	5			4	5		5		5	5		5			3			5	4		5	5	5	4.47	45%
50		0	3	4	5	5	4	4	5	5	4	4	2	3	6	3	4	4	5	5	4	4	4	5	4	3	3	2	4	5	3.90	67%
51		0	0	0	2	2	0	3	0	0	2	2	0	0	3	2	3	3	3	3	3	3	3	4	0	0	0	1	1	3	1.59	27%
52		0	0	2	4	4	0	2	4	3	4	5	6	6	0	4	4	4	4	0	0	0	0	0	0	0	3	4	6	6	2.59	45%
53		0	0	0	0	0	0	0	3	1	5	0	4	0	5	5	5	5	5	0	3	0	5	5	0	0	0	0	0	5	1.93	33%
53		0	6	4	4	2	0	3	6	6	5	5	6	0	5	6	6	6	6	6	5	4	6	6	0	6	6	5	6	6	4.55	79%
54		0	3	2	4	4	3	4	4	4	3	4	3	0	4	3	3	3	4	4	4	4	4	4	0	3	3	2	4	4	3.14	54%
54																															0	0%
54		0	0	0	2	0	0	0	0	0	0	1	1	0	4	4	4	4	4	4	4	4	4	4	0	0	0	0	0	4	1.66	29%
55		0	0	0	1	0	0	0	1	0	2	0	4	0	4	4	4	4	4	4	0	0	4	4	0	0	0	0	0	0	1.38	24%
56		0	0	1	5	4	5	5	5	5	4	5	4	4	2	4	5	4	4	0	0	0	0	1	4	5	5	4	5	5	3.28	57%
57		0	6	4	6	3	4	2	6	6	6	3	5	5	6	6	6	6	6	3	5	5	6	6	3	6	6	6	6	6	4.97	86%
58		0	0	0	2	2	5	5	5	5	3	5	1	5	0	1	0	0	1	0	0	0	0	0	0	5	5	1	5	5	2.10	36%
59		0	0	0	4	4	0	3	4	2	6	4	6	6	0	4	4	4	4	4	4	4	0	0	6	4	4	4	4	6	3.28	57%

Figure 16: Flexibility Index tracking the probability of any given TM capable of fulfilling a specific role at any given time within SS (with permission from (Stryker, 2022)).

SWAT: Fries

Date 12/2/2021

Target Cycle Time

Boxing	16s
Cooking	22s

KEY:

O	Standard Met
X	Standard Not Met

Turfland

X	Cyclic Work as per SWES	Prepare basket for use by lifting basket out of oil	Drop frozen Waffle Potato Fries into basket to be cooked	Lower basket of fries into oil with a GENTLE shake and start timer	Transfer cooked Waffle Potato Fries to compartment 1	Salt cooked Waffle Potato Fries	Keep batches of fries seperated	Monitor KPS screen to package fries to order	Monitor hold time on fries	Met Target Cycle Time	Competency Score (0-6)	a) Standards Met b)Standards clarified c)Standards not known	Trainer Initial	Date
Managers:														
		O	O	O	O	O	O	O	O		6	b	KM	11/30/2021
		O	O	O	O	O	O	O	O		6	a	KM	12/8/2021
		O	O	O	O	O	O	O	O		6	b	KM	12/1/2021
		O	O	O	O	O	O	O	O		6	a	KM	12/8/2021
		O	O	O	O	O	O	O	O		6	b	KM	12/9/2021

Figure 17: Standard Work And Tracking (SWAT) document used to audit TM capability to meet the standards set out by the SWES within each role (with permission from (Stryker, 2022)).

The overall percentage of the flexibility index currently sits at 56%. This means that at any given time within SS if a TM is asked if they are capable of fulfilling a certain role, 56% of the time that answer will be yes. The importance of cross-training can be presented when looking at the effects of COVID-19. From April 9, 2020, to December 31, 2020, SS recorded 201 COVID-19 related cases among their employees. These cases amounted to the loss of approximately 6817.25-man-hours due to TM inability to work. In terms of the 16-hour working day, this is the equivalent of 426 days lost. During that time in the pandemic, from April to December of 2020, SS sales amounted to $6,012,745.12. The previous year, pre-COVID-19, in 2019 for the same date range, April to December. SS had sales amounting to $5,767,362.88, which indicates a 4.1% increase from 2019 to 2020 amid COVID-19. **Figure 18.** Shows the percentage increase of the entire year compared to the previous year. A local competitor's percentage increase is also displayed to show any difference between the performance of a TPS standardized system versus an unknown system within extremely similar market conditions.

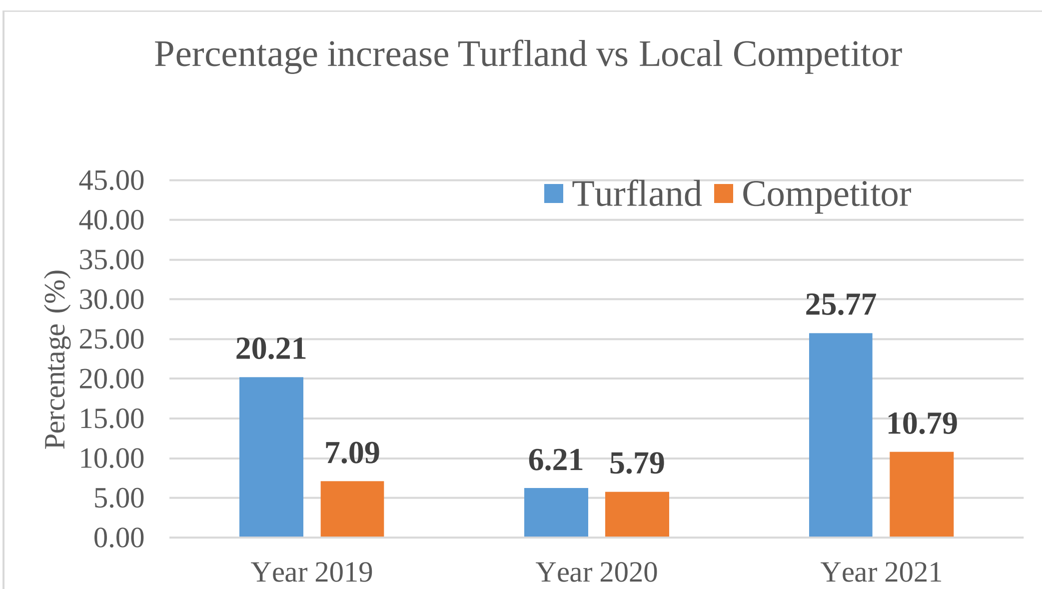

Figure 18: Overall yearly sales % increase compared to the previous year.

6.4) Stability and Standardization

This section will highlight the support structure needed for standardization to create a stable environment and provide further evidence of flexibility through standardization. **Figure 19** shows the 11 sales channels currently operated by SS incorporated into a mock-up of the production line layout. As seen in the figure, the HL plays a major role in supporting these channels both in volume and size. SS has been able to use their standardized system to easily add sales channels with little change and/or impact on overall operations and other sales channels. Another reason for presenting this figure is that due to COVID-19 lockdown restrictions, these 11 sales channels were reduced to 7 channels. Although SS experienced a significant decrease in sales channels, as seen in the previous section SS still had a 4.1% sales increase from April to December 2019 (pre-COVID-19) when compared with April to December of 2020 (during COVID-19).

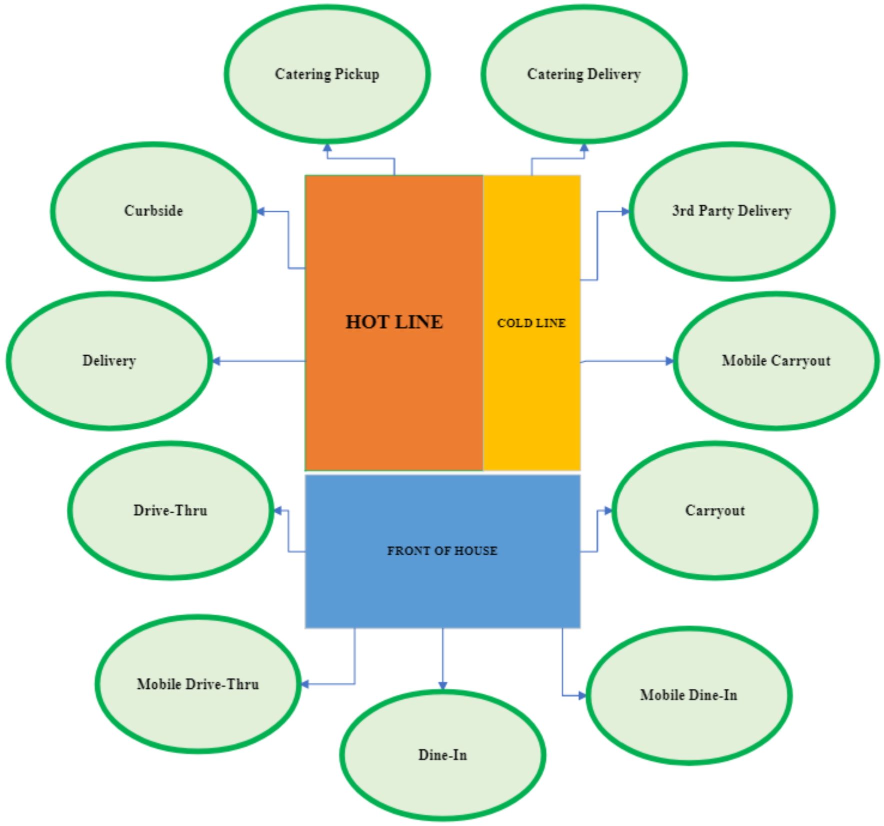

Figure 19: SS sales channels supported by HL.

TPS utilizes systematic problem-solving which is based on the plan, do, check, act (PDCA) learning cycle. This methodology helps in maintaining the stability of existing work processes in accordance with the standards already in place (Maginnis, Cooper, & Parsley, 2021). By using this method, a root-cause analysis is done to find a true countermeasure that aims to eliminate the problem from ever occurring again. This type of problem-solving is most effective when there are measures in place for abnormality management, which aids in quickly identifying problems as they are occurring in the system (Maginnis et al., 2021). Identifying these abnormalities as they occur within the system is the start to continuous improvement as the standardization in place is either successful or being exposed leading to the need for improvements. It is important to note here that abnormalities are not easily identified without standardization in place.

Standardization once again plays an important role in the development of another TPS tool and way of thinking which reiterates that the foundation to successfully implementing TPS is standardization. Standardization needs to be a constant focal point as it has the ability to expose waste in the system as well as the potential to minimize TM burden and improve overall efficiency. The key to a stable system is therefore being able to easily identify the difference between normal and abnormal work. UK True Lean teachings showcase a support structure, as seen in the appendix, that details how abnormality management feeds into the standard work process which feeds into problem-solving and TM engagement, all with the end goal of customer satisfaction (UK IR4TD, 2020). The support structure and role layout for SS can also be found in the appendix, where three lead roles are present whose primary duties are to support TM if abnormalities occur throughout the restaurant.

CHAPTER 7. CONCLUSION

The purpose of this study was to fulfill a business need of maximizing sales capacity through reducing process fluctuation, to provide evidence of a possible relationship between standardization and flexibility, and to contribute to the literature around TPS implementation outside of the traditional and/or automobile industry. This study shows the importance of standardization and how standardization can be considered the foundation of TPS implementation. The study provides creative ways that TPS tools can be implemented such as TCT and work balance charts, which may be leveraged as a highly effective tool to access process variability, all within a non-traditional manufacturing environment. Evidence has been presented that standardization promotes flexibility in the system with a support structure in place for abnormality management. Further, in answering the research questions posed in this study:

1. There seems to be an impact on process fluctuation by adding a TCT to STW. This impact may lead to potential financial gains by reducing process fluctuation and improving the overall production line performance.
2. SS has evidence that was presented in this study that suggests standardization does impact flexibility and can minimize the effects of ever-changing market conditions and unforeseen events such as COVID-19.

This study further contributes to the literature in presenting work done in an industry that does not contain many published works. The results and evidence presented may be significant to the industry in displaying that there is another way to approach the fast-food operation. This approach is not only financially fruitful but also rewarding in creating an environment where TM can be developed.

Lastly, the study provides insight and tools that can be utilized outside of lean but are primarily presented to provide an initialization blueprint of lean within other industries and organizations that may not know where to start. The tools presented are for both early lean adoption as well as tools to improve processes within an already lean system, as seen in this study.

CHAPTER 8. STRENGTHS & LIMITATIONS

8.1) Strengths

The strengths of this study include:

- The initial condition was a true reflection of the actual work being done in real-time within SS.
- TM were actual employees of SS reflecting a realistic TPS implementation scenario.
- Actual data on restaurant sales, product mixes, and the number of employees contributed to the analysis.
- Generalizable to the entire Fast-Food industry by providing resources detailing:
    - Evidence of the possible relationship between standardization and flexibility.
    - Tools that can be used to implement standardization such as the SWES, SWAT, and TCT.
    - Tools that can help improve standardization such as a TCT to STW, and Work Balance charts.
    - Positive results through standardization in TM development and financial performance

8.2) Limitations

The limitations of the study include:

- The number of observations in the initial condition heavily outweighed the number of observations in the experimental condition due to time limitations
- TM awareness of TCT was not fully reached due to time limitations, which impacted the full implementation of the experimental condition within the HL.
- Observations were timed using a stopwatch therefore there was a potential for error based on personal reaction time and visual interpretation of start/stop points.

CHAPTER 9. RECOMMENDATIONS & FUTURE WORK

9.1) Recommendations

- The recommendations for SS would be to continue the implementation of TCT on the STW within the HL and further expand the implementation throughout the entire restaurant.
- Recommendations that can be generalized include the commitment to implement standardization within processes. Use model areas such as the HL in this study to start the implementation on a small scale to get an idea of what a support structure may look like as well as to get TM buy-in. Capture the current condition as the current standard and improve from there with data-driven decisions.

9.2) Future Work

Further research needs to be done on the implementation of a TCT or takt time if applicable, outside of the traditional manufacturing sector. More work and research need to be done around the food and particularly the fast-food industry from a process standpoint. From a big picture standpoint, this industry has enormous reach and plays a huge role in food supply, therefore work needs to be done to aid in the improvement of the industry and further promote efficiency and sustainability where possible.

APPENDIX

Additional Background

SS operates the most visited store within the entire CFA corporation, these visits are from other CFA operators and people from the corporate office visiting the site at 2025 Harrodsburg Rd Lexington KY to witness the operation first-hand. SS has also become a significant player in helping CFA roll out new ventures by being a test subject. This has been made possible by the culture of one system, one voice, which allows SS to easily add to their already standardized system whereas most others find the complexity to add additional steps to processes too overwhelming. This speaks volumes about the systems in place at SS, which have been made possible through standardization and TPS implementation. SS has also received many awards within the corporation for their innovative nature and consistent growth performance. The most fascinating part about witnessing these awards being won (the few I have been a part of) is that they have never been a priority or on SS's radar, there is no knowledge of the awards or incentives to try and win these awards. The awards are won by focusing on the continuous improvement of the standardized systems in place.

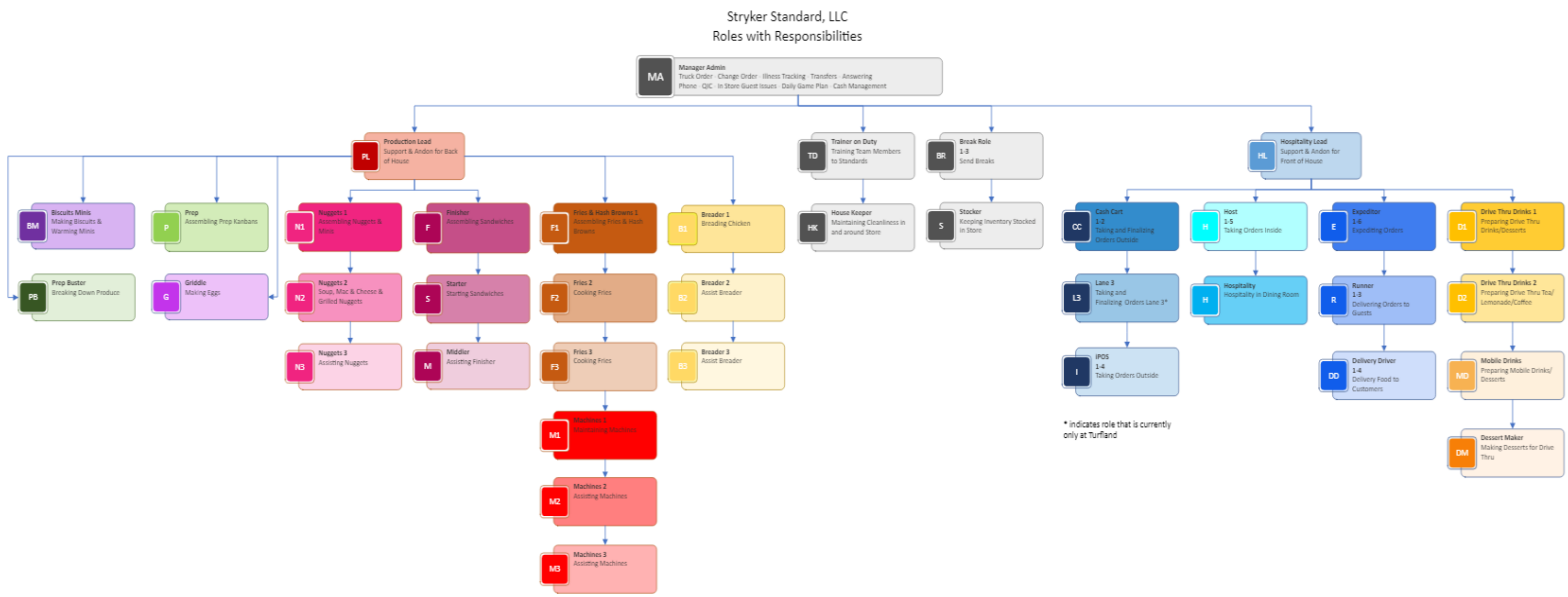

Figure 20: SS STW Support Structure and Role Clarity Layout (HL represented in the dotted box) (with permission from (Stryker, 2022)).

Table 2: Fluctuation Breakdown per process

Process	LNCT	Overall Initial Fluc	Overall AVG Initial Fluc	LNCT	Overall EXP Fluc	Overall AVG EXP	Difference in AVG Fluc Initial vs EXP (avg per cycle)	Diff in Overall Fluc Initial vs EXP (avg per role)
Breading Filets	35	36	16	31	6	4	12	30
Breading Nuggets	51	37	14	46	30	17	-3	7
Machines Filets	32	15	3	30	7	3	0	8
Machines Nuggets	47	31	14	36	11	5	9	20
Starter	4	7	2	5	3	2	0	4
Finisher	12	14	4	11	4	1	3	10
Nuggets 8ct	10	4	2	9	4	2	0	0
Nuggets 12ct	13	10	2	13	4	2	0	6
Fries	9	8	3	6	5	2	1	3
Total AVG 6 Process	20	16	6	17	7	4	2	9

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