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International Journal of Lean Six

# A relationship between Bias, Lean tools and waste.



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| Journal: | *International Journal of Lean Six Sigma* |
| Manuscript ID | IJLSS-03-2021-0045.R2 |
| Manuscript Type: | Case Study |
| Keywords: | Lean manufacturing, Process wastes, Bias, Human factors engineering, Production management |
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# A relationship between bias, Lean tools, and waste.


## Purpose

This multi-disciplinary study highlights the system-wide potential relationships between forms of human bias, selected Lean tools and types of waste in a manufacturing process.

## Methodology

A longitudinal single-site ethnographic case study using digital processing to make a material receiving process Lean was adopted. An inherent knowledge process with internal stakeholders in a stimulated situation alongside process requirements was performed to achieve quality data collection. The results of the narrative analysis and process observation, combined with a literature review identified widely used Lean tools, wastes and biases that produced a model for the relationships.

## Findings

The study established the relationships between bias, Lean tools and wastes which enabled 97.6% error reduction, improved on-time accounting, and eliminated three working hours per day. These savings resulted in seven employees being redeployed to new areas with delivery time for products reduced by seven days.

## Practical implications

Application of the model can identify potential relationships between a group of human biases, twenty-five Lean tools and ten types of wastes in Lean manufacturing processes that support decision-makers and line managers in productivity improvement. The model can be used to identify potential relationships between forms of human biases, Lean tools, and types of wastes in Lean manufacturing processes and take suitable remedial actions. The influence of biases and the model could be used as a basis to counter implementation barriers and reduce system-wide wastes.

## Research limitations/implications

The single site case study with a supporting literature survey underpinning the model would benefit from testing the model in application to different industries and locations.

## Originality/value

This is the first study that connects the cognitive perspectives of Lean business processes with waste production and human biases. As part of the process, a relationship model is derived.


**Keywords:** Lean manufacturing, Process wastes, Bias, Human factors engineering, Production management.

**Article Classification**: Case study

# 1 Introduction

Global competition, economic factors, and environmental concerns are key factors that enable organisations to exist and grow. Organisations have adopted Lean philosophies to address these key factors (Wen et al., 2015). Lean

addresses the elimination of wastes within a manufacturing process, however, additional wastes occur in business processes such as management, information technology and design that escalate cost and environmental concerns. Lean Manufacturing is widely adopted to reduce waste using existing resources (Bhamu and Sangwan, 2014, Sreedharan et al., 2020), in multiple products or mixed model environments (Womack and Jones, 2010). Lean offers quantitative waste reduction techniques (Ahmed et al., 2019) by using an array of tools from all types of manufacturing systems (Fercoq et al., 2016).

Multiple studies connect Lean and human resources, for example, Singh and Rathi (2019) and Gleeson et al. (2019) linking pre-attentive bias (knowledge of items' location) to Lean Six Sigma methods. Linkage of Lean modelling to biases related to research included Shi et al. (2019), who considered selectivity bias, selection bias and self-selection (self-serving/self-centred) bias in productivity modelling. Many authors considered or verified nonresponse bias, (Tortorella et al., 2020, Sahoo, 2019, Negrão Léony Luis et al., 2019), review and response biases (Ibrahim et al., 2020) in lean related research to correct research errors. Antomarioni et al. (2020) observed perception bias, self-serving and actor-observer biases to Lean practices while Cruz et al. (2019) linked operational bias to Lean performances. Gleeson et al. (2019) linked observational bias to Lean barriers, Valente et al. (2019) linked subjective bias to decision making in Lean and Claudia and Geraldo (2020) linked technocratic bias to Lean project performances. This study examines the connections encompassing system-wide relationships between bias (cognitive interventions), Lean tools and wastes in Lean implementation processes. The research focuses on biases other than research-methodological types such as non-response, review and response biases that bring the originality to this article. The findings could contribute to better understanding of cognitive biases in a Lean environment and influencers and barriers of Lean and waste. This is the first study that makes the connection between all three factors, and as part of the process, a relationship model was derived. The following sections encompass a literature review focussing on the effects of combinations of factors, a description of the methodology, the results, discussion and finally draws conclusions with a description of the limitations of the study and future directions. This is the first study that connects the cognitive perspectives of Lean business processes with waste production and human biases. As part of the process, a relationship model is derived.

# 2 Literature review

Lean tools, waste, and biases each have considerable literature as individual themes. This review considers the literature of combinations of these optimisation techniques to achieve increased productivity with a reduction in time and/or material waste.

Lean philosophy incorporates a variety of quality management systems, tools and practices envisioned to achieve robust results and enhance productivity (Tyagi et al., 2015). Individual management systems/methodologies and tool development has been superseded by combinations of management systems/methodologies and tools to achieve enhanced productivity. Combinations have included: Lean, Six-Sigma and HR practices, (Sreedharan et al. (2020); Just in Time, Kanban, Automation, Andon and error proofing (Dave and Sohani (2019); Just in Time and Total Quality Management (Al-Aomar and Hussain (2019); Value Stream Mapping, Kanban and Key Performance Indicators (Shruti and Kant (2017); 5S and Kaizen as a part of Total Productive Maintenance (Jain et al. (2014); and Heijunka, Takt and Kanban (Matzka et al. (2012). Lean tools drive an organisation to continuously improve business processes by eliminating waste (Pearce, 2014). However, in spite of existing for over half a century, Lean implementers still experience barriers that lead to sub-optimal performance. For example, the traditional Lean analysis of NVA and Muda and Kaizen activity, as well as being popular tools, would not generate results to the desired level due to these barriers (Alvarado-Ramírez et al., 2018). The systematic literature review undertaken by various authors and the key barriers/critical failure factors (CFF) identified is shown in Table 1.

Table 1: Lean barriers/critical failure factors

| Critical failure factors | (Jagdish et al., 2014) | (Kumar et al., 2016) | (Shamsi and Alam, 2018) | (Yadav and Desai, 2017) | (Ruben et al., 2018) |
|---|---|---|---|---|---|
| Attitude | | | | ✓ | ✓ |
| bonus, rewards, or incentives systems | ✓ | ✓ | | ✓ | |
| commitment and support | ✓ | ✓ | | ✓ | ✓ |
| communication | ✓ | | | | ✓ |
| Complexity | | | ✓ | | |
| consultation | ✓ | | | | |
| cost | | | | ✓ | |
| Cross-functional conflicts | ✓ | ✓ | | ✓ | |
| Culture | ✓ | ✓ | | ✓ | |
| Customer focus | | ✓ | | ✓ | |
| Difficulties | | | ✓ | | |
| empowerment | ✓ | | | | |
| Focus | ✓ | | | | |
| Funds | | ✓ | | ✓ | ✓ |
| Human factors | | | | ✓ | |
| improvement | | ✓ | | | |
| Incompetency | | ✓ | | | ✓ |
| involvement | ✓ | | ✓ | ✓ | ✓ |
| Infrastructure | | | | ✓ | ✓ |
| Leadership | ✓ | | | | ✓ |
| Management | | ✓ | | ✓ | |
| Parameters | | | ✓ | | |
| Performance measurement system | | | | ✓ | ✓ |
| perseverance | ✓ | | | | |
| planning | | | | ✓ | |
| Policy | | | | | ✓ |
| Resistance | ✓ | | | | |
| resources | ✓ | ✓ | | ✓ | ✓ |

| Critical failure factors | (Jagdish et al., 2014) | (Kumar et al., 2016) | (Shamsi and Alam, 2018) | (Yadav and Desai, 2017) | (Ruben et al., 2018) |
|---|---|---|---|---|---|
| scope | | | ✓ | | |
| Slow response | ✓ | | | | |
| Staff turnover | | | ✓ | | |
| Statistical thinking | | ✓ | | ✓ | ✓ |
| Technology | | ✓ | | ✓ | |
| Time | | | ✓ | ✓ | ✓ |
| Training | ✓ | | ✓ | | |
| Uncertainty | | ✓ | | | |
| Unknown | | | ✓ | | |
| Wrong tools | | | | ✓ | |

Table 1 demonstrates that the commonly cited barriers to successful Lean implementation are commitment and support, involvement, and resources. These are closely followed by: bonus, rewards or incentives systems; cross-functional conflicts.; culture; funds; statistical thinking; and time. Unsurprisingly, these are all people-centric factors which require behavioural change to mitigate their effects.

Lean philosophy advocates for value augmentation through elimination or minimisation of waste (Dieste et al., 2019, Pearce, 2014). Initial work classified manufacturing related wastes into seven categories (Ohno, 1988):

- Overproduction;
- Waiting;
- Transportation;
- Over Processing;
- Inventory;
- Movement; and
- Defective products.

Subsequently, wastes ancillary to production waste were identified, based on excessive use or underutilisation of a resource, method, or substance while performing activities. Underutilisation negatively affects an organisation's business, people, and the environment (Womack and Jones, 2010). Efforts to reduce or eliminate waste induces stress in a system which affects people associated with an organisation. From an organisational perspective, manufacturing and related functions are important while from the human perspective, well-being has attained significance (Minh et al., 2019).

Organisations engage people to perform activities that enhance, create or add value (Charlwood and Hoque, 2017). An activity results from physical and mental actions and reactions (Wrzesniewski and Dutton, 2001) that enhance value (Cook, 2016) and/or reduce drawbacks (Charlwood and Hoque, 2017). Mental actions and reactions are subject to cognitive biases that impact decision-making (Busenitz and Barney, 1997). Cognitive biases are anomalies in the thought processes resulting in doubtful decisions (Dvorsky, 2013). These biases influence the decision-making process when negativity is more prevalent than positivity (Weyman and Barnett, 2016, Wells et al., 2016, Whiting et al., 2016). Erroneous decisions due to biases adversely affect a decision-maker and their allied organisation (Tversky and Kahneman, 2016). Deficiencies due to decision-making biases influence organisations and inherent biases induce stress for individuals (Kahneman et al., 2011). Cognitive bias distorts decision-making processes (Kahneman, 2011, Tversky and Kahneman, 2016) and reduces judgement ability (Moen et al., 2016). However, some biases, such as loss aversion, enable faster decisions (Kahneman, 2011, Tversky and Kahneman, 2016).

Decision-making in organisations is typically intuitive, whereby individuals accumulate biased information and deliver decisions that produce negative outcomes (Saaty, 2012). In this paper bias is defined as the tendency of people to make decisions based on perception, prejudice, interpretation, temperament, and outlook, resulting in a favoured position without understanding it (Kahneman, 2011). The literature review based on keywords such as cognitive influence, cognitive bias, and Lean through relevant search engines (GOOGLE SCHOLAR, WEB of SCIENCE, EMERALD, SCIENCE DIRECT, SCOPUS) had 1040 strong focused cognitive bias articles revealed 239 biases of which 50 were observed in this case study.

Relationships between Lean and waste (for example, Purushothaman et al. (2020)), Lean and participants (for example, Coetzee et al. (2019)) have been observed. Participants' collaboration occurred in the performance of a systemic set of activities by pooling resources using Lean (Hammer and Champy, 2009, Coetzee et al., 2019). Lean's foundation is that people add value by undertaking tasks and responsibilities (Minh Khaw et al., 2019) within a system to trace every problem to its ultimate cause, thereby reducing the overall cost of the process through collaboration (Womack and Jones, 2010)which involved discussion, decision-making, and attitude alignment (Kvarnstrom, 2008, Hilda, 2019). However, Lean implementation is not easy to achieve, manifesting human barriers (Upadhye et al., 2016, Zhou, 2016) and organisational culture issues (Bortolotti et al., 2015). Examples of these issues include leadership, management, financial culture, people skills factors, and expertise which are key barriers to Lean implementation in small and medium industries (Zhou, 2016) while Dubey et al. (2015) also highlighted the influence of institutional pressure. These obstacles affect productivity, implementation cost, employee satisfaction, trust, commitment (Ciarniene and Vienazindiene, 2012, Antony and Gupta, 2019) and the capability of organisations to respond to change (Kamalahmadi and Parast, 2016).

Implementation of processes and management's capability to take decisions affect Lean systems (Reijula and Tommelein, 2012), while unionised enterprises faced significant resistance from workers (Shah et al., 2017). Management's ability to provide credence, demonstrate responsibility, develop appropriate work modes and engage in communication, directly impact Lean's success (Losonci et al., 2011, Antony and Gupta, 2019). Significantly, decision-making plays an important role in various business aspects like process implementation, change management, and continuous performance, since an individual's decisions are subjective and influenced by human factors such as biases and framing effects (Kahneman, 2011, Tversky and Kahneman, 2018). Such decisions are often biased towards initial values and arise from previous decisions (Pranoto, 2005).

Depending on the circumstances cognitive bias distort decision-making process to either enable faster decisions or hinder them, (Hama, 2010). This bias arises because organisational decision-making is of the intuitive type where an individual accumulates information biased by their values. These decisions may be without persuasive logic, hard to act on, weak, and result in distorted future learnings (Saaty, 2012). Although many factors affecting decision-making have been identified (Refer to Table 1), human bias factors have not been connected to the entire business process and the understanding of influences by considering all stakeholders in a process. In a business environment, bias is an inherent property that influences actions and decision-making process. However, bias is often not considered as a major barrier (Kahneman, 2011). In addition, connections between bias, Lean tools, and wastes have not been studied (Singh and Rathi, 2019, Antomarioni et al., 2020, Cruz et al., 2019). The objective of the paper is to focus on the cognitive biases influence on Lean and waste in the organisations that adopt Lean practices. The research question for this study was:

- What was the relationship between bias, Lean tools, and waste in an organisation that adopted Lean practices?

# 3 Methodology:

## *3.1 Method of study*

This research aimed to explore the influence of biases on Lean tools and wastes. This was achieved by analysing Lean

implementation in the inward goods department of the case study. A longitudinal single-site ethnographic case study spanned 18 months and was designed to gain knowledge on the influence of bias on the process and types of wastes generated in the system. The approach produced in-depth knowledge from a real-time situation using a longitudinal case study following the approach of Powell et al. (2017). The longitudinal field study allowed the researcher to observe the change process as it developed in real-time (Powell et al., 2017).

An ethnographic approach was chosen since the researcher was an active participant through personal engagement and process observation, participant observation, and group discussions (Dick, 2006). Ethnography advocated acquiring knowledge by understanding the experiences of people being studied through participation and immersion in their activities to construct comprehensive descriptions of their values and beliefs (Rachel et al., 2013). In ethnography, the researcher becomes immersed in the research as an active participant through personal engagement and records all-encompassing study notes through participant observation, interviews, conversational and discourse analysis, documentary analysis, film and photography, and life histories (Dick, 2006). Further, ethnography uses behaviour examination in specific social conditions as a method of data collection and then interprets and understands behaviour (Dewan, 2018). It is useful in a predesign phase of research to generate questions to be investigated by other methodologies (Savage, 2000). However, limitations include (Savage, 2000):

- Unintended generalisation;
- The approaches of ethnographic research foster ethical issues; and
- Requires skilled supervision.

Inherent knowledge of the process by the researcher and people working in the plant were used to stimulate situation and process requirements to extract quality data and analysis of the results. The system-wide study involved management, staff, operators, suppliers, contract employees, and contracted third-party drivers. Participants were experts in process steps and their narration, combined with process observation and an archived-data study (multiple methods employed), provided the required information (Dick, 2006).

The research revolved around the cognitive biases with respect to Lean tools and waste, which are obtained from participants by interaction and construction of their experiences. Hence, it was appropriate to choose the ethnography methodological position for the research. For the current research, the ethnography methodology is substantiated with the method of data collection through a system-wide case study approach that emphasised in-depth qualitative focus through process observation, participant observation, and review of records and narrative analysis.

A systematic literature review substantiated the ethnographic approach which identified, evaluated and amalgamated empirical confirmation to meet pre-specified eligibility criteria (Fink, 1998). This process was similar to (Pedrini and Laura, 2019). Five databases were selected to search for articles published from 1993 to 2020. The keywords used were Lean, cognitive biases, and wastes. The 69201 articles identified using the keyword search provided 1040 key journal articles that were systematically reviewed using both bibliometric and qualitative methods for analysis. Global sourcing of the articles ensured comprehensive coverage and citation numbers ensured academic acceptability. The highest quoted article on wastes was cited 19833 times and the least cited 27 times. The steps followed are given below.

A) Identification of keywords: Lean, cognitive biases, and wastes.

B) Development of exclusion and inclusion criteria (articles relevant to Lean, cognitive biases, wastes) and methodology (Systematic literature review and ethnography).

C) Specification of relevant search engines and execution of the search (5 engines: Google Scholar, Web of Science, Emerald, Science Direct, and Scopus).

D) Development of a list of articles for the study.

E) Descriptive and thematic analysis to identify central themes and interpret results.

The details are tabulated below:

Table 2: Systematic literature review

| Process | | Individual steps | Analysis resulting | No. of articles |
|---|---|---|---|---|
| Search process and data collection | 1 | Identification of keywords: (cognitive bias, Lean, waste) | Previous research and reviews | |
| | 2 | Development of exclusion and inclusion criteria, methodology | Quality of the article and limitations | 30 |
| | 3 | Specification of relevant search engines and execution of the search (5 engines: GOOGLE SCHOLAR, A WEB OF SCIENCE, EMERALD, SCIENCE DIRECT, SCOPUS) | Title and abstracts (automated based on keywords) | 534,911 |
| | 4 | Development of A-, B-, and C-list: | | |
| | | C-list | Key words w.r.t Cognitive bias, lean and waste | 69201 |
| | | B-list | Title and abstracts that referred to Cognitive bias, lean, and waste | 3544 |
| | | A-list | Full text (strong focus cognitive bias, lean waste) | 1040 |
| | | Narrative inclusions in this article | Full text | 141 |
| Descriptive and thematic analysis | 5 | Descriptive categories (e.g., journals covered, methodologies applied) | Cognitive bias, lean and wastes | 1040 |
| | 6 | Deductive and inductive categories to identify central themes and interpret results | Definition of bias, lean and waste influence. | 1040 |

Field notes were converted into detailed process and study descriptions. The adopted deductive approach used narrative analysis to plot the process with a thematic analysis in combination with a literature survey to identify biases. Combining the narrative analysis, process observation, and review of archival data achieved triangulation. Procedures for data analysis were followed using thematic analysis according to Braun and Clarke (2006) who identified, analysed and reported patterns (themes) within data that minimally organized and described the richness of data set in detail. This approach stressed the participants' voice while disregarding the researcher's voice. The following steps were conducted (Braun and Clarke, 2006):

- Familiarising yourself with the data;
- Generating initial codes;
- Searching for themes;
- Reviewing themes;
- Defining and naming themes; and
- Producing the report or presenting a model.

The case study focused on biases' effects caused by introducing digital processing to the inwards goods department at a manufacturing facility in India and converting it into a Lean process. The manufacturer, which previously adopted Lean, is the sixth-largest compressor manufacturer globally and has worldwide facilities. The systemwide case study involved 102 of the 1500 employees in the facility. The manufacturer had been struggling to make the supplementary manufacturing processes Lean despite training in Lean methodologies, personality development and skill enhancement for all employees. Human resources training was based on the human influence which included: attitude; abilities; resistance; skills; and motivation(Pearce, 2014, Zhou, 2016). However, the organisation, which had people from different cultures (castes), struggled to eliminate wastes. The manufacturer was keen to understand the missing link of systemwide human influence on their process.

The 18-month study focused on the material receiving process before, during and after Lean implementation and involved organisation personnel, suppliers, and consultants. The researcher had the dual role of participant and observer of the process. The study focused on the issues encountered, problems employees faced and human roadblocks such as biases for improving the process through digitisation.

Reliability depends on the ability to demonstrate organised data and ideas in order to promote understanding (Walliman, 2017). Walliman (2017) affirmed that ethics, large sample size (102 participants), triangulation, data from a large organisation, careful sampling, and rigorous coding enhance reliability in qualitative research.

For this research, the following seven actions were taken to ensure reliability:

- Ethical research: The primary step to ensure reliability was to design ethical research. The research was designed to keep the confidentiality of the participant and organisation, and people were protected from any risk;
- Large sample size: To ensure reliability, the research was conducted with large participation, 102 participants were involved in the seven case studies;
- Triangulation: Methods, environment, theory, and data triangulation methods were used to collect the data that assured reliability.
- Data from a large organisation: Smaller organisations or commercial companies' records are difficult to examine for reliability, The case study was conducted in a large organisation ( > 1800 people worldwide).
- Careful sampling: To ensure reliability, importance was given to the quality of participants, who were the employees at the workplace and were able to communicate effectively so that data could be examined as per the participant experience to achieve generalisability and the development of knowledge; and
- Rigorous coding: The data collection for this research employed three sources of evidence: process direct observation, recorded interviews, and documentation. The data were analysed to set themes and codes that ensured reliability.

Validity in research is “the extent of the legitimate generalisability of the results of an experiment” (Walliman, 2017). The validity of research depends on the robust ethical design that used the same protocol all across and carried out in the normal life settings that provided data representativeness of influence on sought variables (Denzin, 1978). Yin (1994) stated that robust designed case study evidence establishes the construct validity and reliability, while Carter et al. (2014) argued triangulation is a strategy to achieve validity. Golafshani (2003) emphasised that reliability, validity, and triangulation reflect the multiple ways of establishing the truth. The validity of the current research was ensured by:

- The robust ethical design of research aided to obtain data that genuinely reflect the influences of the variables (Cognitive bias, Lean tools, and waste);
- Methods, theory, and data triangulation methods used to collect the data;
- Methods, theory, and data triangulation methods used to analyse the data;
- Following the same study protocol and obtaining feedback and result validation for the case study from the senior management team.
- Process observation, participant observation, and document review happened at the actual work site;
- Confirmability: The research generalised theory through the analysis of case study data and reported the process improvement to the organisation and obtained feedback of the study;
- Credibility: Following Patton (1999), the credibility was ensured by gathering and analysing high-quality data from a large reputable organisation that had implemented Lean, robust case studies, and triangulation; and
- Transferability: The research was conducted in normal work-life settings with high ethical practices to ensure transferability.

The current research adopted ethical practices and was conducted at multiple sites, with the same protocol and triangulation aided to obtain data that genuinely reflect the influences of the variables (Cognitive bias, Lean tools, and waste). The case studies were conducted in normal work life settings with high ethical practices that obtained high-quality data and feedback on the usefulness of the study in mostly large reputable organisations ensuring the reliability and validity of the current research.

# 4 Results

## 4.1 Initial process

The inward goods department suffered from delays, incorrect data entries, missing processes, production stoppages, and integrity issues due to the scale of the receipts/day (averaging 637 goods receiving notes and 3185 parts/ day). The receiving process is represented in Figure 1.

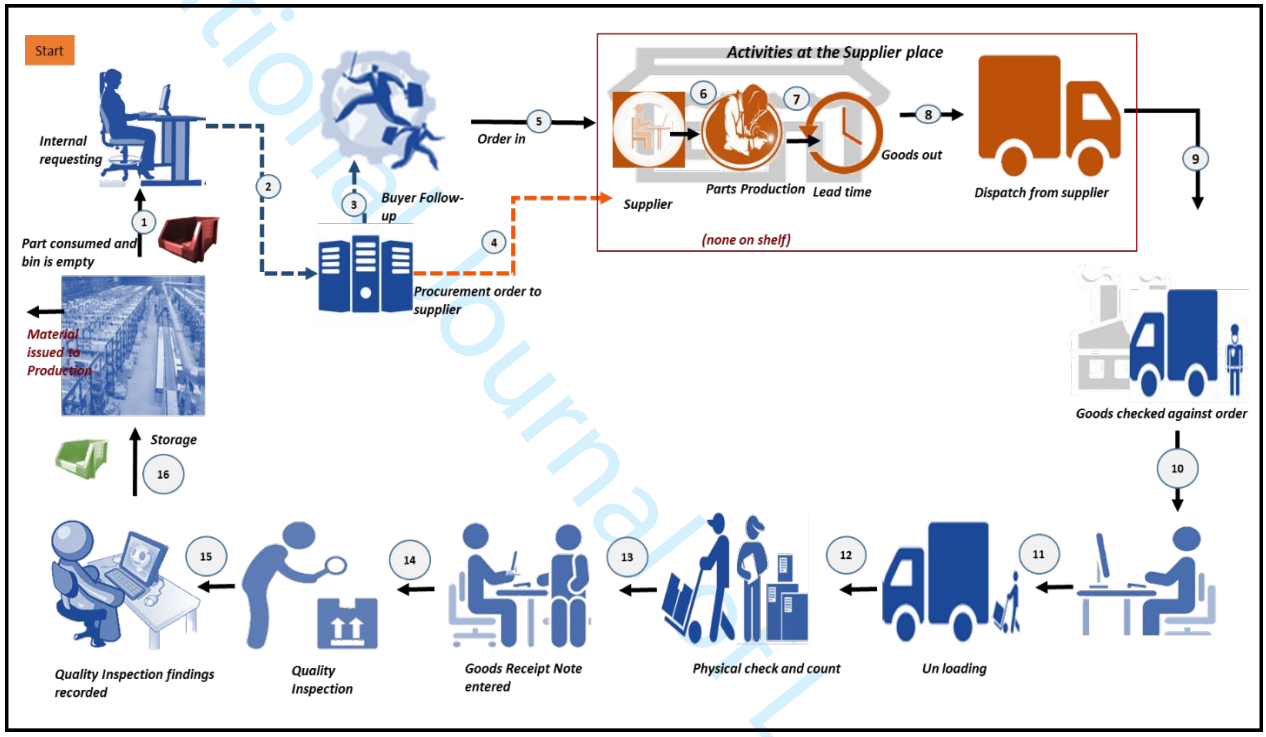


Figure 1 Receiving process before the Lean exercise

The process (1) started with an empty bin in a bin-based storage system. The operator informed the internal requestor who keyed in the requirement daily, which was communicated to the buyer and supplier via an email. The buyer (2) verified the purchase order and initiated a follow-up with the supplier (3-5). The Supplier (6-8) made the parts within an agreed lead time and dispatched (9) them to the manufacturer. At the entry gate (10) a security check verified the number of boxes or packets according to the invoice and a gate-entry for goods arrived (11) was entered into the system. The gate entry generated a serial number which was noted on the invoice. This number was manually used by accounts to confirm arrival and make subsequent payment.

Delivery vehicles moved to the warehouse, where the physical unloading (12) was done and a receiving acknowledgement was signed and given to the vehicle driver. The boxes/packets were opened, counted (13), a goods receipt note (GRN) was produced, and a tag was printed and attached to the material. The parts were passed to inspectors for a quality check. The inspectors (14) checked and passed the results to the inspection supervisor (15) who provided an acceptance decision into the database and the warehouse person then moved the materials to storage (16).

The analysis of data and interaction with employees across all levels revealed that proper training had been imparted on lean over 3 years and the management had allocated resources and funds. The commitment from team was imminent and other barriers listed in Table 1 was either non-existent or within acceptable limits.

## 4.2 Lean tools

A linkage derived from the tools used based on the case study is given in Table 3.

Table 3 Lean tool categories

| Category of tools | Lean Tool | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Value to the customer (cost, waste elimination, quality, and Continuous Improvement) | Muda | Value Stream Mapping | Kaizen | Root cause analysis | Plan, do, check and Act | Jidoka | Poka-Yoke | Gemba |
| Scheduling (Focus on delivery to Customers and earn revenue) | Heijunka | Just in time | Kanban | Takt Time | Bottle neck Analysis | Continuous Flow | Single minute exchange of dies | Standardized Work |
| Maintenance (practices to meet stakeholder's requirement) | Total productive maintenance | Original equipment efficiency | Six Big Losses | | | | | |
| Policy (focus on policy, goals, and monitoring) | Hoshin Kanri | SMART Goals | Key Performance Indicators | | | | | |
| Factory Focus (Value adder's working environment and visualisation) | Visual Factory | Andon | 5S | | | | | |

The manufacturer used most of the tools listed in Table 3 in the process. The maintenance department used Total Productive Maintenance, Original Equipment Efficiency, and Six Big Losses for the equipment used for unloading and internal management like the dock leveller, forklift, and pallet trucks. The production team used Andon to examine the customer to process chain to indicate delays and status. Suppliers used SMED, while the other tools were a regular part of the manufacturer's production culture.

## 4.3 Waste

The case study identified factors including human delays, inaction, procrastination and passing on issues, but previous researchers have not categorised these as wastes and measured them appropriately. Considering these factors, wastes identified in the organisation are classified and tabulated as shown in Table 4.

Table 4: Organisational waste categories

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| Core Manufacturing Waste | Manufacturing (wastes classified by Ohno) | Waste generated by the manufacturing activities. | Waiting; Over-production; Over-processing; Defects; Motion or Movement; Inventory; Transport; | (Womack and Jones, 2010, Dinis-Carvalho et al., 2019). | Waiting: Received materials were waiting for processing and intermediate processes within the receiving process had materials waiting for processing. |

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| | | | | | Over-production: The process had multiple checks and counting.<br><br>Over-processing: The same data regarding part number and quantity were entered multiple times.<br><br>Defects: Manual errors and process steps missing noticed.<br><br>Motion or Movement: Unnecessary movement to inspection area and back to receipt area.<br><br>Inventory: The process took 24 hours to 36 hours to complete, which necessitated additional inventory in the system<br><br>Transport: Unnecessary movement to inspection area and back to receipt area. |
| | Environment | Waste generated by the organisational activity, which could affect human health or the environment. | Excess use of resources; Material constituent disposed to the air, water, or land. | (Alotaibi and Alotaibi, 2016, Bianciardi et al., 2017) | Excess use of resources: multiple data entry consumed excess electricity. Forklifts were used to transport material multiple times (between the storage area and Inspection area) exerting gasses. |
| Non-Core Manufacturing Waste | Information technology waste | Waste generated due to the information technology-related activity. | Delay, programming defect, hardware defect, connectivity defect, inadequate training and documentation, data security and storage defect. | (Yamazaki et al., 2016, McFarlane et al., 2016) | Programming defect: Multiple times the same data being entered for completing the process. Hardware defect, connectivity defect, inadequate training and documentation observed. |
| | Decision-making individual waste | Waste generated due to an individual's activity. | Lack or Wrong or delayed decisions. | (Mann et al., 1997, Busenitz and Barney, 1997, Bernal, 2017) | Store staff kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error. |

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| | Department or Function Waste | Waste generated due to department or function boundaries, procedures, policies hierarchy, and interest. | Lack or Wrong or delayed decisions. | (Micevski et al., 2016, Hennart, 2016) | The procedures for the receipt process had loopholes and each receiving section interpreted it differently. |
| | Decision-making cross-functional team waste | Waste generated due to a cross-functional team activity | Lack or Wrong or delayed decisions. | (Scott and Boyd, 2016, Womack et al., 2007). | The Store and purchase cross functional team delayed decisions on short and wrong supply. |
| | Human resources waste | Waste generated due to human resources department activity. | Imparting non-rewarding training or development workshops; wasted creativity; underutilisation of talents, experience, or creativity; loss due to absenteeism; over staffing and unutilised labour | (Sela et al., 2016, Womack and Jones, 2010) | Loss due to absenteeism of operators. |
| | Enterprise engagement waste | Waste generated due to enterprise engaging external agencies. | Consulting or audits, which cause delay or wrong decisions. | (Brandon-Jones et al., 2016, Dranove and Jin, 2010) | The auditors insisted on zero variation and defect due to the receiving process. |
| | Methods waste | Waste generated due to a method of an activity that affects the organisation.<br>1. Design Waste: Waste generated due to design activity or function.<br>2. Overhead Wastes: Waste generated due to those functional | Design function, design element, design department, design process, and designer at an individual or combined level.<br>Lack or Wrong or delayed decisions because of supervision, managerial | (Womack et al., 2007, Shaar et al., 2017)<br>(Chipeta et al., 2016, Swatuk and Vale, 2016) | The receiving process design had flaws.<br>The supervisors kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error. |

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| | | activities, which are accounted for as overheads.<br>3. Eagerness and Error Wastes: Waste generated by the eagerness to perform activities. | activities, and management.<br>Eagerness | (Nezam et al., 2016) | Often operators found shortcuts and missed process steps to help production running |
| Well-being | Stress waste | Waste due to induced stress in an organisation. | Work stress | (Womack et al., 2007, Andre et al., 2016) | Long work hours created stress for people working in stores. Priorities processing created stress in the working environment. |

## 4.4 Biases

Analysis of data, observation, and minutes of meetings, reviews plus discussion with stakeholders, revealed biases at each stage of the change management process. A summary of the 50 biases (from 239 in the literature) narrated by 102 people, out of which 81 of them were workers and 21 was staff, is shown in Table 5.

Table 5: Observed Biases

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Agreement | The tendency of agreement of consciences to achieve a common goal. | (Sacramento, 2019) | Incremental improvements were taken only after the agreement of people to achieve a common goal |
| Authorization | The tendency to avoid the risk of unauthorized actions. | (Alfawaz et al., 2010) | 88 out of 102 people involved felt it was important to eliminate the risk of undertaking unauthorised processes |
| Bandwagon effect | The tendency in which people do something primarily because other people are doing it, regardless of their own beliefs, which they may ignore or override. | (Shaikh et al., 2017, Howard, 2019) | Process owners and the team responsible (94 out of 102 people) avoided using digital technology and were following previously successful manual processes. |
| Chain of command | The tendency to act based on superior's instruction. | (Cavaletto et al., 2019) | After an initial drive from management, the process started to change with the entire team of 102 following the advice of senior management. |
| Change dilution | The tendency to keeping the process live to support the stakeholders and implementing the required changes for correcting the issues | (Cameron and Green, 2015) | The team were committed to the requirement of keeping the process running and simultaneously undertaking specified improvements. |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Change of job | The tendency to worry about the unknown or known changed Job. | (Zhou et al., 2017) | Instituted system changes created new stresses on the employees, even though management offered alternate jobs for any redundancies created. Employees worried about the changes and about whether they were fit for the new job (54 out of 102) |
| Choice-supportive | The tendency to remember one's choices as better than they actually were | (Zorn et al., 2020) | During the meetings for drafting the improved material receiving process flow, the team (70 out of 102) attributed past successes and support their choice |
| Clustering Illusion | The tendency to see patterns where actually none exist. | (Howard, 2019) | The occurrence of side talks and guessed pattern of activities was identified by 91 out of 102 participants |
| Confirmation | The tendency to search for or interpret information in a way that confirms one's preconceptions. | (Howard, 2019, Devlin and Billings Andrew, 2018) | People were holding onto manual Kanban cards and cited lots of failure information to argue that a physical card was needed (48 out of 102) |
| Congruence | The tendency to test hypotheses exclusively through direct testing, in contrast to tests of possible alternative hypotheses | (Berg Nodtvedt et al., 2020) | People felt that data could not be reconciled in any way other than to physically see the Kanban cards (48 out of 102) |
| Conjunction Fallacy | The tendency to assume that specific conditions are more probable than general ones | (John, 2018) | People stating specific conditions are more probable than general one was evidenced at various occasions (78 out of 102 people narrated the same). For example, while discussing the removal authorisation of buyers from the process, one buyer cited excess engine order because of a manual error which was stopped by him thus saving Rupees 3 million in inventory and stated this could happen on all occasions. |
| Easy study | The tendency to take an easy and non-problematic area for study to prove the subject worth ness | (Bodek, 2002) | The new process trial to test effectiveness was carried out at a low transaction warehouse due to low material transaction (received standard parts from three flexible suppliers) |
| Fear of Failure | I will be blamed if a new process fails. | (Engel et al., 2019) | 98 out of 102 people feared the consequence of failures, both personally (affect their KPI and in turn their bonus) and for the organisation (as it affects the organisation KPI and in turn their bonus). |
| Fix it fallacy | Wanting quick nailing of the problem | N/A | Top management push and review processes were periodic, and it was observed that some of them demanded a quick solution to all problems to improve performance. |
| Gender | Unequal treatment in employment opportunity based on the sex of an employee or group of employees | (Robnett, 2015) | Women were not a part of the operation due to the belief that the job required lifting and they did not have the strength. |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Group formation | The tendency to form small groups and have a positive or negative talk on the side-lines of the meetings or work hours on a related subject. | (Guo et al., 2020) | Workers formed small groups to have positive or negative talks on the side-lines of the meetings or during work hours. |
| Guidance | The tendency to seek guidance from superiors | (Kotlyar and Karakowsky, 2007) | A series of meetings were set up with top management to seek their approval for every process change. |
| Herd instinct | A common tendency to adopt the opinions and follow the behaviours of the majority to feel safer and to avoid conflict. | (Guo et al., 2020) | Workers adopted the opinions and followed the behaviours of the majority to feel safer and to avoid conflict (75 out of 81 workers). |
| Hyperbolic discounting | The tendency for people to have a stronger preference for more immediate payoffs relative to later payoffs, the closer to the present both payoffs are. | (Kim and Zauberman, 2019) | Workers preferred to look for a quick payoff during each stage of improvement (68 out of 81 workers) |
| Illusion of control | The tendency for human beings to believe they can control or at least influence outcomes that they clearly cannot | (Suzanne, 2018) | Top management and senior staff assumed they had control of the process, but in reality, deviation from, and skipping process steps was common. The manual process had a dual procedure, an inspection at the factory and entering the respective inspection status in the system. |
| Illusion of transparency | People overestimate others' ability to know them, and they also overestimate their ability to know others | (Janning et al., 2020) | People overestimated their ability to know others in doing their part of the work and vice versa (65 out of 102) |
| Information | The tendency to seek information even when it cannot affect action. | (Vaughan, 2013) | Buyers were following up on their ordered parts, even though they knew it could not affect the action |
| Irrational escalation | The tendency to make irrational decisions based upon rational decisions in the past or to justify actions already taken. | (Zalewski et al., 2017) | The buyers' made irrational decisions based upon their rational decisions made in the past or to justify actions already taken without realising the cost involved |
| Lead bias | who will take the lead, like on the old saying Who will bell the cat? | (Lynskey, 1955) | Periodic updating their superiors and their superiors that they would lead in addressing the problem permanently (73 out of 102) |
| Long work | The belief of increased working time gives increased quality | (Kodz et al., 2003) | People believed working long hours enhanced productivity and quality (77 out of 102) |
| Loophole | The tendency to catch the week link or loopholes to pass the blame to others. | (Sterman, 2006) | Team members found someone to blame for anything that went wrong in the process instead of acknowledging a system failure (84 out of 102) |
| Loss aversion | The disutility of giving up an object is greater than the utility associated with acquiring it. | (Schleich et al., 2019) | People were clear to avoid loss of money in any form (84 out of 102) |
| No time and energy | The tendency to cite non-availability of time and energy for doing a process. | (Barrouillet et al., 2004) | Some processing of the project was cut short due to availability of time and long working hours (95 out of 102) |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Omission | The tendency to omit things or actions. | (Howard, 2019) | The members had taken turns to present in the weekly review, highlighting the suggestion maker or makers, providing an opportunity to all for presenting and giving due credit to the participants of a group, thereby ensuring no one got omitted |
| Over entry | The tendency to repeat the per entry step screens by the information technology design | (Howard, 2019) | Repeated data entries were made in the process due to software design. (99 out of 102) |
| Patenting | The tendency to use common technology for an organizational solution and not use exclusive technology that could be patterned for future business | (Levin et al., 1987) | People were not interested in patenting the new process (52 out of 102) |
| Person-environment fit | The tendency to worry about the unknown or known changed job nature thinking they were not fit for it. | (Piszczek and Berg, 2020) | People worried about the unknown or known changed job nature thinking they were not fit for it (53 out of 102) |
| Person identification | the tendency of recording the person who did the action to appreciate or blame him. | (Coates and Tognazzini, 2013) | The team recommended documenting the person who performed a process so that credit or blame could be allocated if things went wrong (77 out of 102) |
| Planning fallacy | the tendency to underestimate task-completion times, also formulated as Hofstadter's Law: "It always takes longer than you expect, even when you consider Hofstadter's Law. | (Love et al., 2019) | People underestimated the task completion times (45 out of 102) |
| Priority | The tendency to work based on priority and not First in First out or a set pattern | (Dutilh and Rieskamp, 2016) | The physical unloading of the goods vehicles was done prioritising production urgency |
| Project Shortcoming | The tendency to move on with the project even though the rated success level is not achieved. | (Kerzner, 2013) | Management decided to move ahead in implementing the improved process without achieving the intended results in the process improvement during the initial trial. |
| Pseudo certainty effect | The tendency to make risk-averse choices if the expected outcome is positive, but make risk-seeking choices to avoid negative outcomes. | (Tversky and Kahneman, 2018) | People perceived an outcome of the current process was certain and good while it was uncertain due to delays and errors in the process (68 out of 102) |
| Self-integrity | One Self fearing that his integrity is under questioning when he performs his duties or process. | (Kroon, 2008) | High workloads and production urgency meant that sometimes materials were passed to production without accounting. Sometimes this practice brought the integrity of the employees into question as there were material accounting issues. |
| Self-perceived job insecurity | The fear of Job loss due to innovation, improvement or alternate process | (Ferrie et al., 2002) | There was self-perceived anxiety that could have been driven by the fear of job loss due to technology advancement innovation, improvement, or alternate processes (72 out of 102) |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Self-serving | The tendency to consider oneself in unrealistically positive terms for example: Assuming oneself as the complete master of the process and presenting himself in the process and directing others, even when the requirement is not there. | (Mazzurega et al., 2020) | Work would stop or suffer if a person were not present in the place. This assumed that the absentees were the driving force for the project (18 out of 21 staff). |
| Stake-holder trust | The tendency to trust or mistrust the stakeholders of an organization in general and every aspect of the relationship | (Berg Nodtvedt et al., 2020) | A security check verifying that the number of boxes or packets tallied against the invoice and a gate entry for the parts was made. |
| Standardisation | The tendency to be technically correct or correct to the standard format, rather agreeing to the format understood by everyone in the team or aggregable to the culture of the organization. | (Ungan, 2006) | There was no evidence of standardisation bias, the tendency to be technically correct or correct to the standard format, rather people agreed to the format understood by everyone in the team or agreeable to the culture of the organisation |
| Survivorship | A form of selection bias focusing on what has survived to the present and ignoring what must have been lost | (Amaya et al., 2019) | More junior people focused on what has survived to the present and ignored those things that had been lost due to manual process. |
| System- human | The tendency of not acknowledging system and /or human influences | (Arthur, 1994) | People did not acknowledge system and/or human influences and continued the old process thinking it was robust (84 out of 102) |
| Talent misjudgement | Assuming that the ordinary people working are the experts, innovators and they are chosen to work and paid because of the belief that they are capable of finding solutions. | (Scullion and Collings, 2011) | People believed that everyone is an expert innovator and paid accordingly because of the belief that they are capable of finding solutions (66 out of 102) |
| Technology aversion | The aversion to using technology without understanding what the technology offers | (Howard, 2013) | Process owners and the team responsible avoided digital technology as they were not comfortable using it. |
| Trust | The tendency to suspect everything. | (Berg Nodtvedt et al., 2020) | Trust deficit was narrated by people (64 out of 102). |
| Unacceptability | Questions that may embarrass or invade privacy are refused or evaded | (K. Choi and P. Pak, 2014) | Archived data revealed questions that may have embarrassed or invaded privacy were refused or evaded (97 out of 102) |
| Zero defect | The tendency to assume or insist on zero defects in a process despite knowing that it is impractical. | (Ghosh et al., 2006) | Top management realised that, in the material receiving exercise, the tendency to insist on zero defects in a process was evident as they repeatedly stated during the meetings despite knowing that it was impractical |
| Zero-risk | The preference for reducing a small risk to zero over a greater reduction in a larger risk. | (Baron et al., 1993) | The preference for reducing a small risk to zero over a greater reduction in a larger risk resulted in the duplicate work of keeping the inspection process at the material receipt stage |

The link between the identified biases to where they occurred in the process is shown in Figure 2.

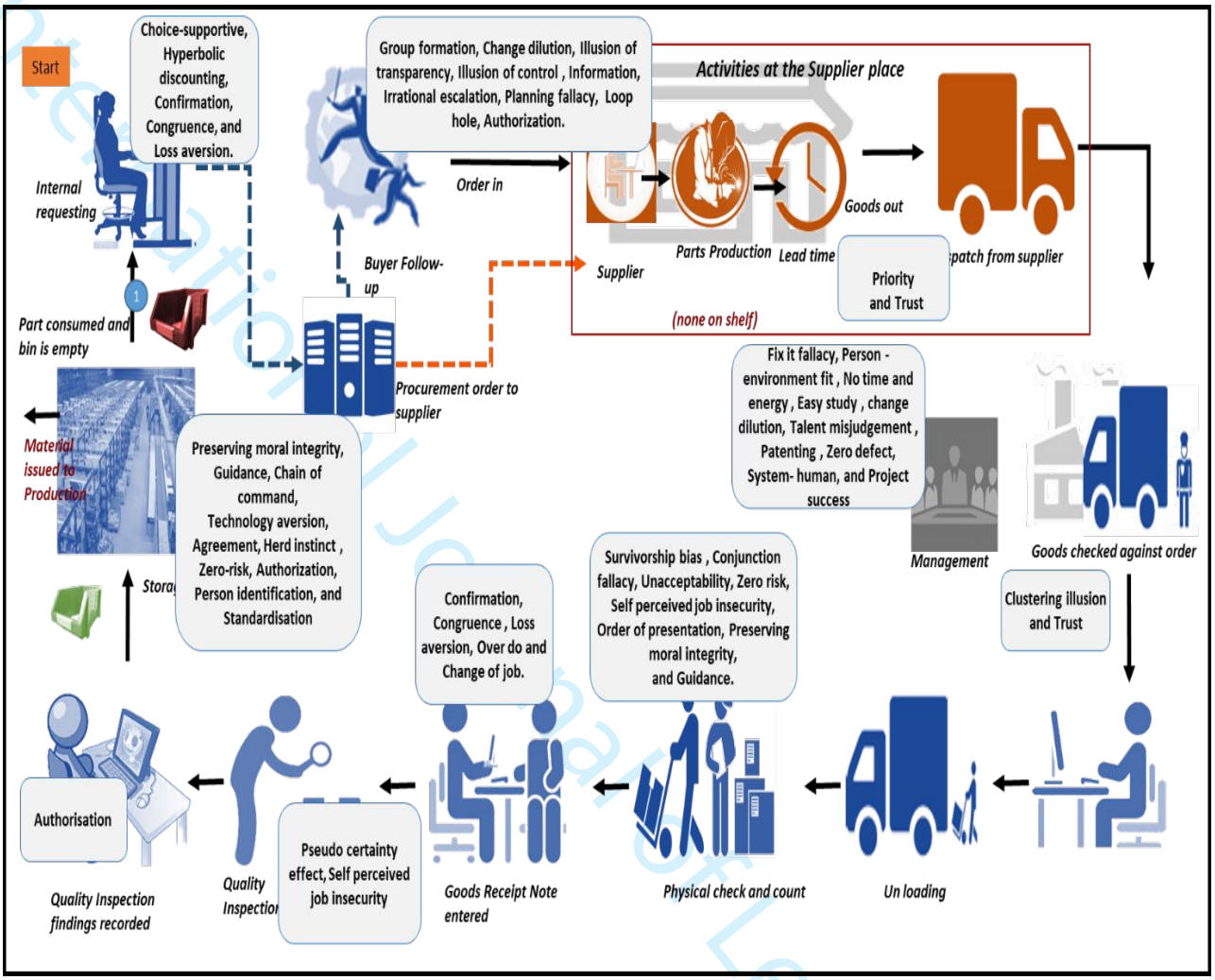


Figure 2 Biases in the receiving process before the Lean exercise

The manufacturer's top and middle management acted on the biases (refer to Table 6 and Table 7) that paved way for process improvement. The action aided removal of the cognitive barrier and helped to plot the future process state with speedy implementation of Kaizen.

Table 6: Biases action taken

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| Agreement | Incremental improvements were taken only after the agreement of people to achieve a common goal | Daily meetings and weekly review by top management reduced disagreements and speeded up the implementation process. |
| Authorization | 88 out of 102 people involved felt it was important to eliminate the risk of undertaking unauthorised processes | Digital process for authorising various procurement and receipt steps based on system stock. |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| Bandwagon effect | Process owners and the team responsible (94 out of 102 people) avoided using digital technology and were following previously successful manual processes. | Management clarified the advantages of digital technology and agreed to trial run and implement in phases where confidence was low. |
| Chain of command | After an initial drive from management, the process started to change with the entire team of 102 following the advice of senior management. | Drive from Management was continuous. |
| Change dilution | The team were committed to the requirement of keeping the process running and simultaneously undertaking specified improvements. | The process was not stopped for implementation, the implementation was parallel. |
| Change of job | Instituted system changes created new stresses on the employees, even though management offered alternate jobs for any redundancies created. Employees worried about the changes and about whether they were fit for the new job (54 out of 102) | HR Counselling and new Job training were imparted. |
| Choice-supportive | During the meetings for drafting the improved material receiving process flow, the team (70 out of 102) attributed past successes and support their choice | Management, Lean experts & HR continually clarified that trial is an experience and improvement results would change the mindset. |
| Clustering Illusion | The occurrence of side talks and guessed pattern of activities was identified by 91 out of 102 participants | Management, Lean experts & HR continually emphasised to reduce assumptions and work on data. |
| Confirmation | People were holding onto manual Kanban cards and cited lots of failure information to argue that a physical card was needed (48 out of 102) | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Congruence | People felt that data could not be reconciled in any way other than to physically see the Kanban cards (48 out of 102) | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Conjunction Fallacy | People stating specific conditions are more probable than general ones were evidenced on various occasions (78 out of 102 people narrated the same). For example, while discussing the removal authorisation of buyers from the process, one buyer cited excess engine order because of a manual error which was stopped by him thus saving Rupees 3 million in inventory and stated this could happen on all occasions. | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Easy study | The new process trial to test effectiveness was carried out at a low transaction warehouse due to low material transaction (received standard parts from three flexible suppliers) | This was an action to dilute the Bandwagon effect and change dilution |
| Fear of Failure | 98 out of 102 people feared the consequence of failures, both personally (affect their KPI and in turn their bonus) and for the organisation (as it affects the organisation KPI and in turn their bonus). | Management, Lean experts & HR continually allayed the fears. |
| Fix it fallacy | Top management push and review processes were periodic, and it was observed that some of them demanded a quick solution to all problems to improve performance. | Lean experts continually emphasised continuous and long-term solution instead of short-term solutions. |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| Gender | Women were not a part of the operation due to the belief that the job required lifting and they did not have the strength. | Management, Lean experts & HR initiated the women employment and women were employed subsequently. |
| Group formation | Workers formed small groups to have positive or negative talks on the side-lines of the meetings or during work hours. | Management, Lean experts & HR continually encouraged the team to have informal talks and this resulted in multiple ideas and solutions. |
| Guidance | A series of meetings were set up with top management to seek their approval for every process change. | This practice continued. |
| Herd instinct | Workers adopted the opinions and followed the behaviours of the majority to feel safer and to avoid conflict (75 out of 81 workers). | Management, Lean experts & HR continually encouraged counter arguments in a healthy atmosphere. |
| Hyperbolic discounting | Workers preferred to look for a quick payoff during each stage of improvement (68 out of 81 workers) | Lean experts continually emphasised continuous and long-term solution instead of short-term solutions. |
| Illusion of control | Top management and senior staff assumed they had control of the process, but in reality, deviation from, and skipping process steps was common. The manual process had a dual procedure, an inspection at the factory and entering the respective inspection status in the system. | Lean experts continually emphasised automation and reduction of manual control on the process. |
| Illusion of transparency | People overestimated their ability to know others in doing their part of the work and vice versa (65 out of 102) | This continued throughout the case study. |
| Information | Buyers were following up on their ordered parts, even though they knew it could not affect the action | This continued throughout the case study. |
| Irrational escalation | The buyers' made irrational decisions based upon their rational decisions made in the past or to justify actions already taken without realising the cost involved | Management, Lean experts & HR continually emphasised taking decisions based on data and statistical thinking. |
| Lead bias | Periodic updating their superiors and their superiors that they would lead in addressing the problem permanently (73 out of 102) | Management, Lean experts & HR continually emphasised bringing out the problem and had set up a system for employees to anonymously disclose problems which were discussed in quarterly employee open meeting. |
| Long work | People believed working long hours enhanced productivity and quality (77 out of 102) | Log work hours were discouraged and the approval process for extended work hours was set up. |
| Loophole | Team members found someone to blame for anything that went wrong in the process instead of acknowledging a system failure (84 out of 102) | This continued throughout the case study. |
| Loss aversion | People were clear to avoid loss of money in any form (84 out of 102) | Management, Lean experts & HR continually emphasised taking decisions based on data and statistical thinking and clarified negative trial results are acceptable and will form the basis for the next improvement. |
| No time and energy | Some processing of the project was cut short due to availability of time and long working hours (95 out of 102) | Data was sort as justification. |
| Omission | The members had taken turns to present in the weekly review, highlighting the suggestion maker or makers, providing an opportunity to all for | This continued throughout the case study. |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| | presenting and giving due credit to the participants of a group, thereby ensuring no one got omitted | |
| Over entry | Repeated data entries were made in the process due to software design. (99 out of 102) | Digital conversion and data link at each stage. |
| Patenting | People were not interested in patenting the new process (52 out of 102) | This continued throughout the case study. |
| Person-environment fit | People worried about the unknown or known changed job nature thinking they were not fit for it (53 out of 102) | Management, Lean experts & HR continually allayed the fear and imparted training for the new roles. |
| Person identification | The team recommended documenting the person who performed a process so that credit or blame could be allocated if things went wrong (77 out of 102) | This continued throughout the case study to appreciate people while blame was taken by the management collectively. |
| Planning fallacy | People underestimated the task-completion times (45 out of 102) | This continued throughout the case study. Future training on time calculation planned. |
| Priority | The physical unloading of the goods vehicles was done prioritising production urgency | First in First out was made mandatory and were deviations approved by Top Management. |
| Project Shortcoming | Management decided to move ahead in implementing the improved process without achieving the intended results in the process improvement during the initial trial. | This continued throughout the case study. |
| Pseudo certainty effect | People perceived an outcome of the current process was certain and good while it was uncertain due to delays and errors in the process (68 out of 102) | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Self-integrity | High workloads and production urgency meant that sometimes materials were passed to production without accounting. Sometimes this practice brought the integrity of the employees into question as there were material accounting issues. | Accounting was made mandatory, with no deviations. HR had set up a process to identify such issues and take up with concerned department heads. |
| Self-perceived job insecurity | There was self-perceived anxiety that could have been driven by the fear of job loss due to technology advancement innovation, improvement, or alternate processes (72 out of 102) | Management, Lean experts & HR continually allayed the fears. |
| Self-serving (self-centre) | Work would stop or suffer if a person were not present in the place. This assumed that the absentees were the driving force for the project (18 out of 21 staff). | The digital process was designed to counter this and trials proved effective to extent that manual interventions were not needed. |
| Stake-holder trust | A security check verifying that the number of boxes or packets tallied against the invoice and a gate entry for the parts was made. | This continued throughout the case study. |
| Standardisation | There was no evidence of standardisation bias, the tendency to be technically correct or correct to the standard format, rather people agreed to the format understood by everyone in the team or agreeable to the culture of the organisation | This continued throughout the case study. |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| Survivorship | More junior people focused on what has survived to the present and ignored those things that had been lost due to the manual process | Management, Lean experts & HR continually allayed the fears and educated them on issues pertaining to the manual process. |
| System- human | People did not acknowledge system and/or human influences and continued the old process thinking it was robust (84 out of 102) | The case study bought an understanding to people in the system and/or human influences and trials changed this mindset. |
| Talent misjudgement | People believed that everyone is an expert innovator and paid accordingly because of the belief that they are capable of finding solutions (66 out of 102) | Management, Lean experts & HR continually emphasised that innovation is teamwork. |
| Technology aversion | Process owners and the team responsible avoided digital technology as they were not comfortable using it. | Management, Lean experts & HR allayed their fears. |
| Trust | Trust deficit was narrated by people (64 out of 102). | Management, Lean experts & HR continually encouraged collaboration and set the value system based on it. |
| Unacceptability | Archived data revealed questions that may have embarrassed or invaded privacy were refused or evaded (97 out of 102) | This continued throughout the case study. |
| Zero defect | Top management realised that, in the material receiving exercise, the tendency to insist on zero defects in a process was evident as they repeatedly stated during the meetings despite knowing that it was impractical | Management, Lean experts & HR continually emphasised error is possible in manual and digital modes. |
| Zero-risk | The preference for reducing a small risk to zero over a greater reduction in a larger risk resulted in the duplicate work of keeping the inspection process at the material receipt stage | Management, Lean experts & HR continually emphasised taking reasonable and calculated risk and the process was designed to pass inspection at the source with an exception for defects captured on the production line and field. |

Table 7: Waste-Related biases and action taken

| Waste | Examples | Related biases and action taken |
|---|---|---|
| Manufacturing<br><br>(wastes classified by Ohno) | Waiting: Received materials were waiting for processing and intermediate processes within the receiving process had materials waiting for processing.<br><br>Over-production: The process had multiple checks and counting.<br><br>Over-processing: The same data regarding part number and quantity were entered multiple times.<br><br>Defects: Manual errors and process steps missing noticed. | Waiting was influenced by the bandwagon effect and survivorship biases that resulted in long work bias. The inspection process was altered and<br><br>Over-production was influenced by loss aversion, multiple checks removed.<br><br>Over-processing was influenced by agreement, confirmation, system human and survivorship bias. The data entries were linked to reducing the number of entries.<br><br>Defects were influenced by long work bias and process redesigned.<br><br>The movement was influenced by fear of failure |

| Waste | Examples | Related biases and action taken |
|---|---|---|
| | Motion or Movement: Unnecessary movement to inspection area and back to receipt area.<br><br>Inventory: The process took 24 hours to 36 hours to complete, which necessitated additional inventory in the system<br><br>Transport: Unnecessary movement to inspection area and back to receipt area. | and confirmation bias, the Inspection process reduced to check on field failure and production defects. Inventory was influenced by confirmation and hyperbolic discounting, process redesigned to reduce process time.<br><br>The transport was affected by herd instinct, Inspection process reduced. |
| Environment | Excess use of resources: multiple data entry consumed excess electricity. Forklifts were used to transport material multiple times (between the storage area and Inspection area) exerting gasses. | Confirmation, herd instinct, long work, herd instinct, system human, agreement, and survivorship bias were primary influencers. Process redesigned to reduce data entry and transport. |
| Information technology waste | Programming defect: Multiple times the same data being entered for completing the process. Hardware defect, connectivity defect, inadequate training and documentation observed. | Irrational escalation, loss aversion, bandwagon effect, and agreement were primary influencers that influenced multiple data entry. Process redesigned. |
| Decision-making individual waste | Store staff kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error. | Loss aversion, bandwagon effect, irrational escalation, and agreement was influencing issue pending. Process redesigned to declare count based on photographic evidence. |
| Department or Function Waste | The procedures for the receipt process had loopholes and each receiving section interpreted it differently. | The bandwagon effect, agreement and confirmation bias were primary influencers. The procedure was documented and people were trained to have uniform practices all across. |
| Decision-making cross-functional team waste | The Store and purchase cross-functional team delayed decisions on short and wrong supply. | Group formation, clustering illusion, irrational escalation, and agreement were the primary influencers. Management intervention and periodic review reduced differences and speeded up decisions. |
| Human resources waste | Loss due to absenteeism of operators. | Long work and agreement (over ~~work load~~workload) was a primary influencer. Process redesigned to complete tasks within working hours. |
| Enterprise engagement waste | The auditors insisted on zero variation and defect due to the receiving process. | Loss aversion, Choice supportive, Irrational escalation and agreement biases were the primary influence. Management intervened with data from other organisations to convince auditors that corrective and preventive actions will be placed when variation occurs. Process redesigned to reduce variation. |
| Methods waste | The receiving process design had flaws. | The bandwagon effect, agreement and confirmation bias were primary influencers. Process redesigned and the procedure was documented and people were trained to have |

| Waste | Examples | Related biases and action taken |
|---|---|---|
| | | uniform practices all across. |
| | The supervisors kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error. | Loss aversion, bandwagon effect, irrational escalation was influencing issue pending. Process redesigned to declare count based on photographic evidence. |
| | Often operators found shortcuts and missed process steps to help production running | Fear of failure was the primary influencer, process redesigned and corrective and preventive actions were placed when production had issues due to the receiving process. |
| Stress waste | Long work hours created stress for people working in stores. Priorities processing created stress in the working environment. | Long work, zero risk, zero defect, and priority were the primary influence. Process redesigned to complete tasks within working hours and follow first in first out. |

## 4.5 Improved process

Lean implementation involved devising an improved receiving process using digital architecture in consultation with the allied department and suppliers. Management addressed the negative biases while the positive biases were used advantageously during regular review meetings that augmented the Kaizen ~~and~~ and ~~V~~value stream mapping (VSM) lean tools that the manufacturer adopted. The manufacturer used a combination of electronic functions to interact with suppliers, a mobile network, Radio Frequency Identification Cards (RFID), which have been widely used in industry to collect real-time data (Guo, Ngai, Yang, & Liang, 2015), to communicate back to the plant, as well as visual identification using digital image capture. The improved process is represented in Figure 3.

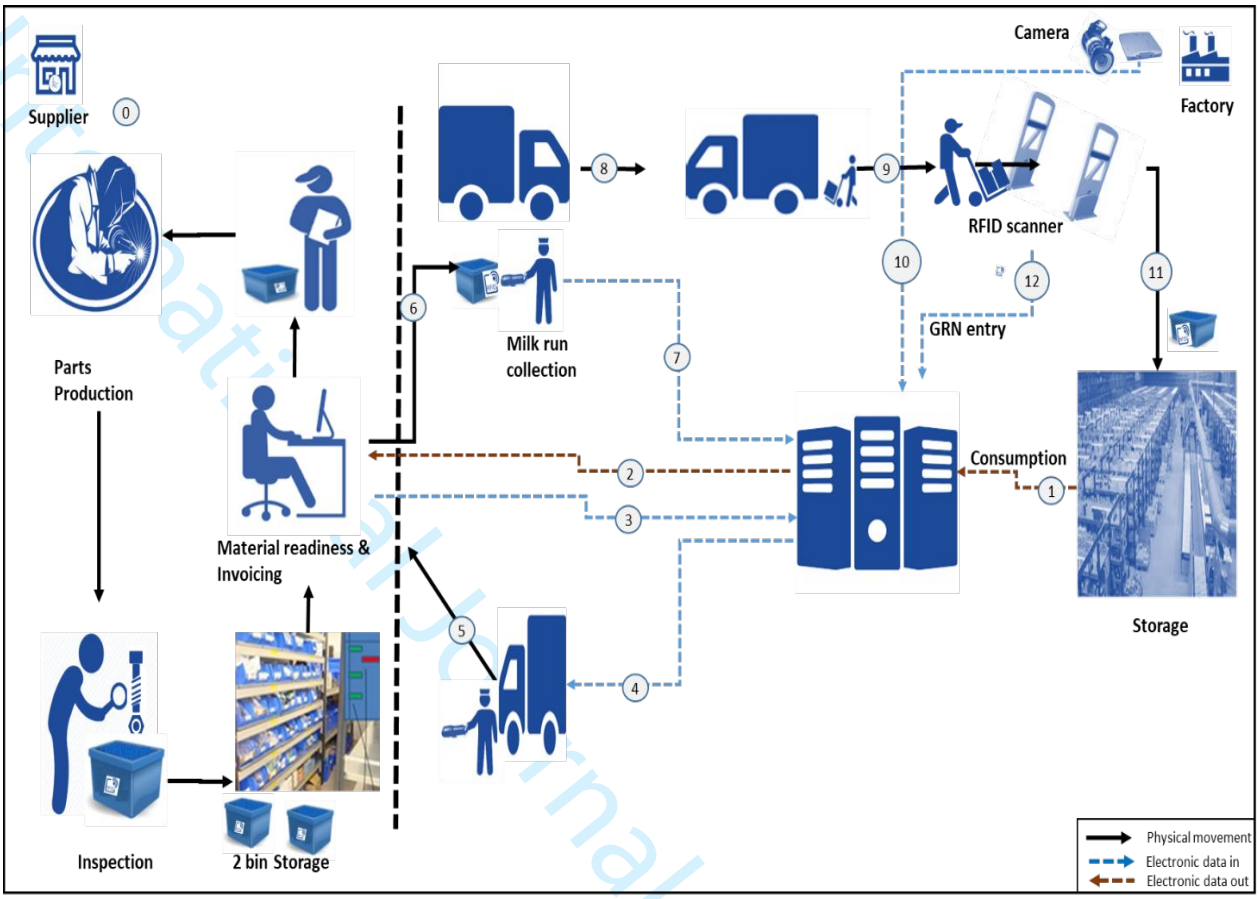


Figure 3 Improved receiving process

The process eliminated manual operations (step 1-4, step 10, and step 13- 15) shown in Figure 1 by digitally integrating the whole process. The process required the manufacturer to send a request to supply materials electronically based on his stock status (1-2). The supplier entered details of its readiness (invoice) to supply in custom RFID-binned containers from their two-bin stock and the delivery vehicle was alerted through a handheld device connected to mobile networks (3-4). The driver visually verified the component and scanned the RFID tag, which was electronically transmitted to the server (6-7). At the manufacturing plant, when the vehicle reached the stores, the material was unloaded, photographed and tags were scanned (8-10). The server then verified the scanned data with the collection list, prepared a GRN and the material was moved to storage (11-12).

The process eliminated the need to check for and count missing parts, apart from images being stored for future dispute management. The study assisted the company to understand the cognitive factors and by addressing them ~~to agree and~~by plotting future state VSM and through the speedy implementation of Kaizen, reduced errors by 97.6%, which also ensured on-time accounting and ~~reduced~~decreased three working hours per day. These savings resulted in seven employees being deployed to new areas, and delivery time commitment to customers was reduced by seven days.

## 4.6 Integration Model for Lean Tools, Wastes, and Biases

The case study highlighted a set of prominent biases that determined the way that a typical process works. For example, KPI and RCA impacted all types of wastes. Data analysis revealed that there were instances recorded on disagreement on KPI (7 instances) and RCA (18 instances). Similarly, agreement bias impacted manufacturing, enterprise, stress, environment, information technology and cross-functional team wastes (see Table 7). A causal loop diagram as shown in Figure 4 represents the relationship between wastes, tools used and biases. However,

several biases impacted the process tools and wastes and plotting them in a causal loop diagram increased understanding difficulty.

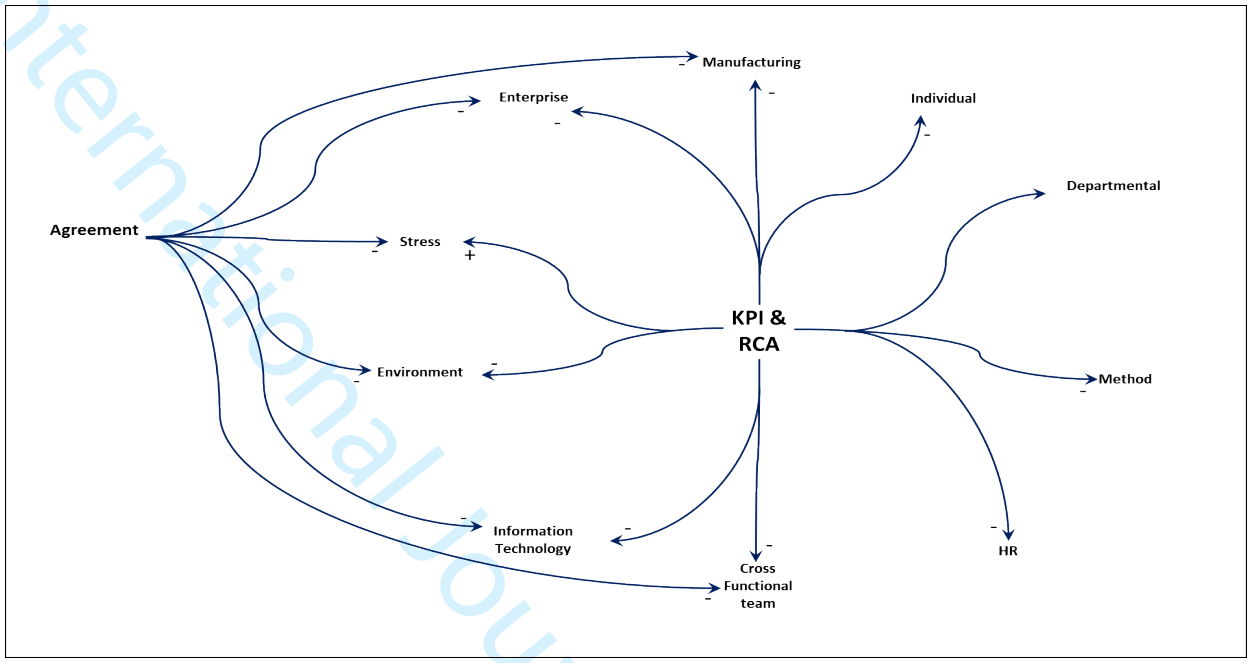


Figure 4: Causal loop diagram

It is important to understand how biases impact through a simpler diagram so that it is useful for future process implementations in an organisation. Based on the narrative analysis and process observation on the case study and literature surveyed, the identified biases were linked to the Lean tools and wastes.

A new model represented in the Circle Slice Diagram was developed to understand the correlation between prominent Lean tools, wastes, and biases in the organisation as shown in Figure 5. In the model, biases are linked to waste categories that were observed during the study and similarly, Lean tools are linked to waste categories. The common impact of the bias and tools on waste were analysed to arrive at linkages.

The construction of the Lean, bias and waste correlation model is described below.

1. Organisational wastes were numbered and the impact of biases on the organisational waste was tabulated.
2. Lean tools and their impacts on organisational waste categories were tabulated.
3. The impact of Lean tools on organisational wastes that had similarities were grouped and tabulated.
4. Based on the influence of wastes, Lean tools and biases were correlated.
5. The resultant common numbers of bias and tools that impact wastes were correlated to arrive at the linkage between Lean tools, wastes, and biases.
6. The correlation from point 5 formed the basis of Figure 5.
7. The biases that influenced the wastes were subgrouped and plotted in Figure 5.
8. The Lean tool group and types of wastes that were influenced by the bias are plotted against each bias as shown in Figure 5.

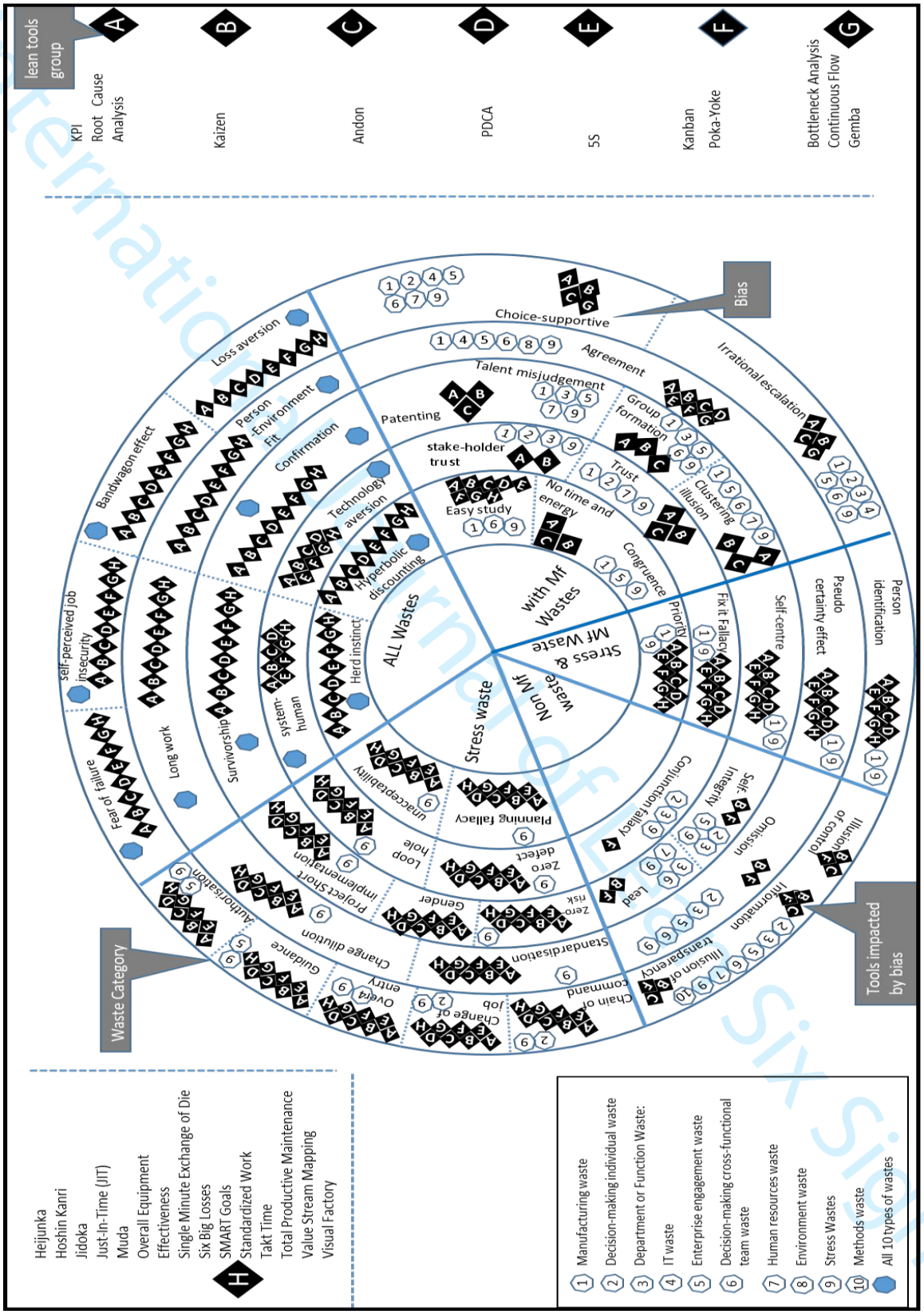


Figure 5 Circle Slice Diagram: Biases, Lean tools, and wastes relationship.

From Figure 5 it can be seen that connectivity indicated that biases influenced manufacturing, non-manufacturing and stress wastes. The impact of Lean tools on organisational wastes that had similarities were grouped (A – H). All biases were found to influence stress wastes, which indicated the need to find ways to overcome these biases to reduce stress and anxiety of the people involved and improve their work well-being. For example, the fear of failure could impact all waste types are symbolised by the blue heptagon in Figure 5, and all Lean tool groups denoted by A-H. Similarly, the irrational escalation that affected wastes (e.g. manufacturing) are denoted by 1- 6, and 9. Further, it was found that irrational escalation affected Lean tool groups A, B, C, and G.

# 5 Discussion

A business process consists of a structured set of activities decided and performed by humans, in an organisation to achieve a common business goal, which often creates wastes from adding value to the product. Waste is also an outcome of human factors, particularly cognitive factors such as biases in the workplace that influence decision-making, ~~function~~function, and logical abilities. The identification of biases would aid in understanding the reasons behind lean tool barriers that aid waste elimination. For example, Kaizen and VSM barriers such as lack of staff involvement, understanding, lack of clarity, commitment, support (Alvarado-Ramírez et al., 2018) , less effort made, awareness, attitude, attitude, and resistance to change (Berhe, 2021) could be addressed by understanding the biases.

This study identified 50 biases that influence lean tools/methodologies and wastes. The study evidenced all the 10 types of wastes that the literature review revealed. The study found similarities to self-serving bias and self-selection (self-serving/self-centred) to that of Antomarioni et al. (2020) and Shi et al. (2019) and further observed different biases to that identified by Singh and Rathi (2019), Gleeson et al. (2019), Shi et al. (2019), Tortorella et al. (2020), Sahoo (2019), Negrão Léony Luis et al. (2019), Ibrahim et al. (2020), Cruz et al. (2019), Gleeson et al. (2019), Valente et al. (2019), Claudia and Geraldo (2020), refer to Table 4. The probable reasons could be that this study was a case study and others had multiple case studies. Another reason could be that the study had different scope. For example, Singh and Rathi (2019) and Gleeson et al. (2019) linked pre-attentive bias (knowledge of items' location) to Lean Six Sigma methods while this study had Lean as its scope. Another reason could be that this research focused on Lean related biases other than research-methodological errors related biases such as nonresponse bias, (Tortorella et al., 2020, Sahoo, 2019, Negrão Léony Luis et al., 2019), review and response biases (Ibrahim et al., 2020).

As shown in Figure 5, biases such as fear of failure, self-perceived job insecurity, bandwagon effect, loss aversion, long work, person-environment fit, survivorship, confirmation, system-human, technology aversion, herd instinct, and hyperbolic discounting affect all the lean groups (A-H) and all the 10 wastes. Biases such as person identification, pseudo-certainty effect, self-serving, fix it fallacy and priority influence all lean groups (A-H), stress waste and manufacturing wastes. Planning fallacy, unacceptability, loophole, gender, zero-defect, zero risk, project short implementation, standardisation, change dilution, chain of command, change of job, over entry, guidance, and authorisation influence stress wastes predominantly. Non-core manufacturing wastes were influenced by conjunction fallacy, self-integrity, lead, omission, illusion of control, ~~information~~information, and illusion of transparency biases. Biases such as choice supportive, irrational escalation, agreement, patenting, talent misjudgement, group formation, clustering illusion, stakeholder trust, trust, easy study, no time and energy, and congruence influenced Manufacturing wastes along with other wastes.

In organisations decision-making is intuitive, whereby an individual accumulates information biased by their values and delivers a decision, which may be without persuasive logic, hard to act, weak, and influence future learning (Saaty, 2012). Cognitive biases are a part of decision-making and anomalies in the studied process resulted in doubtful decisions (Dvorsky, 2013, Busenitz and Barney, 1997). For example, a status quo bias (holding onto the current situation or method), sunk cost bias (allowing previous investments to have an irrational influence on future decisions) and confirming-evidence bias (looking for information, data, events, or facts that confirm the initial choice), which are all cognitive biases, adversely affected the decision-maker and consequently the organisation (Hammond et al., 1998). These adverse effects created wastes. This paper includes the wastes based on human factors in its classifications and identifies biases influences based on literature and the case study. Further, Lean tools have been categorised by researchers based on the link between them and have been used as a management tool. However, it is important to classify Lean tools based on the wastes they influence to ascertain the constraints

present in a process and organisation. This paper provides a classification based on the literature surveyed and case study. Further, the paper uses a practical study to identify the biases during a Lean process enhancement and attempts to plot the influence of bias on Lean tools and wastes that have not been systematically identified previously.

In a Lean environment, various literature studied human factors that affect processes. However, only a few studies connected the Lean and cognitive biases (Singh and Rathi, 2019, Gleeson et al., 2019). Previous authors had linked selectivity, selection, and self-selection biases and Lean modelling (e.g. Shi et al. (2019)). Many authors considered or verified nonresponse bias, (Tortorella et al., 2020, Sahoo, 2019, Negrão Léony Luis et al., 2019), review bias and response bias (Ibrahim et al., 2020) in their case studies. The influences of perception's bias, self-serving bias, actor-observer bias (Antomarioni et al., 2020), operational bias (Cruz et al., 2019), observational bias (Gleeson et al., 2019), subjective bias (Valente et al., 2019) and technocratic bias (Claudia and Geraldo, 2020) were linked to Lean projects. However, the connections between the bias, Lean tools and wastes have not been studied previously. This study examined the connections encompassing system-wide relationships between bias (cognitive interventions), Lean tools and wastes in a Lean implementation process. Biases that influenced core manufacturing and non-manufacturing wastes always combined with stress wastes, however, a significant finding is the biases like standardisation and zero-defect impacted only stress wastes. This study, for the first time, revealed tangible and intangible biases had positive and negative effects (refer to **Error! Reference source not found.**) and there was a correlation between cognitive biases and Lean tools (refer to Figure 5). These findings provided tangible results through the narrative analysis, process observation, and a longitudinal single-site ethnography case study.

# 6 Conclusion, limitations, and future outlook

The study assisted the company to understand the cognitive factors (bias) and addressing them helped to improve productivity. A combination of biases influenced the process, and they delayed improvement to those processes. There is a strong connectivity between the biases, Lean tools, and wastes that induce considerable cost of delay or inaction. Cognitive biases (tangible and intangible biases) had impacted both positively and negatively on the implementation of Lean tools. The correlation showed that biases impacted core manufacturing, non-manufacturing, and stress wastes. It has been found that biases influencing core manufacturing and non-manufacturing wastes always combined with stress wastes, while biases like standardisation and zero-defect bias impacted only stress wastes. The paper agrees with previous literature that Lean influences more on the value adders that induces stress (stress waste) and this aspect provides an avenue to study and propose future remedies. The study highlights the relationship between the bias, Lean tools, and wastes and concludes that the human bias induces waste and influences productivity, which has significant effects on the cost of the overall production and associated business processes. The relationship enables new avenues for multidisciplinary research for evolving systematic remedies concerning bias reduction in organisational processes.

***Findings***

The study established the relationships between bias, Lean tools and wastes which enabled 97.6% error reduction, improved on-time accounting, and eliminated three working hours per day. These savings resulted in seven employees being redeployed to new areas with delivery time for products reduced by seven days.

***Practical implications***

Application of the model can identify potential relationships between a group of human biases, twenty-five Lean tools and ten types of wastes in Lean manufacturing processes that support decision-makers and line managers in productivity improvement. The model can be used to identify potential relationships between forms of human biases, Lean tools, and types of wastes in Lean manufacturing processes and take suitable remedial actions. The influence of biases and the model could be used as a basis to counter implementation barriers and reduce system-wide wastes.

***Limitations***

A limitation of this study is that it is a single case, which indicates further empirical research is needed to generalise prevalent biases in industry. Another limitation is that the study focused on biases in the organisation and did not

deal with social, economic, and family-related biases that influence the business process. There is a connectivity between cognitive factors, Lean tools and wastes as demonstrated by the case study. However, cognitive factors may differ based on the process, the people involved and the organisation. A single site case study with a supporting literature survey underpins the model and it could be useful to test the proposed model by research in more industries and countries.

***Future research.***

This is the first study that connects the cognitive perspectives to Lean business processes. Future research could focus on identifying common biases across industries and ways to overcome them. Future research focusing on the impact of individual biases on Lean tools in an organisation would be also useful. Future study on multiple cases to be undertaken to augment biases influence on Lean. Further, the biases and waste related to the culture of an organisation could be studied in future to improve the empirical validity of the results.

## Acknowledgement:

All staff and members of the Indian manufacturing plant.

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# A relationship between bias, Lean tools, and waste.

Table 1: Lean barriers/critical failure factors

| Critical failure factors | (Jagdish et al., 2014) | (Kumar et al., 2016) | (Shamsi and Alam, 2018) | (Yadav and Desai, 2017) | (Ruben et al., 2018) |
|---|---|---|---|---|---|
| Attitude | | | | ✓ | ✓ |
| bonus, rewards, or incentives systems | ✓ | ✓ | | ✓ | |
| commitment and support | ✓ | ✓ | | ✓ | ✓ |
| communication | ✓ | | | | ✓ |
| Complexity | | | ✓ | | |
| consultation | ✓ | | | | |
| cost | | | | ✓ | |
| Cross-functional conflicts | ✓ | ✓ | | ✓ | |
| Culture | ✓ | ✓ | | ✓ | |
| Customer focus | | ✓ | | ✓ | |
| Difficulties | | | ✓ | | |
| empowerment | ✓ | | | | |
| Focus | ✓ | | | | |
| Funds | | ✓ | | ✓ | ✓ |
| Human factors | | | | ✓ | |
| improvement | | ✓ | | | |
| Incompetency | | ✓ | | | ✓ |
| involvement | ✓ | | ✓ | ✓ | ✓ |
| Infrastructure | | | | ✓ | ✓ |
| Leadership | ✓ | | | | ✓ |
| Management | | ✓ | | ✓ | |
| Parameters | | | ✓ | | |

| Critical failure factors | (Jagdish et al., 2014) | (Kumar et al., 2016) | (Shamsi and Alam, 2018) | (Yadav and Desai, 2017) | (Ruben et al., 2018) |
|---|---|---|---|---|---|
| Performance measurement system | | | | ✓ | ✓ |
| perseverance | ✓ | | | | |
| planning | | | | ✓ | |
| Policy | | | | | ✓ |
| Resistance | ✓ | | | | |
| resources | ✓ | ✓ | | ✓ | ✓ |
| scope | | | ✓ | | |
| Slow response | ✓ | | | | |
| Staff turnover | | | ✓ | | |
| Statistical thinking | | ✓ | | ✓ | ✓ |
| Technology | | ✓ | | ✓ | |
| Time | | | ✓ | ✓ | ✓ |
| Training | ✓ | | ✓ | | |
| Uncertainty | | ✓ | | | |
| Unknown | | | ✓ | | |
| Wrong tools | | | | ✓ | |

Table 2: Systematic literature review

| Process | | Individual steps | Analysis resulting | No. of articles |
|---|---|---|---|---|
| Search process and data collection | 1 | Identification of keywords: (cognitive bias, Lean, waste) | Previous research and reviews | |
| | 2 | Development of exclusion and inclusion criteria, methodology | Quality of the article and limitations | 30 |
| | 3 | Specification of relevant search engines and execution of the search (5 engines: GOOGLE SCHOLAR, A WEB OF SCIENCE, EMERALD, SCIENCE DIRECT, SCOPUS) | Title and abstracts (automated based on keywords) | 534,911 |
| | 4 | Development of A-, B-, and C-list: | | |
| | | C-list | Key words w.r.t Cognitive bias, lean and waste | 69201 |
| | | B-list | Title and abstracts that referred to Cognitive bias, lean, and waste | 3544 |
| | | A-list | Full text (strong focus cognitive bias, lean waste) | 1040 |
| | | Narrative inclusions in this article | Full text | 141 |
| Descriptive and thematic analysis | 5 | Descriptive categories (e.g., journals covered, methodologies applied) | Cognitive bias, lean and wastes | 1040 |
| | 6 | Deductive and inductive categories to identify central themes and interpret results | Definition of bias, lean and waste influence. | 1040 |

Table 3 Lean tool categories

| **Category of tools** | **Lean Tool** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Value to the customer (cost, waste elimination, quality, and Continuous Improvement) | Muda | Value Stream Mapping | Kaizen | Root cause analysis | Plan, do, check and Act | Jidoka | Poka-Yoke | Gemba |
| Scheduling (Focus on delivery to Customers and earn revenue) | Heijunka | Just in time | Kanban | Takt Time | Bottle neck Analysis | Continuous Flow | Single minute exchange of dies | Standardized Work |
| Maintenance (practices to meet stakeholder's requirement) | Total productive maintenance | Original equipment efficiency | Six Big Losses | | | | | |
| Policy (focus on policy, goals, and monitoring) | Hoshin Kanri | SMART Goals | Key Performance Indicators | | | | | |
| Factory Focus (Value adder's working environment and visualisation) | Visual Factory | Andon | 5S | | | | | |

Table 4: Organisational waste categories

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| Core Manufacturing Waste | Manufacturing (wastes classified by Ohno) | Waste generated by the manufacturing activities. | Waiting; Over-production; Over-processing; Defects; Motion or Movement; Inventory; Transport; | (Womack and Jones, 2010, Dinis-Carvalho et al., 2019). | Waiting: Received materials were waiting for processing and intermediate processes within the receiving process had materials waiting for processing.<br>Over-production: The process had multiple checks and counting.<br>Over-processing: The same data regarding part number and quantity were entered multiple times.<br>Defects: Manual errors and process steps missing noticed.<br>Motion or Movement: Unnecessary movement to inspection area and back to receipt area.<br>Inventory: The process took 24 hours to 36 hours to complete, which necessitated additional inventory in the system<br>Transport: Unnecessary movement to inspection area and back to receipt area. |
| | Environment | Waste generated by the organisational activity, which could affect human health or the environment. | Excess use of resources; Material constituent disposed to the air, water, or land. | (Alotaibi and Alotaibi, 2016, Bianciardi et al., 2017) | Excess use of resources: multiple data entry consumed excess electricity. Forklifts were used to transport material multiple times (between the storage area and Inspection area) exerting gasses. |
| Non-Core Manufacturing Waste | Information technology waste | Waste generated due to the information technology-related activity. | Delay, programming defect, hardware defect, connectivity defect, inadequate training and documentation, data security and storage defect. | (Yamazaki et al., 2016, McFarlane et al., 2016) | Programming defect: Multiple times the same data being entered for completing the process. Hardware defect, connectivity defect, inadequate training and documentation observed. |

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| | Decision-making individual waste | Waste generated due to an individual's activity. | Lack or Wrong or delayed decisions. | (Mann et al., 1997, Busenitz and Barney, 1997, Bernal, 2017) | Store staff kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error. |
| | Department or Function Waste | Waste generated due to department or function boundaries, procedures, policies hierarchy, and interest. | Lack or Wrong or delayed decisions. | (Micevski et al., 2016, Hennart, 2016) | The procedures for the receipt process had loopholes and each receiving section interpreted it differently. |
| | Decision-making cross-functional team waste | Waste generated due to a cross-functional team activity | Lack or Wrong or delayed decisions. | (Scott and Boyd, 2016, Womack et al., 2007). | The Store and purchase cross functional team delayed decisions on short and wrong supply. |
| | Human resources waste | Waste generated due to human resources department activity. | Imparting non-rewarding training or development workshops; wasted creativity; underutilisation of talents, experience, or creativity; loss due to absenteeism; over staffing and unutilised labour | (Sela et al., 2016, Womack and Jones, 2010) | Loss due to absenteeism of operators. |
| | Enterprise engagement waste | Waste generated due to enterprise engaging external agencies. | Consulting or audits, which cause delay or wrong decisions. | (Brandon-Jones et al., 2016, Dranove and Jin, 2010) | The auditors insisted on zero variation and defect due to the receiving process. |
| | Methods waste | Waste generated due to a method of an activity that affects the organisation.<br>1. Design Waste: Waste generated due to design | Design function, design element, design department, design process, and designer at an individual or combined level. | (Womack et al., 2007, Shaar et al., 2017) | The receiving process design had flaws. |

| Group | Waste | Definition | Components | Reference | Examples |
|---|---|---|---|---|---|
| | | activity or function.<br><br>2. Overhead Wastes: Waste generated due to those functional activities, which are accounted for as overheads.<br><br>3. Eagerness and Error Wastes: Waste generated by the eagerness to perform activities. | Lack or Wrong or delayed decisions because of supervision, managerial activities, and management.<br><br>Eagerness | (Chipeta et al., 2016, Swatuk and Vale, 2016)<br><br>(Nezam et al., 2016) | The supervisors kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error.<br><br>Often operators found shortcuts and missed process steps to help production running |
| Well-being | Stress waste | Waste due to induced stress in an organisation. | Work stress | (Womack et al., 2007, Andre et al., 2016) | Long work hours created stress for people working in stores. Priorities processing created stress in the working environment. |

Table 5: Observed Biases

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Agreement | The tendency of agreement of consciences to achieve a common goal. | (Sacramento, 2019) | Incremental improvements were taken only after the agreement of people to achieve a common goal |
| Authorization | The tendency to avoid the risk of unauthorized actions. | (Alfawaz et al., 2010) | 88 out of 102 people involved felt it was important to eliminate the risk of undertaking unauthorised processes |
| Bandwagon effect | The tendency in which people do something primarily because other people are doing it, regardless of their own beliefs, which they may ignore or override. | (Shaikh et al., 2017, Howard, 2019) | Process owners and the team responsible (94 out of 102 people) avoided using digital technology and were following previously successful manual processes. |
| Chain of command | The tendency to act based on superior's instruction. | (Cavaletto et al., 2019) | After an initial drive from management, the process started to change with the entire team of 102 following the advice of senior management. |
| Change dilution | The tendency to keeping the process live to support the stakeholders and implementing the required changes for correcting the issues | (Cameron and Green, 2015) | The team were committed to the requirement of keeping the process running and simultaneously undertaking specified improvements. |
| Change of job | The tendency to worry about the unknown or known changed Job. | (Zhou et al., 2017) | Instituted system changes created new stresses on the employees, even though management offered alternate jobs for any redundancies created. Employees worried about the changes and about whether they were fit for the new job (54 out of 102) |
| Choice-supportive | The tendency to remember one's choices as better than they actually were | (Zorn et al., 2020) | During the meetings for drafting the improved material receiving process flow, the team (70 out of 102) attributed past successes and support their choice |
| Clustering Illusion | The tendency to see patterns where actually none exist. | (Howard, 2019) | The occurrence of side talks and guessed pattern of activities was identified by 91 out of 102 participants |
| Confirmation | The tendency to search for or interpret information in a way that confirms one's preconceptions. | (Howard, 2019, Devlin and Billings Andrew, 2018) | People were holding onto manual Kanban cards and cited lots of failure information to argue that a physical card was needed (48 out of 102) |
| Congruence | The tendency to test hypotheses exclusively through direct testing, in contrast to tests of possible alternative hypotheses | (Berg Nodtvedt et al., 2020) | People felt that data could not be reconciled in any way other than to physically see the Kanban cards (48 out of 102) |
| Conjunction Fallacy | The tendency to assume that specific conditions are more probable than general ones | (John, 2018) | People stating specific conditions are more probable than general one was evidenced at various occasions (78 out of 102 people narrated the same). For example, while discussing the removal authorisation of buyers from the process, one buyer cited excess engine order because of a manual error which was stopped by him thus saving Rupees 3 million in inventory and |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| | | | stated this could happen on all occasions. |
| Easy study | The tendency to take an easy and non-problematic area for study to prove the subject worth ness | (Bodek, 2002) | The new process trial to test effectiveness was carried out at a low transaction warehouse due to low material transaction (received standard parts from three flexible suppliers) |
| Fear of Failure | I will be blamed if a new process fails. | (Engel et al., 2019) | 98 out of 102 people feared the consequence of failures, both personally (affect their KPI and in turn their bonus) and for the organisation (as it affects the organisation KPI and in turn their bonus). |
| Fix it fallacy | Wanting quick nailing of the problem | N/A | Top management push and review processes were periodic, and it was observed that some of them demanded a quick solution to all problems to improve performance. |
| Gender | Unequal treatment in employment opportunity based on the sex of an employee or group of employees | (Robnett, 2015) | Women were not a part of the operation due to the belief that the job required lifting and they did not have the strength. |
| Group formation | The tendency to form small groups and have a positive or negative talk on the side-lines of the meetings or work hours on a related subject. | (Guo et al., 2020) | Workers formed small groups to have positive or negative talks on the side-lines of the meetings or during work hours. |
| Guidance | The tendency to seek guidance from superiors | (Kotlyar and Karakowsky, 2007) | A series of meetings were set up with top management to seek their approval for every process change. |
| Herd instinct | A common tendency to adopt the opinions and follow the behaviours of the majority to feel safer and to avoid conflict. | (Guo et al., 2020) | Workers adopted the opinions and followed the behaviours of the majority to feel safer and to avoid conflict (75 out of 81 workers). |
| Hyperbolic discounting | The tendency for people to have a stronger preference for more immediate payoffs relative to later payoffs, the closer to the present both payoffs are. | (Kim and Zauberman, 2019) | Workers preferred to look for a quick payoff during each stage of improvement (68 out of 81 workers) |
| Illusion of control | The tendency for human beings to believe they can control or at least influence outcomes that they clearly cannot | (Suzanne, 2018) | Top management and senior staff assumed they had control of the process, but in reality, deviation from, and skipping process steps was common. The manual process had a dual procedure, an inspection at the factory and entering the respective inspection status in the system. |
| Illusion of transparency | People overestimate others' ability to know them, and they also overestimate their ability to know others | (Janning et al., 2020) | People overestimated their ability to know others in doing their part of the work and vice versa (65 out of 102) |
| Information | The tendency to seek information even when it cannot affect action. | (Vaughan, 2013) | Buyers were following up on their ordered parts, even though they knew it could not affect the action |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Irrational escalation | The tendency to make irrational decisions based upon rational decisions in the past or to justify actions already taken. | (Zalewski et al., 2017) | The buyers' made irrational decisions based upon their rational decisions made in the past or to justify actions already taken without realising the cost involved |
| Lead bias | who will take the lead, like on the old saying Who will bell the cat? | (Lynskey, 1955) | Periodic updating their superiors and their superiors that they would lead in addressing the problem permanently (73 out of 102) |
| Long work | The belief of increased working time gives increased quality | (Kodz et al., 2003) | People believed working long hours enhanced productivity and quality (77 out of 102) |
| Loophole | The tendency to catch the week link or loopholes to pass the blame to others. | (Sterman, 2006) | Team members found someone to blame for anything that went wrong in the process instead of acknowledging a system failure (84 out of 102) |
| Loss aversion | The disutility of giving up an object is greater than the utility associated with acquiring it. | (Schleich et al., 2019) | People were clear to avoid loss of money in any form (84 out of 102) |
| No time and energy | The tendency to cite non-availability of time and energy for doing a process. | (Barrouillet et al., 2004) | Some processing of the project was cut short due to availability of time and long working hours (95 out of 102) |
| Omission | The tendency to omit things or actions. | (Howard, 2019) | The members had taken turns to present in the weekly review, highlighting the suggestion maker or makers, providing an opportunity to all for presenting and giving due credit to the participants of a group, thereby ensuring no one got omitted |
| Over entry | The tendency to repeat the per entry step screens by the information technology design | (Howard, 2019) | Repeated data entries were made in the process due to software design. (99 out of 102) |
| Patenting | The tendency to use common technology for an organizational solution and not use exclusive technology that could be patterned for future business | (Levin et al., 1987) | People were not interested in patenting the new process (52 out of 102) |
| Person-environment fit | The tendency to worry about the unknown or known changed job nature thinking they were not fit for it. | (Piszczek and Berg, 2020) | People worried about the unknown or known changed job nature thinking they were not fit for it (53 out of 102) |
| Person identification | the tendency of recording the person who did the action to appreciate or blame him. | (Coates and Tognazzini, 2013) | The team recommended documenting the person who performed a process so that credit or blame could be allocated if things went wrong (77 out of 102) |
| Planning fallacy | the tendency to underestimate task-completion times, also formulated as Hofstadter's Law: "It always takes longer than you expect, even when you consider Hofstadter's Law. | (Love et al., 2019) | People underestimated the task completion times (45 out of 102) |
| Priority | The tendency to work based on priority and not First in First out or a set pattern | (Dutilh and Rieskamp, 2016) | The physical unloading of the goods vehicles was done prioritising production urgency |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Project Shortcoming | The tendency to move on with the project even though the rated success level is not achieved. | (Kerzner, 2013) | Management decided to move ahead in implementing the improved process without achieving the intended results in the process improvement during the initial trial. |
| Pseudo certainty effect | The tendency to make risk-averse choices if the expected outcome is positive, but make risk-seeking choices to avoid negative outcomes. | (Tversky and Kahneman, 2018) | People perceived an outcome of the current process was certain and good while it was uncertain due to delays and errors in the process (68 out of 102) |
| Self-integrity | One Self fearing that his integrity is under questioning when he performs his duties or process. | (Kroon, 2008) | High workloads and production urgency meant that sometimes materials were passed to production without accounting. Sometimes this practice brought the integrity of the employees into question as there were material accounting issues. |
| Self-perceived job insecurity | The fear of Job loss due to innovation, improvement or alternate process | (Ferrie et al., 2002) | There was self-perceived anxiety that could have been driven by the fear of job loss due to technology advancement innovation, improvement, or alternate processes (72 out of 102) |
| Self-serving | The tendency to consider oneself in unrealistically positive terms for example: Assuming oneself as the complete master of the process and presenting himself in the process and directing others, even when the requirement is not there. | (Mazzurega et al., 2020) | Work would stop or suffer if a person were not present in the place. This assumed that the absentees were the driving force for the project (18 out of 21 staff). |
| Stake-holder trust | The tendency to trust or mistrust the stakeholders of an organization in general and every aspect of the relationship | (Berg Nodtvedt et al., 2020) | A security check verifying that the number of boxes or packets tallied against the invoice and a gate entry for the parts was made. |
| Standardisation | The tendency to be technically correct or correct to the standard format, rather agreeing to the format understood by everyone in the team or aggregable to the culture of the organization. | (Ungan, 2006) | There was no evidence of standardisation bias, the tendency to be technically correct or correct to the standard format, rather people agreed to the format understood by everyone in the team or agreeable to the culture of the organisation |
| Survivorship | A form of selection bias focusing on what has survived to the present and ignoring what must have been lost | (Amaya et al., 2019) | More junior people focused on what has survived to the present and ignored those things that had been lost due to manual process. |
| System- human | The tendency of not acknowledging system and /or human influences | (Arthur, 1994) | People did not acknowledge system and/or human influences and continued the old process thinking it was robust (84 out of 102) |
| Talent misjudgement | Assuming that the ordinary people working are the experts, innovators and they are chosen to work and paid because of the belief that they are capable of finding solutions. | (Scullion and Collings, 2011) | People believed that everyone is an expert innovator and paid accordingly because of the belief that they are capable of finding solutions (66 out of 102) |

| Bias | Explanation | References | Examples of biases in the case study |
|---|---|---|---|
| Technology aversion | The aversion to using technology without understanding what the technology offers | (Howard, 2013) | Process owners and the team responsible avoided digital technology as they were not comfortable using it. |
| Trust | The tendency to suspect everything. | (Berg Nodtvedt et al., 2020) | Trust deficit was narrated by people (64 out of 102). |
| Unacceptability | Questions that may embarrass or invade privacy are refused or evaded | (K. Choi and P. Pak, 2014) | Archived data revealed questions that may have embarrassed or invaded privacy were refused or evaded (97 out of 102) |
| Zero defect | The tendency to assume or insist on zero defects in a process despite knowing that it is impractical. | (Ghosh et al., 2006) | Top management realised that, in the material receiving exercise, the tendency to insist on zero defects in a process was evident as they repeatedly stated during the meetings despite knowing that it was impractical |
| Zero-risk | The preference for reducing a small risk to zero over a greater reduction in a larger risk. | (Baron et al., 1993) | The preference for reducing a small risk to zero over a greater reduction in a larger risk resulted in the duplicate work of keeping the inspection process at the material receipt stage |

Table 6: Biases action taken

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| Agreement | Incremental improvements were taken only after the agreement of people to achieve a common goal | Daily meetings and weekly review by top management reduced disagreements and speeded up the implementation process. |
| Authorization | 88 out of 102 people involved felt it was important to eliminate the risk of undertaking unauthorised processes | Digital process for authorising various procurement and receipt steps based on system stock. |
| Bandwagon effect | Process owners and the team responsible (94 out of 102 people) avoided using digital technology and were following previously successful manual processes. | Management clarified the advantages of digital technology and agreed to trial run and implement in phases where confidence was low. |
| Chain of command | After an initial drive from management, the process started to change with the entire team of 102 following the advice of senior management. | Drive from Management was continuous. |
| Change dilution | The team were committed to the requirement of keeping the process running and simultaneously undertaking specified improvements. | The process was not stopped for implementation, the implementation was parallel. |
| Change of job | Instituted system changes created new stresses on the employees, even though management offered alternate jobs for any redundancies created. Employees worried about the changes and about whether they were fit for the new job (54 out of 102) | HR Counselling and new Job training were imparted. |
| Choice-supportive | During the meetings for drafting the improved material receiving process flow, the team (70 out of 102) attributed past successes and support their choice | Management, Lean experts & HR continually clarified that trial is an experience and improvement results would change the mindset. |
| Clustering Illusion | The occurrence of side talks and guessed pattern of activities was identified by 91 out of 102 participants | Management, Lean experts & HR continually emphasised to reduce assumptions and work on data. |
| Confirmation | People were holding onto manual Kanban cards and cited lots of failure information to argue that a physical card was needed (48 out of 102) | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Congruence | People felt that data could not be reconciled in any way other than to physically see the Kanban cards (48 out of 102) | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Conjunction Fallacy | People stating specific conditions are more probable than general ones were evidenced on various occasions (78 out of 102 people narrated the same). For example, while discussing the removal authorisation of buyers from the process, one buyer cited excess engine order because of a manual error which was stopped by him thus saving Rupees 3 million in inventory and stated this could happen on all occasions. | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Easy study | The new process trial to test effectiveness was carried out at a low transaction warehouse due to low material transaction (received standard parts | This was an action to dilute the Bandwagon effect and change dilution |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| | from three flexible suppliers) | |
| Fear of Failure | 98 out of 102 people feared the consequence of failures, both personally (affect their KPI and in turn their bonus) and for the organisation (as it affects the organisation KPI and in turn their bonus). | Management, Lean experts & HR continually allayed the fears. |
| Fix it fallacy | Top management push and review processes were periodic, and it was observed that some of them demanded a quick solution to all problems to improve performance. | Lean experts continually emphasised continuous and long-term solution instead of short-term solutions. |
| Gender | Women were not a part of the operation due to the belief that the job required lifting and they did not have the strength. | Management, Lean experts & HR initiated the women employment and women were employed subsequently. |
| Group formation | Workers formed small groups to have positive or negative talks on the side-lines of the meetings or during work hours. | Management, Lean experts & HR continually encouraged the team to have informal talks and this resulted in multiple ideas and solutions. |
| Guidance | A series of meetings were set up with top management to seek their approval for every process change. | This practice continued. |
| Herd instinct | Workers adopted the opinions and followed the behaviours of the majority to feel safer and to avoid conflict (75 out of 81 workers). | Management, Lean experts & HR continually encouraged counter arguments in a healthy atmosphere. |
| Hyperbolic discounting | Workers preferred to look for a quick payoff during each stage of improvement (68 out of 81 workers) | Lean experts continually emphasised continuous and long-term solution instead of short-term solutions. |
| Illusion of control | Top management and senior staff assumed they had control of the process, but in reality, deviation from, and skipping process steps was common. The manual process had a dual procedure, an inspection at the factory and entering the respective inspection status in the system. | Lean experts continually emphasised automation and reduction of manual control on the process. |
| Illusion of transparency | People overestimated their ability to know others in doing their part of the work and vice versa (65 out of 102) | This continued throughout the case study. |
| Information | Buyers were following up on their ordered parts, even though they knew it could not affect the action | This continued throughout the case study. |
| Irrational escalation | The buyers' made irrational decisions based upon their rational decisions made in the past or to justify actions already taken without realising the cost involved | Management, Lean experts & HR continually emphasised taking decisions based on data and statistical thinking. |
| Lead bias | Periodic updating their superiors and their superiors that they would lead in addressing the problem permanently (73 out of 102) | Management, Lean experts & HR continually emphasised bringing out the problem and had set up a system for employees to anonymously disclose problems which were discussed in quarterly employee open meeting. |
| Long work | People believed working long hours enhanced productivity and quality (77 out of 102) | Log work hours were discouraged and the approval process for extended work hours was set up. |
| Loophole | Team members found someone to blame for anything that went wrong in the process instead of acknowledging a system failure (84 out of 102) | This continued throughout the case study. |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| Loss aversion | People were clear to avoid loss of money in any form (84 out of 102) | Management, Lean experts & HR continually emphasised taking decisions based on data and statistical thinking and clarified negative trial results are acceptable and will form the basis for the next improvement. |
| No time and energy | Some processing of the project was cut short due to availability of time and long working hours (95 out of 102) | Data was sort as justification. |
| Omission | The members had taken turns to present in the weekly review, highlighting the suggestion maker or makers, providing an opportunity to all for presenting and giving due credit to the participants of a group, thereby ensuring no one got omitted | This continued throughout the case study. |
| Over entry | Repeated data entries were made in the process due to software design. (99 out of 102) | Digital conversion and data link at each stage. |
| Patenting | People were not interested in patenting the new process (52 out of 102) | This continued throughout the case study. |
| Person-environment fit | People worried about the unknown or known changed job nature thinking they were not fit for it (53 out of 102) | Management, Lean experts & HR continually allayed the fear and imparted training for the new roles. |
| Person identification | The team recommended documenting the person who performed a process so that credit or blame could be allocated if things went wrong (77 out of 102) | This continued throughout the case study to appreciate people while blame was taken by the management collectively. |
| Planning fallacy | People underestimated the task-completion times (45 out of 102) | This continued throughout the case study. Future training on time calculation planned. |
| Priority | The physical unloading of the goods vehicles was done prioritising production urgency | First in First out was made mandatory and were deviations approved by Top Management. |
| Project Shortcoming | Management decided to move ahead in implementing the improved process without achieving the intended results in the process improvement during the initial trial. | This continued throughout the case study. |
| Pseudo certainty effect | People perceived an outcome of the current process was certain and good while it was uncertain due to delays and errors in the process (68 out of 102) | Middle Management pulled out data on manual Kanban failures to counter claim the effectiveness. |
| Self-integrity | High workloads and production urgency meant that sometimes materials were passed to production without accounting. Sometimes this practice brought the integrity of the employees into question as there were material accounting issues. | Accounting was made mandatory, with no deviations. HR had set up a process to identify such issues and take up with concerned department heads. |
| Self-perceived job insecurity | There was self-perceived anxiety that could have been driven by the fear of job loss due to technology advancement innovation, improvement, or alternate processes (72 out of 102) | Management, Lean experts & HR continually allayed the fears. |
| Self-serving (self-centre) | Work would stop or suffer if a person were not present in the place. This assumed that the absentees were the driving force for the project (18 | The digital process was designed to counter this and trials proved effective to extent that manual interventions were not needed. |

| Bias | Examples of biases in the case study | Action taken |
|---|---|---|
| | out of 21 staff). | |
| Stake-holder trust | A security check verifying that the number of boxes or packets tallied against the invoice and a gate entry for the parts was made. | This continued throughout the case study. |
| Standardisation | There was no evidence of standardisation bias, the tendency to be technically correct or correct to the standard format, rather people agreed to the format understood by everyone in the team or agreeable to the culture of the organisation | This continued throughout the case study. |
| Survivorship | More junior people focused on what has survived to the present and ignored those things that had been lost due to the manual process | Management, Lean experts & HR continually allayed the fears and educated them on issues pertaining to the manual process. |
| System- human | People did not acknowledge system and/or human influences and continued the old process thinking it was robust (84 out of 102) | The case study bought an understanding to people in the system and/or human influences and trials changed this mindset. |
| Talent misjudgement | People believed that everyone is an expert innovator and paid accordingly because of the belief that they are capable of finding solutions (66 out of 102) | Management, Lean experts & HR continually emphasised that innovation is teamwork. |
| Technology aversion | Process owners and the team responsible avoided digital technology as they were not comfortable using it. | Management, Lean experts & HR allayed their fears. |
| Trust | Trust deficit was narrated by people (64 out of 102). | Management, Lean experts & HR continually encouraged collaboration and set the value system based on it. |
| Unacceptability | Archived data revealed questions that may have embarrassed or invaded privacy were refused or evaded (97 out of 102) | This continued throughout the case study. |
| Zero defect | Top management realised that, in the material receiving exercise, the tendency to insist on zero defects in a process was evident as they repeatedly stated during the meetings despite knowing that it was impractical | Management, Lean experts & HR continually emphasised error is possible in manual and digital modes. |
| Zero-risk | The preference for reducing a small risk to zero over a greater reduction in a larger risk resulted in the duplicate work of keeping the inspection process at the material receipt stage | Management, Lean experts & HR continually emphasised taking reasonable and calculated risk and the process was designed to pass inspection at the source with an exception for defects captured on the production line and field. |

Table 7: Waste-Related biases and action taken

| **Waste** | **Examples** | **Related biases and action taken** |
|---|---|---|
| Manufacturing (wastes classified by Ohno) | Waiting: Received materials were waiting for processing and intermediate processes within the receiving process had materials waiting for processing.<br>Over-production: The process had multiple checks and counting.<br>Over-processing: The same data regarding part number and quantity were entered multiple times.<br>Defects: Manual errors and process steps missing noticed.<br>Motion or Movement: Unnecessary movement to inspection area and back to receipt area.<br>Inventory: The process took 24 hours to 36 hours to complete, which necessitated additional inventory in the system<br>Transport: Unnecessary movement to inspection area and back to receipt area. | Waiting was influenced by the bandwagon effect and survivorship biases that resulted in long work bias. The inspection process was altered and<br>Over-production was influenced by loss aversion, multiple checks removed.<br>Over-processing was influenced by agreement, confirmation, system human and survivorship bias. The data entries were linked to reducing the number of entries.<br>Defects were influenced by long work bias and process redesigned.<br>The movement was influenced by fear of failure and confirmation bias, the Inspection process reduced to check on field failure and production defects. Inventory was influenced by confirmation and hyperbolic discounting, process redesigned to reduce process time.<br>The transport was affected by herd instinct, Inspection process reduced. |
| Environment | Excess use of resources: multiple data entry consumed excess electricity. Forklifts were used to transport material multiple times (between the storage area and Inspection area) exerting gasses. | Confirmation, herd instinct, long work, herd instinct, system human, agreement, and survivorship bias were primary influencers. Process redesigned to reduce data entry and transport. |
| Information technology waste | Programming defect: Multiple times the same data being entered for completing the process. Hardware defect, connectivity defect, inadequate training and documentation observed. | Irrational escalation, loss aversion, bandwagon effect, and agreement were primary influencers that influenced multiple data entry. Process redesigned. |
| Decision-making individual waste | Store staff kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error. | Loss aversion, bandwagon effect, irrational escalation, and agreement was influencing issue pending. Process redesigned to declare count based on photographic evidence. |
| Department or Function Waste | The procedures for the receipt process had loopholes and each receiving section interpreted it differently. | The bandwagon effect, agreement and confirmation bias were primary influencers. The procedure was documented and people were trained to have uniform practices all across. |
| Decision-making cross-functional team | The Store and purchase cross-functional team delayed decisions on short and wrong supply. | Group formation, clustering illusion, irrational escalation, and agreement were the primary influencers. Management intervention and periodic review reduced differences and |

| Waste | Examples | Related biases and action taken |
|---|---|---|
| waste | | speeded up decisions. |
| Human resources waste | Loss due to absenteeism of operators. | Long work and agreement (over work load) was a primary influencer. Process redesigned to complete tasks within working hours. |
| Enterprise engagement waste | The auditors insisted on zero variation and defect due to the receiving process. | Loss aversion, Choice supportive, Irrational escalation and agreement biases were the primary influence. Management intervened with data from other organisations to convince auditors that corrective and preventive actions will be placed when variation occurs. Process redesigned to reduce variation. |
| Methods waste | The receiving process design had flaws.<br><br>The supervisors kept the issues pending whenever they found an error in incoming materials count until the supplier arrived to accept the error.<br><br>Often operators found shortcuts and missed process steps to help production running | The bandwagon effect, agreement and confirmation bias were primary influencers. Process redesigned and the procedure was documented and people were trained to have uniform practices all across.<br><br>Loss aversion, bandwagon effect, irrational escalation was influencing issue pending. Process redesigned to declare count based on photographic evidence.<br><br>Fear of failure was the primary influencer, process redesigned and corrective and preventive actions were placed when production had issues due to the receiving process. |
| Stress waste | Long work hours created stress for people working in stores. Priorities processing created stress in the working environment. | Long work, zero risk, zero defect, and priority were the primary influence. Process redesigned to complete tasks within working hours and follow first in first out. |

# A relationship between bias, Lean tools, and waste.

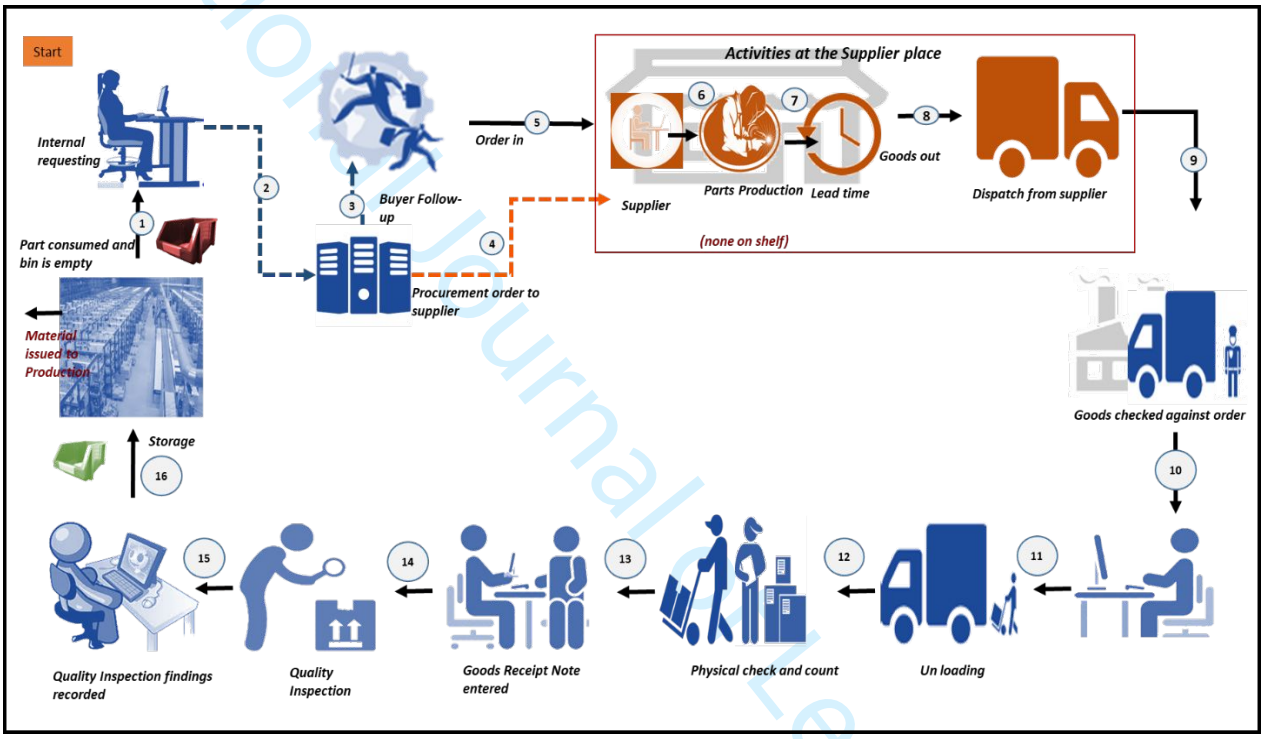


Figure 1 Receiving process before the Lean exercise

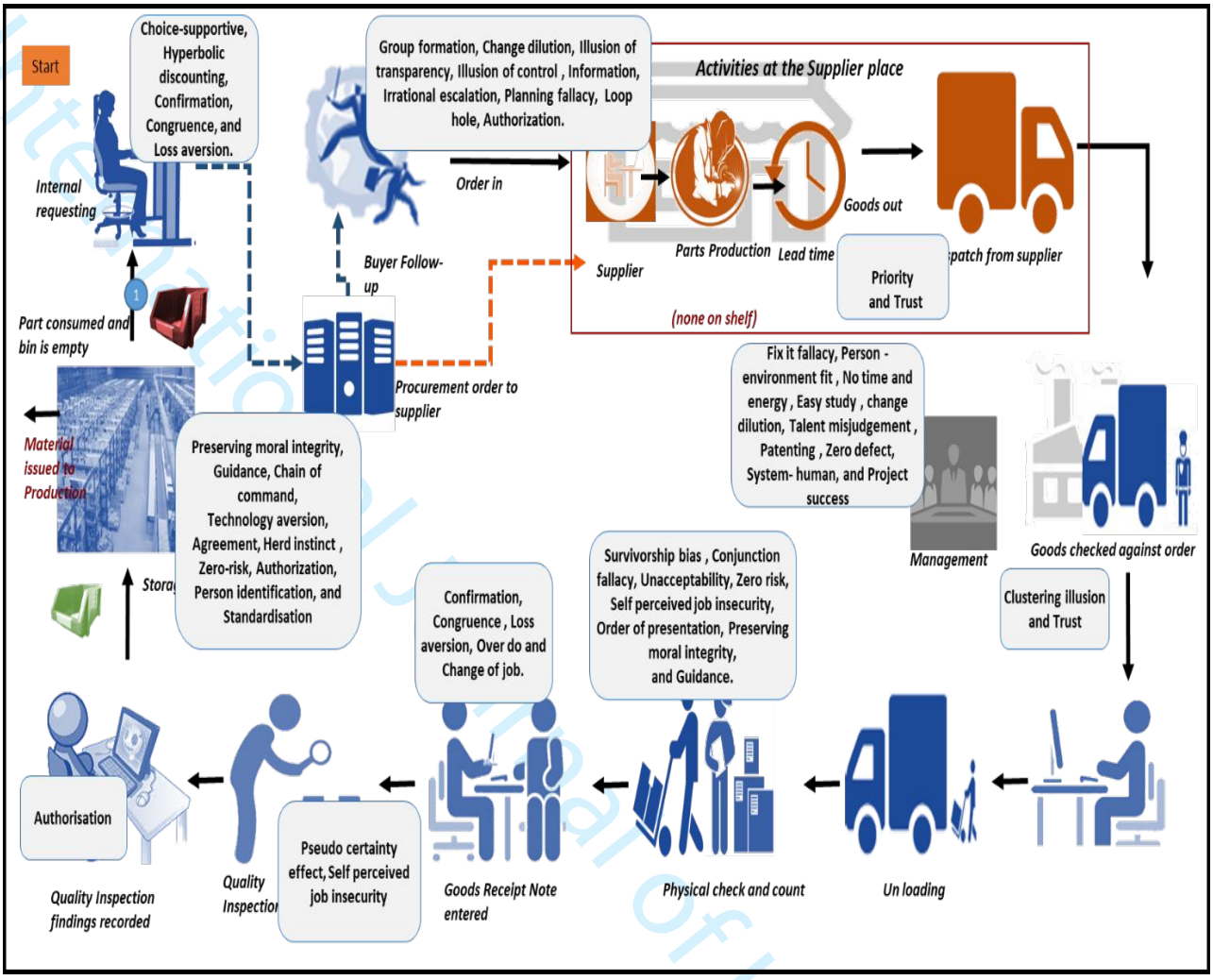


Figure 2 Biases in the receiving process before the Lean exercise

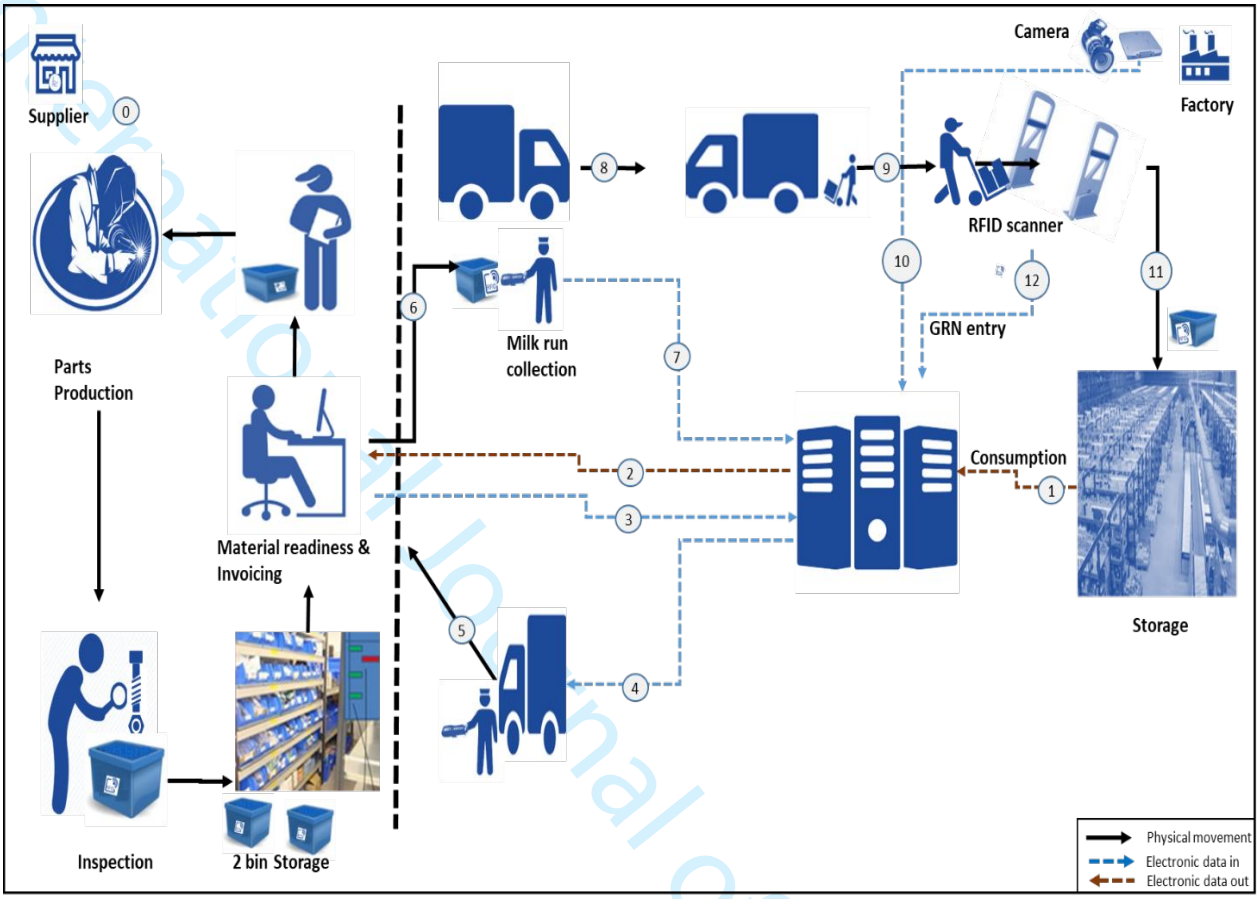


Figure 3 Improved receiving process

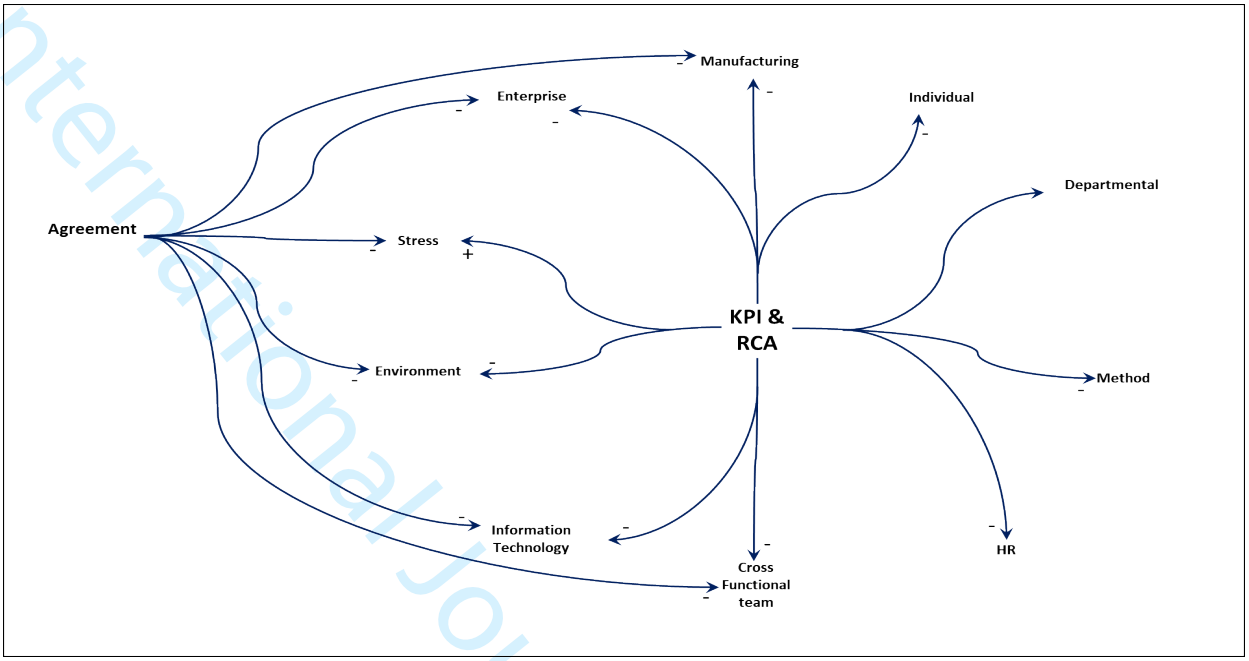


Figure 4: Causal loop diagram

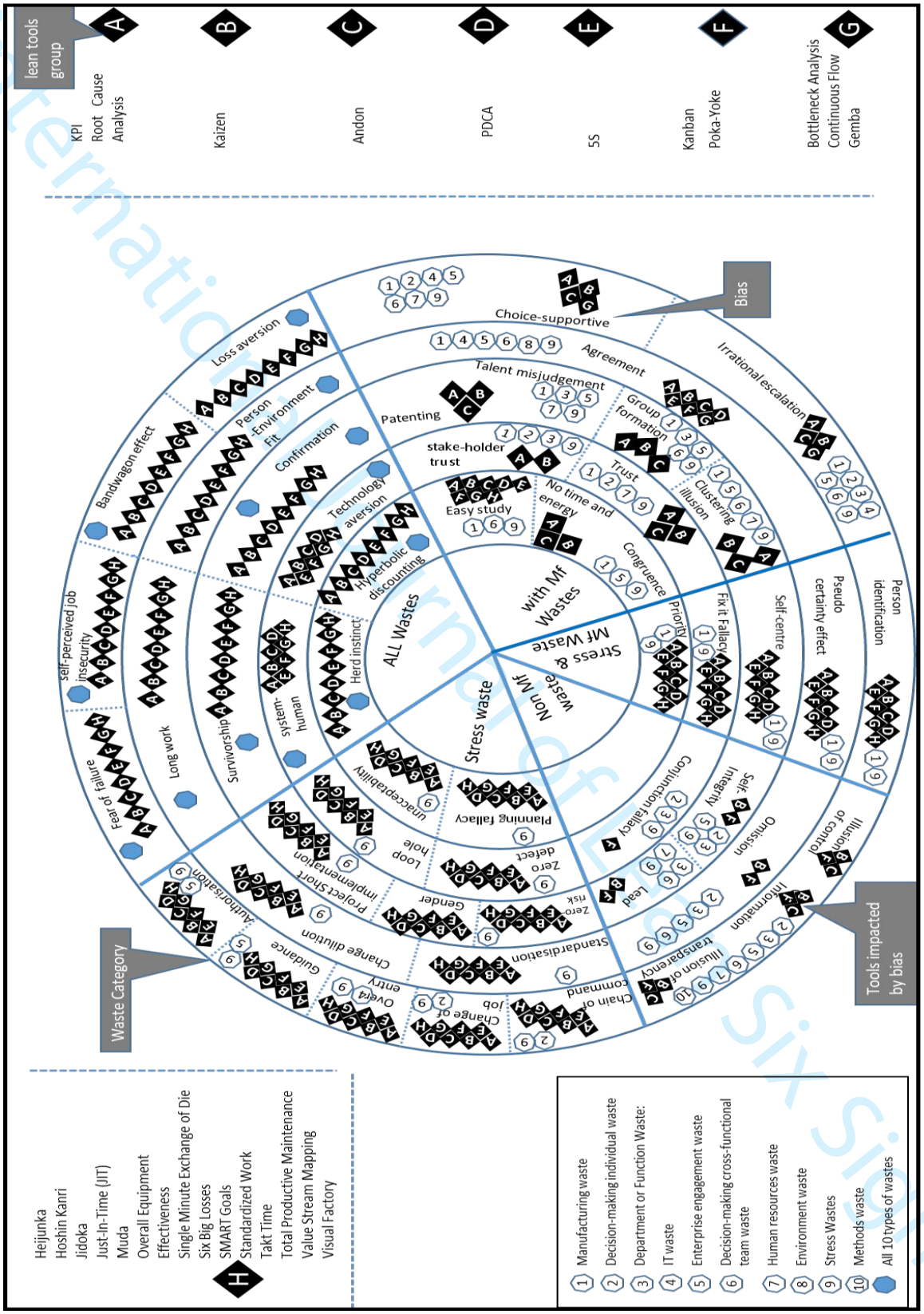


Figure 5 Circle Slice Diagram: Biases, Lean tools, and wastes relationship.