Lean and green in SMEs: Practices for achieving sustainability goals key performance indicators.

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ABSTRACT

This thesis explores how small and medium-sized manufacturing enterprises (SMEs) implement lean and green practices to improve key performance indicators set in order to achieve sustainability goals. In response to the volatile, uncertain, complex, and ambiguous (VUCA) world, the United Nations developed the sustainable development goals in which sustainable transition is a key focus. As a response to these goals manufacturing firms must develop ways to become more sustainable. This thesis identifies how lean and green practices are used, which aim to eliminate waste and enhance efficiency while keeping the goal of environmental harm reduction in mind. Through semi-structured interviews with SME middle managers, this thesis identifies specific lean and green practices such as value stream mapping, just-in-time inventory, product life cycle assessment, and waste management. In total nine interviews were conducted with the participants coming from different countries since the results of this paper can be applied globally. This work also highlights key performance indicators that are specific to sustainability goals by providing real-world evidence and a conceptual model linking lean and green practices with key performance indicators and sustainability goals.

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Keywords
Sustainability, Lean and green Practices, Key Performance Indicators, SME

1. INTRODUCTION

The concept of VUCA was first introduced by the U.S. Army War College to describe the fact that the present world that we live in is more volatile, uncertain, complex, and ambiguous as a result of the end of the Cold War (Khare et al., 2022 as cited in Kinsinger & Walch, 2012). In order to keep up with these changes the United Nations developed the Sustainable Development Goals (SDG) to support global development efforts (Estoque, 2020). More specifically many of the goals such as climate action, life on land, and sustainable cities and communities, are set to promote sustainable transition efforts. Although these goals were implemented as a global effort, the need for adaptability and sustainability is more crucial for manufacturing firms. This claim is supported by Rosen and Kishawy (2012), who emphasized that sustainability is a vital factor for manufacturing firms due to rising environmental concerns and evolving market demands. Furthermore, there is a sense of urgency for manufacturing firms to be more sustainable; as the United Nations reported in 2023 that the manufacturing industry comprised twenty-four percent of global CO2 emissions (United Nations Environment Programme, 2023). The twin transition is a topic that emerged in recent years to address in what ways organizations need to be more agile in response to a VUCA world. The twin transition can be defined as "an intertwined and simultaneous green and digital transition to offset companies' carbon footprint" (Rehman et al., 2023, p.1). However, in this paper, work will be focused primarily on the sustainability portion of the twin transition due to the increasing trend of manufacturing organizations prioritizing environment reduction impact efforts (Chen et al., 2020). Sustainable business practices or green management can be defined as companies implementing eco-friendly business practices throughout their operations to minimize their environmental footprint. (Ma et al., 2018). The challenge at hand now for manufacturing companies is deciding how to adapt current leading practices to support sustainability goals and engrain these practices into their culture. One of the practices used within manufacturing that can be adapted is lean manufacturing.

According to Åhlström et al. (2021), lean manufacturing is an attempt to describe the operational system used by Toyota known as the Toyota Production System (TPS). TPS is defined as a socio-technical system used by Toyota to integrate tools and employees in a way that improves productivity and maintains high-quality standards (Åhlström et al., 2021). This is potentially explained by the traditional explanation of lean principles, which is defined as a philosophy in manufacturing where the main focal point is the elimination of waste (Womack and Jones, 2015). However, the majority of the concluding remarks of Åhlström et al. (2021) were that lean principles is not a theory but rather a system based on many managerial theories that are included within the lean principles. It can be said that lean principles can be applied in many organizations to achieve various goals if there is a supporting theory to back it up (Åhlstrom et al., 2021). Therefore, the conclusion can be made that lean principles can be applied to facilitate sustainable efforts within manufacturing organizations. This is further supported by the work done by Henao et al. (2019) where it was concluded that lean practices also have a positive impact on improving sustainable practices within manufacturing organizations. Furthermore, Afum et al. (2021), found that lean principles have a major role in promoting internal green initiatives and the creation of high-quality, customer-focused goods with environmentally friendly features. A concept that helps encompass these findings, which will also serve as a basis for the work done in this paper, is the concept of lean and green. Lean and green was first introduced by Florida (1996), where it is described as an extension of the traditional concept of lean principles. The goal of lean and green is still to reduce waste and improve organizational performance, however, the goal is now to "manage the elements of organizational sustainability that include emissions, effluent discharge, waste disposal, and energy efficiency" (Mustapha et al., 2017. p.158)

As highlighted by the academic work previously mentioned, vast research has been conducted to study the potential benefits of lean principles on the facilitation of sustainability efforts of organizations. However, most of the work focuses on conceptual work, such as lean and green, to highlight the potential impact of lean principles on sustainability efforts, such as the work done by Florida (1996) and Afum et al. (2021). However, less work has been done on the practical application that organizations can use to implement lean and green practices within their organizations to become more sustainable. For example, Elemure et al. (2023) highlights that there are gaps in the literature on the integration of lean and green practices in manufacturing organizations in a global context. Noting that there is limited specific detail on practical application, suggesting that there is a gap in global understanding of lean and green practices. Likewise, Alipour et al. (2022) note that more research regarding lean and green has to be done in general for manufacturing firms. This is also backed up by Garza-Reyes (2015), where a section of their work is dedicated to identifying potential future research. One of the research areas that they highlighted was the need to identify actual evidence of organizations implementing lean and green. A potential reason for this lack of research in this field is the fact that more work has to be done to identify the key performance indicators used by organizations to analyze if the sustainability goals set by the organization are being effectively fulfilled. This statement is supported by Iranmanesha et al. (2019) who claim that the impact of lean principles, consequently lean and green as well, on sustainable key performance indicators has received less attention in recent literature. Identifying key performance indicators that support sustainability goals is crucial because they serve as a crucial link between business practices and organizational goals (Neely, 2005). Furthermore, Kosasih et al. (2023) highlight that lean and green practices are mostly used by large organizations. However, they argue the importance of SMEs also implementing lean and green as they are the dominant players in various industries. Therefore, the work done in this paper will expand on the concept of 'lean and green' and provide real-world evidence for what lean and green practices manufacturing companies, specifically SMEs, implement in order to achieve their sustainability goals through an analysis of their Key Performance Indicators. The research question that will be explored in this paper is the following: *How do SMEs implement lean and green practices to meet key performance indicators in order to achieve their sustainability goals?*

With this research question, this paper built upon existing literature on the concept of lean and green practices in manufacturing, a concept first introduced by Florida (1996). The main goal of this paper is to show how manufacturing companies can use lean and green practices to achieve their sustainability goals by meeting key performance indicators for the respective goals. This was done through the creation of a conceptualization model. This model clearly shows the connections between lean and green practices, key performance indicators, and their corresponding sustainability goals. This paper also provides evidence for other organizations of what lean and green practices can be used to meet certain or similar sustainability goals. Additionally, the model may act as a tool for managers to evaluate their strategies and make better decisions based on practical evidence. The second goal of this study was to fill a research gap that Garza-Reyes (2015) and Elemure et al. (2023). This was achieved by providing real-world examples of

manufacturing companies that are successfully implementing lean and green practices to achieve their sustainability goals. This evidence will not only help diminish the identified research gap but will also further reinforce the validity of the lean and green concept. Furthermore, the work done in this paper also helps contribute to recent research done on Lean and green such as Kosasih et al. (2023) and Ordonez-Ponce (2023). Finally, the work done in this research paper also helps contribute to the concept of goal setting theory developed by Locke and Latham (2019)

2. THEORETICAL BACKGROUND

2.1 Lean Practices

In order to understand the concept of lean and green, it is important to have a clear understanding of the umbrella concept from which it originated, which is the lean principles concept (Åhlström et al., 2021). Lean principles is a concept in the practice of manufacturing and business operations, where the traditional focal point is the elimination of waste (Womack & Jones 2015). In their work, Shah & Ward (2007) identified three types of waste in lean manufacturing. The first type of waste is overproduction, which is producing more than what the customer demands, leading to excess inventory (Shah & Ward, 2007). The second type of waste is waiting, "to pursue lean production and minimize inventory, firms have to manage variability in supply, processing time" (Shah & Ward, 2007, p.791). For example, this could be the time waiting for materials, information, or equipment leading to idle resources and delays. The third type of waste is inventory waste, "excess capacity is a type of waste and is counter to lean production principles, lowering throughput time reliably to reduce inventory is preferred" (Shah & Ward, 2007, p.791). Besides these three main types of waste, more types are also common in lean principles literature. For example, unnecessary motion is the unnecessary movement of materials or products within the production process, ultimately adding no value (Wahab et al, 2013). Another type of waste is transportation, this type of waste happens when "information or materials change ownership or have to overcome structural barriers. Transportation also occurs when information has to be loaded and unloaded in a person due to knowledge barriers" (Pessôa et al., 2009, p.235). Another type of waste is over-processing, which can be defined as any unnecessary or redundant production steps, creating overly customized or formatted outputs, and performing more iterations than needed, all of which contribute to inefficiency and waste (McManus, 2005). The final common type of waste is defects, more specifically producing defective products, which requires rework or scrapping, leading to increased costs and delays (Wahab et al, 2013). As mentioned before, the goal of lean principles is to reduce as many of these wastes as possible (Shah & Ward, 2007). The reason why these types of waste need to be identified is because according to Fliedner (2008), the practices from Lean Principles, including waste elimination, can also improve sustainable practices within organizations and thus supporting lean and green practices. However, according to Åhlstrom et al. (2021), the focus of lean principles is not just the elimination of waste.

One of the other goals of the lean principles is to identify what value means from a customer's perspective (Womack & Jones, 1990). This involves identifying processes and activities that directly contribute to customer satisfaction (Womack & Jones, 1990). Another goal of Lean Principles identified by Womack & Jones (1990) is value stream mapping which refers to the action of visualizing the entire production process and from there

identifying bottlenecks and areas for improvement. The third goal is to have dedication to continuous operational improvement. Ohno (1988) introduced the concept of "Kaizen" as making small and incremental steps on a regular basis. This means that lean practices are not a one-and-done implementation but also a corporate culture focused on continuous improvement to maintain adaptability to changing business environments. The final goal is to engage employees in the lean process as lean principles can benefit from high levels of employee engagement (Støle and Ekeren, 2015). Furthermore, lean practices can enhance the quality of products through their focus on continuous improvement and defect prevention (Neely, 2005). Another benefit is that lean methods can improve responsiveness to customer needs, and ultimately higher customer satisfaction (Womack and Jones, 2015). Finally, lean practices can introduce a culture of continuous improvement capable of responding effectively to changing market demands and challenges (Fliedner, 2008). Once again, it is important to emphasize that the benefits of lean principles can also be found in lean and green practices. Since Åhlstrom et al. (2021) identified lean principles as an umbrella concept many of the practices of lean principles, such as kaizen, value stream mapping, and respect for people, can also be used within lean and green practices to achieve sustainability goals.

2.2 Lean and green

2.2.1 Overview of lean and green

From the work done by Afum et al. (2021), it was concluded that lean principles can help with the implementation of internal green practices and the production of quality products with eco-oriented features that meet customers' needs. Thus, highlighting the potential positive impact of lean principles on sustainable efforts by organizations. This claim is further supported by Choi et al. (2022) who emphasize the need for manufacturing companies to combine traditional lean methods, such as the ones previously explained before, with sustainability-specific concepts such as energy recovery and waste material reuse. The combination of these two practices has been given the name "lean and green" (Florida, 1996). Furthermore, King and Lenox (2001) further developed the concept of Lean and green by arguing that lean practices complement green initiatives and thus hypothesized that organizations that implement lean practices are also more likely to adopt environmental management systems. Similarly, Dües et al. (2013) hypothesized that reducing waste and improving efficiency in manufacturing processes naturally leads to both economic and environmental benefits, which helps highlight the close relationship that lean practices and lean and green have. This hypothesis is further supported by evidence suggesting that lean practices can lead to enhanced resource efficiency and waste minimization, thereby supporting environmental goals (Garza-Reyes, 2015). There is plenty of research to suggest the positive impact of lean principles on sustainability efforts, such as the ones mentioned previously, however, there are still challenges faced within the implementation of lean and green. If these challenges are not addressed this could result in the improper implementation of lean and green which could prevent organizations from achieving their goals (Florida, 1996).

2.2.2 Challenges in implementing lean and green

Despite the positive outcomes of lean and green, the implementation of these strategies still faces many barriers. It is important to identify these challenges in order to come up with solutions to overcome them, ultimately ensuring that lean and green is implemented properly. One of the initial difficulties

arises with the initial cost of investment required to modify existing procedures and operations within SMEs (Dües et al., 2013). The work done in this paper will be focused exclusively on SMEs. Therefore, questions will be asked to identify if this is indeed true, and then follow-up questions will be asked to identify what practices SMEs implement to overcome them. Additionally, Garza-Reyes (2015) identified that literature regarding lean and green lacks clear and consistent conclusions, thus making it difficult for organizations to implement it. Moreover, the balance between lean practices and green efforts is not always straightforward. Florida (1996) identified that some lean practices may inadvertently lead to increased environmental impact if not properly implemented and managed. The common issue with the implementation of lean and green within organizations is that clear guidelines and frameworks that result in consistent outcomes don't seem to exist for the concept, thus making it difficult to systematically implement (Dieste et al., 2019; Rodrigues & Kumar, 2019; Teixeira et al., 2022). More specifically Dieste et al (2019) states that "the results achieved to date are not always consistent with themselves as some studies strongly highlight the existence of a positive relationship while others are more cautious by suggesting that lean practices' implementation does not necessarily enable green performances in firms" (p.120). This suggests that there seem to be inconsistencies in the lean and green literature. Such inconsistencies make it difficult for any organization to implement lean and green practices which are identified in the literature. Thus, being the purpose of this paper which is to identify what practices SMEs use that could fit under the concept of lean and green and serve as real-world evidence of the literature work already done on the topic.

2.3 Key Performance Indicators

Neely et al. (1995) defined key performance indicators as "the process of quantifying the efficiency and effectiveness of actions" (p.80). Key performance indicators are crucial to an organization because they provide information to decision-makers about the success or failure of past actions and may also provide information about future actions (Neely, 2005). With this information, it can be concluded that key performance indicators for lean and green practices are crucial for understanding whether sustainability goals are being achieved or not. Therefore, it is important to identify key performance indicators that are used to support sustainable transitions which also fall under lean and green. Examples of traditional key performance indicators are financial measures such as ROI or profit margins, productivity measures such as output per worker or labor costs, quality measures such as defect rates, and finally delivery speed measurements such as lead and delivery times (Neely, 2005). It is important to identify these traditional performances because they can be used as examples during interviews to help managers identify or reveal information about similar key performance indicators that they may have to support sustainability goals. Examples of potential sustainability key performance indicators could include the percentage of recycled materials, energy consumption, and greenhouse emissions (Mishra et al., 2017). For example, Fullerton & Wempe (2009) argue that non-financial performance measurements help mediate the relationship between lean manufacturing and financial performance. Although the study was done for financial goals, nonetheless this demonstrates the relative importance of key performance indicators on the achievement of organizational goals in general.

Dües et al. (2013) explain that lean methods should be integrated with the firm's overall strategic objectives to ensure a good established foundation for sustainable transitions, also falling under lean and green practices, which can be quite challenging for organizations to do. As a result of these challenges arising, frameworks can be created to facilitate the selection and application of performance metrics for lean practices, and thus lean and green Practices as well (Farias et al., 2019). One of these frameworks is the Balanced Scorecard framework (BSC). The BSC framework measures the performance of four different perspectives: financial, customer, internal processes, and learning and growth (Kaplan & Norton, 1992). The other framework is the Lean Performance Measurement System (LPMS). The LPMS follows a structured approach for selecting and utilizing performance metrics that are directly aligned with specific lean principles (Shah & Ward, 2007). It is important to highlight these performance measurement frameworks because they can allow organizations to identify and mitigate the challenges they may face when pursuing sustainability goals. Furthermore, for the context of this paper, they can also serve as performance measurement examples that can be asked to ask managers during the interview in order to identify if they have something similar set in place within their organizations to support their sustainability goals. Identifying these key performance indicators that fall under lean and green will then facilitate the identification of practices, which are lean and green, which directly help achieve these measurements.

3. METHODOLOGY

3.1 Research Design

This research aimed to identify lean and green practices, that were implemented within small and medium-sized enterprises, which are used in order to achieve key performance indicators set in place to support sustainability goals. The research is qualitative as it is more useful than quantitative research to identify and explain thematic patterns (Draper, 2004). The first aim was to identify which sustainability goals SMEs have and what their respective key performance indicators to track these goals are. The second aim was to identify which lean and green practices were implemented to achieve these key performance indicators. To resolve these aims a qualitative research design was used, specifically through semi-structured interviews with SME middle-managers. This type of research was selected because it follows the interpretivist philosophy. This means that ideas and conclusions about lean practices and their effects are constructed through the experience and interpretations of SME middle managers themselves (Creswell and Poth, 2017). Furthermore, semi-structured interviews are flexible and give the possibility to go further into specific topics that might be brought up during the interview (Patton, 2014). The interviews had a duration of 45 to 60 minutes approximately to ensure there was enough time for managers to elaborate their answers and gather as much data as possible. Before conducting the interviews with SME middle managers, an ethical approval form was sought from the University of Twente to be able to conduct the interviews. This process ensured that the research conformed to ethical standards when involving human participants. This included informed consent from the managers, where they were informed about the purpose of this research and that what they said would be used as data. Furthermore, it was made clear that any information deemed confidential was not used in the analysis of data. SMEs were the targeted organizations as they represent 90% of businesses and account for more than 50% of employment worldwide (*World Bank SME Finance*, 2024). Therefore, the evaluation of SMEs was valuable as their adoption of Lean and green practices can have a widespread impact on sustainability in the manufacturing industry.

3.2 Data Collection & Sampling

In total nine interviews were conducted as this was enough interviews to make meaningful conclusions and fit within the

Participant/Role	Gender	Industry	Title	Country of Operation
P1, CEO	Male	Metal Parts	CEO	China
P2, Employee	Female	Automotive	Key Account Manager	Italy
P3, Employee	Male	Stamping	Director of Engineering	United States
P4, Employee	Male	Stamping	Environmental, Health, & Safety Manager	United States
P5, Employee	Male	Die Casting	General Manager	Italy
P6, Employee	Female	Die Casting	Key Account Sales Executive	Italy
P7, Employee	Male	Automotive	Managing Director	Mexico
P8, CEO	Female	Automotive	CEO	India
P9, Employee	Male	Manufacturing	Quality Assurance	India
P10, CEO	Male	Surface Finishing	CEO	Germany
P11, Employee	Male	Manufacturing	Director	Mexico

Table 1

scope of the tools and time needed for this research. A summary of the basic information of the participants can be found in Table 1. Purposive sampling was used to recruit SME middle managers or any employee with the knowledge required to participate in the interview. Purposive sampling refers to a group of non-probability sampling techniques in which participants are selected because they have the required characteristics needed to gain information on a subject (Rai, 2015). The main target group for this sample was SME middle managers of organizations that are focused on manufacturing. Middle managers were chosen due to their accessibility and insight into daily operations, including key performance indicators. Furthermore, according to Van Dun et al. (2017), middle managers are in a position where they have contact with both executive management and front-line workers. This facilitated the process of contacting someone else who might know the necessary information, should they not have it. However, any employee who could answer the question was eligible for participation including CEOs, managing directors, executives etc.… Participants were chosen from different countries as previously identified, through the work of Elemure et al. (2023), Lean and green is a global effort, and therefore diverse opinions are valuable and are required for accurate results. Participants were reached out through LinkedIn and connections. Prior to the selection of managers, a quick investigation of the company's website was done to ensure that sustainability or anything related was one of the focal points of the organization. For example, most participants' organizations dedicated a section of their company website to highlighting their sustainability and provided accompanying information that revealed how they plan to achieve these goals. The interviews were recorded for data analysis purposes only if consent was granted from the participants. The tool used for voice recording was a personal smartphone. The interviews were conducted online via Microsoft Teams. Sample questions that were asked include: "What sustainability goals does your organization currently strive for?", "What key performance indicators do you have set in place to track your sustainability goals?", and "What practices do you implement to achieve these key performance indicators?"

3.3 Data Analysis

For the data analysis phase, a thematic analysis approach was used to analyze the transcripts of the interviews. Thematic analysis is a widely used qualitative data analysis method that focuses on identifying, analyzing, and interpreting recurrent themes within data (Braun & Clarke, 2006). This means that rather than applying a pre-established framework to interpret the interviews, the analysis was influenced by the received content from the interviews. To ensure a structured approach for data analysis the following steps were taken. Transcripts from the videos were made using the Sonix.ai website. This was done so that it was possible to read and re-read the comments of the managers. Sonix.ai automatically transcribed what was said in the audio files of the conducted interviews. The transcripts given by Sonix.ai were then re-read in order to delete any information that was deemed confidential or sensitive. For example, the names of participants and the names of any companies were redacted from the transcripts. Furthermore, the transcripts were also cleaned to ensure that what was said in the interviews was what was written in the transcripts. These transcripts were then uploaded to ATLAS.ti for analytical purposes. ATLAS.ti is a qualitative analysis tool, which was used to generate first-order codes from the interview transcripts by following the gioia methodology. The gioia methodology consists of steps required to bring rigor to qualitative research (Gioia et al., 2012). The gioia methodology was used in order to create first-order codes, second-order codes, and the aggregate dimensions which were used to create the conceptualization model shown in Figure 1. The first-order codes were created by reading the transcripts of the interviews and highlighting any direct ideas or comments that the participants mentioned. After having these codes completed a process of examination of the data was conducted. In this examination, recurring themes were uncovered for all variables and thus second order-codes were created. Examples of these are waste reduction, CO_2 emissions, and employee engagement in sustainability. By coding the data in this format, the themes were separated into manageable parts. This approach is aligned with the thematic analysis methods described by Braun & Clarke (2006). Once the key performance indicators were coded, the same process was repeated however, this time the focus was put on identifying what lean and green practices are mentioned by the managers. Once the second-order codes were completed, they were used in order to create the aggregate dimensions. Figure A of Appendix 8 shows all the codes generated using ATLAS.ti and analyzed trough the gioia methodology. These aggregate dimensions were then used to create a visual representation that

clearly shows the relationship between sustainability goals, key performance indicators, and lean and green practices. This visual representation is supported by the work of Lee and Rojas (2013), who argue that project management is facilitated by visual tools. Therefore, managers will be able to use the visual model created in this paper to facilitate their Lean and green practices.

4. RESULTS

This research investigated "How do SMEs implement lean and green practices to meet key performance indicators in order to achieve their sustainability goals?". Figure A, in Appendix 8, illustrates the data structure which shows the relationship between the first and second-order codes, which were then used to derive the aggregated dimensions used in the conceptualization model.

4.1 Sustainability Goals

The data gathered from the interviews indicated that the Sustainability goals that the companies interviewed are striving for can fall under two categories. These two categories are environmental sustainability goals and employee sustainability goals.

4.1.1 Environmental Sustainability Goals

From the interviews, it was gathered the sustainability goals that they followed involved the consumption of energy in some manner. For example, when one manager was asked about what sustainability goals their company follows, they answered by saying "*We have the affordable and clean energy, responsible consumption and production and work and economic growth. It's the least that you can see here*" (P5). Likewise, another participant answered that "*The first thing we, we actually released on the affordable and clean energy I mean supply the economical component to support our clean energy system customer to affordable clean energy strategy*" (P1). These are only two examples, but all participants mentioned energy as one of their goals. These quotes gathered from managers were coded as first-order codes which were then used to derive the second-order quotes category. Codes relating to energy were categorized into the "Affordable and Clean Energy" category. The second goal regarding sustainability which was mentioned by all managers was "Reduce Carbon Emission". For example, one participant stated that "*A target so far for the CO2 was set by the science-based target and the CDP and is a reduction of the emissions by the 50% by 2030*" (P2). The next goal that was mentioned by most managers regards the waste generated and the acquisition of material that is specific to each company. The second order code category given to this is "Resource Conservation". Each company has different goals regarding the materials they use in their production. For instance, one participant mentioned that "*We have our objectives for 2024. And there's four of them. I think mine is dated 2023. I might have an older version, but I don't think it's changed. Extending our coolant life. So, we use a lot of coolants. For our metals. Metal forming processes*" (P3). Moreover, another participant said that "*But for a special company which is specialized in ways of material another point that is really important is water usage. This is the consumption that we have for water. What kind of or how much water we are using in our process*" (P5). Although the goals are different for each company, each one relates to the conservation of an important resource for them, which is why this second-order code is called "Resource Conservation". Finally, all companies acknowledged "Energy Consumption" as being important even though they might not have had it as a direct goal. For example, one participant mentioned that "*And

then, of course also for the maintenance of our facilities, we take care about the reduction of the energy consumption" (P2). To summarize from the data gathered in the first-order codes, four distinct second-order code categories were identified: "Clean and Affordable Energy", "Reduce Carbon Emission", "Resource Conservation" and "Energy Efficiency". After figuring out the companies' respective sustainability goals, questions were then asked with the intention of figuring out how these sustainability goals were communicated across the company. First-order codes gathered from these questions were then labeled "Sustainability Communication" as second-order codes. However, environmental goals were not the only focus for companies regarding sustainability.

4.1.2 Employee Sustainability Goals

When asked about sustainability goals, it was expected that companies would primarily focus on environmental goals. However, a couple of managers highlighted that sustainability doesn't only mean being wary of the environment, but also ensuring the well-being of their employees to ensure the survival of their company. For instance, one manager said that "*We have a couple of things I mean, the first employee engagement in sustainability to encourage employee to actively participate in and contribute to the sustainable practice*" (P1). Furthermore, another participant would agree as they said the following "*What is my concept of sustainability? For me, work environment is also how the people are feeling working in the company. This is why it's important for me also, not just to focus in the environmental topics. Also focus in the team because also the team is a complement to have these sustainability strategy*" (P5). From the data gathered in the interviews, environmental concerns are a significant component of sustainability, however, the insights from these managers underscore the importance of incorporating employee well-being and engagement into a holistic sustainability strategy as well.

4.2 Key Performance Indicators

The second part of the research focused on the respective key performance indicators used by companies to monitor, track, and measure their sustainability goals. From the first part of the research, it was derived that organizations typically follow two sustainability goals: environmental and employee-focused goals. This section of the research focused on asking questions to managers to figure out the respective key performance indicators used for each group of sustainability goals. Therefore, the key performance indicators were also divided into their respective goals: environmental goal key performance indicators and employee sustainability goal key performance indicators. Furthermore, a mediator variable was also derived from the interviews which was given the name "Monitoring Tools". The interviews revealed that monitoring tools were used in order to facilitate the process of monitoring and tracking key performance indicators that were used for sustainability goals.

4.2.1 Environmental Goals Key Performance Indicators

From the data gathered in the interviews, it is evident that key performance indicators vary from organization to organization. This is to be expected given that they all have different sustainability goals. However, there are still elements that are present throughout most if not all organizations. For example, many organizations mentioned that part of the monitoring process of their sustainability goal was greatly achieved through their compliance of the ISO 14,001 certificate. For example, one manager stated that "*So if you use ISO 14,001, a lot of what our

system is modeled after are the requirements of the ISO 14,001" (P3). Likewise, another manager said that "*What's important to say about environment Key Performance Indicators is that we have an environment certificate. So, we are certified with 14,001, which is the norm related to the environment. So, there are some standards that we have to keep have this certification since 2015*" (P4). These are two examples, however, many of the managers interviewed mentioned the certificate as part of their performance measurement. In the discussion portion of this paper, the ISO 14,001 certificate will be further examined and will be analyzed to reveal why many organizations use this certificate as a performance measurement. The second common trend for key performance indicators was that all companies had KPI's that were measured by examining the consumption of a resource for every unit of output of a product. For example, one participant mentioned the following "*We have a couple of so-called aspects for environmental carbon emission, including the total emission per unit of a product and volume by the energy consumption, such as total energy consumption energy consumption per unit of the output*" (P1). From this statement the key performance indicators used are tailored to the specific sustainability goals that this company has; however, they are measure by analyzing the consumption of a resource per unit of output. Another participant had similar key performance indicators "*So based on our objectives, you know how much coolant we have a way of tracking how much coolant per thousand pounds of steel that we use*" (P3). Once again, the performance measurement is tailored to the resource the company uses but is tracked trough the same process previously mentioned. Another example was given by P6 who mentioned the following in regard to keeping track of waste generated "*Waste, how many kilograms we are wasting per month in the whole year. We have a target of four tones per year*" (P6). These examples show how the unit of measurement was tailored specifically to the key performance indicator that each organization was keeping track of.

4.2.2 Employee Sustainability Goal Key Performance Indicators

Similar to the environmental goals, the key performance indicators for employee sustainability goals also vary amongst the organizations. However, there is one manager who was able to give concrete examples of specific key performance indicators used to keep track of employee sustainability. This manager said that "*for the social aspect I mean, like employment satisfaction employee training duration and coverage employee diversity and inclusion indicator, community engagement and contribution.*" (P1). To ensure that the key performance indicators for both environmental and employee sustainability goals are effectively tracked and aligned with the overall objectives companies can employ monitoring tools. These tools act as mediators, bridging the gap between setting sustainability goals and assessing their performance.

4.2.3 Monitoring Tools

From the interviews, another variable was derived that acts as a moderator for the relationship between sustainability goals and key performance indicators: monitoring tools. All managers mentioned key performance indicators that help keep track of their sustainability goals. However, only one manager mentioned specific tools that help the monitoring process of these key performance indicators. This manager had the following to say "*You know, as I mentioned in our monthly basis, we have a thing called a balanced scorecard. In the balanced scorecard, we have our KPIs. We have a yearly target. And in the yearly target*

in December when we are closing the year. we are reviewing what was the performance of every indicator" (P6). The tool that the manager mentioned is the balanced scorecard approach. This will be further examined in the discussion portion of this paper. The same manager also mentioned another tool "*We had a management meeting, and we are making a forecast. So for the next year, how many potential kilowatts we will be using*" (P6). The tool the manager referred to was forecasting. The insights from this manager highlighted the significance of these tools in effectively monitoring and evaluating performance indicators. These tools will be further examined in the discussion portion of this paper to explore their role in enhancing the sustainability efforts of organizations.

4.3 Lean and green

The final focus of the research was to uncover what practices and strategies companies employ in order to achieve the key performance indicators that they had set for their respective sustainability goals. More specifically, the goal was to find what practices they employed that fall under the concept of lean and green. The interviews revealed that all organizations employ lean manufacturing principles, however not all organizations employ specifically lean and green. The interviews revealed that organizations realized that lean manufacturing principles also improved the environmental key performance indicators set by the organizations. Therefore, the strategies identified in the first order codes were grouped into either lean manufacturing principles or lean and green. Moreover, two moderator variables were also identified: employee engagement and automation.

4.3.1 Lean Manufacturing

The interviews revealed that some organizations did not follow specific lean and green strategies in order to improve their key performance indicators. However, all managers commented that they noticed that traditional lean manufacturing strategies helped improve their key performance indicators trough an indirect relationship. The first lean manufacturing principle that many managers mentioned was the concept of "Process Optimization". One participant stated that "*For the lean practice, process optimization with the continuously review and streamline process to eliminate the waste and increase the efficiency*" (P1). The same manager then mentioned that this strategy could be applied in "*in the area related to the energy usage resources consumption and the supply chain management*" (P1). Furthermore, another manager had something similar to say regarding the topic "*So we're a stamping company. And so let's just say we make a thousand different parts. So every one of those parts, everyone has its own process. And if we're trying to increase the, the stroke per minute by 10%, in essence, we're reducing energy, we're reducing waste, we have less scrap. So that's why like if you looked at our metrics that we had an 11% reduction in energy*" (P3). In this quote, the manager mentions stroke per minute, which is something specific to their company. However, it follows the same principle of optimizing their process of production. This manager also reveals how by focusing on process optimization sustainability key performance indicators also improved. Another common lean manufacturing tool used is the 5s principle. One participant had the following to say "*We have A 5S Principle that's in place. We do five S audits. There's layered audits with those*" (P3). Another participant said "*On the other hand you can have 5s which is also important not only for physical processes but also for the information transfer. So I think they are all very important*" when answering what lean principles their company used for their manufacturing processes. The 5s principle and process optimization were the two lean manufacturing principles that were commonly used by most

organizations. However, some managers mentioned lean manufacturing principles that might not be known to the other companies. These methods are heijunka, jidoka, SMED, overall equipment effectiveness & ishikawa diagram. Heijunka, jidoka, SMED, and overall equipment effectiveness were taken from Participant 6, while the ishikawa diagram was taken from Participant 3.

4.3.2 Lean and green

From the interviews, a list of lean and green strategies used to support key performance indicators was gathered. The following lean and green Practices were mentioned: Value stream mapping, just-in-time inventory, product life cycle assessment, and waste management. These methods were acquired from different managers. One manager said the following regarding value stream mapping "*The second for the value stream mapping we Define and address the bottom line. And that the electricity in the flow of a material and the activity impact sustainability performance*" (P1). Just-in-time inventory was mentioned only by one manager who said the following "*And the third point is the just in time inventory management to reduce the waste and the storage related impact by minimizing excess inventory*" (P1). Life cycle assessment was mentioned by five managers, more specifically one manager said the following "*then the consumption and production is so related to the life cycles of our items, our scraps, our process*" (P4). Waste management was mentioned by four, for example, one manager said "*Third, one waste segregation and the recycling program in through the proper separation and recycling of waste to meet the reduction and reuse target*" (P1). Lastly, lean energy was mentioned by three, specifically one manager said that "*we started to make some investments especially for photovoltaic systems in order achieve and reach this target*" (P2). The implications of these lean and green strategies will be further explored in the discussion.

4.3.3 Automation and Employee Engagement

Besides the identified lean and green practices that help achieve the set key performance indicators. From the interviews, two mediator variables were identified. The first one is automation. One manager had the following to say concerning the role of automation in their organization "*We're doing a lot of work with process automation, changing the processes… So it takes hundreds and hundreds of hours out of the process*" (P3). This is the first moderator variable that was identified. Regarding employee engagement in their organization, the manager had the following comment "*We also can set up the example we also can encourage the innovation to establish some kind of a incentive system to encourage employees to come up with a innovative idea and the practice related to the sustainable development*" (P1). The role of both of these moderator variables will be expanded in the discussion.

5. DISCUSSION, LIMITATIONS & FUTURE RESEARCH

5.1 Discussion

This thesis examined the lean and green practices employed by manufacturing organizations to achieve key performance indicators and meet their sustainability goals, while also exploring the relationship between these variables. The research revealed important information about all three variables.

First, sustainability goals were divided into two categories. Environmental sustainability goals and employee sustainability goals. Environmental sustainability goals can be defined as "meeting human needs without compromising the health of ecosystems" (Calicott and Mumford, 1997, p.1). However, the work done in this research revealed that human needs were replaced by organizational needs. This research also found that employee sustainability goals can be defined as goals set in the workplace to ensure the well-being and retention of employees. The reasons why organizations chose to pursue these sustainability goals were primarily due to stakeholder influence, law and regulation compliance, and local environmental issues.

In order to keep track of these goals, the organizations employed the usage of key performance indicators. Key performance indicators are crucial to an organization because they provide information to decision-makers about the success or failure of past actions and may also provide information about future actions as discussed in the theoretical background (Neely, 2005). This was confirmed by this research as all managers mentioned what key performance indicators, they use in order to keep track of their sustainability goals. The interviews revealed that key performance indicators used to track environmental sustainability goals relied more on quantitative units of measurement, whereas employee sustainability key performance indicators were monitored using more qualitative measurements. For example, energy consumption per unit of output was one of the key performance indicators used to keep track of energy consumption, and one way in which it was monitored was through the measurement of kilowatt consumption for that output. The results of this research revealed that some quantitative key performance indicators were tailored to each organization. This means that every organization can look for inspiration from what others are doing, however in the end key performance indicators have to be tailored to the needs and situations of each organization. This is similar to the key performance indicators highlighted by Mishra et al. (2017) in the theoretical background of this paper. On the other hand, qualitative methods such as employee satisfaction were used to keep track of employee sustainability key performance indicators. Furthermore, this research found that monitoring tools is a variable that enhances the connection between sustainability goals and key performance indicators. More specifically, these tools are the Balanced Scorecard Approach (BSA) and forecasting. The BSA is "a set of measures that give top managers a fast but comprehensive view of the business" (Kaplan & Norton, 1992, p. 1). In the context of this research, the BSA was used as a tool to help support the tracking and monitoring of the established key performance indicators that were set to meet environmental sustainability goals. Forecasting is the process of predicting the future based on knowledge from the past (Petropoulos et al., 2022). In this research, managers used forecasting as a method to predict the potential future value of their key performance indicators, thus also serving as a complementary tool in the efforts to measure sustainability goals. This supports the ideas of Neely (2005), who highlights the importance of key performance indicators due to their value to managers in helping make informed decisions about potential future actions. Now that the relationship between sustainability and key performance indicators has been established, the importance of lean and green practices for achieving said key performance indicators will be explained.

First, it is important to mention the role of lean manufacturing in this research. As stated before, the purpose was to analyze what and how lean and green practices help improve key performance indicators. However, this research revealed that lean

manufacturing practices can also have an indirect effect on key performance indicators. The interviews revealed that some organizations don't implement lean and green practices as such but still focus on lean manufacturing practices such as process optimization and the 5s Principle. Although the goal of these two methods was not the improvement of environmental goal key performance indicators, they still had some effect on them. For example, process optimization is the activity of selecting and improving a best practice to achieve a certain task (Afteni & Frumuşanu, 2017). This research revealed that by optimizing their processes organizations were able to improve their key performance indicators values without having them as the central focus. Other examples mentioned by managers of lean manufacturing principles include the 5s principle, heijunka, jidoka, single-minute exchange of die, and overall equipment effectiveness. All of these methods can be applied in the context of lean manufacturing however will also result in improved key performance indicators to a certain extent. These findings are similar to the work done by Afum et al. (2021) who concluded that lean manufacturing practices aid the implementation of internal green practices. However, managers mentioned specific methods they used in order to exclusively improve their key performance indicators, which are the lean and green practices.

This research revealed that lean and green practices can be used in order to achieve the key performance indicators set by organizations. The identified lean and green practices were value stream mapping (VSM), inventory management, energy management, waste management, product life cycle assessment, and lean energy adoption. VSM is normally considered a lean manufacturing tool used to track and control the flow of material through supply chain networks (Lian & Van Landeghem, 2002). However, this research found that managers can also apply VSM in contexts regarding sustainability. As an example, organizations can use VSM to directly track the flow of electricity usage and identify areas where it can be improved. Thus, VSM can also be considered a lean and green practice. This supports the idea of Choi et al. (2022) who claim that traditional lean manufacturing practices should be combined with sustainability-specific concepts such as the one provided in the example. Likewise, inventory management is a strategy that is considered a lean practice whose goal is to identify how much inventory of a product is exactly needed at a time to prevent the extra usage of money, space, and time (Koumanakos, 2008). However, this research revealed that proper inventory management can reduce waste generation and thus support the corresponding waste reduction key performance indicators. This means that inventory management can also be considered a lean and green practice and can be applied to improve any waste reduction key performance indicators. Likewise, another lean and green tool used by managers to manage waste is waste management. Waste management is a structured approach to handling waste which includes the identification and measuring of waste, understanding the causes of said waste, and finding practical ways to reduce it (Fercoq et al., 2013). This research that typically organizations have a person or group in charge of this responsibility. The next lean and green practice used by managers was the product life cycle (PLC). This research revealed that PLC can be used as a lean and green practice. A product's environmental impact should be considered throughout its entire life cycle to make informed decisions. As an example, organizations can use PLC to track the energy consumption of a product through its entire life cycle and identify areas where it consumed the most energy, and then analyze what is the reason for this. Finally, lean energy adoption marks the final lean and green method revealed in this research. Lean energy is the process of focusing on energy efficiency and sustainability while

implementing lean principles (Halldórsson et al., 2018). One of the ways in which lean energy was applied was through the usage of renewable energy, such as solar or wind energy. Furthermore, photovoltaic systems were also implemented to support lean energy adoption. Besides these lean and green practices, two variables were identified as complementors to the process of using lean and green practices to improve key performance indicators.

The first variable is automation. The purpose of automation is "to perform functions more efficiently, more reliably, and more accurately than human operators" (Frohm et al., 2006). These are the qualities why automation serves as a moderator for the process of improving key performance indicators through the use of lean and green practices. This research found that automation does not directly influence the key performance indicators, however, it was implemented by organizations to improve their already existing lean and green practices. This means that automation can act as a moderator to improve the process of meeting key performance indicators through the implementation of lean and green practices. Finally, the second identified variable was employee engagement. In this research, employee engagement refers to the process of involving employees in the process of lean and green practices. For example, this research revealed that organizations can implement incentive systems for employees to encourage innovation. This is supported by Fernandez and Moldogaziev (2012) who concluded that "empowerment practices aimed at offering financial and other rewards for performance will cause employees to feel more encouraged to innovate" (p.161). Furthermore, in this research, it was revealed that there were also employee trainings in which they received information on how they can also be more sustainably aware. This research revealed that employee engagement can be used to encourage employees to improve lean and green practices in order to achieve key performance indicators.

5.2 Theoretical Contribution

The work done in this research contributes to expanding the theoretical understanding of the lean and green concept, by considering insights from lean manufacturing and lean and green practices gathered through interviews from managers of small and medium-sized manufacturing companies. The contribution can be described as identifying and explaining the relationship between sustainability goals, key performance indicators, and lean and green practices. Figure 1 demonstrates the conceptual model that has been developed in order to visualize the relationship between these variables.

Firstly, previous literature such as Florida (1996), provided theoretical work focused on introducing and explaining the concept of lean and green. The biggest limitation of this work was that it was all theoretical. The work done in this research extends the concept of lean and green by examining real-life cases of organizations implementing lean and green practices. Furthermore, this research extends the lean and green concept by identifying concrete lean and green practices, such as product life cycle assessment, waste management, lean energy adoption value stream mapping, and inventory management.

Secondly, Neely (2005) identified the importance of key performance indicators in creating a link between business

all the data was collected through interviews with managers from existing organizations across the globe.
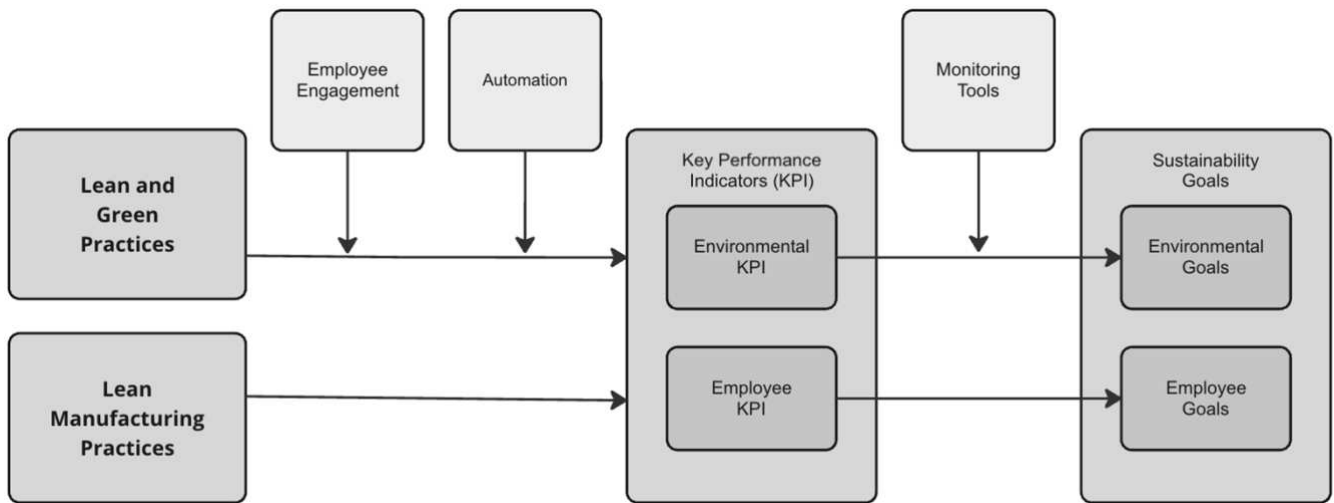

Figure 1 Proposed conceptual model

Source: own information

practices and organizational goals. The work done in this research supports the work done by Neely (2005) by identifying various key performance indicators used by organizations in order to monitor and track their sustainability goals. Key performance indicators were divided into the environmental sustainability and employee sustainability categories. This research reveals that environmental key performance indicators are typically tracked using quantitative metrics whereas employee sustainability was tracked using quantitative methods. Furthermore, the role of monitoring tools, such as the balance scorecard approach and forecasting, in connecting sustainability goals with key performance indicators was discussed. The research done in this work also contributes to more recent academic work. For example, Kosasih et al. (2023) highlight in their work that recent work done for lean and green has been mainly focused on large enterprises and that SMEs have been overlooked. However, the work done in this research and the proposed model have been developed purely from information gathered from SMEs. Therefore, the work done in this paper contributes to more research done for lean and green in SMEs, by providing a conceptualization model of the application of lean and green practices of SMEs. Furthermore, in their research, Ordonez-Ponce (2023) highlights the importance of finding innovative solutions for the achievement of sustainable development goals. The work done in this research also helps contribute to this work by providing examples of how organizations use lean and green practices, these could be considered innovative by anyone reading this work who hasn't thought of applying the same methods to their situation. Moreover, this research also helps contribute to the goal setting theory developed by Locke and Latham (2019). The goal-setting theory identifies the importance of setting clear goals to help focus attention and encourage persistence which in turn leads to higher performance levels. The work done in this research helps contribute to the goal setting theory by delineating the role of key performance indicators in order to monitor goals and thus facilitate persistence.

Finally, these contributions help address gaps identified through the work done by Garza-Reyes (2015), Elemure et al. (2023), and Iranmanesha et al. (2019). The primary gap in research is that there is still a need for more real-life evidence of organizations across the globe applying lean and green practices within their organization. The work done in this research fills in this gap as

5.3 Practical Implications

The findings from this have practical implications for manufacturing SMEs that want to enhance their sustainability efforts through the implementation of lean and green practices. First, organizations can analyze and consider the conceptualization model in Figure 1, which shows the relationship between all the previously mentioned variables. Furthermore, this paper mentions various sustainability goals that exiting manufacturing SMEs are currently striving for and the reasons for this. Other organizations may take these goals as inspiration and apply them to their situation. Furthermore, various key performance indicators used in order to track the sustainability goals were also identified. Also providing specific units of measurement used in order to track said key performance indicators. Finally, lean and green practices that help ensure the improvement of key performance indicators were also highlighted. An explanation of these lean and green practices was also provided, thus facilitating other organizations to examine whether or not the mentioned lean and green practices can be applied to their own situation. Likewise, organizations can identify lean manufacturing principles that they already apply without knowing that they also could be lean and green practices and consequently can be used in order to support their sustainability efforts.

5.4 Limitations and Future Research

A limitation of this research is that the sample size of organizations was limited to eight cases. Future research should expand the sample size of participants. Furthermore, the sample size was limited to only manufacturing companies. The lean and green concept can benefit from investigating its implementation in industries besides manufacturing.

Another limitation is that the method of research for the work done in this paper was purely qualitative and thus did not take into consideration quantitative data. Future studies should attempt to support qualitative findings with quantitative data. Furthermore, the data collected for this research was limited to one-time interviews. The conclusions of this research could benefit from conducting research that gathers data on a long-term scale. This will allow for the understanding of the long-term effects of lean and green Practices.

Finally, the sample size was limited to SMEs' lean and green literature could benefit from the comparison between SMEs and large-scale organizations when implementing lean and green practices. Doing a comparison like this would help identify what resources are available to large-scale organizations that help with the implementation of lean and green practices. Then an analysis can be made to see if any of these resources can be applied to SMEs in order to facilitate the process of lean and green practices implementation. Likewise, large-scale organizations can identify how SMEs implement lean and green and discover potential ideas that can be applicable to large-scale organizations.

6. CONCLUSION

This research explored the relationship between sustainability goals, key performance indicators, and lean and green practices to answer the question: *How do SMEs implement lean and green practices to meet key performance indicators in order to achieve their sustainability goals?*

Through the application of qualitative research with a thematic analysis approach, the research found what sustainability goals manufacturing SMEs currently have and what the corresponding key performance indicators are used to keep track of said goals. Furthermore, this research identified what and how lean and green practices are implemented by these manufacturing organizations. Ultimately, contributing to theoretical literature, expanding the idea of lean and green through the support of practical real-world evidence that can also be used as practical inspiration for any manufacturing organizations reading this work.

7. REFERENCES

Afum, E., Zhang, R., Agyabeng-Mensah, Y., & Sun, Z. (2021). Sustainability excellence: the interactions of lean production, internal green practices, and green product innovation. *International Journal of Lean Six Sigma*, *12*(6), 1089–1114. https://doi.org/10.1108/ijlss-07-2020-0109

Afteni, C., & Frumuşanu, G. (2017). A review on Optimization of Manufacturing Process Performance. *International Journal of Modeling and Optimization*, *7*(3), 139–144. https://doi.org/10.7763/ijmo.2017.v7.573

Åhlström, P., Danese, P., Hines, P., Netland, T. H., Powell, D., Shah, R., Thürer, M., & Van Dun, D. H. (2021). Is lean a theory? Viewpoints and outlook. *International Journal of Operations & Production Management*, *41*(12), 1852–1878. https://doi.org/10.1108/ijopm-06-2021-0408

Alipour, N., Nazari-Shirkouhi, S., Sangari, M. S., & Vandchali, H. R. (2022). Lean, agile, resilient, and green human resource management: the impact on organizational innovation and organizational performance. *Environmental Science and Pollution Research International*, *29*(55), 82812–82826. https://doi.org/10.1007/s11356-022-21576-1

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology (Print)*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Callicott, J. B., & Mumford, K. (1997b). Ecological sustainability as a conservation concept. *Conservation Biology*, *11*(1), 32–40. https://doi.org/10.1046/j.1523-1739.1997.95468.x

Chen, X., Despeisse, M., & Johansson, B. (2020). Environmental Sustainability of Digitalization in Manufacturing: A review. *Sustainability*, *12*(24), 10298. https://doi.org/10.3390/su122410298

Choi, S., Eloot, K., Lee, D., Liu, S., & Von Laufenberg, K. (2022, October 19). *Building sustainability into operations*. McKinsey & Company. https://www.mckinsey.com/capabilities/operations/our-insights/building-sustainability-into-operations

Creswell, J. W., & Poth, C. (2017). *Qualitative Inquiry and research design : choosing among five approaches*. https://openlibrary.org/books/OL28633749M/Qualitative_Inquiry_and_Research_Design

Dieste, M., Panizzolo, R., Garza-Reyes, J. A., & Anosike, A. (2019). The relationship between lean and environmental performance: Practices and measures. *Journal of Cleaner Production*, *224*, 120–131. https://doi.org/10.1016/j.jclepro.2019.03.243

Draper, A. (2004). The principles and application of qualitative research. *Proceedings of the Nutrition Society*, *63*(4), 641–646. https://doi.org/10.1079/pns2004397

Dües, C. M., Tan, K. H., & Lim, M. K. (2013). Green as the new Lean: how to use Lean practices as a catalyst to greening your supply chain. *Journal of Cleaner Production*, *40*, 93–100. https://doi.org/10.1016/j.jclepro.2011.12.023

Elemure, I., Dhakal, H. N., Leseure, M., & Radulovic, J. (2023). Integration of lean green and Sustainability in Manufacturing: A review on current state and future perspectives. *Sustainability*, *15*(13), 10261. https://doi.org/10.3390/su151310261

Estoque, R. C. (2020). A review of the sustainability concept and the state of SDG monitoring using remote sensing. *Remote Sensing*, *12*(11), 1770. https://doi.org/10.3390/rs12111770

Farias, L. M. S., Santos, L. C., Gohr, C. F., De Oliveira, L. C., & Da Silva Amorim, M. H. (2019). Criteria and practices for lean and green performance assessment: Systematic review and conceptual framework. *Journal of Cleaner Production*, *218*, 746–762. https://doi.org/10.1016/j.jclepro.2019.02.042

Fercoq, A., Lamouri, S., Carbone, V., Lelièvre, A., & Lemieux, A. (2013). Combining lean and green in manufacturing: a model of waste management. *IFAC Proceedings Volumes*, *46*(9), 117–122. https://doi.org/10.3182/20130619-3-ru-3018.00164

Fernandez, S., & Moldogaziev, T. (2012). Using employee empowerment to encourage innovative behavior in the public sector. *Journal of Public Administration Research and Theory*, *23*(1), 155–187. https://doi.org/10.1093/jopart/mus008

Fliedner, G. (2008, November). Sustainability: a new lean principle. In *Proceedings of the 39th annual meeting of the decision sciences institute* (pp. 3321-3326).

Florida, R. (1996). Lean and green: the move to environmentally conscious manufacturing. *California Management Review*, *39*(1), 80–105. https://doi.org/10.2307/41165877

Frohm, J., Lindström, V., Winroth, M., & Stahre, J. (2006). THE INDUSTRY'S VIEW ON AUTOMATION IN MANUFACTURING. *IFAC Proceedings Volumes*, *39*(4), 453–458. https://doi.org/10.3182/20060522-3-fr-2904.00073

Fullerton, R. R., & Wempe, W. F. (2009). Lean manufacturing, non-financial performance measures, and financial performance. *International Journal of Operations & Production Management*, *29*(3), 214–240. https://doi.org/10.1108/01443570910938970

Garza-Reyes, J. A. (2015). Lean and green – a systematic review of the state of the art literature. *Journal of Cleaner Production*, *102*, 18–29. https://doi.org/10.1016/j.jclepro.2015.04.064

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking qualitative rigor in inductive research. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Halldórsson, Á., Gremyr, I., Winter, A., & Taghahvi, N. (2018). Lean Energy: Turning Sustainable Development into Organizational Renewal. *Sustainability*, *10*(12), 4464. https://doi.org/10.3390/su10124464

Henao, R., Sarache, W., & Gómez, I. (2019). Lean manufacturing and sustainable performance: Trends and future challenges. *Journal of Cleaner Production*, *208*, 99–116. https://doi.org/10.1016/j.jclepro.2018.10.116

Iranmanesh, M., Zailani, S., Hyun, S. S., Ali, M. H., & Kim, K. (2019). Impact of lean manufacturing practices on firms' sustainable performance: Lean Culture as a moderator. *Sustainability*, *11*(4), 1112. https://doi.org/10.3390/su11041112

Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard: measures that drive performance.

Khare, A., Ojala, A., & Baber, W. W. (2022). Sustainable international business models in a digitally transforming world. In *Routledge eBooks*. https://doi.org/10.4324/9781003195986

King, A. A., & Lenox, M. J. (2001). LEAN AND GREEN? AN EMPIRICAL EXAMINATION OF THE RELATIONSHIP BETWEEN LEAN PRODUCTION AND ENVIRONMENTAL PERFORMANCE. *Production and Operations Management*, *10*(3), 244–256. https://doi.org/10.1111/j.1937-5956.2001.tb00373.x

Kosasih, W., Pujawan, I. N., & Karningsih, P. D. (2023). Integrated Lean-Green Practices and Supply Chain Sustainability for Manufacturing SMEs: A Systematic literature review and research agenda. *Sustainability*, *15*(16), 12192. https://doi.org/10.3390/su151612192

Koumanakos, D. P. (2008). The effect of inventory management on firm performance. *The International Journal of Productivity and Performance Management/International Journal of Productivity and Performance Management*, *57*(5), 355–369. https://doi.org/10.1108/17410400810881827

Lee, N., & Rojas, E. M. (2013). Visual representations for monitoring project performance: Developing novel prototypes for improved communication. *Journal of Construction Engineering and Management*, *139*(8), 994–1005. https://doi.org/10.1061/(asce)co.1943-7862.0000687

Lian, Yang-Hua, and Hendrik Van Landeghem. "An application of simulation and value stream mapping in lean manufacturing." In *Proceedings 14th European Simulation Symposium*, pp. 1-8. c) SCS Europe BVBA, 2002.

Locke, E. A., & Latham, G. P. (2019). The development of goal setting theory: A half century retrospective. *Motivation Science*, *5*(2), 93–105. https://doi.org/10.1037/mot0000127

Ma, Y., Hou, G., Yin, Q., Xin, B., & Pan, Y. (2018). The sources of green management innovation: Does internal efficiency demand pull or external knowledge supply push? *Journal of Cleaner Production*, *202*, 582–590. https://doi.org/10.1016/j.jclepro.2018.08.173

McManus, H. L. (2005, September 1). *Product Development Value Stream Mapping (PDVSM) Manual Release 1.0*. https://dspace.mit.edu/handle/1721.1/81908

Mishra, D., Gunasekaran, A., Παπαδόπουλος, Θ., & Hazen, B. T. (2017). Green supply chain performance measures: A review and bibliometric analysis. *Sustainable Production and Consumption*, *10*, 85–99. https://doi.org/10.1016/j.spc.2017.01.003

Mustapha, M. A., Manan, Z. A., & Alwi, S. R. W. (2017). Sustainable Green Management System (SGMS) – An integrated approach towards organisational sustainability. *Journal of Cleaner Production*, *146*, 158–172. https://doi.org/10.1016/j.jclepro.2016.06.033

Neely, A. (2005). The evolution of performance measurement research: developments in the last decade and a research agenda for the next. *International journal of operations & production management*, *25*(12), 1264-1277.

Neely, A., Gregory, M., & Platts, K. (1995). Performance measurement system design. *International Journal of Operations & Production Management*, *15*(4), 80–116. https://doi.org/10.1108/01443579510083622

Ohno, T. (1988). *Toyota Production System : Beyond Large-Scale production*. http://dx.doi.org/10.4324/9780429273018

Ordonez-Ponce, E. (2023). Exploring the impact of the sustainable development goals on sustainability trends.

Sustainability, *15*(24), 16647. https://doi.org/10.3390/su152416647

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. http://ci.nii.ac.jp/ncid/BB18275167

Pessôa, M. V. P., Seering, W., Rebentisch, E., & Bauch, C. (2009). Understanding the waste net: a method for waste elimination prioritization in product development. In *Advanced concurrent engineering* (pp. 233–242). https://doi.org/10.1007/978-1-84882-762-2_22

Petropoulos, F., Apiletti, D., Assimakopoulos, V., Babai, M. Z., Barrow, D. K., Taieb, S. B., Bergmeir, C., Bessa, R. J., Bijak, J., Boylan, J. E., Browell, J., Carnevale, C., Castle, J. L., Cirillo, P., Clements, M. P., Cordeiro, C., Oliveira, F. L. C., De Baets, S., Dokumentov, A., . . . Ziel, F. (2022). Forecasting: theory and practice. *International Journal of Forecasting*, *38*(3), 705–871. https://doi.org/10.1016/j.ijforecast.2021.11.001

Rai, N., & Thapa, B. (2015). A study on purposive sampling method in research. *Kathmandu: Kathmandu School of Law*, *5*(1), 8-15.

Rehman, S. U., Giordino, D., Zhang, Q., & Alam, G. M. (2023). Twin transitions & industry 4.0: Unpacking the relationship between digital and green factors to determine green competitive advantage. *Technology in Society*, *73*, 102227. https://doi.org/10.1016/j.techsoc.2023.102227

Rodrigues, V. S., & Kumar, M. (2019). Synergies and misalignments in lean and green practices: a logistics industry perspective. *Production Planning & Control*, *30*(5–6), 369–384. https://doi.org/10.1080/09537287.2018.1501812

Rosen, M. A., & Kishawy, H. A. (2012). Sustainable Manufacturing and Design: Concepts, practices and needs. *Sustainability*, *4*(2), 154–174. https://doi.org/10.3390/su4020154

Shah, R., & Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, *25*(4), 785–805. https://doi.org/10.1016/j.jom.2007.01.019

Støle, S., & Ekeren, H. L. (2015). *To Increase Employee Engagement in Lean Continuous Improvement A Case Study at Fibo-Trespo* (Master's thesis, Universitetet i Agder; University of Agder).

Teixeira, P., Coelho, A., Fontoura, P., Sá, J. C., Silva, F. J. G., Santos, G., & Ferreira, L. P. (2022). Combining lean and green practices to achieve a superior performance: The contribution for a sustainable development and competitiveness—An empirical study on the Portuguese context. *Corporate Social-responsibility and Environmental Management*, *29*(4), 887–903. https://doi.org/10.1002/csr.2242

United Nations Environment Programme. (2023). *The sectoral solution to climate change*. UN Environment. https://www.unep.org/interactive/six-sector-solution-climate-change/

Van Dun, D. H., Hicks, J. N., & Wilderom, C. P. (2017). Values and behaviors of effective lean managers: Mixed-methods exploratory research. *European Management Journal*, *35*(2), 174–186. https://doi.org/10.1016/j.emj.2016.05.001

Wahab, A. N. A., Mukhtar, M., & Sulaiman, R. (2013). A conceptual model of lean manufacturing dimensions. *Procedia Technology*, *11*, 1292–1298. https://doi.org/10.1016/j.protcy.2013.12.327

Womack, J. P., & Jones, D. T. (2015). *Lean solutions: how companies and customers can create value and wealth together*. Simon and Schuster.

Womack, J. P., Jones, D. T., Roos, D., & Massachusetts Institute of Technology. (1990). *The machine that changed the world*. Rawson Associates [etc.].

World Bank SME Finance. (2024). World Bank. https://www.worldbank.org/en/topic/smefinance

8. APPENDIX
Appendix A

Figure A.2. Data Structure.

Figure A.2. (continued) Data Structure.

Figure A.2. (continued) Data Structure.

- Balance Scorecard Approach,
- Forecasting

→ Mediators between Performance Measurements and Goals

→ Monitoring Tools

- Process Optimization
- Review and streamline process
- Eliminating waste and increasing efficiency
- Define and address

→ Process Optimization

- Heijunka
- Jidoka
- SMED
- Overall Equipment Effectiveness
- 5s Principle

→ Lean Manufacturing Practices

→ Lean Manufacturing Practices

- Value stream mapping
- Just in Time inventory
- Energy Management System
- Energy Adoption Photovoltaic Systems
- Waste Segregation and Recycling Program
- Life Cycle Assessment
- Lean Machine

→ Lean and Green Practices

→ Lean & Green Practices

- Automation
- Employee Engagement

→ Mediators between Performance Measurements and Practices

→ Automation and Employee Engagement

Table A. 2. Interview Guideline Questions.

QUESTIONS TO FIGURE OUT SUSTAINABILITY GOALS BLOCK
What are the sustainability goals that your company is striving for?
Why did you choose these sustainability goals?
How do you ensure that your employees are aware of and engaged in meeting these sustainability goals?

QUESTIONS FOR PERFROMANCE MEASUREMENTS BLOCK
What Key Performance Indicators or KPIs does your organization use to track sustainability efforts?
Why did you choose these specific Key Performance Indicators to track your sustainability goals?
What criteria do you use to come up with specific Key Performance Indicators to use for each sustainability goal?
How many Key Performance Indicators or KPI's does your organization have for each sustainability goal?
Why do you think these Key Performance Indicators are adequate to achieve your organizations sustainability goals?
How do you know when a sustainability goal has been achieved?
Of the mentioned performance metrics, which ones would you say are the most important? Why?

QUESTIONS FOR LEAN AND GREEN PRACTICES
What practices (Lean and green) does your organization use to make sure Key Performance Indicators are met?
Which Lean and green Practices do you use to meet each performance measurement?
How do you know these Lean and green practices are useful for meeting your Key Performance Indicators?
Do you use multiple lean and green practices to help meet Key Performance Indicators, or can you use one practice for two measurements? If so, please explain why you think one practice can be used to meet multiple or more Key Performance Indicators?
Which Lean and green Practices have you noticed work best for meeting your Key Performance Indicators?