

Achieving Sustainability in Solar Energy Firms in Turkey

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Contributor: Bilal Aldewachi

Lean principles and sustainability are considered important terms in business. Solar firms are witnessing great competition to fulfill energy requirements, suffering from a huge amount of waste, negatively affecting the sustainability dimensions. Thus, the aim of the study is to build a framework for solar energy firms to achieve sustainability through adopting lean principles, which will help to fix many problems as waste and costs. The method included reviewing the literature to explore the founding of the relation between the two terms, and using a questionnaire that was directed to the responsible people in Turkish solar energy firms. The results of the survey were analyzed to: (1) Find out what the responsible people think about the two terms lean and sustainability; (2) Measure the probable relationship between lean principles and sustainability dimensions by applying a linear regression test; (3) Use the results of point number two to build the framework. The result showed there was a high level of relative importance about the two terms from the point of view of managers and experts in solar firms. In addition, the study found a relationship between adopting pull and flow principles of lean, and achieving economic and social dimensions of sustainability, this finding is represented in a framework.

Keywords: : lean ; sustainability ; solar firms ; model

1. Lean and Sustainability: An Overview

The topic of lean became common through a book, "*The Machine That Changed the World*," The lean concept is defined in many ways, because lean is still evolving ^[1]. Lean manufacturing is a common means of continuous improvement that has reshaped global manufacturing processes, practices, and principles.

It revolves around a philosophy of continuous performance improvement through systematic waste disposal on the manufacturing floor ^[2]. A review of the literature agreed that the main principles of lean are (Value, Value Stream, Flow, Pull, and Perfection) ^[3], the principles were presented to address the many challenges that arose inside and between business units as a result of variances in company culture and management thought process ^[2]. The basis of the lean management philosophy is that the overall performance of an enterprise must be directed into a logical and singular system with the main objective of providing value to clients, and indicating that a lean process alone cannot be the source of all benefits ^[1].

In parallel, the concept of sustainability started to be popular after the Brundtland report in 1987 (WCED, 1987), which was interested in the conflict between humanity's desire for a better existence on the one hand and nature's constraints on the other. Over time, the notion has come to be reinterpreted as embracing three dimensions: social, economic, and environmental. There are many definitions for Sustainability, and the popular one of (WCED) in (1987) is: "economic development that meets the needs of the present generation without compromising the ability of future generation to meet their own needs." ^[4]. Sustainability aims to create mechanisms that contribute to maximizing profits while preserving environmental aspects, as well as the need for communities while preserving the rights and protection of employees ^[1].

Although many studies have supported the importance of using lean to improve the flow of operations, there are still many problems in its application. Perhaps the most important limitations are its weakness in dealing with variance and the lack of consideration for human aspects, in addition to the operational focus being confined to the workshop floor ^[5]. There are also a number of other problems represented by complaints from trade unions and the increase in the responsibilities of employees in companies without an appropriate increase in terms of salaries. These problems are the result of a misunderstanding of the mechanism of the way lean works, and these problems appear more clearly in small and medium companies ^[6]. The reason for these problems is not related to lean as much as to the need to understand how it works. According to ^[7], the correct application of lean depends largely on the level of understanding of senior management in companies of its work mechanisms and the correct way to implement it, with the need for an understanding between

senior management in companies and workers to work together in order to create an image of the integrated application of it, in addition to the need for developing long-term employees and leaders.

Many researchers advocate that lean is fundamentally linked to sustainability ^[8], because lean supports the following points, which are considered as the main goals of sustainability, such as reducing cost, emission reduction, creating economic value, improving the condition of work. In fact, even today, the correlation between lean and sustainability is still not conclusive, and, also, the relationship is not well known between these two terms ^[9]. Reviewing the literature showed that there are differences between various sectors about the influences of lean on sustainability. However, there are many sectors that need to be studied to evaluate the relationship between the two terms, as the situation in the solar energy sector in Turkey shows. Reviewing the literature showed that no framework to explain the relationship between lean principles and sustainability dimensions in the solar sector was found; however, the positive impact of adopting lean to reduce waste and, as a result, increase the efficiency, was proved through certain studies.

This shows the probability of finding a relationship between lean principles and sustainability dimensions and that the effect is not a coincidence. However, even today there are different opinions about the relationship between lean and sustainability, which will be explained in the next parts.

2. Lean and Sustainability Relationship through Different Studies

The attention on the relationship between lean principles and sustainability development led the researchers to study the effect of lean to achieve sustainability and the degree of the relationships between them. In fact, there are differing viewpoints in the literature on the relationship between lean and sustainability. This statement can be divided into the following: (1) Studies support that lean achieves the sustainability agenda, (2) Studies advocate that lean does not match the main sustainability agenda, (3) Studies claim the integration between lean and sustainability; these points will be demonstrated in detail in the following section.

2.1. Lean Achieves Sustainability Agenda

In general, the studies support the idea that lean is achieving the sustainability goals, that is lean is removing waste and optimizing the whole operation. One research study found that lean promotes sustainability in manufacturing through an energy-saving and emission-reduction strategy ^[10], and, according to another piece of research, it is possible to create environmental benefits alongside economic value, for example, eco-friendly goods are less expensive to manufacture as lean and green methods are incorporated into the design and service delivery processes ^[11]. A study that analyzed sustainability reporting, found that adopting lean in different companies increases the quality of the work conditions ^[9], another study of analysis and synthesis models found in a selected research, reported that integrating lean–green policies is an effective way to maintain and expand a greener manufacturing operation ^[12]. A study about a solar power plant found that smart lean manufacturing improves the efficiency through the reduction in waste and non-value added activities ^[13]. Another study, which examined the interaction between the principles of lean and sustainability on the AEC industry, showed that by adopting those principles in terms of optimizing processes and stakeholders' quality of life, reducing all forms of wastes, the tracking and self-evaluation for performance growth, and marketing challenges, lean and sustainability production could have a virtually identical agenda ^[14].

2.2. That Lean Does Not Match the Main Sustainability Agenda

Other researchers have argued that lean does not match the main agenda of sustainability. A study to evaluate the relationships in the Iberian Peninsula adopted the view that the relationships remain poorly understood and were dispersed by various sustainability indicators because their results found that the evidence that lean manufacturing is linked to any of the sustainability foundations was inconclusive ^[9]. A study using a green–lean simulation model claimed that implementing lean methods has a negligible impact on the company's environmental results ^[15], while another study reported that lean alone cannot achieve the sustainability targets or address all of the sustainability matters ^[16]. This is because the matters of increasing production in the sector of renewable energy, increasing the salary remuneration, or increasing the turnover were not identified ^[9].

2.3. The Integration between Lean and Sustainability

Some researchers have attempted to incorporate sustainability into the lean concept to maximize its gains; a study about integrating sustainability and lean reported that "Sustainability and leanness are organizational approach concepts for more efficient activities and increased competitiveness" ^[17], and, in another study, the authors suggested the use of lean strategies to improve sustainable manufacturing with an effect on the environment since the study's research results

showed that integrating the two dimensions enhanced the system's performance and led to the growth of a sustainable company ^[18]. Another study reported that lean is the first step towards achieving sustainability. They even declared that environmental sustainability is the next step in the lean philosophy to minimize the product's negative impact on the environment and safe resources, and this was what was happening in the Japanese auto industry; they were beginning to use lean toward currently hybrid engines and vehicles with recycled components ^[19].

In conclusion, we can notice that there are various opinions about the relationship between the two terms, but, at the same time, many researchers support the idea of the ability to find an interaction and an alignment between lean and sustainability goals. Thus, to build a framework that aims to adopt the use of lean principles to achieve sustainability in the solar energy firms in Turkey, there must be a set of steps to follow to make sure that there is a relationship between the two terms in this sector. These steps will be explained in the methodology used in the paper.

3. Influence of Lean in Sustainability Dimension

This section focuses on the degree to which the use of Lean can improve the results of sustainability factors. As pointed out in this research, the views differed among researchers about the impact of the application of lean on sustainability and the relationship between them. In general, some companies have succeeded in achieving better results and higher competitiveness through the application of lean principles, while others have not been able to achieve these results as they have not been able to maintain medium- and long-term results ^[20].

The following paragraphs outline some of the most important recent contributions made by a group of scholars to explain the lean–sustainability area, the main influences are summarized.

3.1. Influence of Adopting Lean in Social Dimension

Despite the importance of the social dimension as one of the main dimensions of sustainability, this dimension has not been sufficiently studied, as referred on the study of ^[14] to the need to pay attention to the social dimension as a goal affecting the situation in the environmental dimension side. The result of reviewing the literature showed that applying lean appeared to impact some sectors of the social dimension, such as increasing the quality of work ^{[21][22]} and increasing the employee's engagement in decision making ^[22].

3.2. Influence of Adopting Lean in Environmental Dimension

Many studies supported the view that environmental management is greater in the firms adopting lean in their progress: adopting lean will help in increasing performance, as well as helping the decrease in industrial waste ^{[20][23]} energy saving, and emission reduction ^[10]. Despite that, we notice that no references were found about the effect of lean on environmental sustainability in renewable energy companies ^[9].

3.3. Influence of Adopting Lean in Economic Dimension

Economic performance, which is assessed by productivity, cost reduction, revenue, profit, cash flow, and business growth, is one of the pillars of sustainable performance. Achieving inclusive sustainability through the lean approach enables institutions to emphasize reaching economic sustainability ^[24]. When reviewing the literature, the results showed that applying lean would help to maximize the profit ^[25], increase the performances of the process, and decrease the operational cost ^[26]. However, there are few references about the effect of lean in the economic dimension and, even for the turnover impact, no references were discovered ^[9].

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