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Towards a Sustainable Innovation Process: Integrating Lean and Sustainability Principles

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Abstract. Many companies are heavily investing resources to innovate faster and smarter in order to gain or retain a competitive advantage. Nevertheless, defining and deploying a sustainable innovation vision still represents a challenge to most companies, as a deep change of mindset is required to reflect going beyond the design, development, production and distribution of new products, to also consider their disposal, recycling or reuse, as part of their end-to-end product life cycle. Therefore, this paper aims to: 1) highlight the relevance of including lean and sustainability principles in the early design and conceptualization phases, 2) explain how lean and sustainability can bring benefits when applied as an integrated system considering three axes: the economic, the social and the environmental, and 3) share a case study providing insights of a successful application.

Keywords: Sustainability, Green, Lean, Innovation, Product Development

1 Introduction

Ever since humans evolved from Hominidae, we have constantly been looking for new products and services to evolve and solve day-to-day challenges. Companies, governments and users continuously strive for innovative products to make our lives simpler, more effective and easier. However, not many consider the effects such products/services have through their lifecycle and their impact on the economy, society and the environment. During the innovation process, products and services are designed to satisfy customer needs, and lean and sustainability thinking are a vital part of the process. There are numerous successful and detailed examples of how companies have applied lean to eliminate waste and decrease costs both in manufacturing and services organizations. But only very few industrial cases show evidence of how lean and sustainability are applied in industrial settings since the very early stages of the conception of new products, thus taking into consideration the end-to-end life cycle.

The first thing that comes to mind when linking lean and sustainability is to eliminate waste or use less resources such as energy to reduce costs. However, sustainable innovation brings much more than just economic benefits from waste reduction, since it also focuses on the impact on the environment and society in an integrated system.

2 Research method

The Lean Analytics Association together with EPFL started the yearly Lean Product Development Best Practices Discovery Project in 2015. Eighteen companies have joined since, and company cases have been collaboratively developed, some of which were published in a book [5]. Through this paper, the authors aim to answer the following research questions:

1. **How are lean innovation and sustainability interconnected?**
2. **Which best practices can be identified in the industry that could increase awareness about the relevance of considering lean and sustainability when developing new products?**

The approach followed six main research steps. Firstly, the need was identified and the research question specified. Secondly, the state-of-the-art literature review was conducted. The literature review aimed to identify the lean and sustainability best practices applied in innovation process. Thirdly, the questionnaire was developed and interviews with the innovation leaders conducted. The interview answers were analyzed and documented to result in research publications. The last step aims to enable the industry and academia to learn from the findings and innovate greener.

3 Lean and Sustainability

3.1 Lean Thinking

The lean concept observed and explored in Japanese companies was expanded to a comprehensive philosophy by Womack and Jones [10]. In their book *Lean thinking: Banish waste and create wealth in your corporation*, they defined the five principles of lean thinking, as shown in Figure 1.

Value	Specify what creates value from the customer's perspective (new product)
The value stream	Identify all the steps along the process chain
Flow	Make the value process flow: eliminate waste
Pull	Make only what is needed by the customer
Perfection/ Continuous Improvement	Strive for perfection by continually attempting to produce exactly what the customer wants

Fig. 1. Five lean principles (adapted from [10])

3.2 Lean Innovation

Lean innovation is the application of lean thinking to the End-to-End Innovation process, as shown in Figure 2. It focuses on value creation, the provision of a knowledge environment and continuous improvement, which together encourage collaborative and sustainable innovation [5].

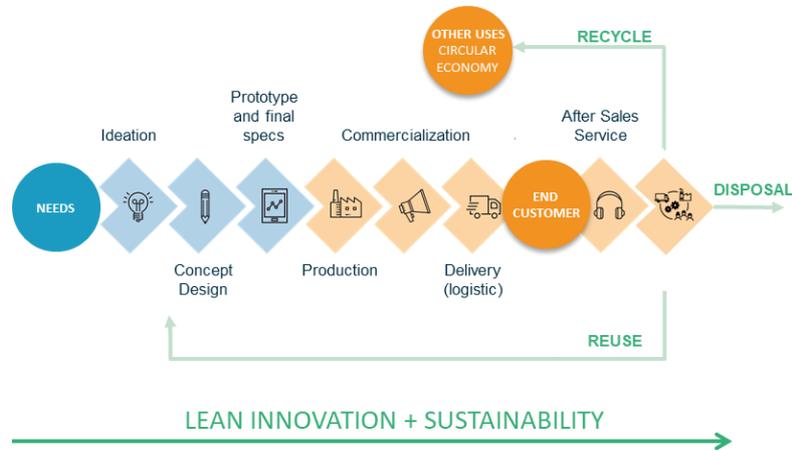


Fig. 2. Lean Innovation and sustainability in the End-to-End innovation process

Lean efforts have focused mostly towards production and other transactional processes where waste was visible and savings in terms of cost were immediately noticeable. Figure 3 illustrates the significantly higher influence of the product design in comparison to the other phases. Therefore, if during the product design, the right decisions are made regarding design, processes and sustainability and the correct deliverables are forwarded, considerable waste will be avoided in the later stages and the whole process will become more efficient. Not only the efficiency but also the forecast of the entire product/service lifecycle with circular vision is determined at the design stage.

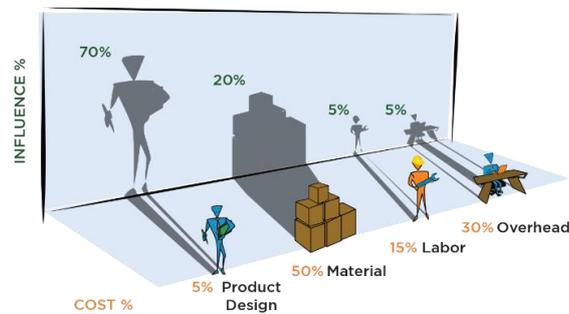


Fig. 3. Who casts the biggest shadow (adapted from [7])

By incorporating Design for Sustainability principles, lean innovation supports and enables waste elimination through the entire value chain and it does not only bring economic benefits to companies, but also to the environment and society. The human factor and their skills are significant enablers towards lean and sustainable innovation. To be able to address sustainability challenges and design products for a green future, the employees in industry require training to develop a new mindset that enables them to integrate into their daily operations not only the economic aspect but also the environmental and social elements [4].

3.3 Sustainability

Sustainability aims to develop and sustain the environmental, social and economic circumstances that enable humans to co-exist with nature in "productive harmony" both in the present and the future [1, 10]. A process where sustainability (environmental, social and economic as shown in figure 4) considerations are integrated into company systems from the idea generation through to research and development (R&D) and commercialization, is called *sustainable innovation*. This applies to products, services and technologies, as well as new business and organization models [2]. Furthermore, the definition of social responsibility (SR) was established in 2010 through the ISO 26000 and is foundational to our methods [3]. The SR Principle "*Respect for Stakeholder Interests*" is examined.

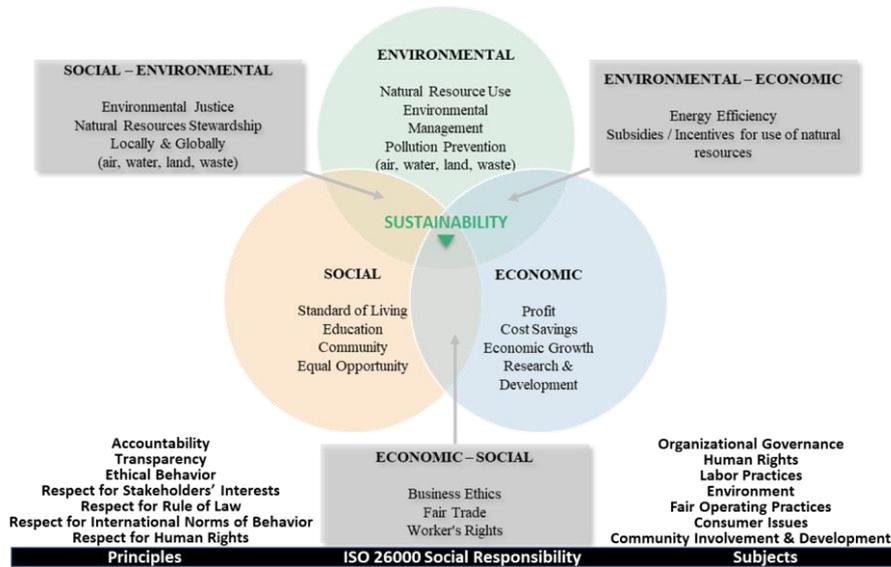


Fig. 4. Aspects of Sustainability (adapted from [8]; addition of ISO 26000)

4 Lean Innovation Model incorporating sustainability aspect

The Lean Innovation Model was developed to provide as a structured guide to create an integrated vision for the companies to start or continue their lean product development journey [5]. It is a framework that incorporates four main building blocks: 1. Strategy and Performance, 2. Skilled People and Collaboration, 3. Efficient Process and Knowledge-based Environment, 4. Continuous Improvement and Change. Each building block is represented by three enablers, giving a total of twelve enablers, as represented in Table 1. The model integrates both the technical enablers, as well as the "soft" aspects of skills, collaboration and leadership which are indispensable for a successful implementation. One of the important enablers is also 7. *Sustainable Innovation Process*.

Table 1. The Lean Innovation Model [5]

1. STRATEGY AND PERFORMANCE	1. Customer Value	3. EFFICIENT PROCESS AND KNOWLEDGE-BASED ENVIRONMENT	7. Sustainable innovation process
	2. Strategy and Leadership Commitment		8. Lean thinking tools and methods
	3. Track Performance		9. Co-create, share and reuse knowledge
2. SKILLED PEOPLE AND COLLABORATION	4. Human Skills	4. CONTINUOUS IMPROVEMENT AND CHANGE	10. Continuous Improvement System
	5. Chief Engineer		11. Internal and External partnerships
	6. Cross-functional Collaboration		12. Communicate, manage and reward change

A truly sustainable lean innovation process is supported by activities during the whole End-to-end innovation phases. Table 2 outlines different innovation phases and which sustainability focused activity areas contribute to each one of them.

Table 2. Sustainable lean innovation phases and sustainability focus areas

Innovation Phases	Sustainability focus areas
Engagement	- Stakeholder analysis <i>and respect for stakeholder interests</i>
Ideation	- <i>Considering stakeholder interests</i> throughout the entire product lifecycle: aiming to reduce CO ₂ footprint & any harm end-to-end
Concept Design	- Reusing some of the components or disposed products - Using recycled materials & reducing material use - Assessing social impact <i>on all stakeholders</i>
Prototype and final specs	- Creating a product that will produce minimal waste - Creating a product that will consume little energy - Ensuring health and safety requirements <i>for all stakeholders</i>
Production	- Reducing energy consumption and using renewable energy - <i>Considering workers as stakeholders</i> - Reducing production waste
Commercialization	- Green marketing [9] - Value-driven model <i>elevates stakeholders/society</i> - Consumer awareness of all types of impact (includes environment)
Delivery	- Using green logistics and reducing the CO ₂ footprint - Promoting local sourcing: <i>engaging local stakeholders</i>
After Sales Service	- Promoting responsible use: repairs vs replacements
Disposal/ Recycling/Reuse	- Encouraging users <i>and other relevant stakeholders</i> to recycle, safely dispose or reuse products

During the *Explore* and *Analyze* phases of the Best Practices Discovery research project carried annually by the Lean Analytics Association (LAA), lean innovation best

practices have been identified and documented. In the third building block of the Lean Innovation Model, *Efficient Process and Knowledge Based Environment*, eleven best practices were consolidated from the 18 companies, six of which were categorized as “common” (well-known in the industrial innovation processes) and five as “emerging practices” (identified in less than five companies) as illustrated in figure 5. As observed, although the 18 interviewed companies have a clear product development process, there is currently poor integration of a sustainability strategy in innovation. Only three have so far integrated the sustainability vision into the product development practice. Therefore, sustainable innovation is still considered as one emerging best practice in lean innovation.

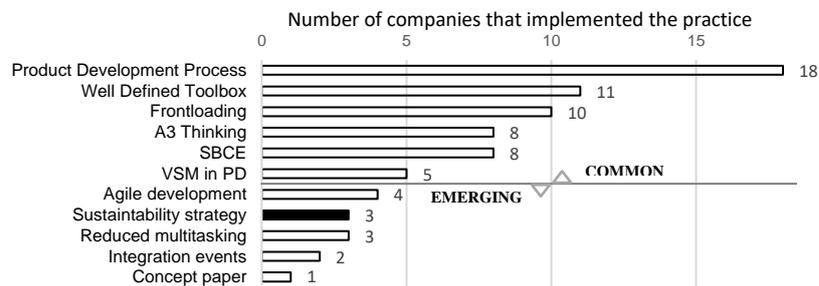


Fig. 5. Emerging and common best practices identified in *the Efficient Process and Knowledge Based Environment* building block of the Lean Innovation model (N=18) [5]

The following section will provide more details about the practices of Interface, since it is the strongest of the three identified companies that continuously pursues the integration of its sustainability strategy into the innovation process.

5 Case Study: Interface Inc. - Implementing the Mission Zero Strategy

Interface is the world’s largest manufacturer and marketer of modular carpet, headquartered in LaGrange, Georgia, USA. The company maintains its position among top sustainability leaders as a result of the company’s focus on sustainability through its Mission Zero strategy which is aligned with the people, process, product, place and profits. Mission Zero was proposed under the leadership of Ray C. Anderson (1994) and its focus is “*to be the first company that, by its deeds, shows the entire industrial world what sustainability is in all its dimensions: people, process, product, place and profits — by 2020 — and in doing so, to become restorative through the power of influence*” [6].

To accomplish this latter goal by 2020 and guide employees through the transformation, Interface developed the Mount Sustainability framework. Seven Fronts of Mount Sustainability were identified and placed on the mountain framework to remind employees of the fronts through which the company needs to pass to reach the top of the mountain before 2020.

Table 3. Interface Mount Sustainability's seven fronts and targets

Front 1: Eliminate Waste	Eliminate all forms of waste in every area of the business - \$16 million in operational cost avoidance
Front 2: Benign Emissions	Eliminate toxic substances from products, vehicles and facilities - \$50 million inventory reduction
Front 3: Renewable energy	Operate facilities with 100% renewable energy
Front 4: Closing the Loop	Redesign processes and products to close the technical loop using recycled and bio-based materials - Recycled and bio-based raw material content increased from 50% to 75%.
Front 5: Efficient transportation	Transport people and products efficiently to eliminate waste and emissions - Reduce transportation costs by 30%.
Front 6: Sensitizing Stakeholders	Create a culture that uses sustainability principles to improve the lives and livelihood of all stakeholders - Connect customers and vendors through Interface, positively influencing both.
Front 7: Redesign Commerce	Create a new business model that demonstrates and supports the value of sustainability-based commerce - Disrupt competitors and raise customer expectations in the industry. Sell 30% more at 15% higher margins.

The entire organization is committed to continuous improvement, and sustainability became a common vision which is deeply embedded in employees' behavior as part of their day-to-day focus. As a consequence, two key projects have shown the positive results and impact of Sustainable Innovation.

Net Works is a collaborative project between the Zoological Society of London, Aquafil (yarn producer) and Interface. An innovative, cross-sector initiative, was designed to tackle the growing environmental problem of discarded fishing nets in the world's coastal communities. Local fishermen in the Philippines usually discarded fishing nets that got tangled whilst out in the sea. The nets polluted the sea water and endangered the wildlife in the local area. The companies offer fishermen payment for the waste fishing nets, if they are brought onshore. Fishing nets are then recycled to produce yarn to be used for the production of new carpet tiles. Whilst benefiting the society by providing income for fishermen, the initiative helps educate the local society about the dangers of water pollution, and maintain the environment clean. Interface fulfils Mission Zero's goal to source 100% recycled materials for its carpet tiles. This can be referred to Circular Economy, in which one sector recycles the waste from another.

TacTiles® is Interface's carpet tile installation system that integrates lean thinking and sustainability to reduce waste and provide value to the customer. TacTiles are small adhesive-backed squares that connect carpet tiles securely to form a floor that "floats" for improved flexibility, easier replacement and long-term performance without permanent adhesion to the subfloor. TacTiles are a result of research and design using lean and sustainability concepts to reduce the environmental footprint and waste generated during the process, to save space and to cut transport costs compared to previously used glue adhesives. TacTiles have been imitated and adopted across the industry as a good practice of carpet tile installation, leading by example.

6 Conclusions

Although Lean and Sustainability have been applied in many organizations, their integration to design and develop new products still represents a challenge. The sustainable innovation approach will enable companies: 1) to develop new products and services, while not only envisioning economic returns, but also integrating the impact those innovations have on the environment and society, 2) to widen the scope, going from the ideation phase to the recycling, reuse or disposal of all products, 3) *to achieve innovative leaps by taking all stakeholders into consideration*. This paper provided evidence of a successful industrial case, in which a carpet producing company has defined and deployed a strategy that successfully integrates lean and sustainability considering the end-to-end innovation process providing economic returns but also impacting the environment and the society, taking care of the Earth's resources for future generations.

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