

The Power of Sensing and Scaling: Leading Business Model Innovation for Sustainability in Textiles

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Abstract: This paper examines how sensing and scaling capabilities drive business model innovation for sustainability in the textile industry. The sector faces significant environmental and social challenges, including high carbon emissions, excessive water consumption, textile waste, and supply chain transparency issues. The paper explains how organizations use sensing to identify emerging sustainability trends, regulatory changes, technological innovations, and evolving consumer preferences, while scaling enables firms to expand and integrate sustainable business across business models across products, markets and value chains. Case studies of Patagonia, H&M, China, Japan, Bangladesh and Vietnam demonstrate how these capabilities support circular economy practices, resource efficiency and long-term competitiveness. The paper also discusses barriers such as high implementation cost, limited recycling infrastructure, consumer behavior and fragmented policies. Finally, it provides recommendations for business leaders and policymakers to strengthen sustainability through innovation, collaboration and support regulatory frameworks. In conclusion, the study concludes that combining sensing and scaling capabilities is essential for achieving sustainable transformation and competitive advantage in the global textile industry. This reflects the paper's focus on sustainability challenges, business model innovation, practical case studies and recommendations.

Keywords: sustainability; circular economy; dynamic capabilities; textile industry; business model innovation

1. Introduction

The textile and apparel industry globally is facing pressure due to environmental degradation, depletion of resources as well as social demand. This industry has employed over three hundred million people worldwide which has led to generation of over 1.7 trillion dollars annual revenue. The fashion and textile industry has significant environmental impacts. It generates approximately 92 million tonnes of textile waste annually, contributes around 10 percent of global carbon emissions, and uses approximately 92 billion cubic metres. As a result, the high supply has raised concerns around labour rights, transparency as well as equity.

The generated pressure has led to immediate need of response by these industries. There is a pressure from consumers, regulators as well as investors to change the industrial models to sustainable models that favour the environment. Therefore, consumers need higher transparency, appropriate strategies are also being introduced by regulators in response to the negative changes. Firms are reacting towards the transformation by innovating their business and designing new methods that can be used in creating, delivering or capturing values in the best ways that suits the environment as well as human being.

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Industries are therefore required to navigate technological uncertainty, where they are required to change customer norms as well as interdependent supply chain. This paper argues that, the two dynamic capabilities are leading this change, including sensing and scaling. Here, sensing refers to the ability to identify and interpret chances and threats that relate to sustainable environment [1]. This may include; consumer values, new materials or regulations. On the other hand, scaling is the ability to capture these opportunities by executing friendly business models in the ecosystem.

The paper tries to analyse how industries use sensing and scaling to drive new business approaches as seen in the textile firms. It examines the effects and power of using the approach. The paper provides recommendations for managers and policymakers that try to look for just and circular transition in textiles.

2. Business Model Innovation for Sustainability

A strategic model defines how an industry generates, delivers, and captures value. Business model innovation [BMI] can be described as the transformation of one or more elements of the business model to generate new value.

When sustainability is the goal, business model for innovation must go beyond incremental efficiency [2]. It needs proper reasoning value propositions, value generation processes, and value capture mechanisms to address environmental and social challenges. Examples in textiles include: product-as-a-service, rental and resale platforms, fibre-to-fibre recycling, and supply chain transparency using blockchain.

The problem is that sustainable business model innovation normally undergoes tensions due to higher costs, unplanned demand, and misaligned institutional environments. This should therefore be navigated by the industrial capacity.

3. The Textile Industry and the Sustainability Problems

The textile value chain is worldwide, and divided based on the resources. This industry however, undergo certain challenges which may include: High water consumption. Producing a single convectional cotton T-shirt requires approximately 2700 litres of water. However, the company can recycle less than one percent of clothing into new clothing.

Another challenge faced by the textile industry is the social issues. According to International Labour Organization (ILO) that tend to address the labour rights. The company is following a circular movement of materials where they are used as long as possible. This has however called for fundamental business model changes.

4. Sensing and Scaling as Dynamic Capacities

The ability of the firm to align, build, redesign internal and external capabilities in order to fight consistence rising challenges within the industry is referred to as dynamic capabilities. This has however been broken into three mechanisms by Teece as mentioned: sensing, seizing, and reconfiguring. Here, we will however focus only on seizing and sensing.

4.1. Sensing for Sustainability

Sensing, in the context of sustainability, refers to the proactive identification of new environmental and social challenges, regulatory changes, technological advancements, and shifts in consumer preferences ahead of competitors. This early detection helps organizations seize opportunities and adapt strategically. Sensing mechanism may involve stakeholder engagement, which involves listening to NGOs, communities, and workers. For instance, brands collaborate with fashion revolution to better understand and address supply chain risks, enhancing sustainability awareness and action.

Technology scouting is keeping an eye on breakthroughs such as chemical recycling, waterless dyeing, and bio-based fabrics. As an illustration, consider the possibility of mycelium leather. Anticipating future regulations, like the EU strategy for sustainable and circular textiles, is necessary for regulatory and foresight analysis in order to maintain compliance and sustainability planning. Data and traceability entail mapping

supply chain implications utilizing technologies. Companies with strong sensing capabilities avoid being blindsided and can proactively shape the sustainability agenda.

4.2. Scaling Sustainable Business Models

Implementation and diffusion are key components of scaling. It is not only growing bigger but it entails reproducing, modifying, and integrating sustainable models across partners, goods, and regions. Textile scaling pathways include: Scaling up which is defined as growing within the company [3]. For instance, increasing a range of recycled polyester products from five percent to a hundred percent. The second pathway is scaling out. Which involves replicating in new market. This can be illustrated by a resale platform that is growing from the United State to Europe. Thirdly, deep scaling pathway. This involves altering of cultural norms and values. For example; Campaigns can be done to normalize wearing of used clothing.

Another pathway is ecosystem scaling that involves coordinating collaborators. Since no single company controls the entire value chain, textiles require cooperation. This is made possible by programs such as the circular fashion partnership and textile exchange. High initial costs, lack of recycling infrastructure, and consumer behaviour are some of the obstacles to growing of these industries. Therefore, dynamic skills aid businesses in overcoming these challenges.

5. Cases and Perspectives on Application to the Textile Sector

5.1. Case 1: Patagonia

Patagonia is renowned for incorporating sustainability into its operations. In his business model, he defined sensing and scaling as discussed. Sensing: Patagonia recognized early on that consumers were concerned about business activism and environmental effect. It made investments in lifecycle analysis and supply chain traceability. Scaling: It used a variety of methods to scale. Worn wear reselling marketplace is expanding. Scaling out: This involves growing repair facilities around the world. Scaling deep: This involves use of campaign in promoting brand loyalty while opposing excessive consumerism. For example, adding a tag with a writing, do not buy this.

Ecosystem: This implies that collaborations with providers of organic cotton and one percent for the planet. As a result, Patagonia shows how understanding social principles and scaling purpose can lead to both profit and influence.

5.2. Case 2: H&M Group—Sensing Regulation and Scaling Circularity

H&M, is one of the biggest fast-fashion stores and is therefore, facing some challenges that is intended to be solved. Sensing: He recognized customer demands for transparency and regulatory risk from the EU. He therefore, joined some initiatives such as the Global Fashion Agenda in solving this.

Scaling: Growing: The “Conscious Collection” and clothing collection initiative were formed which collected more than twenty thousand tons in 2022. Ecosystem: This involves putting money into investment funds and recycling technology firms like renew cell. Critics contend that the fundamental fast fashion concept is still in place and that scaling is still incremental.

6. Scaling Circular Textiles through Policy and Manufacturing Power

6.1. Case 1: China

Circular economy under state leadership including infrastructure for recycling as applied by China in business model. China used sensing in three main drivers including: Policy pressure: This is circular economy promotion law and the 14th five-year plan 2021–2025 require targets for recycled fibre and textile waste reduction. Secondly, resource security is an important driver because China relies substantially on imported cotton. Recycling textile waste can help reduce pressure on virgin raw material demand. Thirdly, export market risk: Recycled content and ESG statistics are now required for “Made in China” textiles by US and EU purchasers.

Scaling up is however shown by China as it is the largest recycler of PET bottles into polyester fibre in the

world. China is a major producer of recycled polyester, supported by a large manufacturing base and recycling infrastructure. Ecosystem scaling: Clothing manufacturers are connected to chemical recycling facilities through government-backed “National Circular Economy Pilot Zones” in Guangdong and Zhejiang. Scaling out: In order to comply with EPR regulations, Chinese platforms such as Shein and Temu are testing take-back initiatives in the US and EU. However, the main problem faced is that majority of recycling still involves downcycling into inferior fibre.

6.2. Case 2: Japan—Scaling Deep Through Technology and Consumer Norms

How Japan used Sensing. Japan sensed two things namely: Landfill space which is extremely limited, and secondly consumers value durability and mottainai idea of not wasting.

How Japan used Scaling. Scaling up: Companies like Teijin developed eco-circle, a chemical recycling system that turns a hundred percent of polyester garments back into new polyester. It is used by brands such as; Patagonia Japan. Scaling deep retailers like Uniqlo run global all-product recycling initiative. Since 2006, Fast Retailing has donated approximately 50.5 million second hand clothing through its clothing reuse initiatives. In Japan, clothing collection and reuse initiative have helped promote alternatives to disposal. Ecosystem scaling: This has been applied where there is partnerships between brands, municipalities, and chemical companies to collect and process textiles.

Japan demonstrates how technological development and cultural norms can support textile reuse and recycling.

6.3. Case 3: Bangladesh & Vietnam

Sensing Supply Chain Risk and Scaling Compliance

Bangladesh and Vietnam have faced increasing pressure to strengthen environmental management and compliance within their textile and garment sectors. They used to scale up: To satisfy the demands of H&M, Nike, and Adidas, factories in Dhaka and Ho Chi Minh City which made investments in solar power, waterless denim technology, and ZDHC-certified dying. Ecosystem scaling: The industry-wide sustainability training and reporting platforms were established by BGMEA in Bangladesh and VITAS in Vietnam. Scaling out: As a result of the EVFTA trade deal, Vietnam is expanding into recycled cotton and bamboo fibre for EU green orders.

Circularity is limited by the high cost of technology and the absence of domestic textile waste collection. The majority of sustainable production is still intended for export rather than domestic consumption.

7. Main Challenges to Sensing and Scaling in Textiles

Textile industries are still faced with a number of challenges that require a solution. These may include the following as discussed below. Lack of facilities for recycling, sorting, and collecting. Recycling from fibre to fibre has been the most difficult task since allot of recourses are required. For example; According to the Ellen MacArthur Foundation, less than one percent of textiles are recycled into new clothing worldwide.

Secondly, economics and cost sustainable and recycled materials are frequently twenty to forty percent more costly than virgin ones. Customers are not always prepared to pay. For instance, the price difference between conventional and organic cotton. Thirdly, complexity of the supply chain; There are five to seven layers in textile chains worldwide. It is therefore difficult to track down and manage. For example, cotton from India is dyed in Bangladesh and sold in the EU. Therefore, it takes time to process fully.

Technology preparedness. Bio-materials and chemical recycling are currently costly and limited in scope. Another difficulty they face is bankruptcy of the Renew-cell factory, example for the case in 2024 that resulted to excessive expenses and poor demand. Consumer behaviour greenwashing fatigue is another challenge that has been faced by the textile industries [4]. Consumers tend to care but still buy cheap fast fashion. Study has shown that sixty percent of consumers would say they want sustainable fashion, and only twenty five percent would pay more.

Another challenge is misalignment of policy different national laws. Many nations lack EPR and recycled content regulations. The US and Africa lag behind the EU’s stringent regulations. The scaling conundrum

increasing productivity may result in more waste. Goals for sustainability are at odds with this every year. Fifty-two micro-seasons are sold alongside H&M's "Conscious" brand. Information and trace-ability. Real impact is difficult to quantify without supply chain information. Many brands are limited to tier 2 suppliers.

8. Discussion on Managerial and Policy Implications

8.1. For Managers

Managers create sensing systems by spending money on trend research, stakeholder panels, and LCA tools. Avoid waiting for regulations. Create a scalable design from the outset: Pilot initiatives needed to have a way to grow. For example; Can our suppliers support this at 10x volume?" is a question to pose. Work together: No company can scale circular textiles on its own. Participate in pre-competitive platforms. Measure the important things: Go beyond earnings. Monitor carbon, water, and social impact.

8.2. For Policy Makers

Governments can make sensing and scaling possible by: regulations pertaining to extended producer responsibility, and financing for infrastructure related to recycling, and transparency criteria [5]. This can be achieved through different regulations including eco-design for sustainable products regulation of the European Union is one such.

9. Recommendations for Textile Firms or Brands

9.1. Build "Sensing" Capabilities First

Invest in supply chain trace-ability. Use blockchain, QR codes, and LCA tools to map tier one to four suppliers Patagonia's footprint chronicles create a sustainability trend. Team dedicated to track regulations, should be taught technology. NGOs, and consumer signals H&M's collaborate in scouting start-ups. Engage stakeholders early through Quarterly panels with workers, NGOs, farmers, recyclers fashion revolution transparency index. Use Foresight for policy model impact of European Union Textile Strategy, EPR laws on your cost structure to anticipate recycled content mandates

9.2. Design Business Models for Scaling from the First Day

Scale up here is seen by a hundred percent sustainable and recyclable materials. This has been achieved by setting 2030 targets. Redesign every product aims to use thirty percent recycled materials [6]. Expand out-take's successful pilots to every area. Standardize global repair and resale wear from Patagonia in eight countries rent, repair, "buy less... Don't Buy This Jacket". Ecosystem Scale, and recycling partnerships are some of the examples of deep-run efforts that aim to alter norms. Partnership for circular fashion and textile exchange. This is most effective as no single company can succeed on its own.

9.3. Solve the Economics

Internalize externalities: This can be achieved by finance recycling, which involves imposing a carbon-water fee on goods. New sources of income: Repair, rental, and resale margins can be two to three times larger than new. Invest in recycling plants using grants and blended finance to reduce risk.

10. Recommendations for Policymakers and Government

In order for saucerful business operation of textile companies, the government and policy makers can recommend the following. Implementing extended producer responsibility (EPR). This involves engaging brands in the collection and recycling textiles, this makes such firms responsible. Secondly, investing in circular infrastructure. This can be done by building textile to textile recycling plants and fibre processing hubs. This can successfully be achieved by partnering with KEBS as well as the universities.

Another recommendation involves creating standards and incentives. This can make it mandatory to recycle the content. Encourage MSMEs and Cooperatives: Contribute to upcycling organizations that deal with mitumba

garbage [7]. Connect them to export markets and AGOA. This is deep and tasks scaling. Harmonize regional policy to facilitate cross-border scaling, the EAC should establish a single textile waste and circularity policy.

11. Recommendations for Ecosystem and Industry Collaboration

In order to overcome these challenges, the industries involved in textile can join together by becoming a member of pre-competitive platforms. This proposal was made by Ellen MacArthur Foundation, Global Fashion Agenda, and Textile Exchange. Another recommendation is building reverse logistics together involving brands, retailers and municipalities. They can join to co-fund collection and sorting of hubs. By exchanging standards, expenses, and data this minimizes cost.

Fund Innovation can as well be recommended. Here, corporate venture funds for example; H&M and CO: LAB can invest in firms that recycle chemicals and biomaterials. Lastly, customers can be educated by different programs for resale. This helps in maintenance and repair within the industry. For example; Change from more clothes to better clothes

12. Conclusions

Patagonia's culture-driven model, H&M's infrastructure push, Renewcell's tech play a crucial role in the global waste-to-wealth strategy as all demonstrate the value of detecting and scaling. The largest obstacle however, is still scaling sustainable models more quickly than the linear model. That calls for entire ecosystems to perceive and scale together, and not just one company.

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