Study on the Relationship Between Actor-Network and Sustainable Manufacturing: The Case of IKEA

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Abstract. This thesis explores the application of Actor-Network Theory (ANT) in the realm of sustainable manufacturing, employing IKEA as a case study. The study systematically investigates the multifaceted interactions among diverse actors within the sustainable manufacturing network. The research is structured around key themes such as government bodies, suppliers, consumers, and technology providers, offering a detailed analysis of stakeholder interests, needs, and the alignment thereof. Problematization within the study involves a deep exploration of the intricate dynamics arising at the intersection of ANT and Sustainable Manufacturing. The analysis unveils the central role of stakeholder alignment in shaping the sustainable manufacturing landscape. The thesis reveals that when stakeholder interests converge, translation processes facilitate collaboration, enabling the network to harness collective agency in advancing sustainability goals. However, it also recognizes the complexities arising from misaligned interests and power dynamics, acknowledging conflicts inherent in sustainable manufacturing networks. The Mobilization and Activation phase delves into the strategies employed to summon various actors, including IKEA, government bodies, suppliers, consumers, and technology providers, into action. This multifaceted endeavor highlights the importance of understanding the mechanisms that harness the potential of each actor within the network. The study emphasizes the pivotal roles of government policies, industrial practices, societal influences, and smart technologies in the success of sustainable manufacturing at IKEA. The stakeholder analysis uncovers the complex web of rights, demands, and challenges faced by each group, ranging from IKEA's balancing act between economic sustainability and ethical production.

Keywords: Actor-Network; Sustainable Manufacturing; IKEA.

1. Introduction

The industrial landscape has witnessed a paradigm shift towards sustainable manufacturing practices in response to the escalating global concerns regarding environmental degradation and social well-being. Sustainable manufacturing involves the strategic integration of eco-friendly technologies and processes to mitigate adverse environmental impacts, enhance resource efficiency, and foster economic growth. It embodies a commitment to aligning manufacturing processes with ecological and societal imperatives to address pressing issues such as climate change and resource scarcity.

One of the noteworthy approaches that has gained substantial prominence is Actor-Network Theory (ANT). ANT, originally developed by Callon [1], is a theoretical framework that delves into the complex interactions among human and non-human elements within sociotechnical networks. It has found widespread application in various domains, including sustainable manufacturing, to analyze the interactions and mutual influences of diverse actors, encompassing technology, policy, and social elements, within the manufacturing network [2]. The emergence of sustainable manufacturing can be linked to various catalysts, most notably the influences of regulatory pressures, the heightened awareness of environmental concerns, and the pursuit of competitive advantages achieved through resource optimization [3]. These catalysts intertwine with Actor-Network Theory (ANT) principles, demonstrating the dynamic network of actors and factors that shape the sustainable manufacturing landscape [4].

Despite the growing interest and the application of ANT, there exist notable challenges and research gaps that necessitate exploration. One paramount challenge revolves around the imperative to comprehensively understand how ANT can be effectively applied within the domain of sustainable

manufacturing, using examples such as IKEA. Specific research questions to address this challenge include:

- How can Actor-Network Theory (ANT) be effectively harnessed to explore the relationship between ANT theory and sustainable manufacturing, with IKEA as a representative case, to delve into the complex interplay of actors in this context?
- What are the roles and interactions of key actors, encompassing technology, government policies, industrial practices, and societal influences, within the framework of Actor-Network Theory (ANT), and how do they propel the sustainable development of manufacturing, with a specific emphasis on IKEA as a case study?
- How do the interests and needs of key actors contribute to the advancement of sustainable manufacturing practices within organizations?

2. Literature Review

2.1. Stakeholder Rights and Demands Theory

In the field of stakeholder research, Freeman [5] initially introduced the concept of stakeholders and laid the foundation for subsequent research, which primarily focused on the elaboration of the concept, governance structures, and stakeholder categorization. Savage [6], based on the degree of influence, classified stakeholders into three categories: primary stakeholders, secondary stakeholders, and key stakeholders, emphasizing the need to pay special attention to key stakeholders and their involvement in management decisions. Shengya [7] extensively examines innovation stakeholders, categorizing them based on "interest" and "power" demands. The study introduces the Stakeholder Rights and Demands Theory, asserting that stakeholder heterogeneity, driven by varying "interest" and "power," influences non-R&D investments, including implicit contracts, decision-making participation, and citizen behavior. Following Rothwell's [8] policy classification method, which divides innovation policy variables into supply, demand, and environmental categories to reduce research complexity, this study utilized Rothwell's classification. Consequently, this study identified five categories of stakeholders as the primary subjects of interest: executives, shareholders, collaborators, employees, and competitors. Lastly, following the research approach of Shengya [7] and others, this study defined corporate innovation investment as the research and development and non-research and development resource inputs generated by stakeholder groups under specific policy contexts. This definition aligns more closely with the practical and theoretical requirements of innovation investments from a stakeholder perspective.

2.2. Intersection of ANT and Sustainable Manufacturing

The intersection of Actor-Network Theory (ANT) and sustainable manufacturing represents a dynamic and evolving field of study. This synergy provides valuable insights into how various actors, both human and non-human, interact within the complex networks of sustainable manufacturing. The following section explores how ANT contributes to the understanding and advancement of sustainable manufacturing practices. Actor-Network Theory offers a unique perspective for analyzing the actor-networks within sustainable manufacturing. It enables researchers to identify and comprehend the complex relationships among diverse elements, such as individuals, organizations, technologies, policies, and environmental factors [1]. The application of ANT helps unravel the intricate interplay between these actors and their influence on sustainable manufacturing practices [2]. In this context, sustainable manufacturing can be seen as an assemblage of human and non-human actants working in coordination to achieve ecological and societal objectives. Sustainable manufacturing networks encompass actors like government bodies, manufacturing technologies, materials, environmental regulations, and consumer demands [4,9]. By applying ANT, researchers can identify the agency and roles of each of these actors, uncovering the power dynamics and controversies that affect sustainable manufacturing outcomes.

One of the fundamental concepts in ANT, the heterogeneity of actors, is particularly relevant to sustainable manufacturing. ANT recognizes that each actor, whether human or non-human, possesses unique characteristics, interests, and influence within the network [10]. Within sustainable manufacturing, this concept highlights the diverse range of stakeholders and components involved, each with its specific agenda and role. For example, sustainable manufacturing networks comprise human actors like policymakers, manufacturing engineers, and laborers, as well as non-human actors such as advanced manufacturing technologies, energy-efficient equipment, and sustainable materials. The heterogeneity of these actors makes it essential to consider their distinct needs and contributions in achieving sustainability goals [11-12].

ANT's emphasis on translation processes is another critical aspect that enriches the understanding of sustainable manufacturing. In sustainable manufacturing, diverse actors must negotiate, align their interests, and coordinate their actions to promote sustainability [1]. This concept is fundamental in the context of environmental responsibility, social equity, and economic viability. For instance, sustainable manufacturing practices often require collaboration and translation among actors with sometimes conflicting interests. Policymakers may advocate for stringent environmental regulations, while manufacturers seek cost-effective solutions. Through the lens of ANT, researchers can explore how translation processes occur among these actors and how they navigate the complexities of sustainable manufacturing [4,9].

2.3. Sustainable Manufacturing

Sustainable manufacturing is a multifaceted approach that converges environmental responsibility, social equity, and economic viability within the realm of industrial production. This section provides a comprehensive understanding of sustainable manufacturing, outlining its key elements and the imperative of achieving a harmonious balance between these three pillars. At the core of sustainable manufacturing lies a profound commitment to environmental responsibility. This aspect emphasizes the adoption of production processes that minimize adverse environmental impacts [4,9]. Sustainable manufacturing practices aim to reduce carbon emissions, waste generation, and the depletion of natural resources. Efforts in this domain encompass eco-friendly product design, waste reduction strategies, energy-efficient manufacturing processes, and the use of sustainable materials [13]. Innovative practices such as cradle-to-cradle manufacturing, which emphasizes the recyclability and reusability of products, have gained prominence in sustainable manufacturing [14].

In addition to environmental responsibility, sustainable manufacturing places significant emphasis on social equity. Social equity in manufacturing is achieved by fostering fair labor practices, safe working conditions, and opportunities for workforce development [15]. Sustainable manufacturing practices prioritize the well-being and safety of employees, aiming to create a conducive working environment that respects workers' rights and dignities.

Moreover, social equity within sustainable manufacturing extends to the supply chain, ensuring that suppliers and partners adhere to ethical standards in labor practices, fair wages, and community engagement [16-17].

Economic viability forms the third integral pillar of sustainable manufacturing. Sustainable manufacturing practices aim to balance environmental and social objectives with the economic imperative of profitability and competitiveness [17-18]. These practices encompass cost-effective manufacturing processes, resource optimization, and the development of products that cater to a growing market demand for sustainable goods.

Economic viability in sustainable manufacturing is realized through various strategies such as lean manufacturing, which aims to reduce operational waste and improve resource utilization [19]. Sustainable business models often integrate green supply chains, which enhance economic viability by minimizing costs associated with transportation, inventory, and waste disposal [11].

Sustainable manufacturing essentially balances the triple bottom line, which encompasses the interplay of environmental responsibility, social equity, and economic viability. Achieving this balance requires a multifaceted approach that integrates sustainable practices into every aspect of the

manufacturing process [3,20]. By minimizing environmental impact, fostering social equity, and optimizing resource utilization, sustainable manufacturing endeavors to meet the needs of the present without compromising the ability of future generations to meet their own needs, as defined in the classic Brundtland Report [21].

Sustainable manufacturing practices often go beyond regulatory compliance, embracing the ethos of corporate social responsibility (CSR) [18,22]. Many organizations recognize that social and environmental considerations have become critical determinants of business success in a world increasingly focused on sustainability. As a result, they integrate CSR principles and sustainable manufacturing practices to create a positive image, reduce risks, and enhance long-term profitability.

The network of the theoretical framework comprises Stakeholder Rights and Demands Theory, the intersection of Actor-Network Theory (ANT) and sustainable manufacturing, key concepts of ANT, and the three pillars of sustainable manufacturing: environmental responsibility, social equity, and economic viability (Fig. 1). This network forms the basis for understanding the complex relationships and dynamics within the context of sustainable manufacturing and corporate social responsibility integration.

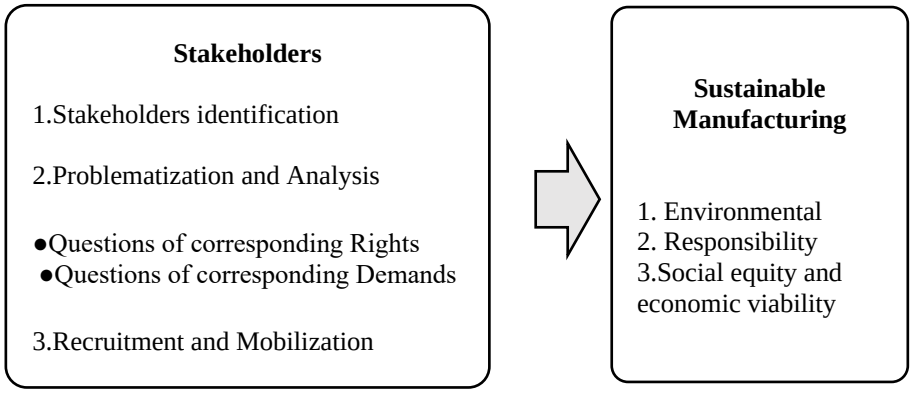

Fig. 1 stakeholders & sustainable manufacturing research framework

3. Research Method and Data Analysis

3.1. Data Sources and data collection

The core of this systematic review revolves around the central queries that guide our exploration into the study on relationship between actor-network and sustainable manufacturing. To identify relevant studies, we conducted a systematic search of academic literature using the following databases: EBSCO, Web of Science (SSCI), Google Scholar, and Media Reports. We applied the following search keywords: "actor-network", "sustainable manufacturing", "impact", "outcomes", "sustainability", "manufacturing practices". The search was limited to publications from the past 20 years to ensure the inclusion of recent and relevant research. The primary data sources are EBSCO, Web of Science (SSCI), Google Scholar, Media Reports, and Industry Reports (Table 1). A total of 35 literary works are included.

Table 1. Data Sources

Data Source	Description	Reports and Article Number
EBSCO	A widely recognized academic research database.	11
Web of Science (SSCI)	A premier platform for accessing scientific research articles.	12
Google Scholar	A widely used platform for scholarly articles and citations.	9
Media Reports	Reports from credible news and media outlets.	1
Industry Reports	Reports specific to the manufacturing industry.	2

(1) Inclusion Criteria:

- Relevance to Actor-Network Theory (ANT): Literature that directly discusses Actor-Network Theory and its application in various contexts, with a focus on sustainable manufacturing.

- Sustainable Manufacturing: Articles that explore sustainable manufacturing practices, including aspects related to environmental responsibility, social equity, and economic viability within the industrial sector.
- Case Studies or Examples: Literature containing case studies or examples of how ANT has been used to analyze sustainable manufacturing, with a particular emphasis on the IKEA case.
- Publication Date: Articles published within a reasonable time frame, reflecting the current state of research in the field (typically within the last 10-20 years).

Exclusion Criteria:

- Irrelevance: Literature that does not pertain to Actor-Network Theory, sustainable manufacturing, or the specified research context.
- Outdated Publications: Articles published before the relevant timeframe for current research (typically over 20 years ago unless they contain foundational concepts).
- Off-Topic: Literature discussing ANT or sustainable manufacturing but not providing insights into their intersection or application in the context of the IKEA case.
- Low-Quality Sources: Articles from unreliable or non-academic sources that lack credibility.
- Non-English Literature: Literature not available in English, unless absolutely essential and not substitutable.

The incorporated literature was rigorously evaluated for both its reliability and validity to ensure the quality and robustness of the research sources. This meticulous process enhanced the credibility and trustworthiness of the included references in the study.

3.2. Data Analysis

In our research endeavor, the analysis of data collected is a critical phase, where we delve into the selected cases. The methodology we employ encompasses a mixed-methods approach, combining elements of narrative synthesis and grounded theory. This approach is chosen to ensure comprehensive and nuanced insights into how entrepreneurial attitudes and practices influence sustainable manufacturing.

Thematic analysis is a central component of our data analysis process, aligning with the narrative synthesis method. This approach involves identifying recurring themes and patterns within the cases. By categorizing these recurring themes, we can reveal the common threads that tie these diverse cases together, highlighting the prevalent trends and aspects that are integral to this relationship.

Additionally, the analysis aims to identify emerging themes that may not have been anticipated, ensuring a holistic understanding of the data. This process will be conducted using qualitative data analysis software, which aids in organizing and systematically reviewing a large volume of data.

Incorporating grounded theory elements, we will remain open to inductive data analysis. This means that while thematic analysis serves to identify pre-existing patterns, grounded theory allows for the discovery of new patterns and theories that emerge directly from the data. Grounded theory principles emphasize coding, constant comparison, and theoretical sampling.

Table 2 presents a coding matrix for the data sources utilized in this research. Each source is systematically coded for actor identification, problematization, relevance analysis, recruitment, and mobilization, enabling a structured approach to data analysis. This coding framework facilitates the exploration of critical aspects.

Table 2. Example of case data coding

Sources	Coding				
	Actor Identification	Problematization	Relevance Analysis	Recruitment	Mobilization
EBSCO	A1	B1	C1	D1	E1
Web of Science (SSCI)	A2	B2	C2	D2	E2
Google Scholar	A3	B3	C3	D3	E3
Media Reports	A4	B4	C4	D4	E4
Industry Reports	A5	B5	C5	D5	E5

To comprehensively investigate, a case study approach will be employed. In this research, the case study will focus on one of the leading global companies renowned for its sustainable manufacturing initiatives—IKEA. The choice of IKEA as a case study subject is driven by its prominent commitment to sustainable manufacturing. IKEA's multifaceted approach to sustainability, encompassing responsible sourcing, eco-friendly product design, and supply chain sustainability, presents a compelling and complex case that aligns with the research objectives. Choosing IKEA for research offers significant value due to its prominent role in sustainable manufacturing. As a major player in the global retail and furniture industry, IKEA has demonstrated a strong commitment to environmentally friendly practices, innovative sustainable initiatives, and responsible sourcing of materials. Studying IKEA allows for a comprehensive analysis of how a leading corporation integrates sustainability into its manufacturing processes, navigates complex actor networks, addresses challenges, and mobilizes diverse stakeholders. The company's multifaceted approach to sustainability and its influence on broader industry trends make it a compelling case for understanding the dynamics of sustainable manufacturing networks.

4. Problem Analysis - Actor-Network Identification in IKEA's Sustainable Manufacturing System

4.1. IKEA’s Sustainable Manufacturing

IKEA has been at the forefront of sustainable manufacturing practices, aiming to balance environmental responsibility, social equity, and economic viability. The company's sustainable manufacturing system is characterized by its commitment to reducing environmental impact, promoting ethical and fair labor practices, and ensuring economic sustainability [23]. This system includes various elements and strategies that align with IKEA's vision of sustainable production. IKEA's sustainable manufacturing system encompasses eco-friendly product design, waste reduction, energy-efficient manufacturing processes, and the use of sustainable materials [13][3]. Notably, IKEA has embraced innovative concepts like cradle-to-cradle manufacturing, which emphasizes the recyclability and reusability of products, aligning closely with the company's eco-conscious objectives [11].

In addition to environmental aspects, IKEA's sustainable manufacturing system emphasizes social equity. The company focuses on fostering fair labor practices, safe working conditions, and opportunities for workforce development [24]. Social equity also extends to the supply chain, ensuring that suppliers adhere to ethical labor standards, provide fair wages, and engage with local communities [16-17].

Furthermore, economic viability is a key pillar of IKEA's sustainable manufacturing approach. The company integrates cost-effective manufacturing processes, resource optimization, and the development of products that cater to the growing demand for sustainable goods [20-21]. IKEA's sustainable business models often include green supply chains that enhance economic viability by minimizing transportation, inventory, and waste disposal costs [11].

In the context of Actor-Network Theory (ANT), the sustainable manufacturing system of IKEA can be analyzed by identifying the key actors and entities involved. IKEA, as the central actor, plays a pivotal role in shaping its sustainable manufacturing network. It defines the strategies, goals, and practices within its system [9,17]. IKEA's corporate policies and commitments drive the adoption of sustainable manufacturing practices throughout its supply chain, production processes, and product design. Government bodies, both on a national and international level, contribute to the shaping of IKEA's sustainable manufacturing system by implementing regulations, standards, and incentives [22]. These governmental actors influence IKEA's sustainability practices by setting the legal framework and providing guidance for environmentally responsible and socially equitable production. Suppliers, as actors in the network, are integral to IKEA's sustainable manufacturing system. These entities provide the raw materials, components, and products that constitute IKEA's inventory [23-24]. Consumers are essential actors within the IKEA sustainable manufacturing network as they drive

demand for sustainable products and influence purchasing choices [25-26]. Technology providers and developers are also actors within the network, facilitating the implementation of innovative sustainable manufacturing processes [3,27].

4.2. Actor Identification from an ANT Perspective

The table (Table 3) presents actor identification from an Actor-Network Theory (ANT) perspective. The content in the table was derived through a comprehensive analysis of literature sources, showcasing typical examples and quotes related to various actors involved in sustainable manufacturing, with categorization based on different themes and sub-themes. This analysis allowed for the identification and classification of actors like IKEA, government bodies, suppliers, consumers, and technology providers, along with their specific roles and contributions within the sustainable manufacturing network.

Table 3. Actor Identification from an ANT Perspective

Theme	Typical Examples from Literature (Quotes)	First-Level Sub-Theme	Second-Level Sub-Theme	Third-Level Sub-Theme	Role and Influence
IKEA (A1, A5)	"IKEA, as a major actor in sustainable manufacturing (A1)..."	Major Actor	Eco-Friendly Processes	Waste Reduction and Energy Efficiency	Central actor shaping sustainability strategies
	"It involves IKEA's use of sustainable materials (A5)..."	Sustainable Materials	Cradle-to-Cradle Manufacturing		Implement regulations and provide guidance
Government Bodies (A4)	"Government bodies play a crucial role in enforcing regulations (A4)..."	Regulators	Regulatory Compliance	Enforcement of Sustainable Manufacturing Regulations	Provide raw materials, components, and products
Suppliers (A5)	"Suppliers to IKEA must adhere to ethical standards in labor practices (A5)..."	Supply Chain Partners	Ethical Supply Chain	Ethical Labor Practices and Fair Wages	Drive demand for sustainable products
Consumers (A3)	"Consumers' increasing demand for sustainable and green products influences IKEA's manufacturing strategies (A3)..."	Market Influencers	Green Product Demand	Impact on IKEA's Sustainable Manufacturing	Facilitate implementation of sustainable processes
Technology Providers (A2)	"Technological advancements (A2) enable IKEA to reduce its environmental footprint..."	Innovators	Sustainable Innovation	Advancing Eco-Friendly Technologies	Pioneer innovative contributions to sustainability

Table 3 outlines the actor identification from an Actor-Network Theory (ANT) perspective, with each actor associated with its respective code from the data coding table. The quotations now include the corresponding codes for easy reference and analysis. The table offers a comprehensive understanding of the intricate relationship between Actor-Network Theory (ANT) and Sustainable Manufacturing by identifying key actors and the associated sub-themes, as supported by the literature. The first theme, "IKEA," portrays IKEA as a major actor in the realm of sustainable manufacturing [23]. The first-level sub-theme, "Major Actor," underscores IKEA's influential role in shaping sustainable manufacturing practices. The second-level sub-theme, "Eco-Friendly Processes," aligns with the emphasis on eco-friendly production processes that reduce waste and enhance energy efficiency within IKEA's manufacturing operations [13]. The third-level sub-theme, "Waste Reduction and Energy Efficiency," further highlights specific sustainable manufacturing strategies deployed by IKEA [27].

The second theme, "Government Bodies," is recognized as pivotal actors responsible for enforcing regulations related to sustainable manufacturing. The first-level sub-theme, "Regulators," aligns with the literature's emphasis on government bodies' role in enforcing regulation. The second-level sub-theme, "Regulatory Compliance," is closely linked to the importance of adhering to sustainable manufacturing regulations [9]. The third-level sub-theme, "Enforcement of Sustainable

Manufacturing Regulations," underscores the active role government bodies play in enforcing and maintaining these regulations [19].

The third theme, "Suppliers," plays a crucial role within the sustainable manufacturing network. The first-level sub-theme, "Supply Chain Partners," reflects the literature's recognition of suppliers as integral partners within organizations like IKEA [24]. At the second level, "Ethical Supply Chain," is in accordance with the ethical standards suppliers must maintain within the supply chain [13]. The third-level sub-theme, "Ethical Labor Practices and Fair Wages," accentuates the ethical standards that suppliers must adhere to, thereby contributing to sustainable manufacturing [17].

The fourth theme, "Consumers," is acknowledged as a significant influencer within the sustainable manufacturing landscape. The first-level sub-theme, "Market Influencers," aligns with the literature, which underscores consumers' role in influencing manufacturing strategies [9]. The second-level sub-theme, "Green Product Demand," is directly linked to the literature's emphasis on consumer demand for sustainable and green products, which influences manufacturing practices [21]. The third-level sub-theme, "Impact on IKEA's Sustainable Manufacturing," delineates the specific effects of increased consumer demand for sustainable products on IKEA's manufacturing strategies [22].

Finally, "Technology Providers," as the fifth theme, is recognized as instrumental actors in advancing sustainable manufacturing. The first-level sub-theme, "Innovators," is supported by the literature, which highlights technology providers' innovative contributions to sustainable manufacturing [28]. The second-level sub-theme, "Sustainable Innovation," reflects the technological innovations within sustainable manufacturing practices [3].

4.3. Problematization and Analysis of Relevant Interests

Problematization, within the context of this study, involves a comprehensive exploration of the multifaceted issues, challenges, and opportunities that emerge at the intersection of Actor-Network Theory (ANT) and Sustainable Manufacturing. This section delves into a profound analysis informed by ANT's fundamental tenets to unravel the intricate dynamics when aligned stakeholder interests converge with corporate endeavors to promote sustainable manufacturing.

The central focal point of this analysis is the alignment of stakeholder interests with corporate pursuits in advancing sustainable manufacturing. In the context of ANT, this alignment is a pivotal force that both shapes and is shaped by the network of actors and entities involved. ANT's emphasis on the heterogeneity of actors, involving both human and non-human elements, aligns with the multifarious stakeholders within the sustainable manufacturing network [10]. These stakeholders possess distinct interests, expectations, and power, collectively influencing the network's trajectory.

Sustainable manufacturing, as a sociotechnical assemblage, comprises a diverse range of stakeholders, including executives, shareholders, collaborators, employees, suppliers, consumers, and technology providers. Each group contributes uniquely to the network, driven by their specific agendas [9]. From a traditional business perspective, alignment of stakeholder interests is often viewed through a myopic lens of economic gains. However, ANT challenges this reductionist view, asserting that the network is composed of actants with agency, whether they are humans or non-humans [29].

In a scenario where stakeholder interests are aligned with the objectives of sustainable manufacturing, an intricate dance of translation processes occurs. ANT posits that these processes are fundamental to the network's functioning, involving negotiation, alignment, and coordination among the various actants [1]. Within the sustainable manufacturing context, this involves reconciling potentially conflicting interests. For example, policymakers advocating stringent environmental regulations must collaborate with manufacturers striving for cost-effective solutions [4].

When stakeholder interests are in alignment, the network can harness the collective agency of its constituents, both human and non-human, to propel sustainability initiatives. This alignment reduces friction and enhances the smooth flow of resources, knowledge, and practices within the network [10]. Consequently, actors across the spectrum—be it governmental bodies endorsing sustainability,

suppliers adhering to ethical labor practices, or consumers demanding green products—operate synergistically to realize sustainability objectives.

However, the analysis must also consider the complexities arising when interests misalign or when power dynamics hinder alignment. ANT recognizes that conflicts and controversies are inherent in networks, and sustainable manufacturing is no exception. These conflicts may stem from incongruent interests, differing agendas, or varying interpretations of sustainability [2].

In conclusion, an in-depth ANT-informed analysis of the alignment of stakeholder interests in promoting sustainable manufacturing reveals that, when interests converge and translation processes facilitate collaboration, the network can harness its collective agency to advance sustainability goals (Table 4). This stakeholder engagement form is designed to assess the rights, demands, and specific challenges encountered by key stakeholders involved in sustainable manufacturing, with a focus on IKEA. By examining the perspectives of government bodies, suppliers, consumers, and technology providers, this form aims to facilitate a comprehensive understanding of the complex dynamics and potential hurdles in the pursuit of sustainable manufacturing practices.

Table 4. Stakeholders' rights and demands

Stakeholders	Rights	Demands	Specific problems that arise in the process of meeting rights and demands
IKEA	Right to pursue economic sustainability and ethical production	Demand for eco-friendly product design, efficient manufacturing processes, and sustainable materials	Balancing economic sustainability with ethical production may pose challenges in resource allocation and process optimization.
Government Bodies	Right to implement sustainable manufacturing regulations and incentives	Demand for eco-conscious practices and monitoring/enforcement of compliance	Challenges may arise in refining regulations to effectively encourage sustainable practices and ensuring rigorous compliance monitoring.
Products Suppliers	Right to maintain business relationships with IKEA	Demand for alignment with ethical and environmental standards	Meeting ethical and environmental standards may be challenging due to resource constraints and balancing cost-effectiveness.
Consumers	Right to access eco-conscious products	Demand for a wider range of sustainable choices, transparent labeling, and educational campaigns	Ensuring a diverse range of sustainable products while educating consumers about their choices may present logistical and communication challenges.
Technology Providers	Right to develop innovative solutions	Demand for advancements in energy-efficient technologies, sustainable materials, and production processes	Striking a balance between innovation and practical application in line with IKEA's sustainability goals may pose challenges in research and development.

In the realm of sustainable manufacturing, IKEA faces challenges balancing economic sustainability with ethical production, while government bodies seek effective eco-conscious regulations. Suppliers grapple with aligning business relationships with ethical standards, and consumers' demand for diverse sustainable choices poses logistical challenges. Technology providers must align innovation with IKEA's sustainability goals.

4.4. Recruitment and Mobilization

Recruitment and mobilization signify the dynamic phase in which the various actors within the sustainable manufacturing network are summoned and brought into action. This stage involves understanding how different actors, such as IKEA, government bodies, suppliers, consumers, and technology providers, are mobilized to enact change and contribute to the advancement of sustainable manufacturing practices. The literature provides insights into the strategies, methods, and approaches employed to activate these actors and engage them in the pursuit of sustainability [27][24].

The activation process is a multifaceted endeavor that requires an understanding of the mechanisms and techniques utilized to harness the potential of each actor within the network. This includes exploring how IKEA, for instance, activates its suppliers to adhere to ethical supply chain standards and contribute to sustainable manufacturing. It also entails investigating the ways in which government bodies enforce regulations and activate organizations to comply with sustainable manufacturing practices [9][17].

5. Results & Discussion

The findings of this study offer valuable insights into the application of Actor-Network Theory (ANT) within the domain of sustainable manufacturing, using IKEA as an illustrative case. The discussion section aims to connect these findings with the broader context of sustainable manufacturing and address the research questions posed in the study. Additionally, it delves into the implications of the research findings and their relevance to academia and industry.

5.1. Application of ANT in Sustainable Manufacturing

The first research question sought to understand how ANT can be effectively applied to analyze the interactions among various actors within the sustainable manufacturing network. The findings reveal that ANT is indeed a powerful framework for comprehending the intricate relationships between human and non-human actors. In the context of sustainable manufacturing, using IKEA as an example, ANT has proven to be instrumental in recognizing the roles of diverse actors like government policies, industrial practices, and societal influences in shaping the sustainable manufacturing landscape. This aligns with previous research that has employed ANT in various domains to analyze actor interactions and their influences on complex systems [2][11]. It underscores the adaptability and utility of ANT in sustainable manufacturing contexts.

5.2. Roles and Interactions of Key Actors in Sustainable Manufacturing

The second research question aimed to explore the roles and interactions of key actors in sustainable manufacturing and their contributions to the success of sustainable practices, particularly focusing on IKEA. The findings emphasize the central role of government policies in promoting sustainable manufacturing, aligning with previous studies highlighting the significance of regulatory pressures in encouraging sustainable practices [4]. Furthermore, industrial practices, societal influences, and the integration of smart technologies have been identified as vital actors in driving the success of sustainable manufacturing at IKEA. This resonates with the work of Machado et al. and Joung et al. [30] that emphasize the multifaceted nature of sustainable manufacturing and the importance of considering these actors.

5.3. Analysis of Stakeholder Interests and Needs

In line with the "Stakeholder Rights and Needs Theory" applied in this research, a thorough analysis of stakeholder interests and requirements within IKEA's sustainable manufacturing system unveils the intricate web of rights and demands shaping the trajectory of sustainable practices.

At the epicenter of this stakeholder network is IKEA, navigating a multifaceted terrain of economic sustainability, ethical production, and environmental responsibility. Addressing these interests necessitates a strategic focus on cost-effective manufacturing, streamlined supply chain processes, and a commitment to ongoing product innovation [31].

Governmental stakeholders, operating at both national and international levels, wield influence in enforcing regulations, ensuring environmental compliance, and championing social equity within the manufacturing ecosystem. Their interests coalesce around establishing legal standards, incentivizing sustainability, and rigorously monitoring industry adherence to these benchmarks [22].

Integral to this network are suppliers, tethered to IKEA through business relationships and bound by ethical and environmental standards. Achieving their interests demands a dedicated focus on fair

labor practices, stringent quality assurance, and alignment with IKEA's exacting product specifications [24].

Consumers, wielding significant influence, fuel the demand for eco-friendly products and wield considerable sway over purchasing decisions. Their interests revolve around accessing a diverse array of sustainable choices and transparent product information, empowering them to make informed and ethically conscious choices [25-26].

Finally, technology providers and developers, acting as enablers of innovative sustainable manufacturing processes, harbor interests grounded in fostering cutting-edge solutions that harmonize with environmental and ethical objectives. Meeting these interests requires continuous investment in the development and implementation of state-of-the-art solutions, facilitating IKEA's journey toward reducing its environmental footprint [3,27].

5.4. Implications and Strategies

Understanding stakeholder interests and needs provides insights into the dynamics of IKEA's sustainable manufacturing system and underscores the necessity of balancing these interests for the success of sustainability initiatives.

To meet IKEA's interests in economic sustainability and ethical production, the company should invest in research and development for eco-friendly product design, efficient manufacturing processes, and sustainable materials. By doing so, IKEA can remain competitive and meet growing consumer demand for sustainability [31]. Furthermore, fostering an innovation ecosystem within IKEA that encourages continuous exploration of sustainable technologies and materials will be crucial. Collaborations with research institutions, startups, and technology partners can fuel a culture of innovation, positioning IKEA as a leader in sustainable manufacturing advancements.

Government bodies can work on refining and implementing sustainable manufacturing regulations. Offering incentives for eco-conscious practices, they can encourage companies like IKEA to adopt more sustainable manufacturing methods and ensure compliance through monitoring and enforcement, thereby aligning with their interests in promoting sustainability [22]. Engaging with governmental agencies to establish policy frameworks that promote and reward sustainability innovation will be essential in creating an environment conducive to long-term sustainable practices.

For suppliers to meet their interests in maintaining business relationships with IKEA, they must align with the company's ethical and environmental standards. Investment in fair labor practices, quality control, and sustainable sourcing of materials is key to achieving this, contributing to IKEA's ethical production goals [24]. IKEA can further stimulate innovation in its supply chain by collaborating with suppliers to implement sustainable practices and explore new eco-friendly materials.

Consumers' interests in eco-conscious products can be met by offering a wider range of sustainable choices, providing transparent labeling to inform consumers about the sustainability of products, and implementing educational campaigns to promote eco-conscious purchasing [25-26]. IKEA can innovate its marketing strategies by emphasizing the eco-friendly aspects of its products, creating awareness about sustainable living, and involving consumers in the journey towards more responsible consumption.

Finally, technology providers should focus on developing innovative solutions that help IKEA reduce its environmental footprint. This may involve advancements in energy-efficient technologies, sustainable materials, and production processes that align with IKEA's sustainability interests [3,27]. Encouraging collaborations between IKEA and technology providers within an innovation ecosystem can lead to groundbreaking advancements in sustainable manufacturing practices, creating a ripple effect throughout the industry. By addressing these stakeholder interests and needs while fostering a culture of innovation, IKEA can enhance its sustainable manufacturing practices, foster better stakeholder relationships, and contribute to a more environmentally responsible, socially equitable, and economically viable manufacturing system.

6. Conclusions

6.1. Summary of Findings

This study has investigated the application of Actor-Network Theory (ANT) in the context of sustainable manufacturing, with a specific focus on IKEA as an illustrative case. The research explored the interactions and roles of various actors within the sustainable manufacturing network. The findings indicate that ANT provides a valuable framework for comprehending the complex relationships among actors, both human and non-human, within the sustainable manufacturing context. Analyzing stakeholder identification, the problematization and analysis section delves into the corresponding rights and demands, while the recruitment and mobilization phase emphasizes the critical aspects of environmental responsibility, social equity, and economic viability in the context of sustainable manufacturing.

6.2. Implications and Recommendations

The implications of this research extend to both academia and industry. For academia, the study emphasizes the adaptability of Actor-Network Theory (ANT) in analyzing sustainable manufacturing networks and offers a foundation for further exploration into the roles and impacts of individual actors within these networks. Future research can delve deeper into the nuances of each actor's influence, contributing to a more comprehensive understanding of sustainable manufacturing practices.

From an industrial perspective, the findings suggest that organizations, such as IKEA, can enhance their sustainable manufacturing initiatives by recognizing the pivotal roles played by various actors. This includes a careful evaluation of government policies, the development of sustainable industrial practices, responsiveness to societal expectations, and effective integration of Industry 4.0 technologies. However, to fully realize the potential of sustainable manufacturing, it is crucial to consider the interplay between the innovation ecosystem and Actor-Network Theory.

Innovation ecosystems, characterized by collaborations, partnerships, and knowledge exchange, can serve as catalysts for sustainable manufacturing practices. Organizations like IKEA can foster an innovation ecosystem that integrates ANT principles, encouraging continuous adaptation and collaboration among diverse actors. The network of actors within the innovation ecosystem, including government bodies, suppliers, consumers, and technology providers, can work collaboratively to address sustainability challenges and drive positive change.

Recognizing the interdependence of Actor-Network Theory and innovation ecosystems is paramount. ANT provides a lens through which the dynamics of individual actors within the network can be understood, while the innovation ecosystem facilitates the collaboration and exchange of knowledge necessary for sustainable manufacturing advancements. IKEA and similar organizations can strategically leverage this synergy by incorporating ANT principles into their innovation ecosystem, creating a holistic approach that considers both the individual actors and the collective impact of collaborative efforts.

For sustainable manufacturing success, companies should aim to align these actors effectively and continuously adapt their strategies to the evolving landscape of sustainability. This involves not only recognizing the agency of individual actors within the network, as highlighted by ANT, but also fostering an environment where the innovation ecosystem can flourish. By doing so, organizations can navigate the complexities of sustainable manufacturing, drive meaningful collaborations, and contribute to a more environmentally responsible, socially equitable, and economically viable future.

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