ROLE OF STANDARDS IN DESIGNING CIRCULAR ECONOMY AND THEIR EFFECT ON UNITED NATIONS SUSTAINABLE DEVELOPMENT GOAL 12

ANSI Student Paper Competition 2020

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MAY 31, 2020

ABSTRACT

The United Nations Sustainable Development Goal 12 (UN SDG), aimed at responsible consumption and production, outlines metrics to achieve by 2030 "that current material needs do not lead to the over extraction of resources or to the degradation of environmental resources [1]." The cause for alarm stems from increasing carbon footprints, rapid consumption, heavy dependence on non-renewable resources, and a lack of concern for long-term maintenance of resources – especially in view of the 13% rise in population expected by the end of the next decade [2]. Standards provide commonly-accepted definitions and practices that can pinpoint methods to be used universally to meet this goal's criteria. This paper recognizes specifics standards that can be used as tools to implement the targets outlined by this Sustainable Development goal.

More specifically, to develop responsible production and consumption patterns and behaviors, it is necessary for organizations to subscribe to the circular economy framework that patronizes closed-loop supply chain design, where outputs become inputs again. For an organization employing this design, it is first recommended that they develop robust remanufacturing sub-processes. This paper looks at the common challenges many industries face in remanufacturing that prevent them from successfully transitioning to sustainable production methods. These include high cost of resources, complex parts design, limited core[1] availability, lack of internationally accepted definitions and protocols, and poor consumer perceptions [4][5][6][13]. Several standards and frameworks have been identified to counter each issue and provide a consolidated solution that will enable organizations to loop their supply chain cycle and meet the UN's sustainability goals by the end of 2030.

There is plenty of research describing remanufacturing as the ultimate form of recycling and as America's biggest untapped resource [15]. However, there have been few studies to show how standards and frameworks can be used to bring about a shift towards the closed-loop supply chain. This paper explores remanufacturing and the circular economy as a solution for the UN's SDG to reduce the rapid pace of resource extraction and minimize the carbon footprint. It is discussed through the lens of the Push-Pull-Mooring (PPM) Theory of Migration, the Triple Helix Model, and predictive models on customer behavior through data-mining to prove that issues related to poor customer perception and high cost of parts, among others, can be solved with a combined effort from different spheres of influence through the commonly accepted use of standards.

1. INTRODUCTION: REMANUFACTURING AND THE CIRCULAR ECONOMY SOLUTION

Responsible consumption and production as one of the United Nation's Sustainable Development Goals speaks to both producers as well as consumers. The UN calls for "Well-

[1] Core is a component of a used product that can be recycled in the process of remanufacturing to make a like-new product.

designed national policy frameworks and instruments" to rapidly enable this transition in order to decrease resource extraction globally [1]. To facilitate the management of such practices, policies regarding "resource efficiency, reduce waste and mainstream sustainability practices across all sectors of the economy," must be examined [1].

Responsible production ensures proper and complete use of material leading to reduced waste. Remanufacturing is the process of re-investing core materials of a used product back into the production of a like-new product. It differs from other recycling procedures because it returns product quality up to the original equipment manufacturer's (OEM) performance. It builds a sustainable supply chain, beginning to end, because it leads to lower costs related to energy and resources and is environmentally friendly by design. One of the areas of focus for sustainable consumption and production according to the UN includes "leapfrogging," which encourages developing countries to bypass inefficient, costly phases of development toward sustainable, resource-efficient methods of innovation [2]. The United Nations Environment Programme (UNEP) report of 2013 discusses the potential remanufacturing has as a national business venture capable of providing new export opportunities for developing countries. Due to the reduced amounts of resources needed to provide remanufacturing services, these products often are much cheaper than originals and range between 40% to 80% of a new product price [3].

Remanufacturing is a central component of the circular economy (CE) model, which is a "restorative, self-generating ecosystem, where outputs of the system (i.e., waste) are recaptured for use as future inputs (i.e. supply) [4]." Resources available to manufacture products are decreasing globally at a rapid pace. The circular economy is stimulated by increasing prices of new products due to high skill labor costs, technologically advanced manufacturing, and the use of rare materials in production [4]. The combination of these factors has the potential to drive consumers away from new products and towards remanufactured materials [4]. Remanufactured products allow a company to contribute to the circular economy by extending the lifetime of those elements and creating value. The remanufacturing industry acts as a critical enabler of the circular economy by minimizing consumption of non-renewable resources and maximizing their circulation [14].

2. LITERATURE REVIEW: HOW STANDARDS CAN AFFECT THE REMANUFACTURING INDUSTRY

Remanufacturing primarily faces three prominent challenges that are preventing this process from making a big impact on sustainability and closing the supply chain loop: product design complexity, lack of common definition or understanding, and unfavorable consumer perception [4][5][6]. Prior to implementing standards, it is important to understand the resistance that the remanufacturing industry faces from consumers as well as corporations to better target specific frameworks that can help overcome these problems.

2.1 Product Design Complexity

Complex production planning and control auditing are risks inherent in remanufacturing systems because of the difficulties and uncertainties associated with reusing product parts [5]. In the United States, barriers to remanufacturing lie also in high cost due to limited availability of core parts, issues in product design and quality leading to corrosion and destructive assembly fits. Therefore, the solution derived from the "Triple Helix Model" focuses on the combined efforts from academia, industry, and the government that can produce operational solutions, citing lean production strategies catering to process, product, and profit improvement [5]. For example, lean production can help lower inventory levels and improve material flow. Standards focusing on efficiently designing product parts and effectively involving multiple bodies of influence, like the "Triple Helix Model" are necessary to resolve these concerns.

2.2 Lack of Global Acknowledgement

Additionally, regulatory barriers in foreign markets are a prominent hindrance in advancing the remanufacturing industry in many countries [6]. Customs officials treat core parts as used products and prohibit them. The European Remanufacturing Network (ERN) states, "An absence of an accepted legal definition was found to exacerbate the issue [6]." This is due to the lack of universally accepted standards regarding the design, quality, manufacturing, and production of used products. Here, it is evident that sourcing core across borders was heavily limited and therefore so is the industry, leading to steep prices and limited availability in local markets. To compete against these challenges and improve consumer perceptions, the ERN recommends several solutions revolving around the idea of using standards to promote the industry including proper labeling of remanufactured products, encouraging public procurement of equipment remanufactured to specified quality standards, creating and promoting universally-developed and accepted standards on remanufacturing to raise public awareness, like PAS 14154 [6]. The study elaborates on the large environmental impacts that remanufacturing will help realize citing that "remanufacturing of automotive components yields some 88 % materials savings compared to using a new product, with an associated 53 % decrease in CO2 emitted and 56 % lower energy requirement [6]." Furthermore, the remanufacturing industry helps contain and circulate advanced critical raw materials such as those with high economic value and supply risk within the economy, while also creating high skill jobs. ISO 20245 is a standard that "establishes minimum screening criteria for the cross-border trade of second-hand goods [7]." This standard heavily affects the import of cores into countries. Therefore, it is pivotal that standards are developed and propagated internationally to provide consistency and transparency within the economy and facilitate free movement of cores that will allow remanufactured products to be more accessible.

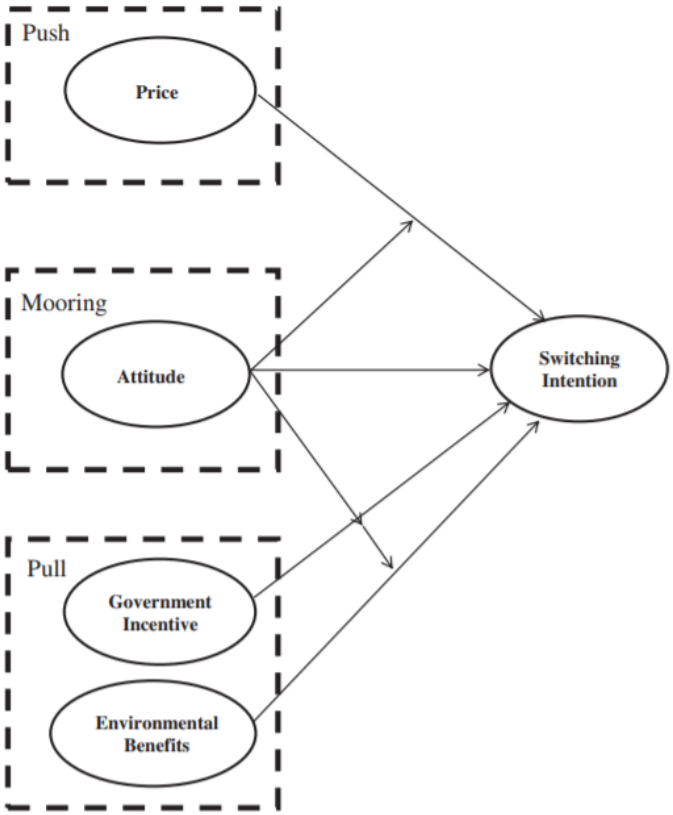

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Figure 1 [4]

2.3 Poor Consumer Perceptions

Aside from the complexities that nations and industries face in implementing remanufacturing procedures, there is significant opposition also coming from consumers that have a negative predisposition towards these products. Products manufactured conscious of the environment must also have a strong, attractive market to sell to in order to build and continue production. A study on consumer switching behavior supports the Triple Helix model theory proposed earlier and advocates for the support of government policies and corporate influence to educate consumers on the benefits – both internal and environmental – possessed by acquiring remanufactured products [4]. There are additional barriers to change, such as the geographic scope of global supply chains and material and product complexity. However, customer engagement is pivotal to the success of transformation toward a closed-loop economy. Figure 1 illustrates the Push-Pull-Mooring (PPM) Theory of Migration [4]. It suggests investigation into some push factors such as high prices or poor service that will push consumers away from original products and pull factors like superior performance, environmental benefits, and government incentives that pull consumers towards alternative solutions that can contribute to

this shift. It is also interesting that a high number of service failures reported can still ultimately have a positive impact on customer buying patterns, suggesting product popularity: ". . . when a large amount of negative feedback (more than 15 cases) is available, the [model] suggests that customers tend to adopt a low-depth information process which uses non-content, peripheral cues, such as a numerical index of product popularity, in order to make their buying decisions [8]." In addition, consumer-generated variables as opposed to seller-generated variables were found to be more reliant, trustworthy sources of information for customers [8]. Therefore, to increase the number of consumers willing to purchase remanufactured products, organizations should use standards concentrated on consumer education when designing a marketing strategy.

3. HOW STANDARDS CAN HELP ACHIEVE SDG 12

The above-mentioned problems can be addressed with a series of standards and frameworks that are designed to make remanufacturing feasible for organizations looking to advance their green agendas in accordance with the UN.

3.1 Remanufacturing Process

The RIC001.1-2016 remanufacturing standard developed by the Remanufacturing Industries Council "addresses the specifications and characteristics of the remanufacturing industry and promotes its understanding and credibility [9]." It aims to resolve the issues caused by a lack of definition and confusion with other processes like refurbishment and reprocessing that have traditionally prevented remanufacturing from gaining momentum. This standard singularly focuses on SD goals 12.5, *substantially reducing waste generation*, and 12.7, *promoting sustainable public procurement processes* [11]. Figure 2 illustrates a flow map of the remanufacturing process according to the RIC001.1-2016 standard and it begins with identifying and inspecting "core" material for reusability, which also includes disassembly and inspection of parts, if necessary. Parts of a core that do not meet qualifying criteria will be replaced with new parts to "ensure conformance to original specifications [9]." The core is then used to rebuild the product, which is tested for performance before it reenters the supply chain. This way, nonconforming core is tossed and not reintroduced into the market. This standard recommends evaluating the quality of recycled parts with standards for quality management systems such as ISO 9001:2008 or ISO 13485:2003. RIC001.1-2016 specifically addresses concerns related to lack of a comprehensive understanding of the remanufacturing industry and thoroughly discusses each sub-process from core acquisition, all the way to product labeling.

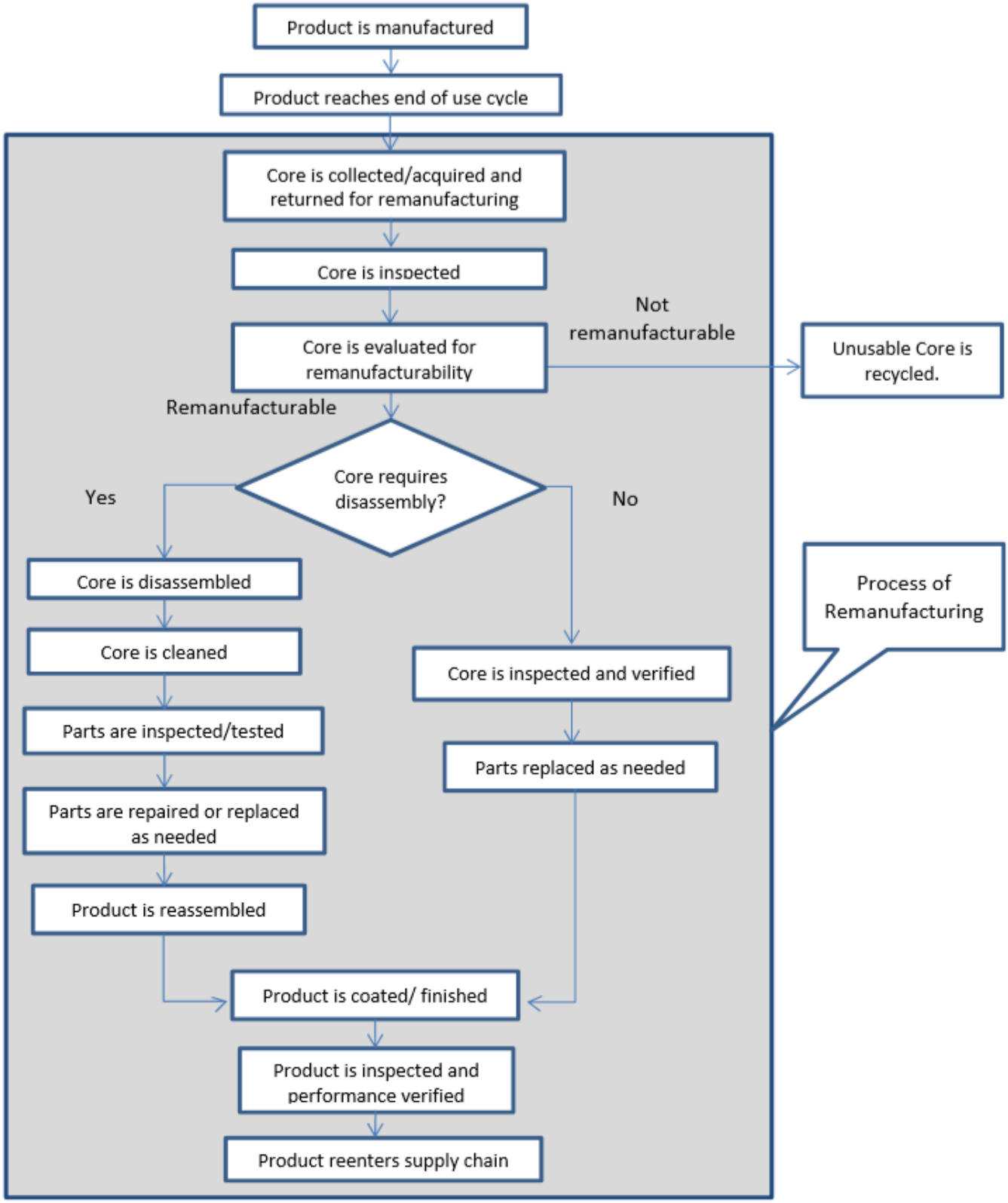
Product is manufactured
Product reaches end of use cycle
Core is collected/acquired and returned for remanufacturing
Core is inspected
Core is evaluated for remanufacturability
Not remanufacturable
Unusable Core is recycled.
Remanufacturable
Core requires disassembly?
Yes
No
Core is disassembled
Core is cleaned
Parts are inspected/tested
Parts are repaired or replaced as needed
Product is reassembled
Core is inspected and verified
Parts replaced as needed
Process of Remanufacturing
Product is coated/ finished
Product is inspected and performance verified
Product reenters supply chain

Figure 2 [9]

3.2 Standards Throughout the Supply Chain

A series of other standards can be used to help businesses walk through each phase of their desirable closed-loop supply chain. ISO/TC 323 holistically examines what the circular economy can look like and how it is measured and assessed for each business. It aims to cover "all aspects of a circular economy including public procurement, production and distribution, end of life as well as wider areas such as behavioral change in society, and assessment, such as some kind of circularity footprint or index [10]." These metrics can clearly delineate success and progress towards sustainability for each company. ISO 14020 is another standard that details environmental labelling best practices, in agreement with section 8 and 9 of RIC 2016.001 [11]. Both standards agree that performance verification through third-party certifications and environmental labels will significantly improve credibility of remanufacturers and convince the consumer of recycled product quality. This specifically answers to goal 12.8 on increasing awareness for environmentally friendly products and improving consumer education on why it is important to advocate for them [1]. ISO 9001 also contributes substantially towards UN'S SDG 12 and can be used to further instill product confidence on the consumer and positively affect their switching behavior [12]. This standard specifies requirements for a quality management system within an organization that can deliver products that consistently meet customer and regulatory requirements and improve customer satisfaction.

3.3 Closed-loop Supply Chain Framework

Using a framework to define closed loop supply chain (CLSC) is conducive to a well-developed circular economy model. This framework on core acquisition, illustrated in Figure 3, focuses on improving quality product returns, which will result in increased availability of core parts while driving down cost of resources [13]. The framework also elaborates on consumer disposition behavior and how this piece fits into the forward, as well as reverse supply chain design. Take-back policies, financial incentives, and collaboration with retailers to provide convenient core collection centers are all methods to improve consumer disposition behavior toward remanufactured products and consequently increase core availability [13]. Employing methodologies like this can help an organization combat the problems related to complex part design and high cost. These standards and frameworks are applicable to any organization, in any industry, which is what makes the circular economy such a translatable, versatile, and moldable solution to environmental sustainability.

4. CONCLUSION

The purpose of SDG 12 is to fundamentally change the way goods are produced and consumed in order to prevent over extraction of non-renewable resources and transition the national economy towards environmentally safe procurement and disposal practices. Remanufacturing allows for holistic evaluation of an organization's environmentally sustainable practices and thereby converts its supply network into one that is capable of self-sustaining. Standards are instrumental in this process because they provide unifying measures that guarantee product

quality, sustainability, and performance to address the challenges that the remanufacturing industry currently faces.

By implementing the standards and frameworks discussed in this paper, an organization can apply life cycle thinking to each phase of its supply chain and achieve maximum resource efficiency. This will enable them to effectively use fewer resources and successfully practice responsible production and encourage its consumers to also play their part in achieving Goal 12 by 2030.

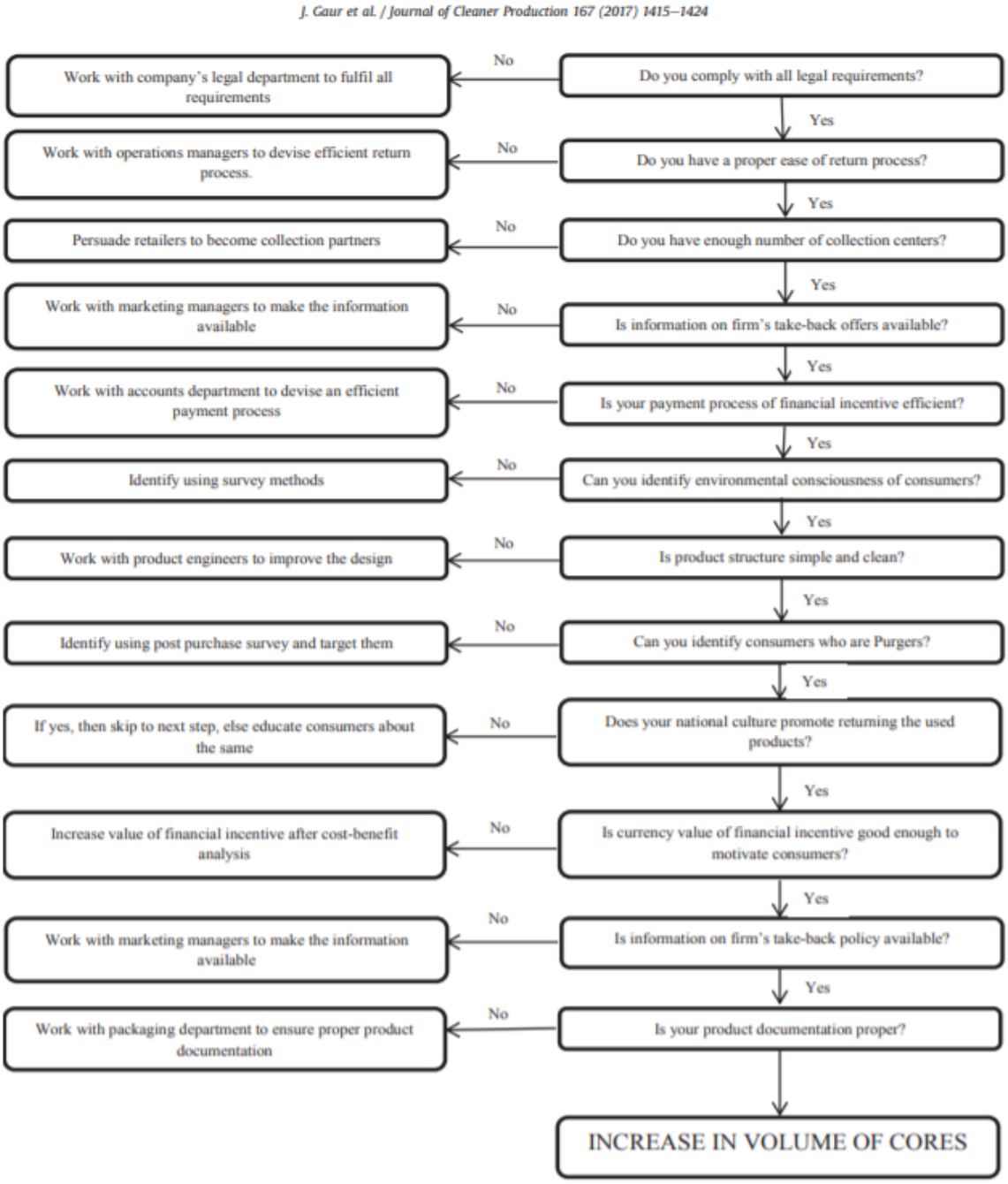

Figure 3 [13]

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