THE IMPACT OF SUSTAINABILITY DRIVERS ON A FIRMS' STRATEGIC DECISIONS REGARDING MANUFACTURING TECHNOLOGIES, NEW PRODUCT DEVELOPMENT AND SUPPLYCHAIN INITIATIVES

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Abstract
This research seeks to shed more light on the drivers of sustainability that firms are exposed to and their impact on management decisions. We have identified three essential paths of action how firms can react to the sustainability challenge. First, firms reassess their manufacturing technologies. Firms have to identify, evaluate and adopt greener technology options which focus on energy and material efficiency in manufacturing processes. Second, new, eco-friendly products are launched. Third, firms extend green practices from the plant out into the supply chain which is referred to as green supply chain practices (GSCP). In order to understand how manufacturing units are affected by the sustainability challenge, exogenous and endogenous factors are analyzed, which drive a firms' sustainability efforts. Exogenous factors include government regulation, norms and values in society as well as the market forces such as customers, competitors and suppliers. Endogenous factors include a firm's strategy, culture and resources at hand in order to deal with sustainability. Therefore, it is the goal of this work to guide firms' management decisions to address the sustainability challenge.

Keywords: Sustainability drivers, advanced manufacturing technologies

1 INTRODUCTION

1.1 Sustainability

The sustainability challenge has increasingly become a key-item on the management agenda of manufacturing firms especially since the Rio Earth Summit in 1992. Global warming and the finiteness of central resources, for instance, have caused different stakeholder groups to adjust their expectations on firms. These developments have significant implications on how firms invest into new or update existing manufacturing technologies to help them reduce resource use (including everything from materials, energy and basic commodities such as water) as well as the environmental impact added (such as emissions and waste).

Dyllick and Hockerts [1] argue that sustainability from a firm's perspective can be defined as meeting the needs of a firm's direct and indirect stakeholders without compromising its ability to meet the needs of future stakeholders. Linton et al. [2] argue that sustainability is widely discussed by practitioners, policy makers, the media, as well as academics. They note further, that a growing concern for sustainability can be observed in industry [2]. Especially manufacturing firms are affected as manufacturing processes are energy intensive and consume significant amounts of resources.

The notion of sustainability is rather broad in nature as it entails the three pillars of the triple bottom line, namely environmental, social and economic aspects [3]. We recognize the importance of the triple bottom line in manufacturing, however, we focus on the ecological aspect, which we refer to as eco-sustainability in this article. The dominant debate about the manufacturing industry's environmental footprint, the likelihood of this trend continuing as well as significant business opportunities that might arise for manufacturing firms are the reasons for this emphasis. In addition, we focus on eco-sustainability issues from the viewpoint of manufacturing managers as they are responsible to successfully implement eco-sustainability considerations in production processes for their firm in order to maintain competitive advantage. In order to master the eco-sustainability challenge and to ultimately derive performance from it, firms need to acquire detailed knowledge and understanding of eco-sustainability drivers they are exposed to. These drivers can significantly influence a firm's strategic decisions regarding the adoption of new manufacturing technology, the development of eco-friendly products or the implementation of green supply chain practices (GSCP).

In terms of the research gap, we have not come across conceptual frameworks which holistically present relevant drivers of eco-sustainability and indicate the link to the strategic decisions of manufacturing firms. In line with that, the overall goal of this article is to develop a conceptual framework by holistically taking into consideration all above-mentioned issues and structuring them. Ultimately, the framework is meant to support understanding among manufacturers how to deal with sustainability and thereby facilitate decision making. Overall, we wish to close the identified research gap by addressing the following research questions:

1. What are the relevant sustainability challenge's drivers that force firms to react?
2. Which actions are firms required to take in response to each of these drivers?

This article is structured as follows. In Chapter 2, we discuss the literature on the sustainability drivers that influence a firms decision context and explain, how new manufacturing technologies are a central argument in mastering the sustainability challenge. Therefore, we reviewed existing literature on sustainability and new manufacturing technologies. In Chapter 3, we bring together relevant aspects by developing a conceptual model and deduce relevant propositions from it. The literature findings were supplemented by various interviews and discussions with managers from manufacturing firms. Chapter 4 briefly summarizes our findings and derivation of propositions. We conclude in Chapter 5 by describing the impact of this research, showing limitations and suggestions for further research topics.

2 THEORY

2.1 Drivers of sustainability

This section is dedicated to the identification of drivers that force firms to take into account eco-sustainability considerations. In our view, it is crucial to analyse what drives firms to engage in eco-sustainable manufacturing processes, eco-friendly products or green supply chains. Various exogenous and endogenous drivers of eco-sustainability can be identified.

Exogenous drivers

The discussion of exogenous drivers focuses on the external forces firms are exposed to. We divide the drivers mentioned in the literature into three groups. First, environmental regulation covers all legislative and regulatory aspects imposed by governments and supranational institutions [4]. Second, societal values and norms include commonly held expectations, opinions, and judgments which are shaped by various interest groups [5]. Third, market drivers contain any aspect related to the environment that firms operate in, which is where firms get their input factors from and where they shift their output to [6].

Environmental policy and regulations in a particular market represent drivers for sustainable management as firms would risk legal consequences and negative effects on their reputation and image by disregarding laws. Sharma and Henriques [7] find that in those instances when manufacturing managers bear personal liability for environmental violations, regulation appears to be a powerful driver for working on environmental manufacturing initiatives. Porter and van der Linde [8] argue further that regulation also represents a driver for environmentally innovation.

Values and norms in society as well as opinions, ideas and resulting expectations held by interest groups represent an influence that firms need to be aware of [9]. Typical interest groups include NGOs, media, politics, local community groups, consumer organizations among others. In addition, interest groups include a fairly new phenomenon, namely value-based networks. In general, dynamic mechanisms can originate from values and norms held collectively by any group of stakeholders. These mechanisms can cause public pressure and indeed some have considerably gained power in recent years. It is critical for manufacturing managers to be aware of these mechanisms and to attempt to benefit from them when engaging in eco-sustainable manufacturing initiatives [10]. Dyllick [11] argues, that expectations of the government and the society can increasingly force a company to commit to the future by innovation in manufacturing processes, thereby avoiding ecological impact.

Market drivers shape the competitive context and form the environment which individual manufacturing firms are exposed to. We will look at the values and norms of different stakeholders as well as the pressures they cause on industry. From the firm's perspective, the stakeholders that play a role in these mechanisms include suppliers, competitors and customers. Outside of the typical supply-chain view, investors can be identified as an additional group of stakeholders. Their existing values and norms have high relevance to firms as they have the power to withdraw capital. Further, we will look at the impact other drivers have on manufacturing firms such as an industry's or market's innovativeness and self-regulation as well as the general state of the economy. Rivera-Camino [6] argues that, based on certain values and norms, customers might respond favourably to a firm's eco-sustainability initiatives and innovation. Delmas and Toffel [4] argue that customer values and norms - next to regulation - are the second most powerful source of pressure. Suppliers might discontinue to deliver inputs for fear of losing their own reputation, if the purchasing manufacturing firm is known for not seriously taking into account environmental considerations in its processes [6]. Likewise, the involvement with environmentally cautious distributors can have a positive feedback on the firm's credibility in managing eco-sustainability in its processes [6]. He also argues that a firm's competition might exert power in that competitors' values and norms may be perceived superior with regards to eco-sustainability.

In terms of innovativeness, Etzion [12] argues that a firm's ability to listen to multi-stakeholder views and to take into account diverging expectations holistically can deliver support in finding innovative solutions to ecological problems in manufacturing. In this context, he notes further that a firm's ability to innovate and to thereby cause a shift to more eco-sustainable manufacturing processes (through the adaption of existing or the adoption of new manufacturing technology, for instance) pushes overall environmental performance.

So far, we have treated environmental regulation as a driver which is imposed by the regulator to which manufacturing firms have to react by creating compliant process solutions. On the market level, however, a specific form of regulation exists which proactively supports eco-sustainability in processes without regulatory enforcement. According to Etzion [12], such industry self-regulation - also known as self-policing - supports manufacturing firms sharing similar technologies and resource dependencies to cooperate in order to reduce external pressures.

The economic cycle and commodity prices - such the oil price - influence demand for eco-sustainable process solutions. As investors provide the required capital to firms, their willingness to invest or divest is affected by economic market sentiment [6]. In addition, the adoption of more efficient manufacturing technologies are affected by rising material and energy prices.

Endogenous drivers

The discussion of endogenous drivers focuses on forces inside the company, which push the firm to advance eco-sustainability in their processes. We suggest to look closely at manufacturing firms' strategy, culture and resource base which constitute crucial endogenous aspects.

Important aspects of eco-sustainable strategy from the firm's perspective include the degree of integration of sustainability considerations into overall strategy, the degree of self-regulation and the responsiveness to potential dynamics.

In order to enhance eco-sustainability, a major challenge for managers is the degree of integration of eco-sustainability into the overall company strategy [12],[13]. Etzion [12] agrees that organizations often tend to see eco-sustainability as a separate aspect of core strategy. Russo and Fouts [14] argue that a proper implementation of an eco-sustainable strategy should become a driver for the development of human resources and organizational capabilities as organizational resources. The degree of implementation of regulatory requirements varies among manufacturing firms. For instance, Ramanathan et al. [15] observed that in some cases firms simply adjusted their processes to meet regulations while others have taken a proactive role (i.e. self-regulation) and that the latter cohort of firms is more likely to succeeded by introducing eco-sustainable innovations to their processes. In terms of responsiveness to potential dynamics, Mitchell et al. [16] argue that management should not exclusively focus on actual relationships to stakeholders but also potential ones in order to avoid a short-term project horizon of manufacturing processes.

A firm's culture consists of certain values, norms as well as believes and behaviours that stakeholders might have. Cultural influences appear to impact motivation, management and employee commitment and openness to change. The latter appears particularly important as regards the adoption of new manufacturing technologies because habits are hard to break. The degree of motivation and values within the firm appears to be a key supporting factor of ecological responsiveness in manufacturing. In an extensive study, Bansal and Roth [5] revealed three major motivations: competitiveness, legitimation and ecological responsibility. In addition, they identified three contextual conditions that lead to these particular motivations: field cohesion, issue salience and individual concern. Regarding the degree of information dissemination, various authors have shown that the flow of information in an accurate and timely manner has positive effects on how eco-sustainability is implemented in manufacturing processes [17],[18]. Etzion [12] sees a considerable potential for manufacturing managers to use a firm's information channels and networks to disseminate information in order to advance sustainability innovation in manufacturing. As with motivation, manufacturing managers commitment has a significant impact on how eco-sustainability in manufacturing is approached. López-Gamero et al. [19] argues that managers' environmental attitude is a significant factor in shaping their firm's eco-sustainable orientation and innovation in manufacturing. Also, it affects the time horizon regarding eco-sustainability process initiatives [20]. According to Dyllick and Hockerts [1], "an obsession with short-term profits is contrary to the spirit of sustainability" (p. 9). Management needs to take into account that it is not enough to promote and practice eco-sustainability processes at the top level. Jiang and Bansal [21] find that enhanced workforce awareness leads to individual behaviour that is conducive to eco-sustainability (i.e. employee commitment).

The provision of adequate resources is central for a firm's operations and therefore, also for sustainability initiatives. Barney [22] assumes that in order to secure competitive advantage, a firm's resources should be valuable in exploiting opportunities, rare among competitors, imperfectly imitable as well as strategically non-substitutable. According to McGee [23], the resource-based view (RBV) is a useful concept in this case as ecological strategies and innovations tend to mature over longer periods which makes it more difficult for competitors to comprehend and then imitate these. Barney [22] mentions physical capital resources including manufacturing technology and equipment as well as human capital resources as important factors for process innovation. Teece et al. [24] argue that manufacturing technology and equipment resources can both, support as well as hinder a firm's productivity depending on whether they are available sufficiently or not. Technology resources belong to what Williamson [25] refers to as physical capital resources which include a firm's manufacturing machinery and equipment, thus making financial investments into these resources crucial for a firm's ability to innovate. In order to compete in a dynamic environment where eco-sustainability innovation is required in manufacturing, Hitt et al. [26] state that a firm must have the knowledge and skills to make the changes needed and invest accordingly into human resources. The ability to innovate is dependent on the skills of the employees as the creation of novelties is only possible with highly skilled employees [27],[28].

These drivers are integrated in the conceptual framework discussed in chapter 3.

2.2 Mastering the sustainability challenge

In order to make progress in terms of sustainability, firms can take different measures. In this regard, we identified three central focus themes on the agenda of manufacturing firms: New manufacturing technologies to make manufacturing processes more sustainable, the development of green products and the integration of green practices in the supply chain.

Global manufacturers experience increasing competitive pressure, such as from manufacturers in low-wage countries, rapidly changing customer demands and tightening legal requirements. Additionally, the paradigm shift from standardized big scale manufacturing to flexible low-volume manufacturing during the last 20 years is still prevailing and forces manufacturing divisions to constantly adopt advanced manufacturing technologies (AMT) and new management practices. Several studies have shown that investments in integrated manufacturing (IM), consisting of Total Quality Management (TQM), Just in Time (JIT) and AMT lead to superior performance [29],[30]. The positive relationship between investments in AMT and performance has been well documented and empirically tested [31][32],[33]. The vast body of literature on AMT provides evidence that new manufacturing technologies are important for the success of manufacturing companies, but existing literature predominantly focused on rationalisation and cost effects due to automation as well as increases in flexibility and quality. Sun [34] points out, that the following issues in production units were the major challenges within the manufacturing industry in the 1990ies and beyond:

1. Reduction of lead time to satisfy customer.
2. Getting new products to market more quickly
3. Flexibility to adapt to changes in the market.
4. Improvement of product quality.
5. Cost Reduction.
6. Increased customer services.

Advanced Manufacturing Technologies have been regarded as valuable weapons to address the proposed challenges for global manufacturers.

More recently, however, the topic of sustainability has increasingly become dominant as environmental pollution and resource scarcity raised public awareness especially for the eco-sustainability challenge. This issue concerns various company functions as consumer requirements are shifting and new products and business models are required that meet the needs of sustainable industrial systems. Due to high energy and water consumption as well as pollution rates and waste, especially manufacturing units are affected by the sustainability challenge. So far, it has not been identified, whether new manufacturing technologies might also be the suitable answer for manufacturers to address the sustainability challenge. We follow the definition that is used by Sinha and Nobel [35] and define manufacturing technologies as the "master tools of industry that magnify the efforts of individual workers and enable production of all manufactured goods, with production tools including machine tools and other related equipment, their accessories, and tooling" (p. 944).

In terms of manufacturing technologies, sustainability enhancements can aim at the use of material and energy as well as the creation of emissions and waste [36]. The concept of eco-efficiency is often mentioned in that context. A commonly cited definition of eco-efficiency has been coined by the WBCSD [37]: "Eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity" (p.4). Eco-efficiency encourages firms to search for environmental improvements on the one side that yield economic benefits (such as cost savings) on the other side [38].

Eco-efficiency is also relevant to products. DeSimone and Popoff [39] argue that efficiency is not only applicable to increasing resource productivity in manufacturing but also to the creation of new goods and services that enlarge customer value while maintaining or reducing environmental inputs. For instance, the Sustainable Product and Service Development (SPSD) approach seeks to support firms to make their products and services more sustainable throughout their entire life cycle including everything from conception to end of life [40]. The overall goal of such initiatives is to design and manufacture products that are not only environmentally friendly but also meet criteria such as functionality or cost-effectiveness. Along these lines, Boks [41] argues that an increasing number of firms introduces product-oriented environmental management systems and have introduced products with superior environmental performance.

However, in order for the industrial system to be truly sustainable, it is not enough to look at a given firm and its processes in isolation [12]. For instance, Vachon and Klassen [42] propose to extend green practices from the plant out into the supply chain which they refer to as green supply chain practices (GSCP). This means that actors in the supply chain build collaborative advantage rather than just competitive advantage [42] which affects numerous links among different stages in the supply chain. In line with this, green supply should include cooperation that aim to minimizing the environmental impact of the entire supply chain [43].

By referring to the importance of the entire supply chain, we intend to put the topic of sustainability into the "wider" perspective which holistically takes into account environmental impact of different supply chain stages. The focus of this paper, however, rests with a given firm's operations in our attempt to make the link between the sustainability challenge and the management decisions towards sustainability.

3 MODEL

The sustainability challenge is the most recent challenge, manufacturing units are concerned with. To guide manufacturing managers in decision making, we derived a conceptual framework from the sustainability literature and the literature on new manufacturing technologies. Identified sustainability drivers are discussed in the theory section above, however, in the model we only focus on the drivers that appear to be the most relevant ones. Additionally, the findings from interviews and discussions with manufacturing managers were incorporated in the development of the framework.

Various exogenous and endogenous sustainability drivers may be the stimulus for certain action to take (see left side of Figure 1).

There are two reasons why firms take action towards more eco-sustainability. First, certain regulations or requirements may impose pressure upon a firm to kick off sustainability initiatives to keep up with competitors and prevent disadvantages or penalties. Second, firms see a potential competitive advantage in the realization of sustainability initiatives. The generation of new markets for sustainable products, or cost savings realized through reduced resource consumption within the manufacturing process are both examples for opportunities that arise because of the sustainability challenge, which can be used to gain competitive advantage.

No matter whether it is because of environmental pressure or the capturing of opportunities, firms are urged to take action as an adequate answer on the drivers of sustainability. That is represented by the construct *Environmental Opportunities & Pressure for action towards Eco-Sustainability* in the center of our model.

There are various ways how firms can possibly master the sustainability challenge. As mentioned, process enhancements due to new manufacturing technologies, new, greener products or the application of green practices within the supply chain are three prominent ways we have identified in order to deal with sustainability.

Although we acknowledge that there are even more possibilities for firms to become more sustainable, we focus on these three items as, according to our experience, they seem to be the most prominent solutions for manufacturing firms.

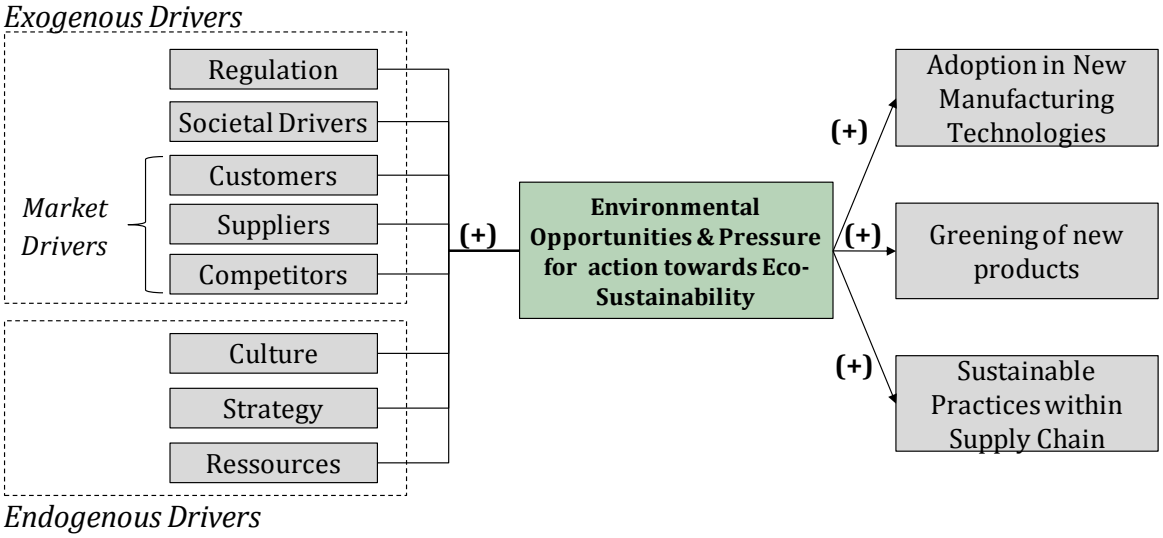

Figure 1: Model of relationships between drivers of sustainability and adoption of New Manufacturing Technologies

3.1 Propositions

Based on the cause-effect relations shown in the proposed conceptual model above, we can now derive research propositions.

Proposition 0

For most manufacturing firms, sustainability has increasingly become a source of significant pressure in recent years. This originates from various drivers that are of exogenous and endogenous nature to firms [11]. However, these developments do not only represent a threat to firms but also an opportunity as action towards eco-sustainability can be a source of competitive advantage ([19], [14].

- Proposition 0: There is a construct of environmental opportunities and pressures that is triggered by exogenous and endogenous drivers for sustainability

Proposition 1.1

Environmental regulation by governmental and supranational authorities are widely seen as the strongest driver for sustainability because firms have no choice unless they are prepared to risk legal consequences [12]. Sharma and Henriques [7] find that regulation - especially if managers are held liable - appears to be a powerful driver for environmental initiatives. Thus, regulation can be assumed to have a significant impact on sustainable actions by firms.

- Proposition 1.1: There is a positive relationship between regulation and the environmental opportunities & pressure construct.

Proposition 1.2

Societal beliefs are held and shaped by various interest groups that have common opinions on an issue, in this case sustainability of manufacturing firms. Values and norms in society as well as resulting expectations held by such interest groups can cause public pressure on firms (Wade-Benzoni et al., 2002). Such public pressure can therefore motivate firms can motivate firms to commit to sustainability action such as innovation. [11],[10].

- Proposition 1.2: There is a positive relationship between societal drivers and the environmental opportunities & pressure construct.

Proposition 1.3

Customers have the power to respond in favour or against a firm and its goods. Different values and norms held by customers are an important determinant [6],[4]. Since firms seek to sell their goods, whatever customers require will be very high on management's agenda. Therefore, customers expectations in terms of sustainability will very likely lead to action.

- Proposition 1.3: There is a positive relationship between customers and the environmental opportunities & pressure construct.

Proposition 1.4

Even though suppliers are upstream to firms, they can impose pressure in terms of sustainability. They might discontinue to supply a particular firm that is feared to be harming the environment which could have reputational repercussions to the supplier. Therefore, even a firm's own suppliers might trigger sustainable action by the firm.

- Proposition 1.4: There is a positive relationship between suppliers and the environmental opportunities & pressure construct.

Proposition 1.5

The way firms deal with sustainability can be seen as a means of differentiation on the market. Therefore, pressure might come from competitors if their attitude towards sustainability is perceived as more credible or more far-reaching than the firm's own [6]. In consequence, competitors' efforts in sustainability have a positive impact on action by other firms in that market.

- Proposition 1.5: There is a positive relationship between competitors and the environmental opportunities & pressure construct.

Proposition 1.6

Culture comprises employees' believes as well as values and norms. This is widely believed to have an impact on motivation, as well as not only on management commitment into sustainability but also on employee commitment [12],[19]. A firm's culture is considered an important endogenous driver for sustainability action as staff needs to be convinced of sustainability for any initiative to work.

- Proposition 1.6: There is a positive relationship between culture and the environmental opportunities & pressure construct.

Proposition 1.7

A sustainability strategy that is well integrated into overall strategy considerably facilitates decision making on sustainability issues [14]. Such integration can be difficult to achieve but the impact on sustainable action is significant as sustainability strategy is better aligned with overall strategy which reduces barriers.

- Proposition 1.7: There is a positive relationship between strategy and the environmental opportunities & pressure construct.

Proposition 1.8

Resources can be regarded as a crucial enabler for firms to transform their sustainability strategy into sustainable action. The better a firm's human resources and capital resources are, the better the influence on sustainable action can be expected to be. For instance, Barney [22] argues that capital resources and human resource are important factors for innovative and hence competitive solutions. In that regard, the education and skill set of employees or the standard of manufacturing technologies can be considered as essential drivers for sustainable action.

- Proposition 1.8: There is a positive relationship between resources and the environmental opportunities & pressure construct.

Proposition 2

Differences exist in terms of the magnitude of pressure that different drivers impose on firms. However, as most academics agree, exogenous drivers of sustainability exert most significant pressure on firms and ultimately affect their decision making processes as regards sustainability in manufacturing [4],[12]. For instance, firms have to be compliant with regulation unless they are prepared to risk legal consequences. In addition, customer requirements are widely seen as dominant as firms primarily seek to sell their goods.

- Proposition 2: The positive relationship between exogenous drivers and the environmental opportunities & pressure construct is stronger than the positive relationship between endogenous drivers and the environmental opportunities & pressure construct.

Proposition 3.1

The adoption of new manufacturing technologies is positively linked to arising opportunities and pressures for sustainable action. Such opportunities and pressures can arise from any of the above-mentioned stakeholders. For instance, customers or the wider community in the

neighborhood of a manufacturing site can demand cleaner production or certain regulatory frameworks are imposed on the firm which have to be implemented in processes [6],[8]. VW, for example, started its sustainability initiatives in the 1960s with a water saving and treatment programme to deal with water shortage in the Wolfsburg production plant.

- Proposition 3.1: There is a positive relationship between the environmental opportunities & pressure construct and the adoption of new manufacturing technologies.

Proposition 3.2

Opportunities and pressures for sustainable action are not only positively linked with the adoption of new manufacturing technologies but also with the products themselves. Again, these opportunities and pressures can arise from any group of stakeholders expressing their expectation regarding more environmentally friendly products with customers playing a major role. A prominent example is the automobile industry, where demand for higher fuel efficiency generates new product groups and new markets for hybrid and electric cars.

- Proposition 3.2: There is a positive relationship between the environmental opportunities & pressure construct and the greening of new products.

Proposition 3.3

We have proposed that opportunities and pressures for sustainable action are positively related with both, new processes technologies and greener products. Taking these propositions a step further, this notion can be extended to the entire supply chain as an all embracing concept. Vachon and Klassen [42] for instance, suggest that green practices should be extended from a firm's own operations in isolation to the wider supply chain. This can be facilitated by collaboration among partners in the supply chain partners. In doing so, especially the food industry makes efforts to collaborate with its suppliers to ensure their compliance with the requirements of certain organic labels.

- Proposition 3.3: There is a positive relationship between the environmental opportunities & pressure construct and the introduction of sustainable practices to the supply chain.

4 DISCUSSION

The paper deals with the existing sustainability drivers and how firms can translate various drivers into action to take. So far, it is not clear which drivers call for which possible strategic initiative, namely the adoption of new manufacturing technologies, bringing new, greener products to market, or to introduce sustainability practices to the supply chain.

Our goal is to explicitly identify those sustainability drivers, that require production units to take action by adopting new, more sustainable manufacturing technologies. Additionally, we show which drivers are more likely to result in new, greener products or the introduction of sustainable practices in the supply chain. By doing so, we intend to give guidance to practitioners, who are exposed to the sustainability challenge to make the right decisions. Therefore, we have developed a conceptual model, which can be empirically tested. The results will show, which sustainability drivers lead firms to action and in which direction.

Furthermore, we extend the existing literature on sustainability and new manufacturing technologies by merging those literature streams. Thus, we are able to show, that sustainability is the most recent challenge manufacturing units are exposed to. As to our knowledge, it has not been empirically tested so far, to which extent the sustainability challenge leads to increased adoption of new manufacturing technologies.

5 CONCLUSION

Various limitations of this paper merit discussion. First, we do not take any contingency factors into account. Since productivity of manufacturing units, for instance, is particularly important in high-wage countries, geographic differences might exist that affect the importance of sustainability drivers for certain actions to take. Therefore, the degree of generalization of the findings might be limited.

Second, we acknowledge, that there might be interconnections between certain drivers or various sustainability initiatives. For example, new and greener products might necessitate new manufacturing technologies or a firm's strategy might well be shaped by certain market drivers. Thus, neither drivers, nor actions to be taken are fully independent from each other.

Third, this paper does not differentiate the magnitude between different drivers. Based on the literature we have argued that regulation and customers are the most powerful drivers. However, in order to be able to test the universe of sustainability drivers, this would need to be done quantitatively based on survey research.

Fourth, we did not integrate any items, which measure the performance aspect of the chosen actions by firms. Therefore, the model does not allow to identify those sustainability initiatives, that really lead to competitive advantage.

Finally, this paper is of conceptual nature. The propositions were not empirically tested so far. Further research should do so to test the validity of propositions. Additionally, further research should shed more light on the trade-off between extra investments in new manufacturing technologies and the positive impact on sustainability.

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