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Achieving Environmental Performance Goals - Evaluation of Impact Factors using a Knowledge Discovery in Databases Approach

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Abstract

In recent past stakeholders have increasingly turned their attention to the environmental performance of companies. This is due to the impact manufacturing has on the environment e.g. climate change or the contamination of soil, air and water. Therefore many companies aim to act responsible and set themselves targets for environmental improvements. Thus they have to measure the performance in terms of energy and fresh water savings or the reduction of waste, volatile organic compounds released and greenhouse gas emissions. This paper aims to support decision makers and corporate management to analyze impact factors influencing a company's environmental performance and therefore to evaluate the possible risks for not achieving the targets set. A knowledge discovery in databases (KDD) approach is applied for an analysis within the automotive industry to determine these influences.

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1. Introduction

The usage of diminishing natural resources and the contamination of soil water and air are of rising concern to society, governments and industrial leaders. The rising population and harmonization of living standards are main reasons for an increasing global footprint [1]. Consequentially, consumption of goods and services is rising. Alongside, an elevated request for personal transportation over the past years challenges the automotive industry in satisfying customer demand. It can be seen by the rising number of vehicle sales worldwide from about 39 million cars in 1999 to 71 million in 2014 [2]. To address the environmental challenges in a competitive market companies set themselves targets for reducing their environmental impact and accordingly production cost. Examples for companies having set themselves such goals are the BMW Group and the Volkswagen group, who aim

to reduce e.g. disposal waste and fresh water consumption per vehicle, compared to a defined base line year [3, 4]. A multitude of improvement measures for the production sites are considered and implemented to achieve the targets set. Also impact factors, like plant size, weather conditions or utilization can influence the attainment of goals in a positive or negative way. Identifying these impact factors and quantifying their influence can support management to take appropriate steps to achieve the environmental targets set. This paper presents an approach to evaluate possible impact factors influencing environmental key performance indicators of the vehicle production by analyzing different automotive production plants worldwide and thereby supports management to recognize possible risks for target achievement.

2. State of research

In this section the state of research is addressed in the matter of environmental performance measurement and the corresponding influencing factors.

2.1. Environmental Performance Measurement

Many scholars worldwide discuss approaches to measure and improve the environmental performance of entities. System boundaries are varying from in house comparison of a single company to measuring the performance of countries and the whole world. One example for a worldwide comparison is the “Environmental Performance Index” that ranks countries by their improvement in different areas considering 20 indicators [5]. According to the ISO 14001 environmental performance on corporate level can be measured against the organization’s environmental objectives or policy using indicators [6]. The ISO 14031 defines an environmental performance evaluation as a process of selecting indicators, collecting and analyzing data using environmental performance indicators (EPIs). The ISO 14031 sets guidelines for selecting EPIs but does not define a mandatory set due to varying structures, sizes and product portfolios of organizations [7].

Many authors address the topic of environmental performance indicators and define and categorize EPIs for various application scenarios. Wagner describes EPIs as quantitative and qualitative means to measure environmental performance of companies using a case of pulp paper and electricity industry considering 14 different EPIs [8]. Jasch defines EPIs as a method to monitor and trace environmental performance enabling benchmarking and reporting on company level [9]. Scholars regard EPIs as a profound way to measure environmental performance within specific boundaries, but the impact factors influencing a company’s EPIs are often neglected or just considered to limit scale [8, 9, 10].

2.2. Evaluation of Influencing Factors

The way environmental performance of a company is addressed in literature varies among authors. Some highlight the importance of an environmental management system (EMS), due to mandatory targets set and the need to plan the implementation of an EMS [10]. Others are focusing on the positive impacts of pull factors like customer and stakeholder demand on the implementation of cleaner production technologies. Blok et al. analyzed the role of regulations, policy and user behavior for promoting a sustainable future [11]. Govindan et al analyzed the factors driving the development of green manufacturing within companies by using a fuzzy approach evaluating mainly external non metric influences [12].

A more detailed view on influencing parameters on plant level was presented by Boyd who developed an energy performance indicator (EnPI) [13]. The EnPI is calculated by using a stochastic frontier approach and takes into account multiple parameters influencing the energy intensity of manufacturing plants. For the automotive

industry product size, weather conditions and utilization as main influences were considered, not quantifying the extent of influence [13].

The literature presented has shown that most authors are concerned with external barriers and drivers promoting a shift to environmental conscious manufacturing. Impact factors directly influencing a company’s EPI are not addressed in depth, with the exception of energy intensity. Therefore the following section introduces an approach to evaluate the factors directly influencing a multitude of environmental performance indicators of manufacturing companies.

3. Knowledge Discovery in Databases (KDD) Approach

Environmental management and reporting, including the use of EPIs, is of increasing relevance in manufacturing companies [8, 14, 15]. In this context environmental data is collected on different levels within a company to validate target achievement, to control environmental performance and to report the current status [3, 4]. A multitude of available data presents an additional opportunity that changes in a company’s EPIs can be reasoned on by impact factors. A KDD approach can be employed to identify the relevant impact factors using a multivariate analysis. It is defined as “[...] the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data” [16]. The KDD process used in this research is based on the process presented by Fayyad et al.. It is divided into six different steps and was extended using an impact analysis [16]. These steps can be seen in Figure 1.

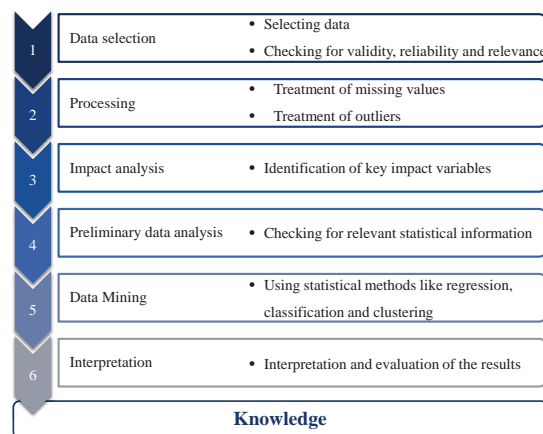


Figure 1: Process steps of the KDD process

The first and most important step is the data selection, because it is the basis for all of the following steps. Data used in the process needs to be reliable, valid and relevant [17]. After selection the target data requires to be processed. Strategies for processing include treating missing values by assigning new values, guessing a value, reselecting the data or to omit wrong values or the whole variable data set due to insufficient data [17].

A qualitative examination is recommended to further reduce

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