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Application of fuzzy analytic network process for barrier evaluation in automotive parts remanufacturing towards cleaner production – a study in an Indian scenario

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ABSTRACT

Increasing numbers of end-of-life vehicles and a burgeoning concern for conservation of resources pressures the implementation of auto parts remanufacturing globally. But unlike in developed nations, developing countries encounter struggle with the implementation of auto parts remanufacturing due to hidden facts. Many researchers have explored such hidden facts in auto parts remanufacturing in developing nations and their emerging economies. However, there is a huge gap in the state-of-the-art remanufacturing practices in India, despite India's strong advancements in the automobile industry. In fact, India's automobile industry is rapidly approaching that of China's in recent years. Although some studies are available regarding remanufacturing implementation, current research has generally failed to offer a deep analysis of the factors and barriers that exist as hurdles to such implementation. Consequently, this paper attempts to investigate the essential barrier to auto parts remanufacturing in an Indian scenario, and we also address vital interrelationships and interdependencies. To achieve the aim of the study, a model framework is proposed and applied to an Indian case industry. The data obtained from the case industry is processed with two solution methodologies: namely, interpretive structural modeling (ISM) and analytic network process (ANP). To avoid inaccuracies and vagueness in results, the data are manipulated under a fuzzy environment. This study reveals results which show that higher cost and lack of customer acceptance are the essential and most influential barriers in auto parts remanufacturing in an Indian scenario. This study contributes to society by assisting closed loop supply chain players to identify and eliminate the barriers to remanufacturing within the scope of the Indian sector. Finally, this paper provides a brief road map and insights into future research for remanufacturing specifically in an Indian context.

1. Introduction

The impact of resource scarcity and environmental considerations has made remanufacturing a popular research topic among researchers and practitioners, especially in developing countries (Rashid et al., 2013). When compared to virgin products, remanufactured products ensure sustainable benefits to organizations. For instance, remanufacturing products may be produced for 50% cost, 60% energy and 70% materials required by virgin products (Zhang et al., 2011; Rathore et al., 2011; Sutherland et al., 2008; Lund, 1984; Ijomah et al., 2007). In addition to energy and cost consumption, remanufactured products also result in fewer greenhouse emissions over virgin manufacturing practices (Sutherland et al., 2008). Due to pressures from stakeholders, society and the environment, remanufacturing often emerges as a mandatory strategy. Whereas many drivers exist to motivate remanufacturing, extended producer responsibility (EPR) is an efficient driver (Zhang et al., 2011; Xiang and Ming, 2011; Govindan et al., 2014a), and after the implementation of EPR, many organizations became involved in remanufacturing practices. To balance various environmental pressures, companies need expertise in systems to avoid landfills. There is also a need to extend the life of EOL products (Rathore et al., 2011). With such rising concerns, remanufacturing

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strategies have been considered by many studies (see Ferrer, 1997; Kiesmüller and Van der Laan, 2001; Majumder and Groenevelt, 2001; Lebreton and Tuma, 2006; Ferrer and Swaminathan, 2006; Sasikumar et al., 2010; Kannan et al., 2010; Chatterjee and Chakraborty, 2013; Sun et al., 2013; Topcu et al., 2013; de Mendonça et al., 2014; Kannan et al., 2009); these approaches explore strategies such as reverse logistics, remanufacturing inventory, material demand, with the aid of case studies and other pursuits (Bernard, 2011).

In the history of remanufacturing practices, the automotive sector was the first sector to gain success regarding remanufacturing (Seitz, 2007). The sheer quantity of EOL vehicles pressured manufacturers and practitioners to adopt suitable EOL vehicle management strategies. EOL vehicles have some alternative management strategies such as repair, reconditioning, or reuse, but remanufacturing gained attention because they offer warranties equivalent to new products with their improved quality, new appearance and original specifications, and upgraded products (Ijomah, 2002; Ijomah et al., 2007). Remanufacturing practices on automotive industries alone can save the annual energy equivalent to five nuclear power plants (Steinhilper, 1998). Due to such success factors, many automotive components (clutches, brake hoses, engine blocks, starters, alternators, water pumps, carburetors, etc.) are currently being remanufactured (Amelia et al., 2009). In developed countries these products are prepared with remanufacturing policies and strategies in place. For instance, Europe has tightened EOL vehicle derivatives and the U.S. utilizes different form of remanufacturers like contract firms, original equipment manufacturers, and conventional firms (Zhang et al., 2011). However, in developing countries, remanufacturing is still in the initial stages and is not a virtual application. Amelia et al. (2009) cited the significant difference between EOL vehicle management strategies in developing and developed countries, noting that China, India, and Brazil are struggling with remanufacturing implementation. Many studies (for instance, Zhang and Chen, 2013; Chen, 2005; Chen and Zhang, 2009) examine Chinese remanufacturing in an EOL vehicle context. But fewer studies pursue Indian and Brazil scenarios, which makes current statistical ratios of EOL vehicles to remanufactured vehicles unknown to researchers (Sharma et al., 2014; Gaur et al., 2015; Saavedra et al., 2013; Rozenfeld and Barquet, 2013; Jabbour and Puppim-de-Oliveira, 2012). Hence, this study attempts a deeper analysis of remanufacturing strategies in an Indian context. While many drivers exist in common remanufacturing scenarios, in the Indian context, Extended Producer Responsibility (EPR), ample labor, market price sensitivity, and environmental effects are major drivers (Rathore et al., 2011). The Indian economy plays a secondary role in remanufacturing even though the concept has been in existence for more than a decade. It needs more extensive strategies (Terkar et al., 2013). In a massive emerging economy like India, remanufacturing is still largely unfamiliar; only a few well-developed organizations such as Xerox India and Timken bearings are currently involved in remanufacturing strategies (Rathore et al., 2011). Remanufacturing is still a dream for many developing or small and medium scale enterprises (SMEs), so it is no surprise that most researchers concentrate on the developing country of China. According to Lattemann et al. (2009) and Govindan et al. (2014b), Chinese economic development is comparatively higher than the Indian context and this difference affects the implementation of future strategies like remanufacturing. Other conceptual differences of remanufacturing exist between these two nations; for instance, Xiang and Ming (2011) state that government support is the major driver for remanufacturing in a Chinese context, whereas in an Indian scenario the major driver is economic benefit according to Sharma et al. (2014). In short, China adopts remanufacturing voluntarily, whereas India is motivated by the potential for profit. Therefore, those studies of the Chinese context do not suit the Indian scenario. Current studies in the Indian context have not fully explored the barriers to automotive parts remanufacturing. Hence, there is an urgent need to analyze the barriers for remanufacturing in virtual applications in an Indian context, so this study attempts to identify those barriers with the assistance of ISM and Fuzzy analytic network process (ANP) (which is explained in the forthcoming sections) through a proposed framework model with a five phase methodology.

The rest of the paper is organized as follows. Section 2 offers a literature review to explore research already conducted on the paper's core objective, the gaps that exist, and some interesting research highlights. The problem of the study and the nature of the case firm are explained in Section 3 along with the proposed framework. Section 4 provides the solution methodology to analyze the attributes of the study. The proposed framework is illustrated in Section 5. Section 6 provides discussions with industrial managers regarding results. Sections 7 and 8 present the managerial implications and the conclusion of the study, respectively.

2. Literature review

The literature review is organized into three subsections. The first provides an overview of automotive remanufacturing information with previous and current attempts of researchers in this field. The second subsection explores the barriers to automotive remanufacturing strategies with the aid of current literature. The third subsection provides the identified research gap and highlights major research contributions. The three categories ensure that the various contributions of this research have been addressed, and it provides better insights of the concepts under this study.

2.1. Remanufacturing in the automotive sector

Many studies (Ferrer and Ayres, 2000; Ferrer and Clay Whybark, 2000; Zhang et al., 2011) affirm that remanufacturing is eco-efficient. Hence, there is a need to use or to implement such strategies as widely as possible. Remanufacturing is defined by many researchers from their own perspectives and according to the studies (Guide, 2000; Xu et al., 2005; Zhang et al., 2011), one famous definition was given by Lund (1984), Guide (2000), Xu et al. (2005), and Zhang et al. (2011) defined remanufacturing as “to make as close to new as possible or even better, wearable parts are replaced, all cores are carefully inspected and checked against original equipment specifications, replacement parts are new or remanufactured, and finally, testing is performed to manufacturer specifications and original production standards.” The above remanufacturing definition is common to all applications, but the U.S. automotive parts remanufacturers association (APRA, 2010) defined remanufacturing as “a process of restoring worn and discarded durable products to like-new condition.”

EOL vehicle remanufacturing has been a topic of interest since the 1970s (Nakajima and Vanderburg, 2005), but only in the mid-1980s did European governments consider end-of-life vehicles (ELVs) a waste, resulting in their issuing laws and regulations regarding EOL vehicles to stem the growing collection of waste cars (Nakajima and Vanderburg, 2005; Rawat and Thakar, 2012). The debate on remanufacturing in the earlier 1900s resulted in the first remanufacturing association called automotive parts remanufacturers association (APRA) which has been active since 1941 (Clottey and Benton, 2010). Afterwards, automotive parts remanufacturing has gone through many evolutions and has spread throughout all developed and developing nations. While regulations and rules were passed in early 1940, history reveals that Robert Lund is remanufacturing's pioneer researcher due to his

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