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# Reprint of "Supply chain-based barriers for truck-engine remanufacturing in China" ☆

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ABSTRACT

This paper introduces a research framework to identify barriers from a remanufacturing supply chain perspective including strategic (governmental) and operational dimensions. Using responses from expert practitioners in a truck engine remanufacturer in China, a grey-based Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is applied to examine the cause-effect relationships among various implementation barriers. The results identify that lack of strong financial support for remanufacturing technologies or equipment updates and innovation are key implementation barriers. Lack of quality standards of remanufactured products, adequate availability of used truck engines, and quality guarantee marketing of remanufactured engines are also major barriers.



## 1. Introduction

Efforts for eco-efficiency, extended producer responsibility, and general concern for the environment has caused industry to embrace energy saving and pollution reduction efforts. Remanufacturing, which can play a central role in these environmentally conscious industrial efforts, has become globally popular within a variety of industries (Webster and Mitra, 2007). Yet, the adoption and implementation of remanufacturing, operationally, strategically and regionally still faces significant hurdles to overcome. Even in developed countries, governments, communities, and organizations face extant barriers for remanufacturing practices. These barriers include reverse logistics costs, disassembling and component inspection technical feasibilities, and remanufactured products customer demand uncertainties (King and Burgess, 2005).

The issues facing developed country remanufacturing barriers have appeared in developing countries. Industries that can benefit and are reliant on remanufacturing have emerged, e.g. heavy machinery, shipping, and automotive in these developing countries. The automotive industry has had especially profound social and economic growth within China, the world's largest developing country and currently the fastest growing economic and environmental influencer in the world. Noting these emergent socio-economic and environmental issues, the Chinese government has introduced a number of regulatory

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initiatives encouraging industry and organizations to adopt remanufacturing practices (Xiang and Ming, 2011; Zhang et al., 2011).

Barriers to implementing remanufacturing practices have been broadly examined (Hazen et al., 2012; Matsumoto and Umeda, 2011; Michaud and Llerena, 2011; Ostlin et al., 2008; Robotis et al., 2012; Xiang and Ming, 2011; Zhang et al., 2011). Previous studies mainly focused on identifying barriers for remanufacturing based on literature reviews and case studies. For example, one study interviewed 11 remanufacturers, and identified barriers from the industry perspective, including barriers related to collection of used products, development of efficient remanufacturing processes, and cultivation of demand (Matsumoto and Umeda, 2011). One study examined barriers of automobile component remanufacturing in China at both the policy and industry level (Zhang et al., 2011). Another study examined cases in Sweden and indicated that lack of efficient supply chain relationships between remanufacturers and suppliers/customers is a key obstacle (Ostlin et al., 2008). Based on these previous studies, we further develop a systematic research framework considering two dimensions. One dimension focuses on the stages of the remanufacturing supply chain. The other dimension is from both the policy and industry perspectives. Using this framework, we identify barriers for remanufacturing from a supply chain perspective by examining a remanufactured truck engine product at the policy (governmental) and industry (remanufacturer) levels. Moreover, we examine the causal-effect relationships among the implementation barriers for remanufacturing using a grey-based Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. This will be the first investigation that utilizes such a framework to more fully understand barriers to remanufacturing. The insights represent an important contribution for policy makers, professional organizations, and individual companies.

To achieve our research goals, we first introduce a framework of supply chain-based implementation barriers for truck engines remanufacturing in China, and then identify barriers at both the policy and corporate levels in Part 2. In Part 3, we introduce the DEMATEL method and data collection for analyses. We present the study results and discuss them in Part 4. We summarize the findings and implications in Part 5.

## 2. Identifying barriers

### 2.1. Background of remanufacturing

Remanufacturing, in many industries, has become an approach for both improving business competitiveness while reducing environmental burdens. The concept has been adopted globally. Two prevalent and leading industries in remanufacturing products are the automobile parts and electronic/electrical industrial sectors (Matsumoto and Umeda, 2011). As far back as 1996, the US remanufacturing industry alone had sales of US$53 billion with about 73,000 remanufacturer firms (Lund, 1996). In developed countries, remanufacturing was first driven by economic considerations in the 1990s, and has been further supported with environmental policy such as extended producer responsibility (Toffel, 2003). Remanufacturing automobile parts is quite common in developed countries and has been occurring for decades, from the early years of the automobile industry (Steinhilper, 1998). Japan has advanced remanufacturing of electronic products such as photocopiers and single-use cameras, although it has not matured as much as in remanufacturing automobile parts (Matsumoto and Umeda, 2011).

Investigation of remanufacturing in emergent economies, especially China, has been relatively insignificant. A study on remanufacturing may be beneficial in these emergent economy nations due to a multitude of pressures including economic and environmental ones. For example, automotive environmental and resource scarcity issues are especially prevalent in China. In response the Chinese government has made efforts to promote remanufacturing in the automobile industry (Xiang and Ming, 2011). In 2006 the National Development and Reform Committee (NDRC), the Ministry of Science and Technology (MST), and the Ministry of Environmental Protection (MEP, previously the Environmental Protection Administration) jointly released a regulatory policy for automotive products recovery. Article 40 of the Circular Economy Promotion Law of the People's Republic of China (enacted in 2009) further identified government support for automotive parts remanufacturing. In 2010, the remanufacturing industry has been positioned as a new economic development area.

To further this economic development and promoting the remanufacturing industry, the Chinese government has supported a variety of demonstration projects. In March of 2008, the NDRC approved 14 demonstration remanufacturing plants with the general goals to promote remanufacturing trade and sales. The demonstration remanufactured products were restricted to five types of automobile components including engines, transmission gears, generators, starters and steering gears. Engines (mainly truck engines) account for the majority of the remanufacturing output values primarily due to a much higher unit value than the other four components. Four of 14 demonstration plants do remanufacturing for truck engines while Sinotruk Jinan Fuqiang Power Co., Ltd. (JFP) is the largest and most influential organization with over half the output of truck engine remanufacturing in China.

With these initial nation-wide pilot experiences, China realized that quality and process control were key developmental issues for their remanufacturing industry. In March of 2013, the NDRC approved 28 demonstration remanufacturing plants with the general goal to establish a process and quality systems throughout the supply chain of remanufactured automobile parts ranging from used parts collection, remanufacturing processes and sale channels. The remanufactured products have been extended to other automobile parts and agriculture machinery while the plants include remanufacturers, used products recycling companies as well as those providing technologies and equipment for remanufacturing.