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## A comparison of best practices of public and private support incentives for the remanufacturing industry

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### Abstract

In the context of resource constraints and the negative environmental and social impacts of the linear “take-make-dispose” pattern, remanufacturing offers a promising solution for the transformation of end of life (EOL) goods into products with equal or superior specifications and lifetime as compared with newly produced goods. The increasing success of this new industrial paradigm results from the possible combination of production costs reduction and profit maximization as well as efforts to increase environmental performance and harvest social benefits, such as job creation. However, a large number of countries faces challenges in building a valuable process because of the lack of communication between public and private stakeholder and the remanufacturing industry.

This paper intends to identify and classify the key stakeholders in categories and define the type of actions taken in selected countries to foster remanufacturing. Guidance for both public and private actors are suggested for the development of specific remanufacturing industries.

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*Keywords:* Remanufacturing business models; circular economy; public and private incentives; best practices

### 1. Introduction

The dynamic between seemingly unrestrained production and mass-consumption reached a level far beyond planetary boundaries so that safety for the environment and all beings that inhabit it is no longer guaranteed. Biodiversity loss, climatic changes, ocean acidification and dysfunctional nitrogen cycles are a few examples that will lead to nature's inability to cope with ecological imbalances and might therefore jeopardize water, food and raw material supply [1–3]. At the same time societies have to face issues of social inequality and questions of poor living conditions, for which solutions often include increased ecological footprints [4]. Radical changes in both production patterns and consumption habits are a necessity if the present generation wants to ensure a future with similar or improved living conditions without jeopardizing growth and economic stability in the present.

Circular economy is a concept that aims at such change; following nature's principle of decomposing and recreation and the knowledge about limited resources it includes different sustainability strategies under the model of thinking through a

product's life-cycle from beginning to end-of-life strategies [5]. Circular Economy can include today's-goods-are-tomorrow's-resources-strategies or life-prolonging measures as long as it aims at closing the loop between production and disposal so that all material is reused, remanufactured or recycled.

Remanufacturing is recognized to be an effective strategy in closing the loop by enhancing resource efficiency through reuse of components and products as input material and guarantees competitive advantages by significant price reductions in comparison to a newly produced product. A variety of definitions for remanufacturing is offered, like the one formulated by the British Standard Institute. But for this paper a more detailed definition is chosen. Widera defines remanufacturing as an "industrial process in which a product that no longer satisfies the initial purchaser or first user, is transformed into a like-new or next generation product in terms of functionality, performance, lifetime and warranty. This is achieved through collection, incoming inspection, disassembly, cleaning, review and sorting, reconditioning, replacement, reassembly and testing of the product" [6]. The

remanufacturing industry is currently limited to a few countries and activity sectors as aerospace and automotive [6–8]. Research mostly focus in industry-specific improvement proposals, whereas influence of public and private external stakeholders on national remanufacturing industry remains with little academic attention.

This paper intends to identify private and public support measures for remanufacturing industry in handpicked nations from the Americas, Europe and Asia, leading to a qualitative results comparison.

## 2. Development of the remanufacturing industry in selected countries

### 2.1 Remanufacturing development in the Americas

The United States of America (USA) is the largest producer of remanufactured goods with a sales volume amounted to at least \$43.0 billion in 2011 compared to \$37.3 billion in 2009 [8]. The highest share of remanufacturing production is comprised by Small and Medium-sized Enterprises (SME). Globally, an estimated number of more than 100.000 enterprises generate around \$100 billion with a workforce of approximately 500.000 employees [9]. USA possess in contrast with other regions a low number of environmental laws indirectly or directly affecting remanufacturing. The main actor in environmental legislation is the Environmental Protection Agency (EPA), and mostly acts on customer preferences to generate change, as in the Safer Choice program [10]. However, support has been given to the industry as soon as 1998 with the creation of a label “Remanufactured in the USA” by the Federal Trade Commission [11]. This public recognition does not represent a certification standard, but according to the United States International Trade Commission (USITC), quality standards are autonomously ensured by motivated Original Equipment Manufacturer (OEM) following a business-oriented approach [8]. This assumption cannot be contradicted by the success of the country having the highest intensity of remanufactured products worldwide. Pioneer companies such as Caterpillar for the Heavy Duty off Road (HDOR) sector are very skilled in promoting the strategy as of one of their major keys to success for customers worldwide, constructing their trust and sustaining their expectations. The public support to the remanufacturing companies is not decided at the federal level, but 20 states are offering direct assistance by opening specific public procurement credits or offering tax subsidies [12]. Another example of public support to the remanufacturing industry is enacted by the public law 114-65, mandating all federal agencies to consider remanufactured parts for maintaining public vehicles fleets [13, 14].

Brazil has a remanufacturing industry in the domains of automotive parts, HDOR equipment and IT products, which is performed mainly by thousands of SMEs employing fewer than 20 operators. No less than 18,000 firms perform remanufacturing of ink cartridges, representing 25% of the broader printing industry companies count. However, in the automotive parts sector, a few large multinational companies account for 75% of the market, while 2000 SME are sharing the remaining 25% [15]. In 1991 and 2006, the Ministry of

Development, Industry and Foreign Trade (MDIC) draw a concept of used and remanufactured products but forbids commercialization of used products, that can only be donated, with ordinances DECEX 8/1991 and DECEX 235/2006 [16, 17]. The country enacted its first environmental legislation in 2010 with the National Policy of Solid Residuals (PNRS) [18] to organize the management of waste and enforcing principles of responsibility of manufacturers, importers and distributors to manage the EOL of their products. By demonstrating paths to economical valuation of waste, the PNRS can indirectly benefit the development of its remanufacturing industry. Private initiatives are taken for the definition for remanufacturing by the Brazilian Association of Technical Standards (ABNT) NBR 15296 standard for road vehicles in 2006 [19]. It defines remanufactured parts as “an original used production part or component, characterized by having undergone an industrial process by the original manufacturer or in an authorized establishment of this manufacturer, to restore the original features and technical functions” [20]. In an effort to ask for the facilitation of remanufacturing activities by legal support, the Brazilian Association of Auto Parts Manufacturers (SINDIPECAS) submitted a report in 2010 to the Federal House of Representatives to ask for regulations in their favor. The same year, an inter-ministerial workshop was created by the Executive Secretariat of Foreign Trade Chamber (CAMEX) to develop a national policy for the import and export of remanufactured goods [20]. The National Association of Auto Parts Remanufacturers (ANRAP) is actively promoting remanufacturing by organizing explicative workshops. In the context of the Brazilian industry, economic aspects are exclusively stated by Brazilian companies as a motivation for implementing new processes, such as remanufacturing. Efforts towards a better communication on the financial opportunities offered by closed loop strategies could act as an enabler for remanufacturing [21].

### 2.2 Remanufacturing development in Asia

Remanufacturing in South Korea mainly consists of automotive parts, accounting for 80% of all activities, followed by IT equipment with 17%. Sporadic activities take place in the HDOR, medical equipment and defense sectors. Overall, the remanufacturing sector increased in value by 11% yearly in the last 5 years while the number of firms and employees decreased by more than 30% in the same period [12]. It has been the world’s first country to give a legal framework for the quality certification of some remanufactured automotive parts and electrical and electronic items, as soon as 2006 by the Korean Agency for Technology and Standards (KATS) [22, 23]. In 2010, the Act on the Promotion of the Conversion into Environmental-friendly Industrial Structure was enacted for supporting quality certification and R&D efforts of environmentally friendly manufacturers. The Korean government intends to support remanufacturers, expand the market and reassure the customers buying remanufactured products [24]. Professional research agencies are supported by universities and public research institutes. The private Korean Automotive Technology Institute (KATECH), for example, is in charge of the further development of the automotive parts

certification process and of the development of sustainable business models. Initiative comes from KATECH, but KATS is responsible for the certification and the issuance of the quality certificate [25]. Currently 13 items in automotive parts and 4 items are electrical and electronic products are officially certified as having KATS quality standards for remanufacturing. The system is expected to reach over 30 products including electrical and electronic products, household supplies, and machineries in a near future [12].

In its role of factory of the world, and with the fastest sustained growth rate worldwide, China set as objective to emerge as a major remanufacturing market. However, market data are largely unavailable as the remanufacturing sector was not formerly established and identified as such before 2008 [26]. The Chinese government foresees remanufacturing as a way to sustain its industrial growth while reducing industrial waste generation. In 2001, authorities established the National Key Laboratory for Remanufacturing (NKLR) for the development of new technologies for the Chinese Remanufacturing Industry [27]. The State Council published an official announcement as 'Opinions on Accelerating the Development of Circular Economy' to draw national strategies for remanufacturing and other EOL strategies in 2005. Year 2008 saw the inscription of Circular Economy in Chinese law to give a legal frame for national investment in remanufacturing, remanufacturing quality certification and labeling, as well as joint penal provision for remanufactured products, such as machinery, equipment and automotive parts. In turn, the Chinese Academy of Sciences included disassembly, recycling, electronic products remanufacturing and automotive remanufacturing in the 18 core areas of the science and technology roadmap for innovative technologies in 2009 [28]. The concretization of such preparatory works found place in the 12th 5-year Plan of the Chinese government from 2011 to 2015 to construct a national standard for remanufacturing by granting assistance in management, subsidies, expertise and public relation to remanufacturers [29].

In contrast, the Japanese remanufacturing industry does not enjoy a customized support from public authorities. The Japanese law for environmental preservation places the country as precursor, stating with the Basic Law for Environment Pollution as early as 1967. A manifold of other law succeeded: Nature Conservation Law was voted in 1972, the Basic Environment Law in 1993, the Basic Environment Plan in 1994. In 2000, the Basic Act for Establishing a Sound Material-Cycle Society encourage the use of EOL strategies. The Home Appliance Recycling Law and the End-of-Life Vehicles Recycling Law, enacted in 2001 specified that recycling was mandatory [12]. Carried by private initiatives, the Japanese remanufacturing industry is not clearly identified as such and suffers a lack of legal recognition to support its expansion [30]. For instance, the Japan Automotive Parts Recyclers Association (JAPRA) designed a quality review standard in 2011 and has been issuing their own quality assurance label for automotive parts [31]. Other private actors offer their own label for rebuilt products, such as Nippon Good Parts Group or the Association of Japan Cartridge Remanufacturers [12].

India counts a one of the most densely populated countries of the world and faces major issues with questions of waste

management and environmental protection. However, the remanufacturing market is only at its inception phase for most sectors, except for printing cartridges. In this sector 30,000 companies reportedly remanufacture 10% of the total sales in value, although there are large differences in the process quality. If the Indian law allows the import of used goods for remanufacturing when their sales are reserved for export, the administrative process is laborious and prevent efficient application [15]. Legislation is existent with such articles as the Environment Protection Rules from 1986, the Recycled Plastics Manufacture and Usage Rules in 1999 as well as the Batteries Management and Handling Rules in 2001, but is not defined as stringent in their implementation and compulsive in their adoption [32]. However, there has not been any known national definition of remanufacturing and doubts are issued on the danger of the increase of dumping if laws in favor of remanufacturing are passed. Some remanufacturing ventures in the fields of copy machines, white goods, industrial bearings, ink cartridges, machinery, railway are showing effective application of remanufacturing in India [33]. However, Sharma et al. judge the current state of the industry lagging as compared to the potential of India as a remanufacturing market and identified customer quality concerns, the absence of a standardized process and lack of governmental support as main roadblocks for the expansion of remanufacturing in India [34].

Malaysia shows the example of a country active in the development of a nascent remanufacturing industry in a local hub for remanufacturing, as there is no institutional barrier to remanufacturing. As a result, the remanufacturing industry in Malaysia is significantly growing in aerospace, automotive components as well as ink and toner cartridges [26, 35]. The aerospace sector is worth €730 million and remanufacturing operations are present, but their extent is still unknown [35]. The import of automotive components cores from Japan and Europe is permitted to the exception of parts with important security functions such as break, and led to a €6,5 million market aiming to feed to the national aftermarket sector, with a ten-fold growth potential if intensity catches with the USA level [36]. The policy makers support to the automotive components remanufacturing industry is not accompanied by a legal framework, although collaboration in this domain is requested by the Malaysian Automotive Recyclers Association (MAARA) [37]. Printer and cartridges remanufacturing represent almost €40 million and shared between OEMs and IRs, although the sector is mined by illegal practices [26].

Vietnam does not have an identified remanufacturing industry. However, its legal standards may incentive the creation of an industry in the next years. Decree 38/2015/NĐ-CP provides for waste management including hazardous waste, domestic waste, industrial solid waste, liquid waste, wastewater, industrial emissions and other particular waste as well as environmental protection in scrap imports. Enacted by the parliament and government on 22 May 2015 and validated on 15 July 2015, the regulation on recovery and processing waste products 16/2015/QĐ applies to manufacturers, consumers and other organizations and individuals involved in the recovery and processing of waste products. Several articles mention the responsibilities of OEMs, who have to organize recovery activities for its waste products by established

recovery points or systems for waste products which have to adapt the standard requirements about collecting, storage, transport, as of the beginning of 2018. Recovery points might be established by the manufacturer or co-operate with other manufacturers. In addition, each OEM should highly encourage recovering the same type of products made by other manufacturers. The regulation has also mentioned that the Ministry of Natural Resources and Environment (MNRE) has the responsibilities to make the guideline as well as the technical standard for these activities.

### 2.3 Remanufacturing development in Europe

Europe is described as the region with the widest remanufactured product portfolio. Despite the recent increase in interest from policy makers, the remanufacturing industry is still lacking recognition and support from public authorities, especially in Europe, where there is no cross-sectoral industrial representation. In a recent study, the European remanufacturing industry is estimated to generate a total of €29.8 billion in turnover with 190,000 employees. Four countries are concentrating 70% of the total remanufacturing activity, with Germany, United Kingdom, France and Italy having the largest respective importance. Provided adequate support from public authorities and steady private investment, remanufacturing could reach up to €90 billion and an associated employment of 600,000 by 2030 [26]. Europe is rich of an extensive framework of laws concerning industrial environmental management. After the transmission of national powers to the European Union, the legislative definition for Europe as a region started significantly later, with the first law stated in 1991 with the directive 91/157/EEC on batteries and accumulators [38] updated by the Directive 2006/66/EC [39] but then sustained a rapid growth in the 21st century. In 2000 the directive 2000/53/EC on End-Of Life Vehicles (ELV) had a first indirect impact on the remanufacturing industry as an incentive for the recuperation of cores for the automotive sector [40]. In 2003, the Directive 2002/95/EC of Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS 1) aims at restricting inclusion of six toxic substances in electronic products [41]. The RoHS 2 directive 2011/65/EU confirms the same substances and clarifies the application of RoHS 1 [42]. The 2015/863/EU amends RoHS 2 by including four additional substances for an application in 2019 [43]. In 2003 the Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE) ensured a proper post consumption treatment of electronic products and therefore indirectly provides better conditions for remanufacturing of electronic equipment [44]. The 2012 updated legislation has defined in legal terms the principle of “extended producer responsibility”, for producers of Electric and Electronic Equipment. Article 12 and 13 assign that the manufacturer of new goods is responsible for financing the collection, handling, recycling and environmentally sound disposal of the waste caused by the products he has brought on a specific market, even after the property of the artifact has been transferred to a customer [45]. The Directive 2005/32/EC on Eco-Design requirements for energy-using products, July 6th, 2005 (EuP) targets energy consumption [46]. The directive

2008/98/CE on waste (Waste Framework Directive) classified EOL strategies, without specifically mentioning remanufacturing as a proper strategy [47]. If some indirect support is offered, there is yet no support legislative framework directly aiming at supporting remanufacturing. However, the interest of the European Commission in remanufacturing-oriented research about is confirmed with the financing of several remanufacturing oriented programs under the Horizon 2020 program.

At the national level, Great Britain is the only European country who created a cross-sectoral standard for differentiating remanufacturing with the BS 8887-2:2009 Design for manufacture, assembly, disassembly and end-of-life processing (MADE) [48]. In the aerospace industry, the European Aviation Safety Agency (EASA) is certifying the companies able to proceed remanufacturing of aircraft parts [15]. In the automotive sector, private remanufacturers associations are active promoters in Europe, such as the Automotive Parts Remanufacturers Association, but do not carry their own quality certifications standards. In Germany, however, the German Association of the Automotive Industry (VDA) for automotive parts established the VDA 6.1 standard. The Consumer Protection Law enforces a warranty period of 1 year [22]. Currently a guideline for the remanufacturing of internal combustion engines is under development by the Association of German Engineers.

In Russia, no law supports the remanufacturing industry. However, according to a case study, Volvo managed to sell products, by remanufacturing a product used in Russia in Sweden and reimporting it into Russia. The Russian regulation does not prohibit the import, export and sales of used products, although the administrative process is time and cost intensive. High barriers, such as low number of machines available in the market and a high education effort to be done amongst the customers, the solution of international remanufacturing solution imposed Volvo as the most successful in implementing remanufacturing in Russia. However, even this extremely supportive OEM with strong international supply chains does not force remanufacturing in Russia as it is doing in other countries, and only promote it as an alternative in specific sales negotiations [49].

### 3. Identification and comparison of regional and national support initiatives

The analysis of several countries allows the identification of stakeholders in the definition of support initiatives to the remanufacturing industry as public and private organizations and is summarized as follows:

- *Regional or national public regulation bodies* define the legislative framework for EOL, the extent of producers' responsibilities and customs regulation for used products.
- *International, regional and national technical standards organizations* can play an important role in defining remanufacturing in terms of general characteristics or specific, product-oriented processes. Their definitions can be in turn referenced by regulation bodies in legal provisions. They are public when linked to nations or

regions and inter-governmental or non-governmental associations when international.

- *Regional and national public research agencies and universities* are offering support to the industry through the development and funding of specific technological and economic research projects to contribute to the development of the remanufacturing industry.
- *Private industry associations* play an important role in many sectors to support with representing a distinct remanufacturing sector towards regulation bodies, scientific communities and society to a wider extent.

An international comparison of relative remanufacturing market intensity with support initiatives is done using a qualitative description of the support measures. The stakeholder analysis permits to identify three categories of support measures from private and public actors, as presented in Table 1:

- *Legal definition of remanufacturing* indicates if and to which extent remanufacturing appears in the national regulation, as this is essential for recognition of the remanufacturing quality level.
- *Public private partnerships* indicate whether concrete partnerships between public and private actors are undertaken for supporting the development of the remanufacturing industry.
- *EOL regulation level* acts as an indicator of the relative state of development of legislative material regarding the EOL of industrial apparatus in a country.

Table 1. Comparison of national support policies for remanufacturing

Region	Country	Market intensity	Legal definition of reman.	Public-private partnerships	EOL Regulation level
Americas	USA	Highest	Key words	Yes	Moderate
	Brazil	Nascent	Key words	No	Nascent
Asia	South Korea	Developed	Key words Processes	Yes	Developed
	Japan	Developed	No	No	Earliest, developed
	China	Fastest growth	Key words Processes	Yes	Developed
	India	Nascent	No	No	Moderate
	Malaysia	Nascent	No	No	Absent
	Vietnam	Absent	No	No	Nascent
Europe	EU	Widest portfolio	Key words Processes (UK)	Yes	Most developed
	Russia	Absent	No	No	Nascent

#### 4. Results discussion

The comparison of support initiatives for remanufacturing in selected countries show that all developed remanufacturing markets also have comprehensive EOL regulation. A comprehensive analysis of the remanufacturing industry activity volume can only take place when its industrial

processes are differentiated by a legal definition. An alternative to a public normative definition is a spontaneous development of normative documents by private industry-specific remanufacturers' associations. This scenario is however only possible when several companies are already operating in a national market. The systematic definition of remanufacturing processes is an instantiation of the collaboration with several stakeholders in public-private partnerships. They actively contribute to a wider diffusion of universally recognized remanufacturing industry and should be encouraged.

However, as trade and industry are increasingly integrating global networks, the focus of international remanufacturing companies identifies the export and import of cores from one country to another as a key factor to become more cost efficient [20]. The EU shows the only cross national application of consistent and constraining environmental laws, even if directives from the European Union have to be transposed in the national law by the member states and the implementation process can be slowed down. Other countries are considering the benefits of core importation for remanufacturing to develop their local industry. As an example, the Indonesian prime minister Saleh Husin authorized the import of second-hand capital goods for remanufacturing purposes if they meet specific requirements in the Regulation 14 of 2016 [50].

#### 5. Conclusion and outlook

In this paper remanufacturing activities in selected countries in the Americas, Asia and Europe have been analyzed, showing a broad variety in the level of development as well as public support activities. From this analysis it is suggested for public authorities aiming at developing their remanufacturing market to foster first on providing a legal definition of remanufacturing. Private associations can support the development of such legal definitions for product-specific processes. Strong EOL regulations are significant to create circular economy activities but their direct influence on remanufacturing development depends on the level of differentiation with other EOL alternatives. The development of international remanufacturing companies should also be considered to incentivize foreign investment in remanufacturing facilities.

A very positive impulse towards the recognition of remanufacturing as a key strategy for the instantiation of sustainable manufacturing practices has been given in the G7 leaders declaration at the 2015 summit in Germany. The G7 Alliance on Resource Efficiency intends to collaborate with industry to foster best practices and innovation and named remanufacturing as a specific focus area [51, 52].

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