

Remanufacturing and the 3Rs in Japan: Lessons for Thailand

*Eric D. Ramstetter**

Abstract

This survey first illustrates that policies making waste disposal relatively expensive have been key determinants of the benefits of remanufacturing and the closely related activities of waste reduction, reuse, and recycling (the 3Rs) in Japan. These policies have generally been product specific and sought to compensate for the failure of private markets to force polluters to bear the costs of negative externalities (costs) imposed or reward those who impart positive externalities (benefits) by reducing pollution through the 3Rs or remanufacturing. Notably they have not discriminated much among different types of firms. Second, the profitability of remanufacturing or more general reuse is found to vary among industries or products, depending on the technologies and consumer preferences involved. Original equipment manufacturers (OEMs) in agricultural and construction machinery and of copiers and related office equipment and services are examples of firms that find narrowly defined remanufacturing relatively profitable. In contrast, other OEMs in non-metallic minerals find that reuse or remanufacturing is not generally possible, largely because of the nature of their products but they have substantial and

*Professor Eric D. Ramstetter, Research Professor, International Centre for the Study of East Asian Development, Visiting Professor, Graduate School of Economics, Kyushu University. Email: ramst@icsead.or.jp

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increasing recycling activities. In contrast to OEMs, who are by definition manufacturers, trading is the main activity of most independent business reuse companies (IBRCs). Some IBRCs, for example in used motorcycles, find substantial remanufacturing to be profitable, while reuse (e.g., clothing, books, software, personal computers) or recycling (e.g., automobile parts) are more efficient for other products. As resources become scarcer and more expensive, markets will gradually reinforce the incentives created by Japan's policies. There are already substantial opportunities for developing economies like Thailand to benefit from emulation of the principles underlying Japan's policies. Japan's national and local governments, as well as its firms, recognize this fact and are actively disseminating knowledge related to their experience with remanufacturing and the 3Rs to neighboring Asian economies such as Thailand.

1. Introduction

Over the last half century, Japan has become a world leader in efforts to reduce pollution or the generation of waste that is harmful to the environment and people. In broad economic terms, this process consists of efforts to reduce the need for (primary and intermediate) inputs and to promote the reuse or recycling of (intermediate and final) outputs. Cognizant of the failure of private markets to force polluters to bear the costs of negative externalities (costs) imposed or reward those who impart positive externalities (benefits), Japan has consistently sought to increase the costs of most kinds of waste generation relative to alternatives.¹

In recent years, Japanese policymakers have promoted the “3Rs initiative”, where the 3Rs are defined as “reduction of waste generation, reuse of parts, and recycling of used products as raw materials” (Ministry of Economy Trade and Industry 2004, p. i).² Emphasis on remanufacturing and the 3Rs is most directly connected to the management of solid waste, but related activities also have implications for the generation of gaseous and liquid waste. Japan's policies have been flexible in that they generally allow producers and consumers to choose methods of waste reduction that best suit their situation. As a result, it is often difficult to

¹ A notable exception is relative the lack of penalties for generating and storing nuclear waste.

² See also Ministry of Economy Trade and Industry (2011) for further details about this policy.

distinguish remanufacturing and reuse activities, or even recycling. It is also equally important to recognize that incentives promoting remanufacturing, reuse, and recycling also encourage technological changes that reduce reliance on waste generating inputs or production processes. It is thus important to understand the connections between these related activities, as well as their distinguishing characteristics.

This survey first overviews Japan's policies related to waste management, remanufacturing, and the 3Rs, and their relationship to overall environmental policies (Section 2). Particular emphasis is placed on how these policies affect firm choices to remanufacture, reuse, recycle, and/or reduce usage of pollution-generating inputs or outputs. The paper then examines definitions of remanufacturing and related concepts in some detail and tries to identify some common technical characteristics of among firms or plants involved in remanufacturing and related activities (Section 3). The following section (4) describes the activities of some Japanese firms engaged in remanufacturing, reuse, or intermediate activities (e.g., refurbishment). Following Matsumoto (2009) it is important to distinguish between original equipment manufacturers (OEMs) and independent business reuse companies (IBRCs), but it is also important to recognize that both of these groups are quite heterogeneous in important respects. Finally, some concluding remarks are offered (section 5).

2. The Policy Framework

In the 1960s, much of Japan was a highly polluted. The town where I work, Kitakyushu, is a very good example. It was dominated by Japan Steel and other heavy manufacturers which used relatively pollution intensive production techniques and materials. Gaseous, liquid, and solid emissions all created severe, often health-related problems for the residents and resulted in strong public pressure to reduce emissions. Kitakyushu was also not unique in Japan; many other manufacturing centers suffered from similarly severe pollution problems of one type or another.

Largely as a result of political pressure to alleviate related problems, the Japanese national government enacted the Basic Law for Environmental Pollution Control in 1967 and the

Nature Conservation Law in 1972.³ These laws created important incentives and requirements for substantial environmental cleanups and reductions of subsequent emissions. Increases in energy prices during the 1970s also created substantial economic incentives for energy conservation and related pollution reduction, which were reinforced by government efforts to spur energy conservation from the mid-1970s.⁴ By the mid-to-late 1980s, Japan's environment was substantially cleaner and its firms much more motivated to avoid harmful emissions than in the 1960s.

Implementation of laws and related government directives designed to reduce pollution and conserve energy were a result of collaboration between the national government and various levels of local governments, all the way down to the neighborhood council level. Although there were inevitable coordination difficulties and differences in objectives among various groups, policy makers generally succeeded in getting firms, citizens, and government to work toward goals of reduced emissions and greater conservation. In contrast, litigation was generally avoided, though there were some high profile cases where polluters were convicted of both civil and criminal offences (e.g., the Minamata case).

The two aforementioned laws were then superseded by the Basic Environment Law in 1993 and the Basic Environment Plan, which was drawn up in 1994 and has served as the basic framework for environmental policy in recent years. These measures are quite comprehensive in scope (see source cited in footnote 2) and they have since been supplemented with several additional laws. In this context, the Basic Act for Establishing a Sound Material-Cycle Society (promulgated in 2000) is also important because it seeks to promote the “proper cyclical use of products” through activities such as remanufacturing, reuse, and recycling. Narrower laws governing the Recycling of End-of-Life Vehicles and the Recycling of Specified Kinds of Home Appliances have also had important effects.⁵

³ See the Ministry of the Environment home page (<http://www.env.go.jp/en/laws/index.html>) for more details on these and other laws governing environmental regulation.

⁴ Japan's emphasis on energy conservation continues to this day (Duffield and Woodall 2011).

⁵ There are also at least 8 other laws governing specific aspects of waste management (Ministry of Economy Trade and Industry 2011).

In short, Japan has created a robust legal and policy framework that has had the net effect of making most types of waste disposal more expensive than they would be if the laws and policies were absent. Although the effectiveness and optimality of specific measures are subjects of important debates, policy has clearly encouraged Japanese firms, consumers, and government officials to view remanufacturing and the 3Rs as key elements of the economic landscape (Gutowski et al. 2005; Nakamura 2010; Organisation for Economic Co-operation and Development 2010). This is in marked contrast to Thailand and many other developing economies, for example, where governments have tended to view environmental policies as cost-imposing measures rather than tools for the encouragement of new economic activities.

3. Definitions and Determinants of Remanufacturing's Benefits

In the economic literature, remanufacturing is often defined narrowly as “an industrial process that transforms an EOL (end of life) product into a product with an ‘as good as new’ condition” (Matsumoto 2009, p. 1547, from Seitz 2007). “It includes product disassembly, cleaning and identification of parts, parts recovery and product re-assembly”. In contrast, “product reuse, in narrow sense, such as a process in secondhand shops includes only product checking and cleaning, and does not necessarily include disassembly, recovery and re-assembly”.⁶ In Japan, many firms are also engaged in various processes that are best described as intermediates between reuse and remanufacturing, or various stages of refurbishment. Correspondingly, in Matsumoto (2009), “reuse is defined as concept that subsumes both remanufacturing and narrowly defined product reuse”, probably because some of the IBRCs he studies are not specialized in either remanufacturing or reuse, but engage in both activities, as well as various intermediate stages of refurbishment.

Although I tend to agree with Matsumoto's (2009) implication that narrow distinctions between remanufacturing, reuse, or refurbishment are often of limited relevance in the Japanese context, trade negotiators, customs departments, and other legal authorities often make important

⁶ These definitions are all from Matsumoto (2009); they are generally consistent with those used by others (e.g., Lund and Hauser 2010 and Seitz 2007).

distinctions between reused products and remanufactured ones (World Trade Organization, Communication from the United States 2005). Indeed, recent discussions among trade negotiators would appear to focus primarily on narrowly defined remanufacturing which “turns a product at the end of its life or lease cycle, called a “core,” into a like-new good” (p. 2). This relatively narrow definition is clearly accurate in cases, where key components can be engineered to outlive original, final products produced by these companies. Moreover, the desire to narrowly define the scope of remanufacturing is understandable among negotiators from economies that seek to protect the proprietary rights of national companies and avoid pirating of products that might compromise the competitive advantages of the companies involved. The focus of trade negotiators on narrowly defined remanufacturing is also understandable given the substantial political influence wielded by the relatively large OEMs that dominate narrowly defined remanufacturing.

On the other hand, narrow definitions of remanufacturing or distinguishing between remanufacturing and the 3Rs are less meaningful if the concern is to avoid the imposition of negative externalities related to waste generation or correspondingly to identify when remanufacturing is likely to be a more efficient way of processing an EOL product than recycling, reuse, or refurbishment.⁷ It is therefore helpful to try and identify the characteristics of products, production processes, firms, and related consumers that affect the relative costs of remanufacturing compared to alternatives such as reuse, recycling, or intermediate stages of refurbishment. In this context, it seems fairly obvious that if simple reuse is possible, reuse is very likely to be the cheapest and most efficient option because producers and consumers do not have to bear the costs of remanufacturing, recycling, or refurbishment. Indeed, if low cost reuse is possible, it is probably not accurate to characterize the item involved as an EOL product. Rather it is a product which has lost its usefulness to one consumer, but retains value for others. In such

⁷ My initial survey suggests that the academic literature has yet to address this question. For example, Lee et al. (2010, p. 1276) assume “that a company’s EOL strategy is already decided to focus on remanufacturing by using non-destructive disassembly”. Sundin and Bras (2005, p. 913) also do not address this question but choose to emphasize that “To achieve an efficient remanufacturing process, the products aimed for remanufacturing should be adapted for the process as much as possible”. The brief survey in Langella (2007, pp. 9-18) is probably the most comprehensive in this respect but it too highlights how related economic literature appears to be sparse.

cases, the best way of avoiding negative externalities related to excessive waste disposal is to foster the growth of (or avoid restrictions on) secondhand shops and other markets for used products.

When products affect human safety or create negative externalities such as pollution, simple reuse is often very difficult. The case of used automobiles in Japan provides an interesting example because Japan's biannual safety check requirements are strict and often impose large biannual costs (often 80,000 yen [about US\$1,000] or more) on operators of older vehicles. These costs also tend to increase with vehicle age because older vehicles are generally found to require relatively costly repairs to meet safety guidelines. Thus, the market for used vehicles, especially older ones, is limited in Japan. There are also legal requirements to recycle EOL autos and it is often more profitable to export them to regions, where the use of older vehicles is relatively cheap, than to recycle them in Japan. The complexity of vehicles and the premium Japanese consumers place on new vehicles also combine to make remanufacturing of autos impractical in most cases in Japan (and most other markets). Thus, reuse in export markets or recycling are the two most common ways of handling EOL vehicles in Japan, though remanufacturing of vehicle parts is more common elsewhere.

Although important, the previous example is exceptional because policies impose relatively large costs on reuse in Japan. More generally, the relative benefits of remanufacturing appear closely related to the technological characteristics of products, production processes, and firms that might engage in remanufacturing, as well as the preferences of relevant consumers. For example, for narrowly defined remanufacturing to be beneficial, relatively large portions of product's costs need to result from the production of two distinct types of components, relatively long-lasting ones that can be recovered and/or refurbished at acceptable cost and relatively short-lived ones that are repaired or replaced during the remanufacturing process. Products like the heavy machinery produced by companies such as Komatsu or Kubota and copiers produced by companies such as Canon, Fuji Xerox, or Ricoh are examples of products where both types of components occupy a relatively large portion of costs. Correspondingly, all of these companies emphasize the importance of remanufacturing or recycling processes in their corporate literature and some of their remanufacturing activities have been studied previously (Kerr and Ryan 2001;

Matsumoto 2009, p. 1548). Motorcycles and scooters are another example with similar characteristics. In this case, remanufacturing is usually done by IBRCs, which often engage in trading (reuse) or intermediate stages of refurbishment as well (see below). On the other hand, remanufacturing is generally impractical in numerous other industries where hygiene is important (e.g., sanitaryware [see below], food products, apparel) or where production technologies often make costs of recycling relatively cheap (e.g., wood, paper, basic metals).⁸

It is also important that Japanese consumers have a reputation of discarding various used products relatively early in their life-cycles. I know of little hard evidence on this point, but casual observation from decades of living in Japan and the United States, as well as numerous, shorter stays in Australia, Singapore, Thailand, and many other Asian economies, suggests that this reputation may be deserved. However, it is less clear as to whether the reputation is a result of consumer responses to policies (e.g., the vehicle example above) or differences in consumer preferences *per se*. Nonetheless, to the extent that Japanese consumers do discard used products relatively early, they create relatively large opportunities (i.e., cheap supplies) for firms seeking to reuse, remanufacture, refurbish, or recycle products.

4. Some Examples of the 3Rs and Remanufacturing in Japanese Firms

This paper follows Matsumoto (2009) and the literature cited there by highlighting important differences between OEMs and IBRCs in Japan's remanufacturing and reuse activities. OEMs are by definition manufacturers, but both Matsumoto (2009) and Seitz (2007) emphasize that OEMs often view direct profit generation by remanufacturing activities as a secondary priority. Rather the goals of OEMs are more often related to securing parts supplies and discouraging other firms from competing with the OEM in the remanufacturing or reuse of its products. In other words, the direct contributions of the remanufacturing and related activities to firm profits appears to be relatively small, though indirect contributions may be larger. Many IBRCs also generate relatively large portions of revenues from activities other than

⁸ See Oakdene Hollins (2004) pp. 18-44 for a survey of remanufacturing activities in numerous U.K. manufacturing industries.

remanufacturing or related activities, often from trading. However, in some of the IBRCs examined below and in Matsumoto (2009) reuse or remanufacturing activities are often key sources of competitiveness and profitability. Another important difference appears to be that many OEMs, including those examined in this paper, operate in markets that are best characterized as oligopolistic, where the number of competitors is relatively small. On the other hand, IBRCs generally face a much larger number of competitors and their markets are more monopolistically competitive. Importantly, both types of firms rely heavily on product and/or service differentiation, which means that these firms are not found in perfectly competitive markets.

4a. Original Equipment Manufacturers (OEMs)⁹

The section examines seven OEMs, two in agricultural and construction machinery (Komatsu and Kubota), three in copiers and related equipment (Canon, Fuji Xerox, and Ricoh), and two in non-metallic mineral products (Toto, Taiheiyo Cement; Table 1). These sample firms were chosen because they illustrate a variety of firm approaches to and experiences with the 3Rs and remanufacturing. However, the small sample means that it cannot be considered representative. Comparisons with all corporations in Japan for 2009, for example, reveal that all these OEMs were both substantially larger and more profitable than average Japanese corporations in their corresponding industries.¹⁰ Sales per employee, which is a rather poor measure of labor productivity, were also relatively high in Komatsu, Kubota, and Taiheiyo Cement, but relatively low in four other sample firms.

⁹ Except when otherwise cited data in this section come from corporate web sites: Caterpillar www.cat.com; John Deere www.deere.com; Komatsu www.komatsu.com; Canon www.canon.com; Fuji Xerox: www.fujixerox.com; Ricoh www.ricoh.com; Toto www.toto.com; Taiheiyo Cement: www.taiheiyo-cement.co.jp. Most reports were downloaded in April-August 2011, but a few older reports were downloaded in 2005-2010 and may no longer be available online.

¹⁰ Because of the recession, 2009 is not a very good year to use for comparison. However, industry definitions changed in this year allowing the inclusion of office machinery in the definition of electric and electronic machinery includes, which is not possible for previous years. Because this change is important when comparing with sample firms that have substantial operations in office machinery, this year was used.

If one does an internet search on the term “remanufacturing” or “reman” as it is often abbreviated in corporate reports, sites related to manufacturers of agricultural and construction machinery such as Komatsu or Kubota, and their U.S. competitors Caterpillar and John Deere, are often displayed prominently. As explained above, the major products of these companies contain both important parts and components that are capable of lasting a long time with relatively small maintenance expenditures and other crucial parts and components that need relatively frequent replacement. Expenditures on these products are also a relatively large cost for many consumers, most of whom are other firms that use the machinery in their production processes. Compared to markets for passenger cars, for example, the number of consumers and the number of units produced each year is relatively small, like the number of producers. Correspondingly, the costs of remanufacturing coordination between consumers and the relatively small number of producers are often far lower than corresponding costs related to disposal of old products and delivery of new ones. Annual reports and reports on the environment or corporate social responsibility (CSR, often defined to include environment-related activities) published by these companies suggest that remanufacturing and other environment-related activities are key and rapidly growing elements of corporate strategies in these companies.

Since the early 21st century, Komatsu has aggressively pursued the expansion of its remanufacturing operations. By 2010, it operated seven major remanufacturing centers worldwide, with the facilities in Indonesia and Chile now serving as global as well as local centers. New centers are also being considered for China, Russia, and India. The establishment of relatively large-scale remanufacturing operations in Indonesia and Chile has been closely related to Komatsu’s ability to capture substantial shares of relatively large markets for mining equipment in these countries. Considerations in Russia are likely to be similar, but those in China and India will probably differ because of the relatively small size of mining industries in these economies (where construction and agricultural equipment are likely to be a bigger focus). Unfortunately, as in most companies examined in this study, the remanufacturing business is still too small to be considered

a major segment in Komatsu's financial reporting. Is thus difficult to figure out the importance of remanufacturing to Komatsu or the extent to which it has changed in recent years.¹¹

For example, according to Toyo Keizai (2010), the remanufacturing affiliate in Indonesia employed only 128 workers in July 2009, or only 7 percent of the 1,817 workers in Komatsu's seven Indonesian affiliates, and a much smaller fraction of the worldwide total (38,518 consolidated and 8,142 non-consolidated in March 2010). This suggests that remanufacturing is still a relatively small business for Komatsu, despite the emphasis it receives in corporate reports. On the other hand, the company's *Environmental and Social Report* for 2010 (p. 16) indicates that CO₂ emissions per unit of sales have fallen 10-11 percent in 2006-2009, both in Japanese manufacturing operations and in the companies shipping activities. It also highlights reduced waste generation and water use per unit of sales, as well as recycling rate for waste of over 99 percent (p. 19).

Kubota is another important Japanese competitor in agricultural and construction machinery, but it does not mention remanufacturing activities in its recent (2005-2010) annual or CSR reports. Rather this company's documents highlight Kubota's "Global Environment Charter" (revised June 2006) as well as its efforts to promote the 3Rs and greater environmental awareness in Kubota, Kubota's suppliers or related companies, and the general public. The company's 2010 *CSR Report* (p. 37) also highlights a 20 percent increase in the ratio of sales to waste discharges in 2006-2010 and an 11 percent increase in the ratio of sales to the release of designated chemicals controlled by Japanese law. On the other hand, the ratio of net sales to CO₂ emissions was lower in 2009-2010 than in 2006-2008. Moreover, like Komatsu, Kubota reports present no hard data that allow one to evaluate the importance of environment-related expenses in total costs, for example. More importantly, there is little evidence as to why Kubota has yet to promote remanufacturing to the extent that Komatsu, Caterpillar, and John Deere have.

¹¹ Corporate reports for U.S. competitors Caterpillar and John Deere are also similar to those for Kubota in emphasizing the importance of remanufacturing and other environment-related activities and reports for Caterpillar often discuss remanufacturing particularly prominently. However, none of these companies identify remanufacturing as a major business segment or clarify the extent of related costs.

Fuji Xerox is a supplier of copiers, printers, as well as related equipment, software, and services. This company is ultimately owned by Fuji Film Holdings (75 percent) and US Xerox Corporation (25 percent), and operates as Xerox's representative in Japan and 12 other Asia-Pacific economies. It has also been carefully studied in the previous literature (Kerr and Ryan 2001; Matsumoto 2009, p. 1548). Fuji Xerox's corporate documents do not discuss remanufacturing in much detail. Rather, they emphasize recycling.¹² Because it is privately held, it is not required to publish financial statements in the same detail as listed companies such as Komatsu, and it does not appear to provide any segment information on its website (in either Japanese or English). Thus, here again, it is impossible to objectively evaluate the size of its recycling or remanufacturing output or its expenses on remanufacturing or other environment-related activities.

Previous studies, corporate documents, and discussions with corporate officials all emphasize the importance of the company's "integrated recycling system". This system is based on the concept of the "zero landfill", which emphasizes the economic value of recycling parts in the manufacturing processes and the corresponding elimination of waste. This recycling system was first introduced in 1993 and production using the system began in 1995. According to the company's website, it reached a milestone of 100,000 products being remanufactured with recycled parts in 1999. The company has since established integrated recycling plants in Thailand (construction began in 2004) and China (operations began in 2008). Importantly, Fuji Xerox does not distinguish between "new" and "remanufactured" products. Rather all products are expected to perform to identical, rigorous quality standards. Together, this evidence suggests that remanufacturing with recycled parts may have become the dominant mode of production in the company.¹³ Fuji Xerox's corporate documents (e.g., its annual *Sustainability Report*) also

¹² For example, the company's *Sustainability Report* for both 2008 and 2009 do not even mention the word remanufacturing and the 2010 issue only mentions it in conjunction with China's official recognition of the company's China Integrated Recycling System as a Pilot Remanufacturing Enterprise.

¹³ It is important to recognize the important contributions of Xerox and its technology to Fuji Xerox's environmental efforts, though it is also likely that Xerox benefits from feedback about environmental efforts from its Japanese affiliate, which operates in a relatively strict policy environment in many respects and whose Japanese parent has strong competitive advantages in the production of related chemicals and chemical products.

highlight substantial CO₂ savings from reusing parts and reduced energy consumption. Reduced water usage is also emphasized.

Canon and Ricoh are two larger competitors of Fuji Xerox in the market for copiers, printers, and related equipment, software, and services in Japan and the Asia-Pacific. Canon and Ricoh also operate worldwide. Canon is by far the largest of these three, with sales of 4.1-4.5 trillion yen in 2006-2008 and 3.2-3.7 trillion yen in 2009-2010 (Table 1). Ricoh's sales were about half this amount in all these years except 2009 (63 percent) and Fuji Xerox's sales were 27-29 percent of Canon's during this period. Canon's relatively large consumer division (35-41 percent of sales in 2006-2010) distinguishes it from the other two companies, which are heavily concentrated in the production of office and corporate equipment. Canon's heavy reliance on overseas sales (78-81 percent of total sales) is another distinguishing characteristic. On the other hand, in the Japanese market, Ricoh's sales exceeded Canon's for the decade 2001-2010.

Like Fuji Xerox, websites and recent corporate reports for Canon and Ricoh emphasize their total environmental efforts and do not mention remanufacturing prominently. For example, Canon's annual *Environment Report* (1999-2003) and *Sustainability Report* (2004-2011) highlight how remanufacturing is just one, apparently small part of its recycling systems. The 2008 report (p. 59) indicates that remanufacturing activities had reduced the CO₂ equivalent of "all stages until the manufacturing stage" by 76 percent in 2007. The recycling of copying machines is done by affiliates in Japan, Europe, and the United States and recycling of toner cartridges also took place in these three regions and China, but recycling of printer cartridges was only conducted by one Japanese affiliate. The 2001 report (p. 37) claimed a material (resins and metals) recycling rate of 87 percent. The 2000 report (p. 27) describes remanufacturing activities in more detail, highlighting how they began in the United States in 1992 and expanded to Europe and Japan by 1999. Like Fuji Xerox, Canon emphasizes how remanufactured products are made to the same standards as new ones.

The 2003-2010 issues of Ricoh Group's *Sustainability Report (Environment)* never mention remanufacturing explicitly, but they too describe an emphasis on recycling components and using recycled components in the production (remanufacturing) of new machines that seem

similar to the processes used by Canon and Fuji Xerox.¹⁴ Ricoh also claims a 99 percent recycling rate for used copiers and toner cartridges (2010 report, p. 27) and its reports emphasize numerous awards that the company has received for its superior environmental performance (e.g., 2010 report, p. 7). The 2010 report also highlights how its newer product mixes are more energy efficient than older ones (p. 24) as well as trends in CO₂ emissions and energy consumption (pp. 37-38), and waste generation and water consumption (p. 41). According to the company, it continues to make progress consistent with its goals in these respects. Ricoh's reports also include some of the more comprehensive environmental accounts in the reports reviewed. For example, in 2009 these data imply that environment-related items accounted for 3.9 percent of the increase in net property, plant, and equipment, 2.9 percent of R&D expenditures, and 2.2 percent of selling, general, and administrative expenses (2010 report, pp. 63-64). However, Ricoh appears to rely more heavily on subcontracting of recycling activities to joint ventures or other companies than Canon and Fuji Xerox, who appear conduct most of such activities in house or in more tightly controlled affiliates.¹⁵ In short, all three of these companies have clearly recognized the economic benefits of the 3Rs and remanufacturing in their industry, much like Komatsu and to a lesser extent Kubota in the agricultural and construction machinery industry.

Comparisons with the Toto, a producer of sanitaryware (restroom, bathroom, kitchen, and wash products) provide an instructive contrast. Largely because of hygiene-related issues and the production technologies used, many of Toto's products are almost impossible to reuse or remanufacture, or even to recycle into raw materials for new products. Thus, Toto's environmental efforts have therefore focused primarily on reducing the need for material and energy inputs. According to its 2010 *Corporate Report: Financial and CSR Section* (pp. 27-30), Toto's recent achievements have been substantial in this regard. For example, between 2006 and 2010 it

¹⁴ Older issues (1999-2002) of the Group's *Environment Report* do mention remanufacturing some, but here again the primary emphasis is on the 3Rs and broader environmental initiatives.

¹⁵ One company involved in this activity is Recycle Tech, a joint venture between Ricoh and a subsidiary of Mitsubishi Chemical Corporation located in Kitakyushu's Eco-Town. According Recycle Tech officials, about half of the firm's sales go to Ricoh and the other half go to other firms. The Eco-Town Project is run by the Ministry of Economy, Trade and Industry and subsidized the start-up costs of Recycle Tech and many other firms. Kitakyushu's Eco-Town is among the largest, if not the largest, set up under this project.

reduced CO₂ emissions in domestic group companies by 25 percent, water consumption by 22 percent, energy consumption by 20 percent, and plant waste by 19 percent. Part of these reductions are a result of the 15 percent decline in sales during the period, but these figures still suggest important declines in resources used or CO₂ emissions per unit of sales. The report also highlights high rates of recycling of plant waste (sludge clay) and paper in the company. Moreover, the report indicates that 12 percent of R&D costs and 2.4 percent of investment by the company was used for environmental conservation purposes in 2010. In short, although Toto is not heavily involved in remanufacturing or reuse, it too recycles and has made substantial reductions in the use of important inputs.

Taiheiyo Cement is another firm in the non-metallic mineral products industry, its main business being the manufacture of cement. Like Toto it does not engage in much reuse or remanufacturing, but it does have substantial recycling operations. It is included in this sample primarily because it is one of the few companies in Japan which identifies its “environmental business” (mainly recycling of coal ash, waste plastic, reclaimed waste, sludge, and, municipal waste incinerator ash, among other things) as a separate segment in its accounting. Between 2006 and 2009 revenues from environmental business grew from 6.6 percent of total revenues to 8.4 percent, but fell back to 8.0 percent in 2010 (Table 1). Operating profit ratios (to total sales) were also relatively large in environmental business from 2007, and at least 4 times higher than the company average in 2008-2010, when the economic slowdown hit its other businesses hard. Reflecting its capital intensive technology, sales per employee were also much higher in environmental business than for the company overall. In other words, this company’s environmental business has been profitable and growing relatively rapidly in recent years, though it remains relatively small.

The most important point here is that the relative economic and environmental efficiency of remanufacturing and reuse in OEMs varies greatly among industries and products, largely because of differences in cost structures (i.e., technologies) and consumer preferences (i.e., demand patterns) involved. By comparison, recycling and especially reduction of input usage (conservation) are probably relatively efficient in a larger number industries and product lines, but the benefits of these activities also vary greatly across industries and products. This presents a

substantial challenge to policy makers who often lack the necessary resources to determine efficient mixes of environmental policies for different groups of firms or industries.

4b. Independent Reuse Business Companies (IBRCs)

Perhaps the primary difference between IBRCs and OEMs involved in reuse or remanufacturing is that many prominent IBRCs have their roots in trading rather than manufacturing. For example, the 14 major, listed IBRCs identified by Matsumoto (2009, Table 1) are all probably best classified as wholesale or retail traders. There are now numerous Japanese IBRCs involved in the wholesaling and/or retailing of used clothes, books, CDs, DVDs, videos, software, brand-name goods, and jewelry, for example. These companies generally engage in very little refurbishment and almost never in what could be understood as remanufacturing. However, if the concern is to promote the reduction of waste and reuse, these businesses clearly make important contributions, not only to the economy but to the environment. These IBRCs are now much more prominent than even two decades ago, for example, primarily because Japan's slow growth during this period (after the financial bubble burst in the early 1990s) has apparently led Japanese consumers to be more price conscious and willing to purchase used products than previously.¹⁶

Many IBRCs involved in the wholesaling or retailing of motorcycles, automobiles, personal computers (PCs), and related parts, for example, also refurbish or remanufacture substantial portions of the product lines they sell. The used motorcycle business is a good example of an industry in which substantial remanufacturing is often required, but in which the technical and capital requirements are relatively limited. It is thus possible for relatively small firms such as Kanmon International in Kitakyushu to carve out niches in a market dominated by larger

¹⁶ Greater emphasis on price competitiveness is evidenced by increased prominence of retailers that emphasize price competitiveness with limited service (e.g., Aoyama, Carrefour, Costco, Aeon [Jusco], Uniqlo) and the decline of traditional department stores with relatively high prices but better service (e.g., Daimaru [who now owns Matsuzakaya], Mitsukoshi [now merged with Isetan], Sogo [now bankrupt], Takashimaya). The number of unique users on the price comparison website kakaku.com (which translates as price.com) also increased from an average of under 2 million in February-July 2009 to well over 3 million in the same period in the same period in 2011 (http://corporate.kakaku.com/company/userdata_kakaku.html, accessed August 2011 and in Japanese only).

companies such as IK (the operator of the Bike-Oh chain).¹⁷ Kanmon has been successful by focusing on the wholesale of used motorcycles, tractors, and other equipment from Japan to overseas markets, while the larger competitors have focused more on the local market and more on retail. The degree of remanufacturing in such activities is hard to evaluate, because required repairs vary greatly depending on the condition of the items purchased by the IBRC and the needs of the customers involved. Thus, even when a fair amount of remanufacturing (e.g., replacement of key parts or an engine) is required, the key competitive advantage of firms in this industry, large or small, continues to be their trading know-how. In other words, they profit primarily because they know how to match buying and selling opportunities at relatively low cost. However, the environmental and economic contributions of refurbishing or remanufacturing are also conspicuous. For example, Kanmon officials claim that they never dispose of any used part or product because “there is always someone willing to buy” or “a use for it in the firm’s remanufacturing or refurbishing tasks”.

The three auto-parts firms analyzed in Matsumoto (2009, pp. 1952-1953) also appear to be companies in which refurbishing or remanufacturing capability is a key supplement to trading skills that form the core of these firms’ expertise. Recycling capability also facilitates competition in this industry by firms such as West-Japan Auto Recycle (WARC), which operates in Kitakyushu’s Eco-Town and sells parts directly to both wholesale and retail consumers.¹⁸ WARC’s web page also indicates that another 10 dismantling (recycling) companies are scheduled to open plants nearby and that “the area is going to become a huge parts-supplying location”. If this becomes the case, planners of the Kitakyushu Eco-Town will have recorded an important success in their efforts to encourage environmentally friendly, small-medium businesses in the area. This is important economically as well, because relatively small firms generate much

¹⁷ For more details on Kanmon’s operations, see <http://www.kanmoninternational.com>. For information on IK, see www.ikco.co.jp/en/index.html. For information on IK, see www.ikco.jp

¹⁸ See www.warc.co.jp/english/english.html.

of the employment in Japan.¹⁹

In contrast to the used motorcycle and automobile parts businesses, where wholesale traders appear to dominate, the used PC business is apparently dominated by retailers such as Sofmap (Matsumoto 2009, Table 1; now a subsidiary of Bic Camera). As illustrated by the takeover of Sofmap, many large retail chains selling home electronics (e.g., Best Denki, Bic Camera, Joshin, Kojima, Yamada Denki) also deal in used PCs. In addition, there are also a large number of smaller, net-based retailers in this business.²⁰ In many respects, this is primarily a reuse business and the refurbishing performed usually focuses on data deletion and/or software reinstallation. The short life-cycle of most PCs means that there is very limited scope for remanufacturing or even refurbishing of products that are more than 2-3 years old. However, it is sometimes profitable to replace parts that have failed in newer used machines. As in the case of automobiles, Japanese law forbids the simple disposal of PCs and required them to be recycled.

Here again, perhaps the most important point of this discussion is that is that the relative economic and environmental efficiency of remanufacturing and reuse in IBRCs varies greatly among industries and products for the same reasons (differences in cost structures and consumer preferences). It is also important to reemphasize the important role of policy, because both several of the OEM and IBRC examples discussed in this paper illustrate how policies have generally given firms greater incentives to pursue remanufacturing and the 3Rs than they otherwise would have had. It is also important to note that Japan's environmental policies have not discriminated much among manufacturers, traders, OEMs, or IBRCs, for example. Rather policies have generally been product specific and designed to minimize the negative externalities caused by production and use of various products.

¹⁹ In 2009, firms with equity below 50 million yen (about US\$0.55 million at March 2010 rates) generated 47 percent of the 11 million jobs in Japan's manufacturing firms and 48 percent of the 10 million jobs in wholesale and retail traders. This compares to shares of 28 percent in manufacturing and 14 percent in trade for large firms with equity of 1 billion or more. Shares of large firms were much bigger in terms of sales, however, 58 percent and 30 percent, however. Data come from Ministry of Finance (2010).

²⁰ See <http://kakaku.com/used/pc/> (in Japanese only).

5. Conclusions: What are the Lessons?

Three major conclusions arise from this survey of remanufacturing and the closely related activities of waste reduction, reuse, and recycling (the 3Rs) in Japan. First, policy has been a crucially important determinant of the benefits of remanufacturing and the 3Rs. In Japan, the primary policy goal has been to make waste disposal expensive relative to the 3Rs and/or remanufacturing. Policies have generally been product specific and sought to compensate for the failure of private markets to force polluters to bear the costs of negative externalities (costs) imposed or reward those who impart positive externalities (benefits) by reducing pollution through the 3Rs or remanufacturing. Notably they have not discriminated much among different types of firms (e.g., manufacturers, traders, OEMs, or IBRCs).

Second, the profitability of remanufacturing or more general reuse varies greatly among industries or products, depending on the technologies and consumer preferences involved. OEMs in agricultural and construction machinery and of copiers and related office equipment and services are examples of firms that find narrowly defined remanufacturing relatively profitable. However, several of these firms prefer to emphasize recycling or reuse rather than remanufacturing and it is sometimes difficult to distinguish these activities. In contrast two other OEMs in non-metallic minerals find that reuse or remanufacturing is not generally possible, largely because of the nature of their products. However, these firms do have substantial and increasing recycling activities. In contrast to OEMs, who are by definition manufacturers, trading is the main activity of most IBRCs and they often focus on simple reuse of used goods such as PCs, rather than remanufacturing. Some IBRCs, for example in used motorcycles, find substantial remanufacturing to be profitable. Meanwhile, other IBRCs find reuse (e.g., clothing, books, software, personal computers) or recycling (e.g., automobile parts) are more efficient for other products. Reduction of input usage (conservation) is also important in most firms operating in Japan, because resource scarcity and policies both make energy and other inputs relatively expensive.

Finally, as resources become scarcer and more expensive, markets will gradually reinforce the incentives created by Japan's policies. Indeed, some of these policies may become redundant

as producers and consumers internalize costs and benefits that were previously externalities. Correspondingly, the 3Rs and remanufacturing are likely to yield increasingly large economic benefits in the future, in addition to their environmental benefits. Japan's national and local governments recognize this fact and are active in disseminating knowledge related to their experience with remanufacturing and the 3Rs, as well as other experiences with pollution reduction, to neighboring Asian economies such as Thailand. Many Japanese firms, including several of those examined in this study are also increasing emphasis on remanufacturing and the 3Rs in their affiliates operating in Thailand and in other developing economies such as Indonesia and China. There are also important examples of local firms becoming more concerned with remanufacturing and the 3Rs in China and Malaysia.²¹ There should thus be ample opportunity for Thailand to learn from Japan's experience and related experiences in other Asian developing economies. However, fundamental reforms of Thai policy to make waste disposal more expensive and to allow all firms operating in Thailand more equal access to markets and technologies will be required if Thailand is to fully realize the economic and environmental benefits of remanufacturing and the 3Rs.

²¹ See Amelia et al. (2009) on Malaysia and Zhang et al. (2008, forthcoming) and Zhu et al. (2007) on China.

Table 1
Indicators for OEMs (Consolidated Reporting)

Item, company	Company data					Industry
	2006	2007	2008	2009	2010	2009
SALES (current yen billions)						
Komatsu	1,893	2,243	2,022	1,432	1,843	0.56
Kubota	1,128	1,155	1,108	931	934	
Canon	4,157	4,481	4,094	3,209	3,707	
Fuji Xerox	1,163	1,203	1,088	944	983	1.83
Ricoh	2,069	2,220	2,092	2,016	1,942	
Toto	512	501	465	422	434	
Taiheiyo Cement	941	928	872	729	726	0.57
Environmental	62	62	68	61	58	
OPERATING INCOME/SALES (%)						
Komatsu	12.93	14.84	7.52	4.68	12.10	0.41
Kubota	11.56	11.86	9.28	7.49	9.22	
Canon	17.01	16.89	12.12	6.76	10.45	
Fuji Xerox	5.66	7.37	3.81	2.13	5.70	-0.67
Ricoh	8.43	8.18	3.56	3.27	3.10	
Toto	5.11	4.53	1.41	1.56	3.25	
Taiheiyo Cement	8.15	5.56	1.28	0.49	2.26	1.14
Environmental	4.42	6.46	5.69	6.82	8.98	
SALES/EMPLOYEE (current yen millions)						
Komatsu	55.91	57.12	50.73	37.17	44.89	25.59
Kubota	47.52	47.20	44.05	37.56	36.75	
Canon	35.08	34.11	24.52	19.00	18.78	
Fuji Xerox	na	na	26.73	23.45	23.12	39.07
Ricoh	25.26	26.62	19.30	18.58	17.81	

(continued)

Table 1 (continued)

Toto	25.35	23.85	19.41	18.23	17.95	26.63
Taiheiyo Cement	54.36	51.85	47.04	43.09	45.77	
Environmental	246.33	246.92	274.43	257.03	392.14	

Note and sources: Industry data are averages for all corporations in respective industries (general machinery, electric & electronic machinery [broadly defined], non-metallic mineral products) from Ministry of Finance (2010); firm data are from the corporate web sites detailed in footnote 9 and Financial Services Agency (2011); data refer to fiscal years ending March of the following calendar year.

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