

Remanufacturing in the United States

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Abstract

Remanufacturing, the sale of products recovered and reconditioned to like-new or better functionality, is a characteristic of any modern industrial economy. While most US remanufacturers have been in business for decades, this component of the economy has been growing rapidly in scope and scale over the past few decades. Wherever savings in raw materials processing, primary manufacture and assembly substantially exceed costs of collection, cleaning and reconditioning, remanufacturing will thrive in the market place. Because remanufacturing conserves inputs that generate substantial externalities (e.g., greenhouse gases, raw material extraction, and unreliable fossil fuel import channels) or whose future scarcity is insufficiently reflected in current market prices, a great deal of policy attention has turned to promoting demand for and supply of remanufactured goods.

1. Background

Strictly speaking, remanufacturing is neither an industry nor sector, but rather an overlay classification of economic activity. Unlike recycling, it does not easily fit into our conventional production accounting exercise. In its purest form, recycling extracts from final products a share of their constituent raw materials, which in turn are plugged back into the usual flow chart by which

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natural resources are combined with energy and technological know-how embodied in capital equipment and skilled workers to produce goods and services to meet consumer needs and desires. By starting with recycled feedstock, it is possible in principle to trace out recycling's contribution to the national income accounts. Not so remanufacturing.

No governmental statistical agency keeps track of the extent of remanufacturing in the US economy. Lund and Hauser (2008; p. 3) summarize the challenge of organizing a census.

Does 'remanufacturer' designate the primary activity of the company? Should we exclude those who are "sometime" remanufacturers, whose annual volume is just a few units? Should we exclude firms where remanufacturing is a small (how small?) fraction of their total business? Another complication arises because of the increased practice of outsourcing. Do we classify a firm as a remanufacturer if it once remanufactured the products that it sells but now contracts the production to others?

Nor does remanufacturing appear in the environmentalist's mantra of reduce, reuse, recycle.¹ Sellers of a remanufactured product are adamant that they are not selling a used product; neither are they selling an up-cycled or down-cycled product (McDonough & Braungart 2002); but rather a product whose functionality has been restored to the point where it is indistinguishable from that of the original product. In the eyes of the U.S. Environmental Protection Agency (EPA 1997), that sort of restoration of functionality if carried out by the end-user would be an example of reuse. From the original purchase date businesses and consumers strive to maintain or restore the productivity of durable goods through regular maintenance and replacing worn components. Farmers are famous for tinkering with tractors and other equipment to keep them in service. It is said that when commercial aircraft are finally retired one can be challenged to find a single original component. *Reconditioning, rebuilding, refurbishing, and recharging* are all common terms for delaying or reversing the depreciation of productive services from durable goods.

¹ The slogan has been used in the United States since at least the first Earth Day in 1970 (Cooper 1998).

However, the literature (starting with Lund and Kutta 1978; Lund 1996) reserves the term *remanufacturing* for products recovered from end-users, restored to “like new” or better functionality and resold in the marketplace. Promoters of the concept trace the industry’s origins to 1861, when the Hon. Stephen R. Mallory, Confederate Secretary of the Navy, authorized the rebuilding of the USS *Merrimack*, a steam frigate (Elmore 2010).² But, it was the development of assembly line manufacturing with standardized, interchangeable parts in the 20th century that allowed remanufacturing to take on a commercial identity. A second spur to remanufacturing has come from the desire, reinforced by the Resource Recovery and Conservation Act of 1976, to keep toxic materials out of the solid waste disposal system (EPA 2002).

Remanufacturing involves the following steps (Bras 2007; Lund & Hauser 2008; Savaskan Bhattacharya & Wassenhove, 2004; Willis 2010):

- Collecting the used product from the end-user
- Disassembly and inspection of the “core” component
- Cleaning, refinishing or otherwise restoring the core
- Disposal of waste from that process
- Replace missing, defective, broken or substantially worn parts
- Reassembly
- Testing to insure functional equivalence to a new product
- Packaging
- Resale

Excluded from this definition of remanufacturing would be *repackaged* or *restocked* products.

These distinctions are intuitively clear, but challenging to measure through data collection.

² On April 20, 1861, just three days after Virginia seceded from the Union, the U.S. Navy burned *Merrimack* and sank her before evacuating Norfolk Navy Yard in what was ultimately an unsuccessful attempt at preventing repossession. The ship’s remains were raised soon after and inspection revealed an undamaged hull and machinery. Since the Union was in desperate need of a fleet and did not have the time or the money, Mallory selected the *Merrimack* for the conversion into the South’s first ironclad warship, the *CSS Virginia*.

One leading source of information on remanufacturing is a proliferation of trade associations, which exist with the goal of promoting the industry. These include:

Automotive Engine Rebuilders Association

– www.aera.org

Automotive Parts Remanufacturers Association

– www.apra.org

International Association of Medical Equipment Remarketers & Servicers

– www.iamers.org

International Compressor Remanufacturers' Association

– www.icracomp.com

Motor & Equipment Remanufacturers Association

– www.mera.org

Office Furniture Recyclers Forum

– www.ofdanet.org

Professional Electrical Apparatus Recyclers League

– www.pearl1.org

Production Engine Remanufacturers Association

– www.pera.org

Remanufacturing Industries Council

– www.remancouncil.org

Remanufacturing Institute

– www.reman.org

Predictably, these organizations extol the virtues of remanufactured products. Relying on reports from these organizations is complicated by the fact that many member firms engage not only in remanufacturing but also provide repair services and sell used products “as is” (Lund and Hauser 2010).

An additional complication for consumer and analyst alike flows from historical differences in terminology across industries (Lund and Hauser 2008). Terms generally recognized as describing maintenance or other restorative activities falling well short of like-new condition may

nevertheless meet the criterion for remanufacturing in specific industries. “Recharged” laser printer toner cartridges, “overhauled” aircraft engines, “repaired” industrial valves and “rebuilt” automotive parts would all be understood by industry members as describing fully remanufactured products.

Not surprisingly, government regulators have been concerned with transparency involving the sale of remanufactured products. The Federal Trade Commission is charged with restricting unfair or deceptive marketing practices and has implemented regulations (FTC 1998) to ensure that remanufactured products or products with remanufactured components cannot be sold in such a way as to give consumers the impression that they are either new (16 CFR §20) or recycled (16 CFR §260.7). And a product cannot be described as remanufactured or rebuilt unless it has

...been dismantled and reconstructed as necessary, all of its internal and external parts cleaned and made rust and corrosion free, all impaired, defective or substantially worn parts restored to a sound condition or replaced with new, rebuilt (in accord with the provisions of this paragraph) or unimpaired used parts, all missing parts replaced with new, rebuilt or unimpaired used parts, and such rewinding or machining and other operations performed as are necessary to put the industry product in sound working condition. (16 CFR § 20.3(a))

For example, to avoid a charge of deceptive trade practice, packaging for a recharged laser printer toner cartridge might include a statement that it contains “65% recycled content is 25% recycled raw material by weight, 40% from reconditioned parts.” Under this regulatory scheme, the assessment of whether a remanufactured product’s functionality is truly “like new,” falls short of or exceeds that of the original is left to the eye of the consumer. Lund and Hauser (2008) speculate that this level of uncertainty may explain why sales of remanufactured goods are largely limited to commercial, industrial and government customers or where frequency of purchase by final consumers builds know-how in evaluating product quality.

2. Structure

Of the standard determinants of market structure (Scherer and Ross 1990), the process of obtaining a key input – the core – plays a crucial role for remanufacturing. Entry barriers are lowest where cores are collected by independent businesses providing services to end-users as in the case of automobile parts or office equipment. When core collection depends on end-users segregating them from the waste disposal stream, then economies of scale and network effects tend to create barriers, especially when combined with laws requiring the manufacturer or seller to take back products at the end of their useful lives. These entry barriers in turn lead to more concentrated markets and allocative inefficiency.

No government statistical agency collects systematic data on remanufacturing in the United States. The Economic Censuses classify only one remanufacturing industry, tire retreading (NAICS 326212) with 523 establishments in 2007 producing \$1.6 billion in sales with 7974 paid employees (U. S. Census Bureau, 2007). The most reliable data on remanufacturing in the United States come from the surveys and estimates of Robert T. Lund and William Hauser, currently of Boston University's Department of Manufacturing Engineering. Estimates from Lund (1996) are still widely cited as facts, even though the authors have concluded (Lund and Hauser 2010) that these early estimates generally overstated the sales of remanufactured products, but understated the scope of the industry. Trade associations tend to overestimate the level of remanufacturing by non-association members and association members may classify within sales of remanufactured products revenue from repairs and from sales of used products. On the other hand, individual trade associations tend to exclude whole product categories.

Lund (1996) initially assembled a database of 9905 firms tentatively identified as remanufacturers. He surveyed 1003 of these, extrapolating survey findings to the full database and to the nation as a whole. By 2001, the database had grown to just under 14,000, from which the Lund and Hauser team sampled 1249 in six selected product clusters (Lund and Hauser 2003). Of this sample, 20 percent were no longer in business and 15 percent had been misclassified, i.e., should not have been in the database.

Today's database (Lund and Hauser 2008) consists of roughly 2000 confirmed remanufacturers and another 7000 tentatively identified as likely remanufacturers. They have identified remanufacturing operations in 114 product areas, corresponding roughly to six-digit North American Industrial Classification codes. Table 1a provides a frequency distribution of these product areas by number of establishments identified by Lund and Hauser. For ten of the 114 product areas, they have been able to confirm only one establishment (a remanufacturing operation at a distinct geographic location). (Table 1) Fifty-eight product areas contain two to 10 confirmed or tentatively identified establishments. Table 2 identifies the ten product areas containing more than 100 confirmed or tentatively identified establishments.

Table 3 and 4 (assembled from Lund and Hauser 2003 Tables 1 and 2) summarizes the original 1995 data on the scale of remanufacturing. Table 3 extrapolates survey results to the full database for number of firms, sales and employment by industry. Table 4 provides the original Lund extrapolation to the national level. These data constitute lower and upper bounds on the actual scale of remanufacturing in the United States. Twenty-six billion dollars (or even \$53 billion) may not seem large in comparison to 1995 US GDP of \$7.4 trillion (U.S. Bureau of Economic Analysis). But, were remanufacturing listed as its own industry, it would compare favorably in size with other durable goods industries such as electrical equipment, appliances and components (\$45.6 billion); motor vehicles, bodies and trailers, and parts (\$96.1 billion); and furniture and related products (\$27.8 billion).

Lund and Hauser (2003) obtained quite detailed (2000-2001) data from 274 remanufacturers in six product clusters: automotive, electrical, furniture, machinery, tires and toner cartridges. Remanufacturing was the primary business for just over half. Except for toner cartridge remanufacturers, the vast majority of respondents had been in business for over 10 years, 30 percent for more than 30 years. There is substantial diversity in entry patterns. Eighty-six percent of toner cartridge remanufacturers entered the business directly, while 60 percent of electrical remanufacturers started out in service and repair. Eight percent of respondents were original equipment manufacturers (OEM's) that added remanufacturing operations.

Median firm sales in 2000 from remanufacturing for the full sample were \$800 thousand, ranging from \$374 thousand for toner cartridges to \$3 million for furniture (with two furniture

remanufacturers reporting sales in the hundreds of millions of dollars). Median employees were seven. All but two respondents met the Small Business Administration definition of a small business based on employment. Only four of the 48 tire retreaders exceeded the SBA sales threshold. Yet, there are substantial economies of scale in remanufacturing: Sales per employee averaged \$57 thousand for remanufacturers with sales ranging from \$100 thousand to \$500 thousand, but rose to \$313 thousand for remanufacturers with sales exceeding \$25 million.

The most important distribution channel reported overall is direct sales to end-users (64 percent). But, there are exceptions: Just over 36 percent of sales of remanufactured automotive components are made to installers, with 45 percent made direct to end-users. Only 17 of 269 firms answering the question reported more than 10 percent of revenues from exports.

Almost 70 percent of cores are obtained through direct returns or trade-ins. Again, there are exceptions: Fifty-four percent of furniture cores and 25 percent of worn tires are obtained through brokers. Automotive is the only category (10.3 percent) with at least 10 percent of cores extracted from the solid waste disposal stream.

Thus, remanufacturing constitutes a significant overlay of economic activity involving a wide array of product categories. Although there are substantial economies of scale, driven by the collection process, the remanufacturing overlay remains dominated by smaller enterprises

3. Conduct

Relatively little is known of the strategic behavior of remanufacturers. That behavior is likely to be driven by competitive conditions in individual product categories as well as by the interaction among OEM's, middle-men and remanufacturers in the context of final demand.

In the absence of air-tight guarantees and credible third-party certification, asymmetric information yields a degree of skepticism about the quality of remanufactured goods. Hence, Lund and Hauser (2008) find that the prices for remanufactured products are typically 45 to 65 percent of those for comparable new products. Demand is greater to the extent that remanufactured parts are components of larger products (batteries for cars; cartridges for printers or copiers) for which replacement parts are no longer available. Reliance on remanufacturing reduces inventory costs for

OEM's (Bras, 2007). In more extreme cases, the remanufactured part could cost even more than the original part, especially if the alternative is buying an entirely new system. Lund and Hauser (2003) report rivalry from new products, particularly imports, is perceived to be the greatest threat for remanufacturers in furniture, electrical, and tire product clusters. Automotive parts remanufacturers see other remanufacturers as the primary source of rivalry.

OEM design decisions have a great effect on the viability of remanufacturing, determining the ease and costs of disassembly; the feasibility of swapping in replacement components; and the rate of functional and aesthetic obsolescence of new durable equipment. There is no incentive for an OEM to design a product to support remanufacturing unless the firm expects to make substantial sales of its own remanufactured products or unless the expected availability of remanufactured components enhances consumer demand for the original system. Conversely, OEMs can utilize their design capabilities as an effective strategy to block out individual remanufacturers from the market. By designing a product such that disassembly is extremely complicated or requires technology that only the OEM possesses, OEM's can exclude third-party remanufacturers. For these reasons, Lund and Hauser (2008) have concluded that the number of OEM's in the United States explicitly designing products to facilitate remanufacturing remains quite low.

Reverse logistics is the process by which used cores are collected and obtained by the remanufacturer for processing. Two main approaches are used (Guide & Van Wassenhove 2001): waste-stream recovery system or market-driven (through deposit, rebate, repurchase or voluntary returns) acquisitions. Remanufacturing processes are inherently more complex than new product assembly because of variability in the quality of used products from which cores are recovered. Waste stream recovery systems require a high level of sorting, inspection subsequent waste disposal to obtain usable cores, but yield high volume. Market-driven recovery systems shift the burden to maintaining the quality of returns to the end-user or middle-man. Remanufacturing strategies based on the former (particularly when imposed by take-back laws) are often driven by a desire to minimize over-all costs, while the latter are organized so as to minimize the cost of the remanufactured product. Recovery costs for the remanufacturer are minimized when returns are processed at the point of contact with the end-user, e.g., by a retailer or service agent (Ferguson 2010; Ke 2011; Savaskan, Bhattacharya, and Van Wassenhove 2004). Extending warranties when

worn components are exchanged for remanufactured parts is a frequent element in a market-driven system, encouraging customers to return cores.

To sum up, the strategic environment for remanufacturers is driven by channels for obtaining cores and the interaction with OEM's. Pricing is constrained by competition from new products, sales of other remanufacturers and consumer uncertainty over product quality.

4. Performance

The most obvious benefit to society from remanufacturing is the conservation of raw materials and energy from starting with used cores rather than virgin raw materials. Remanufacturing reclaims more than 80% of the initial value of a product in contrast to 8% preserved by recycling (Lund & Hauser 2008). In promoting more open trade in remanufactured products, the United States (US-WTO 2005) made the following arguments: The energy needed to manufacture a new automobile starter is eleven times greater than that needed to remanufacture a comparable unit. Globally, the total amount of energy saved through remanufacturing comes to approximately 120 trillion BTUs. That new automobile starter uses nine times the amount of raw materials by weight as the equivalent remanufactured unit. Extrapolating to a global scale yields an estimate of a million tons of raw materials conserved each year. Remanufacturing reduces global emissions of greenhouse gases on the order of 28 million tons per year and reduces demands on solid waste disposal systems. For example, one major construction equipment manufacturer's recovery of two million cores per year diverts roughly 100 million pounds for scrap from landfills annually.

Expanding the analysis to include total product life cycles tempers these calculations somewhat (Gutkowski et al. 2011). For most durable goods, energy consumption in use tends to be much greater than energy consumed in manufacturing. Hence, if reliance on remanufactured components sufficiently delays the shift to more energy efficient substitutes, the net impact of remanufacturing on energy consumption could be negative. In the cited study of 25 product categories, remanufacturing saved energy in eight cases over the product life-cycle, failed to save energy in six cases and had no clear impact in 11.

Remanufacturing also has economic benefits. First, to the extent that remanufactured products truly offer functionality comparable to the newly manufactured components for which they are substitutes, pricing at 45-65% new product levels (Lund and Hauser 2008) results in an expansion of total sales both by meeting the needs of consumers with lower reservation prices and through competition with new product manufacturers. This expansion in market output implies a net gain in consumer and producer surplus.

The industry has been growing rapidly – on the order of 20 to 30 per cent per year (Lund and Hauser 2008). Because remanufacturing, with its emphasis on sorting, disassembly, reconditioning and reassembly, is labor intensive and requires relatively low skills, the effect of this growth on US employment is even greater (Giutini and Gaudette 2003).

However, there is reason to believe that growth in remanufacturing has been retarded substantially by a number of market failures:

1) Externalities in reliance on raw materials: The demand for remanufactured goods is suppressed by inefficiently low prices for newly manufactured goods resulting from failing to internalize negative externalities in virgin resource extraction, energy consumption, and final goods production.

2) Transaction costs in collection systems and disassembly: Product design and the trash disposal systems in the United States did not evolve with remanufacturing in mind. Most consumer waste collection in the United States is financed through municipal taxes or fixed-fee service contracts with private haulers. As a result, households perceive the marginal cost of trash disposal to be near zero, certainly well below the marginal social cost. Hence, cost savings provide little incentive for consumers to remove the cores of outmoded products from the stream of household solid waste. Laws or social suasion have led to a substantial increase in the flow of post-consumer waste entering the recycling stream. But, it is almost as challenging to extract cores for remanufacturing from single stream recycling flows as from indiscriminate household waste.

Consumers are more likely to return cores for remanufacturing when manufacturers or retailers offer refundable deposits on products (e.g., as a result of “bottle bills”), discounts for new

purchases when accompanied by the return of an old, or free shipping for returns (as with printer ink or toner cartridges).

Transaction costs are substantially reduced when cores are collected by service providers as when service stations replace used automobile parts or technicians upgrade office equipment. This helps to explain the long tradition of remanufacturing in the automobile industry and for companies supplying manufacturing equipment.

On purely technical grounds, one would design a product differently if the eventual goal were to recover components intact than if one planned to recover raw materials through a recycling and refining process. Investment in the former will be less to the extent that disassembly is undertaken by third party firms.

3) Asymmetric information and transparency: In the absence of credible third party certification, the market for remanufactured products suffers from the lemons problem. How can the customer be confident that the remanufactured product is indeed functionally equivalent to substitute newly manufactured products? Full enforcement of government regulations against deceptive or unfair trade practices (so that remanufactured products or products containing remanufactured components are clearly labeled as such) protects new product markets from negative consequences of information asymmetries. However, the failure of the industry to make credible its claims for functional equivalence inefficiently suppresses demand. Otherwise, these products would not sell at such steep discounts relative to the new product price.

4) Market Power: Lund and Hauser (2010) report a trend toward consolidation among third party remanufacturers as firms exploit scale and network economies in collection and sorting. As OEM's expand their investment in remanufacturing, whether as a result of rising manufacturing costs or the passage of take-back laws, there is the danger that they may squeeze out traditional third party participants in the market and leverage market power in new product sales to expand market power in the collection of cores and the sales of remanufactured products.

For once, the glowing pronouncements of trade associations about the social and economic benefits of an industry appear to have great merit in the case of remanufacturing. Expanding remanufacturing's share of the economy will conserve energy and raw materials and stimulate

employment. However, there remain substantial market failures impeding that growth that merit public policy intervention.

5. Public Policy Issues

As with most nascent industries, the fundamental public policy challenges facing remanufacturing involve correcting for market failures and avoiding the unanticipated consequences of government interventions.

Getting prices right: The fundamental reason sales of remanufactured products remain inefficiently low in the United States flows from flawed pricing of raw materials, energy and waste disposal services. So long as natural resource extraction industries fail to bear the full costs of negative externalities in production and their reliance on fossil fuels, the demand for remanufactured goods will remain suppressed by the artificially low price of their newly manufactured products.

Similarly, the growth of retrieval and collection networks for many post-consumer cores will be stunted so long as solid waste collection systems fail to reflect marginal costs

Subsidies: Getting prices right requires imposing higher costs on consumers, never an attractive options for politicians and particularly challenging in the current macroeconomic and political climate in the United States. Far more politically appealing is offering subsidies to encourage desired activity.³ The most recent effort was Congressman Phil English (R-Pa.) introducing H.R. 5659 in 2008, which sought an income tax credit equal to 20 percent of the amount of a taxpayer's expenditures on certain recycling or remanufacturing equipment (Martin 2008). The Automotive Parts Remanufacturers Association (APRA) is currently working with its membership to find a member in Congress that will reintroduce this legislation (After Market News 2011).

Another boost to demand for remanufacturing could take the form of government purchasing policies that favor remanufactured goods. It has been the policy of the federal

³ Mitra and Webster (2008) present a model showing that optimal subsidies should include a share for OEM's to encourage design standards that lower the costs of remanufacturing.

government since 1992 to develop procurement practices that “reflect cost-effective use of recycled products, recovered materials, water efficiency devices, remanufactured products and energy-efficient products, materials and practices” (OMB 1992).

Take-back Laws: Environmental legislation has been forcing companies to seek production methods that use less energy and leave less waste. In fact, many U.S. states have recently passed or are considering legislation requiring manufacturers of electronic products to take back used or obsolete goods and to be responsible for their remanufacture and/or disposal in order to keep toxic metals out of landfills (Eseduran, Kemahioglu-Ziya & Swaminathan 2009; Webster & Mitra 2007).

Take-back legislation seeks to achieve several goals such as shifting the cost of recycling off of tax-payers, encouraging manufacturers to design for longer product life, and encouraging the use of more eco-friendly materials. While these laws appear to facilitate remanufacturing because they create more concrete ways of gathering used products, which otherwise might be dispersed in landfills, they can have a negative effect on the economic efficiency of the industry. First, by increasing the flow of solid waste entering the core collection process, take-back laws raise remanufacturers’ inspection, separation and waste disposal costs and, by shifting out the minimum efficient scale, raise the size of barriers to entry. Take-back laws also shift the flow of available cores from the open market OEMs, giving them a strategic advantage over third party remanufacturers.

Intellectual Property Restraints: A coalition including the American Automobile Association and major automobile parts retail chains has been promoting legislation to force automobile manufacturers to share proprietary diagnostic and operating software codes with third party automobile service providers (www.righttorepair.org). One argument in support of the legislation is that it would make increase demand for remanufactured products in the automobile industry by decreasing barriers to the use of such products. There is some evidence to suggest that such barriers, if they ever existed, were substantially eliminated by an initiative of the National Automotive Service Task Force in 2001 (Consumer Reports 2006).

Non-Tariff Trade Barriers: Just as data on the contribution of remanufacturing to national product accounts is lacking, so there are no good data on international trade in remanufactured products. Lund and Hauser (2010) describe remanufacturing as largely a domestic industry, with

few exports and only a few firms relying on lower labor costs in Mexico and China as part of the remanufacturing process. On the other hand, US trade representatives (US-WTO 2005) claim that trade in remanufactured products “contribute significantly” to developed and developing economies. For that reason, the US government has pressed for action to address non-tariff barriers affecting remanufactured and refurbished goods.

In January 2011, the BRIC nations (Brazil, India and China) as well as South Africa refused to back the U.S.’ proposal to open up trade in developing countries (The Recycler, 2011). Opposition comes from other nations’ fears that the U.S. is simply making the case for remanufacturing as a means for dumping shoddily-constructed products into their markets or exposing their workers or their landfills to toxic waste or hazardous materials resulting from disassembly processes. Major U.S. remanufacturers, including Caterpillar Inc., General Electric Co., General Motors Co., Eastman Kodak Co. and Xerox Corp., will continue to push for unobstructed international competition in remanufacturing (Hagerty and Glader 2011).

6. Conclusion

While remanufacturing is a natural response to rising new product prices in a host of product areas, it remains hard to monitor and its growth will lag so long as policy makers fail to address a number of market failures. With the exception of tire retreads, no reliable statistics exist on the extent of remanufacturing in the United States, because the production processes that characterize remanufacturing are difficult to distinguish from repair, maintenance and final steps in new product manufacturing. Remanufacturing is widely lauded as an effective means of conserving raw materials and energy consumption, reducing demands on the solid waste disposal system and avoiding other production processes linked to environmental harm. No policy proposal to promote remanufacturing can be as effective as those that adjust prices in other sectors of the economy to reflect these externalities.

However, if remanufactured goods truly are equivalent or better than newly produced products, then substantial discounts for remanufactured goods reflects an additional market failure meriting policy intervention. Product certification, enforceable warranties and educational

campaigns are examples of public interventions that would usefully promote remanufacturing. Global standards for product certification and global environmental and safety standards in disassembly and collecting cores would go a long way toward easing opposition to international trade in remanufactured goods.

At the same time, policy makers need to be aware of the unintended consequences of their actions. Take-back laws have a tendency to advantage OEM's at the expense of much smaller traditional remanufacturers. End-user subsidies for remanufactured products will direct most tax savings to companies already committed to buying them and may induce OEM's to adopt design strategies that raise costs for remanufacturers.

Finally, a sensible evaluation of the pace of transformation of the US economy to a sustainable basis will require government statistical agencies to address the challenge of distinguishing in national income accounts and economic censuses among original product manufacturing, lengthening product lifecycles through repair and reuse, remanufacturing and recycling down to raw materials. The Lund and Hauser estimates, while extremely useful, contain too much variability and uncertainty for effective monitoring of the growth of this vital overlay of economic activity.

Table 1
Product Area Count by Number of Establishments

Establishments	Product Areas
One Confirmed	24
2 – 10	58
11 - 100	22
> 100	10
Total Product Areas	114

Source : Compiled from Lund and Hauser (2008) Appendix A and NAICS (2009)

NAICS: North American Industrial Classification System

*Standard Industrial Code, includes 7 NAICS categories

Table 2
Number of Confirmed or Possible Establishments by NAICS Product Category
For Which Number of Establishments Exceeds 100

NAICS	NAICS Title	Confirmed	Possible
333512	Machine Tool (Metal Cutting Types) Manufacturing	103	5
333911	Pump and Pumping Equipment Manufacturing	100	177
335311	"Power, Distribution, and Specialty Transformer Manufacturing	82	53
335313	Switchgear and Switchboard Apparatus Manufacturing	70	94
335312	Motor and Generator Manufacturing	382	932
335314	Relay and Industrial Control Manufacturing	3	302
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	40	77
3714*	Motor Vehicle Parts and Accessories	337	3532
333315	Photographic and Photocopying Equipment Manufacturing		1207
326212	Tire Retreading		202

Source : Compiled from Lund and Hauser (2008) Appendix A and NAICS (2009)

NAICS: North American Industrial Classification System

*Standard Industrial Code, includes 7 NAICS categories

Table 3
Estimated 1995 Number of Firms, Sales and Employment
Database Extrapolation

Industry	Firms	Sales (millions)	Employees
Automotive	4,538	16,184	133,571
Compressors	55	149	1,878
Electrical Apparatus	2,231	3,016	30,780
Machinery	90	344	2,555
Office Furniture	220	513	3,648
Tires	1,210	3,678	24,667
Toner Cartridges	1,401	537	6,882
Valves	110	469	3,227
Other	50	889	6,372
Total	9,905	25,779	213,580

Source : Compiled from Lund and Hauser (2003) Tables 1 and 2

Table 4
Estimated 1995 Number of Firms, Sales and Employment
National Extrapolation

Industry	Firms	Sales (millions)	Employees
Automotive	50,538	36,546	337,571
Compressors	155	249	2,878
Electrical Apparatus	13,231	4,633	47,280
Machinery	120	434	3,155
Office Furniture	720	1,663	12,148
Tires	1,390	4,308	27,907
Toner Cartridges	6,501	2,475	31,872
Valves	410	589	4,577
Other	250	2,009	14,372
Total	73,315	52,906	481,760

Source : Compiled from Lund and Hauser (2003) Tables 1 and 2

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