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BY TIM LASETER, ANTON OVCHINNIKOV, AND GAL RAZ

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by Tim Laseter, Anton Ovchinnikov, and Gal Raz

Since Earth Day in 1970, schoolchildren have heard the mantra "reduce, reuse, recycle" as the solution for the growing problem of consumer waste. One could argue that the slogan has worked remarkably well. In the U.S., according to the Environmental Protection Agency, the average consumer generated 2.7 pounds of trash each day in 1960 — and 2.5 pounds of that went straight to the landfill. Over the next 20 years, per capita waste generation grew 37 percent, to 3.7 pounds per person, but thanks to increased recycling and energy recovery techniques, discards to landfills increased only 29 percent, to 3.2 pounds, and, more importantly, hit a peak. From 1980 to 2000, U.S. landfill discards actually decreased by 19 percent, even though waste generation continued to grow, to 4.7 pounds per person per day. Over the last decade, the *reduce* and *reuse* parts of the slogan have shown signs of catching on, as per capita waste generation has declined to 4.5 pounds per day, and the volume going into U.S. landfills is now less on a per capita basis than it was 50 years ago. Europe has, if anything, made even more progress.

Some forms of recycling have become the dominant mode for consumers. For example, 88 percent of newspapers and 77 percent of corrugated boxes are now recycled. Even though 38 percent of paper bags are recycled, consumers are now attacking the source by shifting to reusable shopping bags.

But consumer durable products — including televisions, refrigerators and other appliances, cell phones, and automobiles — offer a more intractable problem that requires deeper thought for consumers and — especially — for the businesses producing them. Overall, a third of municipal waste is now recycled, but the percentage for durable goods stands at only 17 percent. Worse yet, durables often contain hazardous materials not found in consumables and packaging. Unlike consumables, durable products face an "end of life" problem that requires more options than simply reducing, reusing, and recycling. For this set of products, the new mantra for producers increasingly includes a fourth "R": rethink. Rethinking the environmental challenges posed by durable-goods waste also provides interesting opportunities for businesses. The challenges presented by discarded and unused cell phones, which we have studied closely, are a particularly good example.

Flaws of the "Three Rs"

1. Reduce. Decreasing the generation of waste makes sense, and has proven highly effective for consumer goods. For example, new concentrated products such as laundry and dishwashing detergent offer benefits by reducing packaging and transportation requirements.

Some consumer durables offer a similar opportunity to reduce size. The Commodore PET, the first personal computer, weighed 44 pounds, whereas the new Apple iPad weighs a little over 1.5 pounds. Reducing the size and weight does not work for many categories of durable goods, however. Consider the original Ford Mustang, introduced in 1964. It was 182 inches

long and weighed 2,930 pounds. The latest Ford Mustang GT is only six inches longer but weighs 500 pounds more, despite an increased use of plastic and aluminum. (From a positive environmental standpoint, the Mustang's fuel efficiency has improved from 18 miles per gallon (mpg) on the highway to 24 mpg — and more than 30 mpg for less-souped-up versions.)

Moreover, reducing product dimensions may have unintended negative consequences. Consider the fate of the largest carpet recycling facility ever built. The state-of-the-art Polyamid 2000 recycling facility in Premnitz, Germany, which cost US$200 million to build in 1999, closed after only three years. It turned out that a "reduce" strategy by European carpet manufacturers had shortened carpet pile and reduced the nylon content to a level that made recycling uneconomical.

2. Reuse. Shifting a culture from the disposable to the reusable has also worked well in general. The cycle experienced by the bottled water industry offers a great case in point. At the beginning of the new millennium, consumption of bottled water grew at double-digit rates to the point where water became the second-largest beverage category, behind only carbonated soft drinks. After peaking around 2007, however, the industry contracted by 1 percent in 2008 and 2.5 percent in 2009. Environmentally conscious (as well as cash-strapped) consumers had turned to tap water and refillable bottles. Reusable plastic, stainless steel, or aluminum bottles are now common on college campuses and in health clubs across the country, offering an option that is far superior to trying to increase the 27 percent recycling rate for disposable plastic bottles.

In the case of durable goods, the issue of reuse proves a bit more complex. In fact, academics in the field use the terms *refurbishment* and *remanufacturing* to clarify the extent of work needed to make a used product serviceable again. Consumer electronics are often refurbished simply by having their software tested and upgraded. But the reuse of products such as automotive parts and toner cartridges requires extensive remanufacturing labor, including such tasks as disassembly, cleaning, and parts replacement.

Reusing durable products can offer substantial economic and environmental improvements. Currently, remanufactured cartridges make up 6 percent of toner sales, and can be produced at 20 percent of the cost of a new cartridge. Lexmark and Hewlett-Packard consider this market such a strategic opportunity that they build microchips into the cartridges to prevent unauthorized remanufacturing, which can degrade print quality (not to mention their profits).

But reuse can also have drawbacks. From a broad environmental perspective it is better, for example, to recycle than to reuse energy-inefficient cars. The recent "cash for clunkers" programs in the U.S. and Europe were designed to stimulate the economy while helping the environment by retiring cars with low fuel efficiency. Other energy-intensive products — such as home appliances and even high-power computer chips — often offer similar benefits if they receive "early retirement" ahead of their functional life expectancy.

3. Recycle. Recycling comes last in the hierarchy of waste management techniques for decreasing landfill disposals, but has generally had the greatest environmental impact to date. Lead acid batteries provide the best case study of recycling of consumer durable products, with a 99 percent recycling rate. At the other extreme, consumer electronics offer one of the biggest areas of opportunity. Americans own an estimated 3 billion consumer electronic devices, about 10 per person. Because product life cycles for electronic gadgets are growing ever shorter, electronics represent a growing component of the waste stream, but currently attain only a 15 percent recycling rate. (Also of note: A substantial portion of electronic waste is exported to developing countries for reuse; instead, however, these devices and parts end up being discarded in countries with minimal environmental oversight.)

The reuse of products such as automotive parts requires extensive remanufacturing labor.

Rethinking Durables

Sustainability for consumer durables demands deeper thinking than the simple "reduce, reuse, recycle" framework. And unlike consumables, where the responsibility for rethinking falls on consumers, for durables, the primary rethinking job belongs to business executives and

environmental regulators.

A rethinking of the problem should start with an examination of the ecological impact and economics across the full product life cycle — from manufacture through use, reuse, recycling, and disposal. The economic incentives for the various industry players must also be considered, including original equipment manufacturers (OEMs), retailers, service providers, remanufacturers, recyclers, and waste management companies. Every industry has a unique set of players; for each of them, the costs and benefits vary considerably, and are sometimes at odds. This insight provides a starting point for thinking strategically about reshaping the industry value chain in ways that increase profits while reducing environmental impact. Such rethinking can be employed by business executives to seek out new profit pools — or, alternatively, by regulators to alter the profit pools and enhance overall societal benefits.

Consider the case of cell phones. Motorola introduced the first cell phone in 1983. Though it was expensive ($4,000), heavy (more than a pound), and awkward (a foot long), it tapped an unmet need for wealthy people on the move. Today, prices have plummeted, a typical cell phone weighs between 3 and 5 ounces, and cell phones are seen as essential for nearly everyone. Annual sales of new phones worldwide exceeded 1.2 billion units in 2009. In the United States, entry-level designs are priced at less than $40 and high-end smartphones like the iPhone or Android are still less than $700 at full retail and less than $200 when combined with a two-year service contract. Some 285 million people in the U.S. have cell phones; that is, the penetration rate stands at 91 percent.

Cell phones, however, quickly become obsolete, creating a glut of older, unused phones with waste and environmental implications. In the U.S., for example, the high rate of market penetration has led to intense battling among phone service providers to entice customers away from the competition — and with ever-decreasing costs, it's profitable for them to offer ever-lower phone prices. Meanwhile, manufacturers have made continued improvements in handset designs — some of them significant, such as Apple's introduction of the iPhone, which gained a 40 percent market share in its first three years. As a result, the initial lifespan of a phone has fallen to between 18 and 24 months. In other words, roughly half of the phones in use one year are retired the next year. An estimated 10 to 15 percent of these are simply discarded and merged invisibly into the municipal waste stream. A much larger percentage of those retired are "stockpiled." Because of their small size but high perceived value, roughly 65 to 70 percent of the old phones end up in a drawer as a rarely used backup.

That leaves less than 20 percent of retired phones in the U.S. to be collected for reuse or recycling. Of those, about 65 percent are reused, mostly in emerging markets in Africa and Latin America. Prices for reused phones range from around 10 to 50 percent of the price of the new version as fresh designs with better technology continuously displace — and devalue by 30 to 80 percent — functional older models. This being the case, used phones quickly become obsolete and unwanted even in the secondary market.

Ultimately, only 6 or 7 percent of cell phones are recycled for scrap metal. The typical recycled phone generates less than a dollar of revenue from the recovery of about an ounce of copper and trace levels of the more expensive precious metals such as gold, palladium, and silver. Frustratingly, the typical recycled phone easily could have remained operational for four or five more years from a functional point of view.

Electronic waste, which includes cell phones, makes up less

Tim Laseter
lasetert@darden.virginia.edu
holds teaching appointments at the London Business School, the Darden School at the University of Virginia, and the Tuck School at Dartmouth College. He is the coauthor of *Strategic Product Creation* (McGraw-Hill, 2007) and the newest edition of *The Portable MBA* (Wiley, 2010). Formerly a partner with Booz & Company, he has more than 20 years of experience in operations.

Anton Ovchinnikov
aovchinnikov@darden.virginia.edu
is an assistant professor of business administration at the Darden School of Business at the University of Virginia. His research addresses theoretical and application issues, including behavioral operations and environmental sustainability in the business, government, and nonprofit sectors.

Gal Raz
galraz@virginia.edu
is an associate professor of business administration at the Darden School of Business at the University of Virginia. His research focuses on supply chain pricing and contracts and the public policy implications of supply chain management. Previously, he was on the faculty of the Australian Graduate School of Management in Sydney.

Also contributing to this article was Vered Doctori Blass, who holds a teaching and research appointment at the Leon Recanati Graduate School of Business Administration, Tel Aviv University.

than 2 percent of the mass disposed of in landfills, but it accounts for 70 percent of the hazardous waste. Since most old handsets remain stockpiled in a drawer, cell phones have had little impact on landfills to date. But with the retirement of 130 million handsets per year, there may well be more than a billion stashed handsets that could eventually end up as toxic waste.

Rethinking the Cell Phone Cycle

Our research into the cell phone value chain, in collaboration with Vered Doctori Blass of Tel Aviv University, offers two examples of how industry players at different points along the value chain could potentially increase profits while reducing the environmental impact.

The first opportunity is in phone design. Design decisions can affect the economic and environmental performance in different stages of the phone's life cycle by affecting the manufacturer's costs and consumer demand (in turn, affecting profitability), as well as the environmental impact at different stages. For example, cell phone manufacturers employ "design for assembly" techniques such as modular designs and snap-together fasteners to simplify the assembly process. Using common "platforms" for a range of models allows manufacturers to deal with unpredictable mix issues by delaying customization to the final steps, which reduces the need for expensive inventories. But cell phone manufacturers have been less aggressive in implementing "design for disassembly." By focusing explicitly on the end-of-life stage in addition to the initial production stage, cell phone companies can design the product to automate the disassembly process and lower the cost of refurbishment and component reclamation. A clear technology road map for such modular designs would increase the odds that components can be reused rather than merely recycled. And components that are not likely to be reused can be designed for easier recovery of valuable raw materials.

Additionally, innovative design can reduce the energy consumption of the phone, therefore reducing the cost to the consumer and increasing demand. In some cases, new technology can save up to 90 percent of the energy consumption in the usage phase. Changes in design that reduce the quantity of precious metals in cell phones can also be critical. For example, from 1999 to 2003 the amount of gold in phones was reduced by an estimated 25 percent; however, the tiny gold concentration in cell phones (0.03 percent) accounts for up to 80 percent of the recycling revenue. The downside is that if cell phone manufacturers keep decreasing the amount of gold, recycling will become unprofitable

Cell phones have had little impact on landfills to date. But more than a billion stashed handsets could end up as toxic waste.

(unless gold prices continue to increase or government regulation provides incentives or makes recycling mandatory).

These trade-offs illustrate that cell phone companies need to rethink their design efforts. Although process innovation has the potential to affect costs, and product innovation can increase the demand for the product, the short-term benefits of innovation for recovery are less apparent. Cell phone manufacturers may invest in design that affects the end-of-life stage only if they are required to take back their own products (not just subcontract collection and disposal via a third party, as they do today) or if they incorporate refurbishing and recycling activities as part of their business strategy. Because innovation can be applied to different aspects of design, manufacturers need to rethink where changes in design can be most effective economically and environmentally.

The second opportunity is in refurbishing older phones. Our research into smartphone pricing in a monopoly environment — such as the U.S. partnership between Apple and AT&T for the iPhone or Sprint and HTC for the Android-based Evo 4G — indicates that a service provider could significantly increase profits by offering refurbished models along with new ones. Careful pricing of refurbished phones can entice traditional handset users to upgrade from voice-only to data plans — while minimizing the cannibalization of new product sales. Our research shows that sales of smartphones could go up if the introduction of a remanufactured version induced the service provider to lower the price of new models. Such a price reduction would prove optimal because the manufacturer would sell more new units at a lower price. This in turn would encourage a second tier of consumers to upgrade to the data plans. In short, a service provider such as AT&T or Sprint could use refurbishing to expand its market by actively creating a secondary market to serve a more cost-conscious set of consumers.

The environmental and societal impacts of such a refurbishing strategy, however, would require further assessment. On the one hand, refurbishing a used smartphone consumes less energy than manufacturing a new one. For that reason, a refurbished phone — which requires about 7 megajoules (MJ) of energy for collection and refurbishment — places far less demand on the environment than a new phone, which consumes about 200 MJ. On the other hand, in this example, refurbishment does not displace production but instead is used to expand the market.

Some of this negative impact could be offset by expanding processes to collect the phones after the second use. ReCellular Inc., founded in 1991 in Dexter, Mich., dominates the market for reclaiming cell phones in the U.S. after their first use, with a market share exceeding 50 percent, thanks in part to its in-store take-back partnerships with Verizon, Motorola, Walmart, and others. But ReCellular captures less than 5 percent of retired phones. With a sufficiently scaled "closed loop" supply chain, service providers and OEMs might be able to dramatically increase the collection rate at the end of both first and second lives, thereby reducing the longer-term environmental threat from millions of stockpiled smartphones. Ultimately, a service provider like AT&T might find it necessary and lucrative to expand geographically to developing regions to control both the demand for the refurbished products and their eventual collection and disposal.

Independent of whether better collection and recycling offsets the environmental impact of more smartphones, industry leaders must make sure that government regulators understand the societal benefits of such a strategy. Expanding the reach of smartphones to more of the world's population offers a low-cost way to reduce the digital divide between people in developed versus developing nations, with perhaps even less environmental impact than the much-lauded $100 laptop. Regulations must avoid discouraging such innovation.

As these examples suggest, creating a more sustainable solution to managing consumer durables' end of life requires significant rethinking. By taking a strategic perspective that embraces a wide range of levers, from design to pricing to vertical integration, companies could avoid the win–lose mind-set so often imposed on them through government regulation. Given the current unsustainable approach to consumer durables life-cycle management, the creative capitalist can easily find opportunities to increase profits while reducing environmental impact. +

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