CHAPTER 7

Muda, Service, and Flow

Mental muda *spectacles — A continuous flow of value — Eddies and undertows of waste — Simple now and always — Allowing value to flow — Making money the same way — Leasing carpets, color, and chemicals — Ending the business cycle*

PERHAPS "THE MOST FEROCIOUS FOE OF WASTE HUMAN HISTORY HAS PRODUCED"[1] was Taiichi Ohno (1912–90). Ohno-sensei was the father of the Toyota Production System, which is the conceptual foundation of the world's premier manufacturing organization, and one of the pivotal innovators in industrial history. His approach, though adopted successfully by Toyota, remains rare in Japan. However, it has shown remarkable results in America and elsewhere in the West, and is poised for rapid expansion now that it has been systematized by industrial experts Dr. James Womack and Professor Daniel Jones. With their kind permission, we gratefully quote and paraphrase their book, *Lean Thinking,* in the hope that more business leaders will read it in full.[2]

Ohno created an intellectual and cultural framework for eliminating waste — which he defined as "any human activity which absorbs resources but creates no value." He opposed every form of waste.[3] Womack and Jones restated thus his classification of the forms of waste: "mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren't actually needed, movement of employees and transport of goods from one place to another without any purpose, groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don't meet the needs of the customer." Ohno called these *muda,* which is Japanese for "waste," "futility," or "purposelessness." Each of these classes of *muda* involves a whole family of blunders, which range from activities like having to inspect a product to see if it has the quality it should have had in the first place (an unneeded process step) to filling a new-car lot with vehicles that meet no specific demand — if the cars

were wanted, customers would have bought them already — and then discounting them enough to sell them. Ohno's and his students' vast practical experience helped them to develop penetrating modes of perception — mental "*muda* spectacles" — that reveal the previously invisible waste all around us.

So where is all this *muda?* Start, say, by visiting a job site where builders are constructing a custom house. You'll notice periods of recurrent inactivity. But these lags aren't taking place because the workers are lazy. Builder Doyle Wilson discovered that five-sixths of the typical custom-house construction schedule is spent in *waiting* for specialized activities to be completed and fitted into a complex schedule, or in *reworking* — tearing out and redoing work that was technically wrong or that failed to meet the customer's needs and expectations. Eliminating even part of that wasted time can create a huge competitive advantage for a savvy construction firm.

Or take a much more familiar experience: air travel. Often you can't get a direct flight to where you want to go. Instead, you must somehow get to a major airport, fly in a large airplane to a transfer point quite different from your actual destination, become "self-sorting cargo" in a huge terminal complex once you arrive there, and board another large plane going to the destination you originally wanted. Most travelers tolerate this because they are told that it's a highly efficient system that fully utilizes expensive airplanes and airports. Wrong. It looks efficient only for the tautological reason that the airplanes are sized for those large hubs, which are designed less for efficiency than to monopolize gates and air-traffic slots, thus *reducing* competition and economic efficiency as well as convenience.

Much if not most air travel would cost less, use less fuel, produce less total noise, and be about twice as fast point-to-point by using much smaller and more numerous planes that go directly from a departure city to a destination. That concept, reinforced by turning around planes in fifteen instead of thirty minutes, is the secret of Southwest Airlines' profits. In contrast, most other airlines have established systems designed to transfer idleness from capital to customers. These systems are so riddled with waste that Jones once found nearly half the door-to-door time of a typical intra-European air trip to have been spent in waiting in ten different lines, seven baggage-handling operations, eight inspections asking the same questions, and twenty-three processing steps performed by nineteen organizations. Each was specialized to

perform its own narrowly defined task "efficiently" — in a way that ultimately added up to dreadful inefficiency for the customer. Removing inefficiencies like these through whole-system engineering of the firm is the next great frontier of business redesign.

The nearly universal antidote to such wasteful practices is what Womack and Jones call "lean thinking," a method that has four interlinked elements: the *continuous flow* of value, as *defined* by the customer, at the *pull* of the customer, in search of *perfection* (which is in the end the elimination of *muda*). All four elements are essential to lean thinking: For example, "if an organization adopts lean techniques but only to make unwanted goods flow faster, *muda* is still the result."[4] The parts of the definition also functionally reinforce one another. "Getting value to flow faster always exposes hidden *muda* in the value stream. And the harder you pull, the more the impediments to flow are revealed so they can be removed. Dedicated product teams in direct dialogue with customers always find ways to specify value more accurately[,] and often learn of ways to enhance flow and pull as well."

Value that flows continuously at the pull of the customer — that is, nothing is produced upstream until someone downstream requests it — is the opposite of "batch-and-queue" thinking, which mass-produces large inventories in advance based on forecast demand. Yet so ingrained is batch-and-queue — and so deeply embedded is the habit of organizing by functional departments with specialized tasks — that Womack and Jones caution: "[P]lease be warned that [lean thinking] requires a complete rearrangement of your mental furniture." Their basic conclusion, from scores of practical case studies, is that specialized, large-scale, high-speed, highly efficient production departments and equipment are the key to *in*efficiency and *un*competitiveness, and that maximizing the utilization of productive capacity, the pride of MBAs, is nearly always a mistake.[5]

Consider the typical production of glass windshields for cars. Economies-of-scale thinking says that the giant float-glass furnace should be as large as possible: a theoretically ideal situation would be if all the flat glass in the world could be made in a single plant. Big, flat sheets of glass emerge from the furnace and are cut into pieces somewhat larger than a windshield. The glass is cooled, packed, crated, and shipped 500 miles to the fabricator. There, 47 days later, it's unpacked and cut to shape, losing 25 percent in the process. It is then reheated and drooped or pressed into the right curving shape. (Because each car

model has different specifications, huge batches of windshields are shaped at once while a given set of dies is installed.) Then the glass is cooled, repackaged, and shipped 430 miles to the glass encapsulator. There, 41 days later, it's unpacked, fitted with the right edge seals and other refinements, repacked, and shipped another 560 miles to the car factory. There, 12 days later, it's unpacked and installed in the car. Over 100 days have elapsed and the glass has traveled nearly 1,500 miles, almost none of which contributes to customer value.

Each part of this sequence may look efficient to its proprietor, but in fact the cooling, reheating, unpacking, repacking, shipping, and associated breakage is all *muda.* An efficient system for manufacturing windshields would build a small plant at the same place as the car factory, and carry out all the steps in the production process in immediate succession under one roof, even though several machines and companies might be involved. The machinery would be sized to deliver windshields only as fast as the automotive assembly line "pulls" them in.

Traditional substitutions of complex machines for people can backfire, as Pratt & Whitney discovered. The world's largest maker of jet engines for aircraft had paid $80 million for a "monument" — state-of-the-art German robotic grinders to make turbine blades. The grinders were wonderfully fast, but their complex computer controls required about as many technicians as the old manual production system had required machinists. Moreover, the fast grinders required supporting processes that were costly and polluting. Since the fast grinders were meant to produce big, uniform batches of product, but Pratt & Whitney needed agile production of small, diverse batches, the twelve fancy grinders were replaced with eight simple ones costing one-fourth as much. Grinding time increased from 3 to 75 minutes, but the throughput time for the entire process *decreased* from 10 days to 75 minutes because the nasty supporting processes were eliminated. Viewed from the whole-system perspective of the complete production process, not just the grinding step, the big machines had been so fast that they slowed down the process too much, and so automated that they required too many workers. The revised production system, using a high-wage traditional workforce and simple machines, produced $1 billion of annual value in a single room easily surveyable from a doorway. It cost half as much, worked 100 times faster, cut changeover time from 8 hours to 100 seconds, and would have repaid its conversion costs in a year even if the sophisticated grinders were simply scrapped.

Just as unwanted weight in a car or unwanted heat in a building is prone to compound and multiply, *muda* tends to amplify itself, because excessive scale or speed at any stage of production turns the smooth flow of materials into turbulent eddies and undertows that suck down earnings and submerge whole industries. Remember chapter 3's saga of the aluminum cola can? It takes 319 days in production to get to the customer's hand, then minutes to reach the trash bin. This is 99 and $^{9}/_{100}^{\text{ths}}$ percent pure *muda.* For such a massive batch-and-queue system to produce what the customer perceives as an uninterrupted supply of cola requires huge inventories at every upstream stage to deal with unforeseen fluctuations in demand or delays in supply. Wherever there's a bottleneck, the supplier adds buffer stocks to try to overcome it — thereby counterintuitively making the stop-and-go traffic of the materials flow even worse.

All this results from the mismatch between a very small-scale operation — drinking a can of cola — and a very large-scale one, producing it. The production process is designed to run in enormous batches, at very high speeds, with very high changeover costs. But that logic is the result of applying to business organization precisely the same design flaw — discussed in the previous chapter at the level of components — namely, optimizing one element in isolation from others and thereby pessimizing the entire system. Buying the world's fastest canning machine to achieve the world's lowest fill cost per can presumably looks like an efficient strategy to the canner. But it doesn't create customer value at least cost, because of such expenses as indirect labor (in such forms as technical support), the inventories throughout the value chain, and the pervasive costs and losses of handling, transport, and storage between all the elephantine parts of the production process. Just as Pratt & Whitney's grinders looked fast and cheap per grind but were slow and costly per finished blade, from a whole-system perspective, the giant cola-canning machine may well cost *more* per delivered can than a small, slow, unsophisticated machine that produces the cans of cola locally and immediately on receiving an order from the retailer.

The essence of the lean approach is that in almost all modern manufacturing, the combined and often synergistic benefits of the lower capital investment, greater flexibility, often higher reliability, lower inventory cost, and lower shipping cost of much smaller and more localized production equipment will far outweigh any modest decreases in its narrowly defined "efficiency" per process step. It's more efficient overall,

in resources and time and money, to scale production properly, using flexible machines that can quickly shift between products. By doing so, all the different processing steps can be carried out immediately adjacent to one another with the product kept in continuous flow. The goal is to have no stops, no delays, no backflows, no inventories, no expediting, no bottlenecks, no buffer stocks, and no *muda.* Surprisingly, this is as true for small- as for large-scale production.

SIMPLIFICATION AND SCALE

One of the keys to lean thinking is simplification. In the previous chapter, simplification was a design opportunity for components and products. Enlarged to the context of the whole process or plant, it gains the wider ability to save simultaneously such resources as space, materials, energy, transportation, and time.

The VW Golf's mirrors have four completely different designs, each containing 18–19 elaborately engineered parts, and each available in 17 colors. The exterior rearview mirrors designed by Nissan for British-assembled Micra cars have one design, with four parts, and come in four colors. As a result, Nissan's production system involves only four mirror specifications while VW deals with sixty-eight, each with more than four times as many parts.[6] While it's not obvious that VW is providing premium value in offering customers more choices — choices they neither necessarily want nor are willing to take the trouble to decide about — it *is* obvious that multiplying product variety times product complexity bears heavy costs.

Another key question is: What's the right size for the task? As the case studies earlier in this chapter illustrate, matching the scale of production equipment to the rate of pull by the next step downstream is another key theme of lean thinking. *Every* tool, machine, or process should be the right size for the job. Too big is at least as bad as too small — and it is often worse, because it allows for less flexibility and creates many indirect forms of *muda.* However, right-sizing doesn't mean making everything small. E. F. Schumacher, whose classic *Small Is Beautiful* (1973) first questioned the cult of gigantism in business, emphasized that it would be just as pointless to run an aluminum smelter with little wind machines as it would be to heat houses with a fast breeder reactor; they're both a mismatch of scale. Moreover, both Schumacher and lean thinking teach that right-sizing is a *system* attribute.[7]

The right size for a soda-canning machine or a blade-grinding machine or a windshield-making machine depends on the entire production process viewed in the context of a whole market structure and business logic. Again, optimizing a machine's size in isolation pessimizes the system of which it is a part: The right size *depends on the rate and location of customer pull.*

History has strongly confirmed this conclusion with regard to electric power systems, the most capital-intensive sector of the economy. The proper size for a power station can't be determined in isolation from the system that supplies its fuel, delivers its electricity to customers, and creates its competitive business context. The U.S. utility industry, and most of its counterparts abroad, will take decades to recover from the financial consequences of doctrinaire gigantism. From that chastening experience, a compelling literature on the economics of power-plant scale emerged during the 1970s and early 1980s, then reemerged in the 1990s. By combining the rigorous analytic tools of portfolio theory, electrical engineering, and other disciplines, a recent synthesis found[8] that approximately seventy-five uncounted effects of scale on economics typically make decentralized power sources about tenfold more valuable than traditionally supposed. That is enough to make even solar cells cost-effective, *now,* in most applications.

While many details differ, the same whole-system design imperative applies, and analogous critiques are starting to emerge, in water and wastewater systems. The whole system that comprises classical central sewage-treatment plants and their farflung collection sewers — each piece optimized in isolation — is far costlier than such local or even on-site solutions as biological treatment. That is the case because even if the smaller plants cost more per unit of capacity (which they generally don't), they'd need far less investment in pipes and pumps — often 90 percent of system investment — to collect sewage from a greater area to serve the larger plant. They'd also recover valuable nutrients and water more thoroughly, with better quality, and closer to where they're needed, saving more distribution costs.

Comparable whole-system scale economics should apply to most technical systems, including transportation, communications, and even manufacturing — whose flow of materials between different production steps is somewhat analogous to the flow of power, water, or wastewater. The exploration of such applications has barely begun. Yet the conceptual lessons of the power-system synthesis have revealed

surprises that resonate with lean thinking's matching of production scale to the rate of demand pull.

LEAN THINKING IN ACTION

How does Ohno's theory actually work in practice? Across a vast range of industries, many in America, the empirical results of applying lean thinking are dramatic. Approximately fifty companies that have tried this approach have typically found that, using the same workers and the same capital, over a period of five to ten years, production increases by two- to fourfold, while inventories, delays, defects, errors, accidents, scrap, and other unwanted outcomes fall by about four- to tenfold. Much of the improvement is immediate and dramatic: Womack and Jones conclude, "If you can't quickly take throughput times down by half in product development, 75 percent in order processing, and 90 percent in physical production, you are doing something wrong."[9] Shifting to a continuous-value-flow, demand-pull system unleashes the sorts of incremental improvements that redouble success again, and then both together set the stage for virtually endless further improvement. Two of Womack and Jones's examples offer impressive case studies of lean thinking in action:

- The biggest North American maker of seals and gaskets, Freudenberg-NOK General Partnership, tracked the February 1992–August 1995 production of a particular part at one factory in Indiana following the introduction of lean thinking there. The number of workers needed to make the part decreased from 21 to 3; pieces made per worker rose from 55 to 600; and space used fell by 48 percent. However, such huge (in this case, 76-fold) gains in labor productivity typically don't lead to workers' losing their jobs. Instead, the same workforce generally produces far more, and more diverse, products with the same capital and facilities, greatly expanding the company's markets — albeit at the expense of workers unfortunate enough to work for firms that don't follow suit. In fact, the specific process of adopting lean thinking often begins with a company-wide or factory-wide guarantee of no job loss on the shop floor, and then delivers on that promise.
- Lantech, a Louisville, Kentucky, firm, reorganized its development and manufacturing of stretch-wrapping machines from batch-and-queue in 1991 to continuous flow in 1995. This cut development time for a new product family from 3–4 years to 1 year. It halved work time and nearly halved the space occupied per machine. It also cut delivered

defects by tenfold, in-process inventory (idle money) by 27 percent, production throughput time from 16 weeks to 0.6–5 days, and lead time for product delivery from 4–20 weeks to 1–4 weeks. In 1991, most of that lead time was needed for production. By 1995, any delay was caused by waiting for a production slot as workers struggled to keep up with soaring sales. Market share rose from 38 percent to 50 percent, and large operating losses turned into industry-leading financial performance.

Gains this dramatic usually demand a cataclysmic shift in thinking. Under the guidance of a changemaster trained by Ohno, a massive Pratt & Whitney plant cut its effort, space, and tooling per unit of product by fourfold in one *week.* In Danaher Corporation's Jacobs Vehicle Manufacturing Company, at 1:00 A.M., the Japanese sensei took a crowbar and uprooted machines that had stood in place for decades, then jockeyed them into new locations for continuous-flow production. The message and the method are stark: Don't study it, just do it, keep trying. If you've fixed it, fix it again.

Lean thinking fundamentally reduces waste at the level not only of the firm but of the whole society, because, as the *Financial Times* put it, "only what is needed will actually be made." It even changes the standards for measuring corporate success. Having performed only six years earlier a pathfinding global comparison[10] of numerous aspects of automakers' performance, Womack and Jones now think such benchmarking is a waste of time for managers who understand lean thinking and a dangerous distraction for those who don't. As they express it: "Our earnest advice to lean firms today is simple. To hell with your competitors; compete against *perfection* by identifying all activities that are *muda* and eliminating them. This is an absolute rather than a relative standard which can provide the essential North Star for any organization."

Charlie Eitel, president and COO of commercial interior materials maker Interface, introduced the same concept several years earlier when, as part of Chairman Ray Anderson's response to the book *The Ecology of Commerce,* he called for a "zero-based waste budget." Waste, Eitel explained (unknowingly echoing Ohno-sensei), was "every measurable input that does not create customer value" — and he insisted that every input had to be presumed waste until shown otherwise. Once Interface started measuring its inputs, it discovered that most of them were indeed waste. The more the company learned about the potential for radically simpler processes, the larger the fraction of apparent waste

became. Workers throughout the company started mining the newly visible waste. What can genuinely be considered "waste" is a moving target, but erring on the side of examining how *every* input can be eliminated is a powerful stimulus to resource productivity, and a source of continuing challenge and satisfaction.

That satisfaction is a hidden benefit: Lean production makes people happier, and not only because workers like to see waste eliminated. The University of Chicago psychologist Mihaly Csikszentmihalyi has found[11] that people all over the world feel best when their activity involves a clear objective, intense concentration, no distractions, immediate feedback on their progress, and a sense of challenge. Skiing just in control, or high-standard rock climbing or kayaking, or hunting something that can eat you, or writing or reading a good book are obvious examples. By creating, as Womack and Jones put it, "a highly satisfying psychological condition of *flow,*" these tasks become the end in themselves, not a means of accomplishing something else. In contrast, traditional batch-and-queue production work fails every one of these criteria, which is why so few people enjoy it. But organizations where value flows continuously also create "the conditions for psychological flow. Every employee has immediate knowledge of whether the job has been done right and can see the status of the entire system."

SERVICE AND FLOW

The logic of lean thinking, with its emphasis on eliminating all forms of waste, combines with the work of such analysts as Walter Stahel, father of cradle-to-cradle production, to give rise to the third principle of natural capitalism: *service and flow.*

Resource productivity and closed loops provide better services, for longer periods, with less material, cost, and hassle. Lean thinking makes customer-defined value flow continuously with the aim of producing zero waste. Together, these practices offer the foundation for a powerful new business logic: Instead of selling the customer a *product* that you hope she'll be able to use to derive the service she really wants, provide her that service directly at the rate and in the manner in which she desires it, deliver it ever as efficiently as possible, share as much of the resulting savings as you must to compete, and pocket the rest.

This isn't an entirely new idea. Ten million buildings in metropolitan France have long been heated by *chauffagistes*; in 1995, 160 firms in this business employed 28,000 professionals.[12] Rather than selling raw

energy in the form of oil, gas, or electricity — none of which is what the customer really wants, namely warmth — these firms contract to keep a client's floorspace within a certain temperature range during certain hours at a certain cost. The rate is normally set to be somewhat below that of traditional heating methods like oil furnaces; *how* it's achieved is the contractors' business. They can convert your furnace to gas, make your heating system more efficient, or even insulate your building. They're paid for results — warmth — not for how they do it or how much of what inputs they use to do it. The less energy and materials they use — the more efficient they are — the more money they make. Competition between *chauffagistes* pushes down the market price of that "warmth service." Some major utilities, chiefly in Europe, provide heating on a similar basis, and some, like Sweden's Göteborg Energi, have recently made it the centerpiece of their growth strategy.

Some American firms are now beginning to test this concept. Carrier, the world's leading maker of air-conditioning equipment, decided that it might as well capture that very efficient and reliable equipment's operating benefits by offering "coolth services." Carrier's new "comfort lease" is just like a *chauffagiste*'s contract, only it focuses on maintaining comfort in hot rather than in cold weather. Customers, Carrier reasoned, don't want what an air-conditioning system *is;* they only want what it *does.* How does one lease coolth? At first, the plan was merely to provide cooling as a commodity. But now Carrier is starting to team up with other service providers so it can not only deliver cooling but also do lighting retrofits, install superwindows, and otherwise upgrade customers' buildings so they'll ultimately need less air-conditioning to provide better comfort — and then Carrier can provide not the coolth but the comfort.

While at first glance it is tempting to regard this company as crazy for striving to sell less of its product, Carrier is in fact in the process of redefining the "product" it's selling. The firm's leaders understand that making comfort flow at the pull of the customer means that Carrier can develop relationships, not just conduct transactions. The system also offers important new opportunities to deliver and capture ever-increasing value. The less equipment Carrier has to install to deliver comfort, the more money Carrier makes. The longer the equipment lasts and the less energy and maintenance it requires, the more money Carrier makes. If Carrier retrofits a building so it no longer needs a lot, or even any, of its air-conditioning capacity, Carrier can remove those

modules and reinstall them elsewhere. Not installing air conditioners is all right, so long as there's an even cheaper way to provide the desired comfort, and Carrier can capture the difference in cost before its competitors do.

The business logic of offering such continuous, customized, decreasing-cost solutions to an individual customer's problems is compelling because the provider and the customer *both make money in the same way* — by increasing resource productivity. This is not the case when selling equipment, where the vendor tries to convince you to buy a device bigger or costlier than you need, while you try to pay less. Nor is it like a traditional capital lease of equipment, which is often based on the hope of "churning" — re-leasing new and improved equipment once the first term expires (or even earlier). Again, this leaves the parties with opposing interests.[13] Rather, a relationship that provides a continuous flow of services to meet the customer's ever-changing needs automatically aligns the parties' interests, creating mutual advantage.

The form of compensation for the flow of service can be a sale (for a given term of service flow, the product's lifetime, or whatever), or a lease with a fixed or continuing term, or perhaps some other arrangement. But whatever its contractual form, such a relationship, by focusing on ends rather than means, can reward both parties for cost-minimizing choices of means. Where this logically leads is a world, not far in the future, where mere product-sellers will become suspect. Why — a prospective buyer may ask — if your product delivers its service with all the operational advantages you claim, don't you want to capture those advantages for yourself by owning the product and just providing me with its service? If you want to sell it to me and leave me to pay its operating costs, there must be something wrong with it!

Some utilities and third parties have been offering "torque services" that turn the shafts of your factory or pumping station for a set fee; the more efficiently they do so, the more they can earn. The same concept is emerging in transportation, which is now moving beyond mere car leases (which cover one-third of U.S. cars today) and short-term drive-it-yourself rentals toward concepts like those pioneered by Schindler. This leading Swiss maker of elevators makes 70 percent of its earnings by leasing vertical transportation services rather than by selling (or leasing) elevators. The logic is impeccable: Schindler's lifts are more efficient and reliable than many competing brands,[14] so by leasing their services, the company can capture the operational savings. As better

ways of vertically moving people become available, Schindler can adopt them to provide better service at still lower cost;[15] its lease provides the service, not the specific equipment.

Dow Chemical Company does an extensive business leasing organic solvents, many of which are toxic or flammable or both. A consumer who purchases them is left with the responsibility of safely handling and disposing of them. But through the lease provisions of Dow or its competitor SafetyKleen, that chemical company's experts will deliver the solvent, help with its application, work with the client to recover the solvent again, and take it away. The customer never owns it and is never liable for it; it belongs to the provider of the "dissolving services" but is always available to do your job. Dow's German affiliate SafeChem, which has increased some solvents' life above one hundred uses, plans to take the next logical step — charging by the square inch degreased rather than by the gallon used — thereby incentivizing itself to use fewer rather than more gallons. It's in a good position to do this, having developed special airtight shipping containers to eliminate evaporative losses.[16] (Even better would be to use benign or no solvents.)[17]

This concept is rapidly spreading in the chemical industry: A Dutch firm, for example, has made a success of leasing photographic chemicals, cycling them many times, and recovering valuable silver en route.[18] (Again, there's a benign competitor: Imation's DryView eliminates the chemicals.) Ciba's Pigment Division is moving to provide "color services" rather than merely selling dyes and pigments.[19] Cookson in England leases the insulating service of refractory liners for steel furnaces, helping to close their materials loop.[20] The service concept has also become standard practice in the fast-moving world of information services. Xerox runs document distribution centers instead of just leasing copiers (they collect the original and you get it back with your copies)[21]. Pitney Bowes handles your firm's mail instead of just leasing postage meters. In data processing, revenues from bundled service provision are growing faster than either hardware or software sales.[22] Again, what the customer wants and gets is the function; what equipment the provider uses, and how it does the job, is immaterial.

A NEW LEASE ON LIFE

Service leasing can be combined with other aspects of natural capitalism described earlier, especially since the provider retains ownership of the equipment.[23] This supports natural capitalism's goal of protecting

vital ecosystem services. For example, it fits perfectly with the manufacturer's life-cycle responsibility for ultimate remanufacturing or other disposition as a technical nutrient for industrial metabolism. Xerox's 95 percent recyclable, virtually 100 percent remanufacturable DocuCenter digital photocopier family, mentioned in chapter 4, was developed with these "zero to landfill" goals. It exceeds all North American and European standards for environmental and energy efficiency, and emits less noise, ozone, heat, and dirt than any other comparable machine on the market. It's designed to use 100 percent recycled paper, which causes some other copiers to jam. But similar thinking also went into its value chain. The machine is manufactured with lean techniques, built to order, and directly delivered from factory to customer in order to eliminate the *muda* (and the cost) of time and haulage to and from a distributor. It's even designed with few parts. Its upkeep will largely be done by the customer, reducing the *muda* of service calls.

Even more far-reaching advances are emerging from Electrolux in Sweden.[24] For example, Electrolux has developed the concept of providing its Swedish customers with a guarantee of quality and reliability, the *service* provided by its professional floor-cleaning equipment, medical refrigeration, and vending machines. It is also experimenting with similar concepts for such commercial food-related services as refrigeration and cooking. The services are billed monthly as long as the customer needs them — but no longer, so the customer isn't bound to the term of a lease or to a period of ownership. There are no hidden costs, so the customer's costs are completely predictable. Besides ensuring optimal use of the resource-efficient machines, this concept "allows used machines and parts to be reused since the supplier always guarantees the performance and the appearance of the products used" and hence gives Electrolux a strong incentive to keep refurbishing them. The operators are also guaranteed to be properly trained. The service is turnkey and comprehensive: A single dedicated partner handles all equipment-related issues and provides continuous innovation and improvement.

Electrolux gains competitive advantage in four main ways: providing better equipment, being able to extend its life through optimal use and maintenance, knowing how to package the offer and control its costs, and sharing a diverse fleet of equipment among many users so as to keep it well matched to their changing uses and well occupied overall with a minimum of financial risk. This approach is clearly moving

beyond traditional service provision. Indeed, it transcends distinctions between "products" and "services," as both "meld into one to become an offer."[25] Its focus is on the *relationship* that continuously provides and improves, for mutual benefit, what Womack calls "solutions to value needs." The acceleration of business makes that relationship ever more central to success. With shorter product life-cycles, as the Ernst & Young Center for Business Innovation notes, "There's no such thing as selling a product to a customer and then forgetting about him. The people who are your customers today will be customers again in six months — if not yours then someone else's. When you're dealing with the same customers with that frequency, doesn't it begin to qualify as a service business?"[26]

The solutions-providing relationship also has important psychological dimensions. Leasing formerly carried the stigma of being too poor to buy, and a corresponding interest penalty; now it is gaining a cachet as the shrewd purchase of a total solution underpinned by mutually beneficial incentives. Taking capital off the balance sheet, because you value "flow and change rather than . . . stock and stasis," is becoming a sign of astute and agile management.[27] And because the relationship requires mutual confidence and focuses on customer solutions rather than on provider products, it also takes "the customer is always right" to new levels.[28]

Perhaps the most novel and exciting application of the service-flow concept is emerging at Interface in Atlanta, the leading innovator in what used to be called the carpet business. Traditionally, old-fashioned broadloom carpet is replaced every decade because it develops worn spots. An office must be shut down, furniture removed, carpet torn up and sent to landfill, new carpet laid down, the office restored, operations resumed, and workers perhaps exposed to carpet-glue fumes. It takes two pounds of fossil fuel to turn one pound of mainly petro-based feedstock into carpet, plus an additional amount to transport it to the customer and back to the landfill, where it resides for the next 20,000 years or so. Over 5 billion pounds of the carpet now in landfills has Interface's name on it. Chairman Ray Anderson realized that not throwing more energy and money into holes in the ground represents a major business opportunity.

Interface therefore launched a transition from selling carpet to leasing floor-covering services. People want to walk on and look at carpet, not own it. They can obtain those services at much lower cost if Interface

owns the carpet and remains responsible for keeping it clean and fresh in return for a monthly fee under the company's Evergreen Lease. Whenever indicated by monthly inspections, Interface replaces overnight the 10–20 percent of the carpet tiles that show 80–90 percent of the wear. This reduces the amount of carpet material required by about 80 percent because the unworn part of the carpet is left in place. It also provides better service at reduced life-cycle cost, increases net employment (less manufacturing but more upkeep), and eliminates disruption, since worn tiles are seldom under furniture. Because the carpet is laid in the form of tiles, glue fumes are also significantly reduced or possibly eliminated.[29] The customer's former capital investment becomes a lease expense.

So far so good: a Factor Five saving in materials, plus considerable energy and money. But Interface's latest technical innovation goes much further in turning waste into savings. Other manufacturers are starting to "downcycle" nylon-and-PVC-based carpet into a lower-quality use — backing — thus losing the embodied energy value of the nylon. Interface has instead made a novel polymeric material into a new kind of floor-covering service, called Solenium, that can be completely remanufactured back into itself. All worn materials can and will be completely separated into their components, fiber and backing, and each component remade into an identical fresh product. The production process is also simpler (several key steps become unnecessary) and less wasteful: Manufacturing the upper surface produces 99.7 percent less waste than making normal carpet, and the other 0.3 percent gets reused. The new product also provides markedly better service. It's highly stain-resistant, and does not mildew. It is easily cleaned with water, is 35 percent less materials-intensive, and yet is four times as durable, so it uses sevenfold less massflow per unit of service. It is suited to renewable feedstocks, and is acoustically and aesthetically improved — so superior in every respect that it won't even be marketed as an environmental product. In fact, it creates a new category of flooring, combining the durability of resilient flooring with the acoustics and aesthetics of soft flooring. It also comes installed, maintained, and reclaimed under a service lease. Compared with standard nylon broadloom carpet, Solenium's *combination* of improved physical attributes (Factor Seven less massflow from dematerialization and greater durability) *and* the service lease (a further Factor Five less massflow from replacing only the worn parts) multiplies to a reduction in the net flow of materials and embodied

energy by 97 percent — Factor 31. Manufacturing cost is also substantially reduced and margin increased.

This higher performance and competitive advantage did not evolve through incremental improvement. Rather, they emerged from a deliberate effort to redesign the flooring business from scratch so as to close all loops, take nothing from the earth's crust, and add nothing harmful to the biosphere. Product development began with seeking "new ways of directly satisfying customers' needs rather than finding new ways of selling what we wanted to make," explains Interface Research's Senior Vice President, Jim Hartzfeld. "'Ecological thinking' led to radically expanding the possibilities we found to meet these needs rather than [to] a new list of constraints that narrowed the design or creative space."[30] Indeed, the philosophical framework is even broader: Solenium reflects Interface's ambition to become the world's first truly sustainable enterprise.[31] In energy, for example, COO Charlie Eitel has lately added all fossil-fuel inputs to his list of "waste" to be eliminated. By substituting process redesign, energy productivity gains, and renewable sources, Interface will avoid fuel costs, increase supply reliability, generate carbon credits for eventual trading, and gain a marketing edge. Ultimately, the firm aims not to use another drop of oil.

Providing a flow of services has other advantages, too. If a satisfactory quality of service isn't being delivered, the problem can be addressed directly and immediately. Service flows can often be structured as an operating lease whose cost can be fully deducted from taxable business income, just like any other normal operating expense. The product's value doesn't have to be capitalized, for its capital cost is entirely off your balance sheet and onto that of the firm that leases it — giving that firm in turn an incentive to minimize capital requirements per unit of service flow.

A client's relationship with a leasing company may also lead in new directions. It would be reasonable, for example, for Interface to lease not only carpet tile but the raised-floor system beneath it. That in turn can be linked to the displacement ventilation that's part of a Carrier comfort lease, which in turn can be part of, say, a Carrier or Enron or Trigen lease of a given site's entire set of energy services. Ideally, such service providers might even help you design your building so it takes no energy or special equipment to provide comfort. That design service could be leased — unbundled or as part of the cost of leasing the space.

Someday businesses will lease their office furniture, office equipment, manufacturing equipment, and even a whole building, just as they may be outsourcing their manufacturing, marketing, order-taking, and delivery services to create a weblike virtual company. These trends, already notable as more and more firms make their daily make-buy-or-lease decisions, are creating a competitive and productive economy defined not by the sporadic sale of objects but by the continuous flow of services.

Such an economy has important macroeconomic implications. The concept of *service and flow* goes to the heart of the business cycle, the periodic booms and busts in capital investments and inventories. Durable goods wear out and need replacement, whether they be metal lathes or trucks. Statistically, capital goods wear out evenly year after year, but you would never know that from observing the strong ebbs and flows in how individuals and businesses purchase. Small changes in economic growth or recession cause larger shifts in behavior, because the surplus funds available for investing in capital goods represent the small difference between two large numbers — total revenue and total cost. Modest fluctuations in revenues are thus magnified into big swings in purchasing, whether of new home starts or machine tools, cars or computers. In economic downturns, the small difference is squeezed, so more products are repaired and fewer bought. If the economy is strong, older goods are scrapped and replacements purchased. When revenues fluctuate moderately, purchasing gyrates vigorously along with such economy-moving figures as manufacturing, auto production, employment, money supply, and GDP growth.

For example,[32] while global passenger-miles traveled have steadily increased by 3 percent a year going back more than a decade, orders for commercial aircraft have soared and plummeted repeatedly. In 1989, 1,650 airframes were ordered. In 1993, netting out cancelations, orders were minus 100. In 1997, orders soared back to 1,200. Such buying frenzies exaggerate the business cycle's peaks and troughs. The leasing of services, on the other hand, "dampens" volatility. Volatility causes worker layoffs and anxiety. It also reinforces the "buy-in-the-good-times" mentality, and the need for enough extra capacity to meet boom-year demands, that help cause the volatility. In 1997, Boeing scrambled to manufacture faster, and when it couldn't speed up enough, had to post huge writeoffs, because aircraft orders were *too good.* The next year, Boeing laid off workers because orders had

slumped again. Converting from this volatile "goods economy," with its inherent feast-and-famine risks for long-lead-time producers, to a continuous-flow "solutions economy," as Womack calls it,[33] would reduce fluctuations by shortening lead times: Fewer customers would order too soon in an effort to beat the peak. More important, it would place assets in the hands of capable "solution provider" entities with a strong interest in maximizing the life-cycle potential of their assets and no interest in churning. If this route can lead us to a "post-cyclical economy," then "producing firms can stop lugging around all the excess capacity they maintain on average through the cycle so as to make sure they don't [lose market] . . . share and long-time customers during the peaks. This permanent average excess capacity . . . is one last bit of *muda* to be squeezed from the lean, solution-focused economy."[34]

In an economy of service and flow, an entire company may end up owning little or nothing but accomplishing more, while being located nowhere to sell everywhere. The more that the services customers want can be met by efficiency, dematerialization, simplification, and lean manufacturing, the more enthusiastically those customers will be willing to pay teams of service providers. For the first time, we can plausibly and practically imagine a more rewarding and less risky economy whose health, prospects, and metrics reverse age-old assumptions about growth: an economy where we grow by using less and less, and become stronger by being leaner.