LEAN THINKING

Banish Waste and Create Wealth in Your Corporation

'*Lean Thinking* has been an enormous influence on my business thinking. It shows you how you can fundamentally transform your business'
Sir Terry Leahy, *Chairman and Chief Executive*, **Tesco PLC**

James P. WOMACK
Daniel T. JONES


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Seeing the Whole: Mapping the Extended Value Stream

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BANISH WASTE AND CREATE WEALTH IN YOUR CORPORATION

Revised and Updated

James P. Womack
and Daniel T. Jones

London • New York • Sydney • Toronto

For Anne
Both necessary and sufficient;
my picture of perfection
J.P.W.

and

for Pat
My patient and wise counselor
D.T.J.

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Preface to the 2003 Edition

Lean Thinking was first published in the fall of 1996, just in time—we thought—for the recession of 1997 and the financial meltdown of 1998. The book's mission was to explain how to get beyond the financial games of the 1990s to create real, lasting value in any business. Toward this end, it demonstrated how a range of firms in North America, Europe, and Japan took advantage of the recession of 1991 to rethink their strategies and embark on a new path.

In our presentations to industrial audiences, we often point out that the only sure thing about forecasts is that they are wrong. (Which is why lean thinkers strive to reduce order-to-delivery times to such an extent that most products can be made to order and always try to add or subtract capacity in small increments.) Instead of a recession in 1997, the most ebullient economy of the entire twentieth century charged ahead for five more years, into 2001, extending a remarkable era in which practically anyone could succeed in business.

Given that the book was published years before our ideas were most needed, it's surprising how many readers took the advice in *Lean Thinking* seriously during the best of times. More than 300,000 copies have been sold in English, and it's been translated into German, French, Italian, Portuguese, Polish, Turkish, Korean, Japanese, and Chinese. We have heard from readers across the world about their successes in applying its principles.

Once reality caught up with our forecast, and the recession of 2001 gave way to the financial meltdown of 2002, reader interest surged. Indeed, *Lean Thinking* reappeared on the *Business Week* business-books bestseller list in 2001—nearly five years after its launch and with no publicity campaign—an unprecedented event, according to our publishers.

Given clear evidence that readers are now finding *Lean Thinking* even more relevant in their business lives than when it was first published, we have decided to expand and reissue the book. In Part I we explain some simple, actionable principles for creating lasting value in any business during any business conditions. We then show in Part II how to apply these principles,

step by step, in real businesses, from large to small. In Part III, we show how a relentless focus on the *value stream* for every product—from concept to launch and order to delivery, and from the upstream headwaters of the supply base all the way downstream into the arms of the customer—can create a true *lean enterprise* that optimizes the value created for the customer while minimizing time, cost, and errors.

In the two new chapters of Part IV, we bring the story of the continuing advance of lean thinking up-to-date. We track the trend in inventory turns—the lean metric that cannot lie—across all industries, singling out one industry for special praise. We also track the progress of our profiled companies. We discover that as economies have gyrated, stock markets have crashed, and the poster companies of the 1990s hailed in other business books have flown a ballistic trajectory, our lean exemplars—led by Toyota—have defied the fate of most firms featured in successful business books. They have continued their methodical march from success to success and have done it the hard way by creating real and truly sustainable value for their customers, their employees, and their owners.

Finally, in the concluding chapter, we share what we have ourselves learned since 1996 about lean thinking and its successful application by describing a range of new implementation tools. These begin with the concept of value stream mapping, which we have found to be a remarkable way to raise consciousness about value and its components, leading to action.

In revising the book we have corrected a few minor errors and omissions in the original text. However, we have been careful not to change the pagination. We know that many organizations use *Lean Thinking* as a text to guide their change process, distributing copies widely and often including their distributors and suppliers. Thus we wanted to ensure that there will be no difficulty in interchanging the two editions.

Today, nearly seven years after its publication, we are even more certain that lean thinking, as explained in *Lean Thinking*, is the single most powerful tool available for creating value while eliminating waste in any organization. We hope that previous readers will use this new edition as an opportunity to renew their commitment to lean principles. And we especially hope that many new readers will discover a whole new world of opportunity.

Jim Womack and Dan Jones
Brookline, Massachusetts, and Ross-on-Wye, Herefordshire, U.K.
February 2003

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PREFACE TO THE FIRST EDITION

From Lean Production to Lean Enterprise

In the fall of 1990, we set out on a trip around the world to launch our previous book, *The Machine That Changed the World*. Our objective was to send a wake-up message to organizations, managers, employees, and investors stuck in the old-fashioned world of mass production. *Machine* presented a wealth of benchmarking data to show that there is a better way to organize and manage customer relations, the supply chain, product development, and production operations, an approach pioneered by the Toyota company after World War II. We labeled this new way *lean production* because it does more and more with less and less.

As we started our travels across North America, then to Japan (where many mass producers still reside) and Korea, and on through Europe, we were greatly concerned that no one would listen. Perhaps the slumber of mass production was too deep to disturb? In fact, *The Machine That Changed the World* found an overwhelming response. More than 400,000 copies have been sold so far in eleven languages (not counting the pirated Chinese translation).[1] Far from ignoring our findings or resisting our advice, many audiences during that inaugural trip and many readers in subsequent forums told us that they were anxious to give lean production a try. Their question was seemingly a simple one: How do we do it?

In posing this question, they were not asking about specific techniques—how to organize teams, how to use Quality Function Deployment in product development, or how to *poka-yoke* (mistake-proof) production processes. After all, there is a plethora of very good books on each of these topics. Rather, they were asking: What are the key principles to guide our actions? and How do we as managers, employees, investors, suppliers, and customers take stuck-in-the-mud mass production organizations and make them lean? A few thoughtful respondents asked an even more difficult question: What comes next? What's the next leap, once you become a Toyota yourself?

The fact was, we didn't know the answers. We had been busy benchmarking industrial performance across the world for fifteen years, but *Machine* focused on aggregated processes—product development, sales, production—rather than broad principles, and we had never ourselves tried to convert a mass-production organization into a lean one. What was more, we had been so busy thinking through the initial leap from mass to lean production that we had not had time to think much about next steps for firms like Toyota.

The idea for this book emerged directly from these questions. First, we realized that we needed to concisely summarize the principles of "lean thinking" to provide a sort of North Star, a dependable guide for action for managers striving to transcend the day-to-day chaos of mass production. This summary was hard for most readers to construct because the Japanese originators of lean techniques worked from the bottom up. They talked and thought mostly about specific methods applied to specific activities in engineering offices, purchasing departments, sales groups, and factories: dedicated product development teams, target pricing, level scheduling, cellular manufacturing. Although they wrote whole books describing specific techniques and a few high-level philosophic reflections as well (such as the memoirs of Taiichi Ohno),[2] the thought process needed to tie all the methods together into a complete system was left largely implicit. As a result, we met many managers who had drowned in techniques as they tried to implement isolated bits of a lean system without understanding the whole.

After interactions with many audiences and considerable reflection, we concluded that lean thinking can be summarized in five principles: precisely specify *value* by specific product, identify the *value stream* for each product, make value *flow* without interruptions, let the customer *pull* value from the producer, and pursue *perfection*. By clearly understanding these principles, and then tying them all together, managers can make full use of lean techniques and maintain a steady course. These principles and their application are the subject of Part I of this book.

With regard to the conversion process, we knew of one heroic example—the original lean leap by Toyota immediately after World War II—but only in sketchy outline. What was more, our most striking benchmark examples in *Machine* were the "greenfield" plants started from scratch by Japanese auto firms in the West in the 1980s. These were critical achievements because they blew away all the claims, so prevalent up to that time, that, to work, lean production somehow depended on Japanese cultural institutions. Greenfields, however—with new bricks and mortar, new employees, and new tools—bore little resemblance to the long-established "brownfields"

most managers were struggling to fix. Our readers wanted a detailed plan of march suited to their reality, and one that would apply in any industry.

We therefore resolved to identify firms in a range of industries in the leading industrial countries that had created or were creating lean organizations from mass-production brownfields. Observing what they had done seemed to be our best hope of discovering the common methods of becoming lean. In doing this, we did not want a survey to discover average practice but rather to concentrate on the outliers—those organizations recently moving far beyond convention to make a true leap into leanness.

But where to find them? We knew the motor vehicle industry well, but we wanted examples from across the industrial landscape, including service organizations. In addition, we wanted examples of small firms to complement household-name giants, low-volume producers to contrast with high-volume automakers, and "high-tech" firms to compare against those with mature technologies.

In the end, through a lot of hard digging and some good fortune, we tapped into networks of lean thinking executives in North America, Europe, and Japan, and gained hands-on experience from a personal investment in a small manufacturing company. Over a four-year period, we interacted with more than fifty firms in a wide range of industries and gained a deep understanding of the human exertions needed to convert mass-production organizations to leanness. We describe our findings and prescribe a practical plan of action in Part II of this book.

To our delight, as we began to find our key examples, this book became an intensive collaboration between a group of like-minded people across the world. They believe passionately in a set of ideas, have made great progress in introducing them, and want to see lean thinking universally embraced. At the end of this volume we list the firms and executives we have worked with and describe ways for you to join them. Here let us simply express our profound appreciation for the hours, days, and even weeks many of them took with us.

Because we needed to look at the entire firm, indeed at the whole *value stream* for specific products, running from raw material to finished good, order to delivery, and concept to launch, and because we needed to examine many things which would rightly be considered proprietary, we proposed an unusual way of working together. In return for access to every aspect of the firm, including interviews with suppliers, customers, and unions, we offered to share our drafts with our respondents, asking for criticism and corrections. We stated in advance that any material our example firms could not bear seeing in the public domain would be deleted, but if the need to protect proprietary interests (or self-esteem) required deletion of those details which

made the story "true," we would simply leave the firm in question out of the book. In the end we didn't lose anyone.

Our method of working as outsider-insiders, perhaps first used fifty years ago by Peter Drucker for his landmark study of General Motors, *The Concept of the Corporation*,[3] placed special demands for "transparency" on the authors. There is today a profound and warranted skepticism about "business" books, both because they promise instant cures and because their authors—especially consultants but sometimes academics as well—have financial links to the firms they write about. We therefore need to assure you that we have no financial or consulting relationship of any sort to any of the individuals or firms we write about in these pages.[4] We need to further assure you that we have verified all the performance data presented. Indeed, in most cases we have verified it with our own eyes by walking the production floor and spending extended periods in the engineering, marketing, sales, customer support, and purchasing functions and with product development teams.

In order to maintain complete independence in our search for leanness, we financed our efforts over four years with an advance from Simon & Schuster and from our personal savings.

As we began to write up our findings on how to make a lean leap in traditional, mass-production organizations, we began to realize that it is both possible and necessary to go even farther than any firms have done to date. A wholly new way of thinking about the roles of firms, functions, and careers to channel the flow of value from concept to launch, order to delivery, and raw material into the arms of the customer is now needed in order to achieve a further "leap." A new concept—the *lean enterprise*—can move the whole "value stream" for products dramatically in the direction of perfection. We introduce this concept briefly in Part I and then look carefully at the challenge of lean enterprise in Part III. There we also dream a bit about the next "leap." No one has made it yet. Perhaps some reader will be the first.

After four years of exhaustive study of organizations around the world who are actually doing it, we now know how to succeed at leanness. As the examples will show, we know how to apply lean thinking, techniques, and organization to practically any activity, whether a good or a service. What's more, we now have a glimmering of the next leap beyond today's best practice. In the pages ahead we'll explain in detail what to do and why. Your job, therefore, is simple: Just do it!

PART I

LEAN PRINCIPLES

INTRODUCTION

Lean Thinking versus *Muda*

Muda. It's the one word of Japanese you really must know. It sounds awful as it rolls off your tongue and it should, because *muda* means "waste," specifically any human activity which absorbs resources but creates no *value:* 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.

Taiichi Ohno (1912–1990), the Toyota executive who was the most ferocious foe of waste human history has produced, identified the first seven types of *muda* described above and we've added the final one.[1] Perhaps there are even more. But however many varieties of *muda* there may be, it's hard to dispute—from even the most casual observation of what gets done in an average day in the average organization—that *muda* is everywhere. What's more, as you learn to see *muda* in the pages ahead, you will discover that there is even more around than you ever dreamed.

Fortunately, there is a powerful antidote to *muda: lean thinking*. It provides a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively. In short, lean thinking is *lean* because it provides a way to do more and more with less and less—less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want.

Lean thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert *muda* into value. And, in striking contrast with the recent craze for process reengineering, it provides a way to create new work rather than simply destroying jobs in the name of efficiency.

Specify Value

The critical starting point for lean thinking is *value*. Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) which meets the customer's needs at a specific price at a specific time.

Value is created by the producer. From the customer's standpoint, this is why producers exist. Yet for a host of reasons value is very hard for producers to accurately define. Business school–trained senior executives of American firms routinely greet us when we visit with a slick presentation about their organization, their technology, their core competencies, and their strategic intentions. Then, over lunch, they tell us about their short-term competitive problems (specifically their need to garner adequate profits in the next quarter) and the consequent cost-cutting initiatives. These often involve clever ways to eliminate jobs, divert revenues from their downstream customers, and extract profits from their upstream suppliers. (Because we are associated with the concept of lean production, they are usually eager to label these programs "lean," although often they are only "mean.") By dessert, we may be hearing about their personal career issues in the current age of "downsizing."

What only comes up when we push it to the foreground is the specific products the firm expects specific customers to purchase at a specific price to keep the company in business and how the performance and delivered quality of these products can be improved while their fundamental costs are pushed steadily down. In raising this issue it's often revealing to ask these executives a simple question: Can you put yourself in the position of a design as it progresses from concept to launch, an order as information flows from initial request to delivered product, and the physical product as it progresses from raw material to the customer, and describe what will happen to you at each step along the way? Usually there is an awkward silence, and then, if we aren't persistent, these issues quickly slip out of sight to be replaced once more by aggregated financial considerations. In short, the immediate needs of the shareholder and the financial mind-set of the senior managers have taken precedence over the day-to-day realities of specifying and creating value for the customer.

When we've gone to Germany, until very recently, we've found a reverse distortion of value specification. For much of the post–World War II era, executives of private or bank-controlled companies could ignore the need for short-term financial performance and were eager to tell us all about their products and process technologies. Even the most senior executives could go into great detail about product features and new processing methods which had taken years to perfect.

But who specified their value? The engineers running the companies! Designs with more complexity produced with ever more complex machinery were asserted to be just what the customer wanted and just what the production process needed. But where was the evidence?

In pressing this point, it often became apparent that the strong technical functions and highly trained technical experts leading German firms obtained their sense of worth—their conviction that they were doing a first-rate job—by pushing ahead with refinements and complexities that were of little interest to anyone but the experts themselves. Our doubts about proposed products were often countered with claims that "the customer will want it once we explain it," while recent product failures were often explained away as instances where "the customers weren't sophisticated enough to grasp the merits of the product."

A central feature of the crisis of German industry in the period since the end of the cold war has been the dawning perception that the complex, customized designs and sophisticated processing technologies favored by German engineers are too expensive for customers to afford and often irrelevant to their real desires.

When we have traveled to Japan, also until very recently, we have encountered yet a third distortion. What's been really important for Japanese firms as they have defined value is *where* value is created. Most executives, even at firms like Toyota which pioneered lean thinking, have begun their value definition process by asking how they can design and make their product at home—to satisfy societal expectations about long-term employment and stable supplier relations. Yet most customers across the world like products designed with an eye to local needs, which is hard to do from a distant home office. And they like products made to their precise order to be delivered immediately, which ocean shipping from a Japanese production base makes impossible. They certainly do not define the value of a product primarily in terms of where it was designed or made.

What's more, the stay-at-home-at-all-costs thinking of Japanese senior managers, even as the yen steadily strengthened, depleted the financial resources these firms needed to do new things in the future. The immediate needs of employees and suppliers took precedence over the needs of the customer, which must sustain any firm in the long term.

Moving beyond these national distortions in the world's three most important industrial systems (and every country probably has its own unique set),[2] we are repeatedly struck how the definition of value is skewed everywhere by the power of preexisting organizations, technologies, and undepreciated assets, along with outdated thinking about economies of scale. Managers around the world tend to say, "This product is what we know how to produce using assets we've already bought, so if customers don't respond we'll adjust the price or add bells and whistles." What they should

be doing instead is fundamentally rethinking value from the perspective of the customer.

One of the best (and most exasperating) illustrations of this backwards thought-process is the current-day airline industry. As frequent users of this service we have long been keeping detailed notes on our experiences and contrasting our own definition of value with that proposed by most companies in this industry. Our value equation is very simple: to get from where we are to where we want to be safely with the least hassle at a reasonable price. By contrast, the airline's definition seems to involve using their existing assets in the most "efficient" manner, even if we have to visit Timbuktu to get anywhere. They then throw in added features—like executive lounges in their hubs and elaborate entertainment systems in every seat—in hopes the inconvenience will be tolerable.

Just today, as this is written, one of us has traveled the 350 miles from his summer home in Jamestown in western New York State, across Lake Erie, to Holland, Michigan, in order to make a presentation on lean thinking to an industrial audience. What was needed was a way to fly from Jamestown directly to Holland (both of which have small airports) at an affordable cost. What was available was either an absurdly priced charter service from Jamestown to Holland (total door-to-door travel time of about two hours) or an eighty-mile drive to the Buffalo, New York, airport, a flight on a large jet to the Detroit sortation center of Northwest Airlines (where the self-sorting human cargo finds its way through a massive terminal from one plane to the next), another flight on a large jet to Grand Rapids, Michigan, and a forty-mile drive to the ultimate destination. (The lower-cost option required a total travel time of seven hours.)

Why aren't airlines like Northwest (and its global partner KLM) and airframe builders like Boeing and Airbus working on low-cost, point-to-point services using smaller jets instead of developing ever-larger aircraft? And why aren't they developing quick turnaround systems for small jets at small airports instead of constructing Taj Mahal terminals at the absurd "hubs" created in America after airline deregulation—and long present in Europe and East Asia due to the politically motivated practice of routing most flights of state-controlled airlines through national capitals? (One hour of the seven hours spent on the trip just cited was taxiing time in the Detroit hub and a second was occupied with self-sortation inside the terminal.)

Few firms are aggressively promoting this definition of value because the airlines and airframe builders start their thinking with extraordinarily costly assets in the form of large aircraft; the engineering knowledge, tooling, and production facilities to make more large aircraft; and massive airport complexes. Old-fashioned "efficiency" thinking suggests that the best way to make use of these assets and technologies is to get larger batches of

people on larger planes and to do this by sending ever more passengers through the expensive sorting centers. This type of efficiency calculation, focused on the airplane and the hub—only two of the many elements in the total trip—loses sight of the whole. Much worse from the standpoint of value for the passenger, it simply misses the point.

The end result of fifteen years of this type of thinking in the United States is that passengers are miserable (this is not what they meant by value!), the aircraft producers make little money (because the airlines can't afford new planes), and the airlines (excepting Southwest and a few other start-ups pursuing the more sensible strategy of flying point-to-point, although still using large aircraft) have flown a decade-long holding pattern in the vicinity of bankruptcy. Europe and parts of East Asia are not far behind.

Lean thinking therefore must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. The way to do this is to ignore existing assets and technologies and to rethink firms on a product-line basis with strong, dedicated product teams. This also requires redefining the role for a firm's technical experts (like the inward-looking German engineers we just cited) and rethinking just where in the world to create value. Realistically, no manager can actually implement all of these changes instantly, but it's essential to form a clear view of what's really needed. Otherwise the definition of value is almost certain to be skewed.

In summary, specifying value accurately is the critical first step in lean thinking. Providing the wrong good or service the right way is *muda*.

Identify the Value Stream

The *value stream* is the set of all the specific actions required to bring a specific product (whether a good, a service, or, increasingly, a combination of the two) through the three critical management tasks of any business: the *problem-solving task* running from concept through detailed design and engineering to production launch, the *information management task* running from order-taking through detailed scheduling to delivery, and the *physical transformation task* proceeding from raw materials to a finished product in the hands of the customer.[3] Identifying the *entire* value stream for each product (or in some cases for each product family) is the next step in lean thinking, a step which firms have rarely attempted but which almost always exposes enormous, indeed staggering, amounts of *muda*.

Specifically, value stream analysis will almost always show that three types

of actions are occurring along the value stream: (1) Many steps will be found to unambiguously create value: welding the tubes of a bicycle frame together or flying a passenger from Dayton to Des Moines. (2) Many other steps will be found to create no value but to be unavoidable with current technologies and production assets: inspecting welds to ensure quality and the extra step of flying large planes through the Detroit hub en route from Dayton to Des Moines (we'll term these Type One *muda*). And (3) many additional steps will be found to create no value and to be immediately avoidable (Type Two *muda*).

For example, when Pratt & Whitney, the world's largest manufacturer of aircraft jet engines, recently started to map its value streams for its three families of jet engines, it discovered that activities undertaken by its raw materials suppliers to produce ultrapure metals were duplicated at great cost by the next firms downstream, the forgers who converted metal ingots into near-net shapes suitable for machining. At the same time, the initial ingot of material—for example, titanium or nickel—was ten times the weight of the machined parts eventually fashioned from it. Ninety percent of the very expensive metals were being scrapped because the initial ingot was poured in a massive size—the melters were certain that this was efficient—without much attention to the shape of the finished parts. And finally, the melters were preparing several different ingots—at great cost—in order to meet Pratt's precise technical requirements for each engine, which varied only marginally from those of other engine families and from the needs of competitors. Many of these activities could be eliminated almost immediately with dramatic cost savings.

How could so much waste go unnoticed for decades in the supposedly sophisticated aerospace industry? Very simply: None of the four firms involved in this tributary value stream for a jet engine—the melter, the forger, the machiner, and the final assembler—had ever fully explained its activities to the other three. Partly, this was a matter of confidentiality—each firm feared that those upstream and downstream would use any information revealed to drive a harder bargain. And partly, it was a matter of obliviousness. The four firms were accustomed to looking carefully at their own affairs but had simply never taken the time to look at the whole value stream, including the consequences of their internal activities for other firms along the stream. When they did, within the past year, they discovered massive waste.

So lean thinking must go beyond the firm, the standard unit of scorekeeping in businesses across the world, to look at the whole: the entire set of activities entailed in creating and producing a specific product, from concept through detailed design to actual availability, from the initial sale

through order entry and production scheduling to delivery, and from raw materials produced far away and out of sight right into the hands of the customer. The organizational mechanism for doing this is what we call the *lean enterprise*, a continuing conference of all the concerned parties to create a channel for the entire value stream, dredging away all the *muda*.

Whenever we present this idea for the first time, audiences tend to assume that a new legal entity is needed, some formalized successor to the "virtual corporation" which in reality becomes a new form of vertical integration. In fact, what is needed is the exact opposite. In an age when individual firms are outsourcing more and themselves doing less, the actual need is for a voluntary alliance of all the interested parties to oversee the disintegrated value stream, an alliance which examines every value-creating step and lasts as long as the product lasts. For products like automobiles in a specific size class, which go through successive generations of development, this might be decades; for short-lived products like software for a specific application, it might be less than a year.

Creating lean enterprises *does* require a new way to think about firm-to-firm relations, some simple principles for regulating behavior between firms, and *transparency* regarding all the steps taken along the value stream so each participant can verify that the other firms are behaving in accord with the agreed principles. These issues are the subject of Part III of this book.

Flow

Once value has been precisely specified, the value stream for a specific product fully mapped by the lean enterprise, and obviously wasteful steps eliminated, it's time for the next step in lean thinking—a truly breathtaking one: Make the remaining, value-creating steps *flow*. However, please be warned that this step requires a complete rearrangement of your mental furniture.

We are all born into a mental world of "functions" and "departments," a commonsense conviction that activities ought to be grouped by type so they can be performed more efficiently and managed more easily. In addition, to get tasks done efficiently within departments, it seems like further common sense to perform like activities in batches: "In the Claims Department, process all of the Claim As, then the Claim Bs, and then the Claim Cs. In the Paint Department, paint all of the green parts, then shift over and paint all the red parts, then do the purple ones." Batches, as it turns out, always mean long waits as the product sits patiently awaiting the department's changeover to the type of activity the product needs next. But this approach keeps the members of the department busy, all the equipment running hard,

and justifies dedicated, high-speed equipment. So, it must be "efficient," right? Actually, it's dead wrong, but hard or impossible for most of us to see.

Recently, one of us performed a simple experiment with his daughters, ages six and nine: They were asked the best way to fold, address, seal, stamp, and mail the monthly issue of their mother's newsletter. After a bit of thought their answer was emphatic: "Daddy, first, you should fold all of the newsletters. Then you should put on all the address labels. Then you should attach the seal to stick the upper and lower parts together [to secure the newsletter for mailing]. Then you should put on the stamps." "But why not fold one newsletter, then seal it, then attach the address label, and then put on the stamp? Wouldn't that avoid the wasted effort of picking up and putting down every newsletter four times? Why don't we look at the problem from the standpoint of the newsletter which wants to get mailed in the quickest way with the least effort?" Their emphatic answer: "Because that wouldn't be efficient!"

What was striking was their profound conviction that performing tasks in batches is best—sending the newsletters from "department" to "department" around the kitchen table—and their failure to consider that a rethink of the task might permit continuous flow and more efficient work. What's equally striking when looked at this way is that most of the world conducts its affairs in accord with the thought processes of six- and nine-year-olds!

Taiichi Ohno blamed this batch-and-queue mode of thinking on civilization's first farmers, who he claimed lost the one-thing-at-a-time wisdom of the hunter as they became obsessed with batches (the once-a-year harvest) and inventories (the grain depository).[4] Or perhaps we're simply born with batching thinking in our heads, along with many other "common sense" illusions—for example, that time is constant rather than relative or that space is straight rather than curved. But we all need to fight departmentalized, batch thinking because tasks can almost always be accomplished much more efficiently and accurately when the product is worked on continuously from raw material to finished good. In short, things work better when you focus on the product and its needs, rather than the organization or the equipment, so that all the activities needed to design, order, and provide a product occur in continuous flow.

Henry Ford and his associates were the first people to fully realize the potential of flow. Ford reduced the amount of effort required to assemble a Model T Ford by 90 percent during the fall of 1913 by switching to continuous flow in final assembly. Subsequently, he lined up all the machines needed to produce the parts for the Model T in the correct sequence and tried to achieve flow all the way from raw materials to shipment of the finished car, achieving a similar productivity leap. But he only discovered the *special case*. His method only worked when production volumes were high enough to

justify high-speed assembly lines, when every product used exactly the same parts, and when the same model was produced for many years (nineteen in the case of the Model T). In the early 1920s, when Ford towered above the rest of the industrial world, his company was assembling more than two million Model Ts at dozens of assembly plants around the world, every one of them exactly alike.

After World War II, Taiichi Ohno and his technical collaborators, including Shigeo Shingo,[5] concluded that the real challenge was to create continuous flow in small-lot production when dozens or hundreds of copies of a product were needed, not millions. This is the *general case* because these humble streams, not the few mighty rivers, account for the great bulk of human needs. Ohno and his associates achieved continuous flow in low-volume production, in most cases without assembly lines, by learning to quickly change over tools from one product to the next and by "right-sizing" (miniaturizing) machines so that processing steps of different types (say, molding, painting, and assembly) could be conducted immediately adjacent to each other with the object undergoing manufacture being kept in continuous flow.

The benefits of doing things this way are easy to demonstrate. We've recently watched with our own eyes, in plants in North America and Europe, as lean thinkers practiced *kaikaku* (roughly translatable as "radical improvement," in contrast with *kaizen*, or "continuous incremental improvement"). Production activities for a specific product were rearranged in a day from departments and batches to continuous flow, with a doubling of productivity and a dramatic reduction in errors and scrap. We'll report later in this book on the revolutionary rearrangement of product development and order-scheduling activities for these same products to produce the same magnitude of effect in only a slightly longer adjustment period. Yet the great bulk of activities across the world are still conducted in departmentalized, batch-and-queue fashion fifty years after a dramatically superior way was discovered. Why?

The most basic problem is that flow thinking is counterintuitive; it seems obvious to most people that work should be organized by departments in batches. Then, once departments and specialized equipment for making batches at high speeds are put in place, both the career aspirations of employees within departments and the calculations of the corporate accountant (who wants to keep expensive assets fully utilized) work powerfully against switching over to flow.

The reengineering movement has recognized that departmentalized thinking is suboptimal and has tried to shift the focus from organizational categories (departments) to value-creating "processes"—credit checking or claims adjusting or the handling of accounts receivable.[6] The problem is

that the reengineers haven't gone far enough conceptually—they are still dealing with disconnected and aggregated *processes* (for example, order-taking for a whole range of products) rather than the entire *flow of value-creating activities for specific products*. In addition, they often stop at the boundaries of the firm paying their fees, whereas major breakthroughs come from looking at the whole value stream. What's more, they treat departments and employees as the enemy, using outside SWAT teams to blast both aside. The frequent result is a collapse of morale among those who survive being reengineered and a regression of the organization to the mean as soon as the reengineers are gone.

The lean alternative is to redefine the work of functions, departments, and firms so they can make a positive contribution to value creation and to speak to the real needs of employees at every point along the stream *so it is actually in their interest to make value flow*. This requires not just the creation of a *lean enterprise* for each product but also the rethinking of conventional firms, functions, and careers, and the development of a lean strategy, as explained in Part III.

Pull

The first visible effect of converting from departments and batches to product teams and flow is that the time required to go from concept to launch, sale to delivery, and raw material to the customer falls dramatically. When flow is introduced, products requiring years to design are done in months, orders taking days to process are completed in hours, and the weeks or months of throughput time for conventional physical production are reduced to minutes or days. Indeed, 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. What's more, lean systems can make any product currently in production in any combination, so that shifting demand can be accommodated immediately.

So what? This produces a onetime cash windfall from inventory reduction and speeds return on investment, but is it really a revolutionary achievement? In fact, it is because the ability to design, schedule, and make exactly what the customer wants just when the customer wants it means you can throw away the sales forecast and simply make what customers actually tell you they need. That is, you can let the customer *pull* the product from you as needed rather than pushing products, often unwanted, onto the customer. What's more, as explained in Chapter 4, the demands of customers become much more stable when they know they can get what they want right away and when producers stop periodic price discounting campaigns designed to move goods already made which no one wants.

Let's take a practical example: the book you hold in your hand. In fact, your copy is lucky. One half of the books printed in the United States each year are shredded without ever finding a reader! How can this be? Because publishers and the printing and distribution firms they work with along the value stream have never learned about flow, so the customer can't pull. It takes many weeks to reorder books if the bookseller or warehouse runs out of stock, yet the shelf life of most books is very short. Publishers must either sell the book at the peak of reader interest or forgo many sales. Because the publisher can't accurately predict demand in advance, the only solution is to print thousands of copies to "fill the channel" when the book is launched even though only a few thousand copies of the average book will be sold. The rest are then returned to the publisher and scrapped when the selling season is over.

The solution to this problem will probably emerge in phases. In the next few years, printing firms can learn to quickly print up small lots of books and distribution warehouses can learn to replenish bookstore shelves frequently (using a method described in Chapter 4). Eventually, new "right-sized" book-printing technologies may make it possible to simply print out the books the customer wants at the moment the customer asks for them, either in a bookstore or, even better, in the customer's office or home. And some customers may not want a physical copy of their "book" at all. Instead, they will request the electronic transfer of the text from the "publisher" to their own computer, printing out an old-fashioned paper version only if they happen to need it. The appropriate solution will be found once the members of the publishing value stream embrace the fourth principle of lean thinking: *pull*.

Perfection

As organizations begin to accurately specify *value*, identify the entire *value stream*, make the value-creating steps for specific products *flow* continuously, and let customers *pull* value from the enterprise, something very odd begins to happen. It dawns on those involved that there is no end to the process of reducing effort, time, space, cost, and mistakes while offering a product which is ever more nearly what the customer actually wants. Suddenly *perfection*, the fifth and final principle of lean thinking, doesn't seem like a crazy idea.

Why should this be? Because the four initial principles interact with each other in a virtuous circle. 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.

In addition, although the elimination of *muda* sometimes requires new process technologies and new product concepts, the technologies and concepts are usually surprisingly simple and ready for implementation right now. For example, we recently watched while Pratt & Whitney replaced a totally automated grinding system for turbine blades with a U-shaped cell designed and installed by its own engineers in a short time and at a quarter of the capital cost of the automated system being replaced. The new system cuts production costs by half while reducing throughput times by 99 percent and slashing changeover time from hours to seconds so Pratt can make exactly what the customer wants upon receiving the order. The conversion to lean thinking will pay for itself within a year, even if Pratt receives nothing more than scrap value for the automated system being junked.

Perhaps the most important spur to perfection is *transparency*, the fact that in a lean system everyone—subcontractors, first-tier suppliers, system integrators (often called assemblers), distributors, customers, employees—can see everything, and so it's easy to discover better ways to create value. What's more, there is nearly instant and highly positive feedback for employees making improvements, a key feature of lean work and a powerful spur to continuing efforts to improve, as explained in Chapter 3.

Readers familiar with the "open-book management" movement in the United States[7] will recall that financial transparency and immediate feedback on results, in the form of monetary bonuses for employees, are its central elements. Thus, there is a broad consistency between our approach and theirs. However, a major question emerges for open-book managers as finances are made transparent and employees are rewarded for performance. How can performance be improved? Sweat and longer hours are not the answer but will be employed if no one knows how to work smarter. The techniques for flow and pull that we will be describing in the pages ahead are the answer. What's more, when employees begin to feel the immediate feedback from making product development, order-taking, and production flow and are able to see the customer's satisfaction, much of the carrot-and-stick apparatus of open-book management's financial reward system becomes unnecessary.

The Prize We Can Grasp Now

Dreaming about perfection is fun. It's also useful, because it shows what is possible and helps us to achieve more than we would otherwise. However, even if lean thinking makes perfection seem plausible in the long term, most of us live and work in the short term. What are the benefits of lean thinking which we can grasp right away?

Based on years of benchmarking and observation in organizations around the world, we have developed the following simple rules of thumb: Converting a classic batch-and-queue production system to continuous flow with effective pull by the customer will double labor productivity all the way through the system (for direct, managerial, and technical workers, from raw materials to delivered product) while cutting production throughput times by 90 percent and reducing inventories in the system by 90 percent as well. Errors reaching the customer and scrap within the production process are typically cut in half, as are job-related injuries. Time-to-market for new products will be halved and a wider variety of products, within product families, can be offered at very modest additional cost. What's more, the capital investments required will be very modest, even negative, if facilities and equipment can be freed up and sold.

And this is just to get started. This is the *kaikaku* bonus released by the initial, radical realignment of the value stream. What follows is continuous improvements by means of *kaizen* en route to perfection. Firms having completed the radical realignment can typically double productivity again through incremental improvements within two to three years and halve again inventories, errors, and lead times during this period. And then the combination of *kaikaku* and *kaizen* can produce endless improvements.

Performance leaps of this magnitude are surely a bit hard to accept, particularly when accompanied by the claim that no dramatically new technologies are required. We've therefore worked for several years to carefully document specific instances of lean transformations in a wide range of firms in the leading industrial economies. In the chapters ahead, we provide a series of "box scores" on precisely what can be achieved and describe the specific methods to use.

The Antidote to Stagnation

Lean thinking is not just the antidote to *muda* in some abstract sense; the performance leap just described is also the answer to the prolonged economic stagnation in Europe, Japan, and North America. Conventional thinking about economic growth focuses on new technologies and additional training and education as the keys. Thus the overwhelming emphasis of current-day popular writing on the economy is on falling computing costs and the growing ease of moving data around the planet, as exemplified by the World Wide Web. Coupling low-cost, easily accessible data with interactive educational software for knowledge workers will surely produce a great leap in productivity and well-being, right?

The record is not promising. During the past twenty years we've seen the robotics revolution, the materials revolution (remember when cars would have ceramic engines and airplanes would be built entirely of plastic?), the microprocessor and personal computer revolution, and the biotechnology revolution, yet domestic product per capita (that is, the average amount of value created per person) in all the developed countries has been firmly stuck.

The problem is not with the new technologies themselves but instead with the fact that they initially affect only a small part of the economy. A few companies like Microsoft grow from infants to giants overnight, but the great bulk of economic activity—construction and housing, transport, the food supply system, manufacturing, and personal services—is only affected over a long period. What's more, these activities may not be affected at all unless new ways are found for people to work together to create value using the new technologies. Yet these traditional tasks comprise 95 percent or more of day-to-day production and consumption.

Stated another way, most of the economic world, at any given time, is a brownfield of traditional activities performed in traditional ways. New technologies and augmented human capital may generate growth over the long term, but only lean thinking has the demonstrated power to produce green shoots of growth all across this landscape within a few years. (And, as we will see, lean thinking may make some new technologies unnecessary.)

The continuing stagnation in developed countries has recently led to ugly scapegoating in the political world, as segments of the population in each country push and shove to redivide a fixed economic pie. Stagnation has also led to a frenzy of cost cutting in the business world (led by the reengineers), which removes the incentive for employees to make any positive contribution to their firms and swells the unemployment ranks. Lean thinking and the lean enterprise is the solution immediately available that can produce results on the scale required. This book explains how to do it.

Getting Started

Because lean thinking is counterintuitive and a bit difficult to grasp on first encounter (but then blindingly obvious once "the light comes on"), it's very useful to examine the actual application of the five lean principles in real organizations. The material in the remainder of Part I, therefore, provides real instances of lean principles banishing *muda*. The place to start, as always, is with *value* as defined by the customer.

CHAPTER 1

Value

A House or a Hassle-Free Experience?

Doyle Wilson of Austin, Texas, had been building homes for fifteen years before he got serious about quality. "In October of 1991 I just got disgusted. Such a large part of my business was waiting and rework, with expensive warranty claims and friction with customers, that I knew there must be a better way. Then I stumbled across the quality movement."

He read Carl Sewell's book on car dealing, *Customers for Life*,[1] and decided to test his claims by buying a car at Sewell's Dallas dealership. ("I thought that if even a car dealer could make a customer feel good, it should be easy for a homebuilder!") His purchase was such a positive experience that he asked Sewell for advice on quality in home building and was told to read the works of W. Edwards Deming.

Doyle Wilson is the archetypical Texan and never does things halfway. By February of 1992 he had launched a wall-to-wall Total Quality Management campaign at Doyle Wilson Homebuilder. Over the next three years he personally taught his workforce the principles of TQM, began to collect and analyze enormous amounts of data on every aspect of his business, got rid of individual sales commissions ("which destroy quality consciousness"), eliminated the traditional "builder bonus" for his construction superintendents (who were qualifying for the "on-time completion" bonus by making side deals with customers on a "to-be-done-later" list), reduced his contractor corps by two thirds, and required the remaining contractors to attend (and pay for) his monthly quality seminars.

Customer surveys showed a steady rise in satisfaction with the homebuilding experience and sales grew steadily even in a flat market as Wilson took sales from his competitors. In 1995, Doyle Wilson Homebuilder won the National Housing Quality Award (often called the Baldrige Award for quality of the construction industry), and Wilson set a goal of winning the Baldrige Award itself by 1998. Yet he was not satisfied.

"I knew I was making progress in competing with other builders for the new-home buyer, but a simple fact, once it lodged in my mind, wouldn't go away: 78 percent of the homes bought in central Texas each year are 'used' or older homes. I've been making progress in increasing my share of the 22 percent seeking a new home, but what about the 78 percent who bought older homes? Obviously, these buyers are the real market opportunity."

So instead of surveying people who were buying new homes, Wilson began to talk with people who were buying older homes. What he discovered was obvious in retrospect but has required a complete rethinking of his business. Specifically, he found that many buyers of older homes hated the "hassle factor" in negotiating for new construction, the long lead times to get the job done and move in, the inevitable "to-be-done" list after moving in, and the "phony choices" available from builders who promise custom homes but then load on as "standard equipment" many features of little interest to buyers.

Wilson soon realized that that was exactly what he had been asking his customers to go through. By contrast, older-home customers could clearly see what they were getting, buy only what they wanted, and, often, move in immediately. "No wonder I was losing 78 percent of my potential customers!"

To create a hassle-free experience to go with the house itself (these together constituting Wilson's "product"), it was necessary to rethink every step in the process. He has recently opened a one-stop sales center where the customer can see and decide on every option available in a house (for example, the forty different varieties of brick, the three thousand varieties of wallpaper, the four styles of built-in home office), customize a basic design with the help of an Auto-Cad computer system, select features beyond the standard level (for example, extra-thick carpet pads, additional outdoor lighting, and heavier-duty wiring), determine the exact price, work out the mortgage, arrange for insurance, and arrange for the title search. For customers truly in a hurry this can be done during one walk-through of the sales center.

To shrink the lead time from contract signing to moving in from six months to a target of thirty days, he has reorganized his contract-writing and job-release process and is developing a system of pull scheduling for contractors who are assigned new jobs as downstream jobs are completed. He is also introducing standardized work statements, parts lists, and tool kits for every job. Eventually these steps will eliminate the "to-do" list because the new system does not allow the next task to start until the previous task is certified as complete with perfect quality.[2]

Finally, Wilson has created a wide range of basic house designs with a minimum construction standard and asks the customer to specify all materi-

als and systems upgrades (using the computer design system) to a selected base design so the customer only pays for exactly what she or he feels is really needed.

Doing all of this will not be easy, as we'll see when we return to this example in Chapter 3 on flow, but Doyle Wilson has already made the key leap. Instead of concentrating on conventional markets and what he and his contractors were accustomed to making in a conventional way, he has looked hard at *value* as defined by his customers and set off down a new path.

Start by Challenging Traditional Definitions of "Value"

Why is it so hard to start at the right place, to correctly define value? Partly because most producers want to make what they are already making and partly because many customers only know how to ask for some variant of what they are already getting. They simply start in the wrong place and end up at the wrong destination. Then, when providers or customers do decide to rethink value, they often fall back on simple formulas—lower cost, increased product variety through customization, instant delivery—rather than jointly analyzing value and challenging old definitions to see what's really needed.

Steve Maynard, vice president for engineering and product development at the Wiremold Company in West Hartford, Connecticut, was trying to deal with these very problems when he reorganized Wiremold's product development system in 1992. For many years previously, Wiremold had developed new products—consisting of wire guides for office and industrial users and surge protectors for PCs and other business electronics—through a conventional departmentalized process. It started with marketing, which commissioned surveys comparing Wiremold's products with the offerings of competitors. When an "opportunity" was identified, usually a gap in the market or a reported weakness in a competitor's offering, a design was developed by product engineering, then tested by the prototype group. If it worked according to specification, the design proceeded to the engineers designing the machines to make the products and eventually went into production.

This system produced designs which lacked imagination and which customers often ignored. (The designs also took too much time and effort to develop and cost too much to make, but these are a different type of problem we'll discuss in Chapter 3.) Simply speeding up this process through simultaneous engineering and then broadening product variety would just have brought more bad designs to market faster. Pure *muda*.

Steve Maynard's solution was to form a team for each product to stick

with that product during its entire production life. This team—consisting of a marketer, a product engineer, and a tooling/process engineer—proceeded to enter into a *dialogue* with leading customers (major contractors) in which all of the old products and solutions were ignored. Instead, the customer and the producer (Wiremold) focused on the value the customer really needed.

For example, traditional Wiremold wire guides (which channel wiring through hostile factory environments and provide complex arrays of outlets in high-use areas like laboratories and hospitals) had been designed almost entirely with regard to their ruggedness, safety, and cost per foot as delivered to the construction site. This approach nicely matched the mentality of Wiremold's product engineers, who dominated the development process and who found a narrow, "specification" focus very reassuring.

As the new dialogue began, it quickly developed that what customers also wanted was a product that "looked nice" and could be installed at the construction site very quickly. (Wiremold had never employed a stylist and knew relatively little about trends in the construction process.) Customers were willing to make substantial trades on cost per foot to get better appearance (which increased the bid price of construction jobs) and quicker installation (which reduced total cost).

Within two years, as all of Wiremold's product families were given the team treatment, sales for these very conventional products increased by more than 40 percent and gross margins soared. Starting over with a joint customer-producer dialogue on value paid a major dividend for Wiremold quite aside from savings in product development and production costs.

While Wiremold and Doyle Wilson Homebuilder and every other firm needs to be searching for fundamentally new capabilities that will permit them to create value in unimagined dimensions, most firms can substantially boost sales immediately if they find a mechanism for rethinking the value of their core products to their customers.

Define Value in Terms of the Whole Product

Another reason firms find it hard to get value right is that while value creation often flows through many firms, each one tends to define value in a different way to suit its own needs. When these differing definitions are added up, they often don't add up. Let's take another nightmarish (but completely typical) travel example.

One of us (Jones) recently took his family on an Easter holiday in Crete from his home in Herefordshire in the United Kingdom. What was wanted was a total, hassle-free package of transport to the airport, a flight to Crete, transport to the villa in Crete, and the villa itself. What was available instead

was a product pieced together by the user and involving nineteen different operating organizations:

The *travel company* (to book the air tickets and the villa), the *taxi firm* (which doesn't deal with the travel company) handling the long trip from Hereford to London Gatwick—no airline flies nonstop between Birmingham (the nearest airport) and Crete at Easter time, the *ground staffs* at both airports (independent contractors to the airline), the *security staffs* at both airports (more independent contractors), the two *customs staffs* (to check your documents at both ends and to keep themselves occupied doing so), the two *airport authorities* (who love long layovers because spending per passenger goes up), the *airline* (which has been deintegrating and performs less of the support activities for its operations itself), the *air-traffic authorities* in five countries along the route of flight (who follow the standard form for governments by being undercapitalized and optimized for delays), the *bank* exchanging currency at Gatwick airport, the *bus company* to convey the family to the villa in Crete, and the *villa.*

The trip was reasonably routine but look at what the Jones family did to "process" itself through the system:

1. Call the travel company to make the booking.
2. Receive the tickets by mail.
3. Call the taxi company to make the booking.
4. Wait for the taxi.
5. Load the luggage (8:00 A.M. GMT).
6. Drive to the airport (three and a quarter hours), arriving two hours before the scheduled flight time as required by the airline.
7. Unload the luggage.
8. Wait in the currency exchange queue (to change English pounds into Greek drachma).
9. Wait in the check-in line.
10. Wait in the security line.
11. Wait in the customs line.
12. Wait in the departure lounge.
13. Wait in the boarding line.
14. Wait in the airplane (two-hour air-traffic delay).
15. Taxi to the runway.
16. Fly to Crete (three hours).
17. Wait in the airplane (taxi and deboarding).
18. Wait in the baggage-claim line.
19. Wait in the immigration line.
21. Wait in the customs line.
22. Load luggage onto the bus.
23. Wait in the bus.

24. Travel by bus to the villa (almost forty-five minutes).
25. Unload luggage and carry to villa.
26. Wait to check in at the villa (9:00 P.M. GMT).

The box score:

Total travel time: 13 hours
Time actually going somewhere: 7 hours (54 percent of the total)[3]
Queuing and wait time: 6 hours
Number of lines: 10
Number of times luggage was picked up and put down: 7
Number of inspections (all asking the same questions): 8
Total processing steps: 23

The problem here is not that there were too many firms involved. Each was appropriately specialized for its current task. The problem instead is that each firm was providing a partial product, often only looking inward toward its own operational "efficiency" while no one was looking at the whole product through the eyes of the customer. The minute the focus is shifted to the whole as seen by the customer, obvious questions emerge:

Could one person at check-in handle the security, customs, and check-in tasks? (Letting you walk past them into the boarding area or even onto the plane.) Better yet, could the ticket sent by your travel agent include your baggage tags, boarding passes, taxi voucher, bus tickets, and villa registration, so you just drop these off as you walk through each point? (Or perhaps travelers could create their own ticket using their personal computer linked to reservations systems. They could simply swipe their credit card through a card reader at each point, eliminating paperwork altogether along with the travel agent.) Could the customs authorities in Crete have your passport scanned at check-in in London and use the hours you are en route to figure out whether you ought to be admitted? (Then, unless there is a problem, you could just walk off the plane without visiting immigration and customs at all.) And why (does *anyone* know?) do you need to arrive at the airport two hours before departure? In short, the appropriate definition of the product changes as soon as you begin to look at the whole through the eyes of the customer.

The Critical Need for Lean Firms to Rethink Value

If you take a few moments to reflect on almost any "product"—a good, a service, or more likely both in combination—you will begin to see the same

issue of the appropriate way to define it. Doing this will generally require producers to talk to customers in new ways and for the many firms along a value stream to talk to each other in new ways. (We'll see many more examples of this need in the pages ahead—for example, the need for car companies to stop selling a product and car dealers to stop selling services, both to be replaced by a new product [personal mobility] provided jointly to the user.)

It's vital that producers accept the challenge of redefinition, because this is often the key to finding more customers, and the ability to find more customers and sales very quickly is critical to the success of lean thinking. This is because lean organizations, as we will demonstrate shortly, are always freeing up substantial amounts of resources. If they are to defend their employees and find the best economic use for their assets as they strike out on a new path, they need to find more sales right now. Beginning with a better specification of value can often provide the means.

Then, once the initial rethinking of value is done (in what might be called *kaikaku* for value), lean enterprises must continually revisit the value question with their product teams to ask if they have really got the best answer. This is the value specification analog of *kaizen* which seeks to continually improve product development, order-taking, and production activities. It produces steady results along the path to perfection.

The Final Element in Value Definition: The Target Cost

The most important task in specifying value, once the product is defined, is to determine a *target cost* based on the amount of resources and effort required to make a product of given specification and capabilities *if* all the currently visible *muda* were removed from the process. Doing this is the key to squeezing out the waste.

Conventional firms set target selling prices based on what they believe the market will bear. They then work backwards to determine acceptable costs to ensure an adequate profit margin, and they must do this any time they begin to develop a new product. So what's different here? Lean enterprises look at the current bundles of pricing and features being offered customers by conventional firms and then ask how much cost they can take out by full application of lean methods. They effectively ask, What is the *muda*-free cost of this product, once unnecessary steps are removed and value is made to flow? This becomes the target cost for the development, order-taking, and production activities necessary for this product.[4]

Because the target is certain to be far below the costs borne by competitors, the lean enterprise has choices: reduce prices (another way to increase

sales volume and utilize freed-up resources); add features or capabilities to the product (which should also increase sales); add services to the physical product to create additional value (and jobs); expand the distribution and service network (again increasing sales, although with a time lag); or take profits to underwrite new products (which will increase sales in the longer term).

Once the target cost is set for a specific product, it becomes the lens for examining every step in the value stream for product development, order-taking, and production (this latter being called operations in the case of a service like insurance or transportation). As we will see in the next chapter, the relentless scrutiny of every activity along the value stream—that is, asking whether a specific activity really creates any value for the customer—becomes the key to meeting the aggressive cost target.

CHAPTER 2

The Value Stream*

The View from the Aisle

An excellent spot for observing the value stream is the aisle of the supermarket, for it is here that a thousand streams empty into the arms of the customer. Not only does the flow of the physical product culminate in the supermarket aisle, as pulled forward by the decisions of the shopper, but also the process of product development as new products are launched. Indeed, Taiichi Ohno found this vantage point in the modern supermarket so stimulating that it inspired him in 1950 to invent the new system of flow management we now call Just-in-Time (JIT).[1]

In the past two years we have been putting ourselves in the aisle, in collaboration with the British grocery chain Tesco[2] and a number of its suppliers, to think through the value stream for specific products in a search for *muda*. To do this we have started to map out every step—each individual action—involved in the process of physical production and order-taking for specific products. Recently we have started to think about product development as well.

Our method is based on a simple premise. Just as activities that can't be measured can't be properly managed, the activities necessary to create, order, and produce a specific product which can't be precisely identified, analyzed, and linked together cannot be challenged, improved (or eliminated altogether), and, eventually, perfected. The great majority of management attention has historically gone to managing aggregates—processes, departments, firms—overseeing many products at once. Yet what's really needed is to manage whole value streams for specific goods and services.

Our initial objective in creating a value stream "map" identifying every

* This chapter is based largely on a case study developed by Nick Rich of the Lean Enterprise Research Centre, Cardiff Business School. We are grateful for his help.

action required to design, order, and make a specific product is to sort these actions into three categories: (1) those which actually create value as perceived by the customer; (2) those which create no value but are currently required by the product development, order filling, or production systems (Type One *muda*) and so can't be eliminated just yet; and (3) those actions which don't create value as perceived by the customer (Type Two *muda*) and so can be eliminated immediately. Once this third set has been removed, the way is clear to go to work on the remaining non-value-creating steps through use of the flow, pull, and perfection techniques described in the chapters ahead.

The Value Stream for a Carton[3] of Cola

The only way to make this method clear is to describe a typical value stream analysis.[4] We'll use a product chosen more or less at random in the beverages aisle at Tesco, a cardboard carton of eight cans of cola. We should, however, tell you at the outset that what we will find is fairly horrific—a lengthy set of actions extending over three hundred days, most of which consume resources but create no value and are therefore *muda*. You should understand that looking at any of the thirty thousand other items in the typical Tesco store would produce very much the same result. The cola example is neither better nor worse than the norm.

You should also bear in mind that the firms arrayed along the cola value stream are all competently managed in terms of mass-production thinking. The problem is not the competence of managers operating the system in accord with an agreed logic. The problem is the logic itself.

Producing Cola

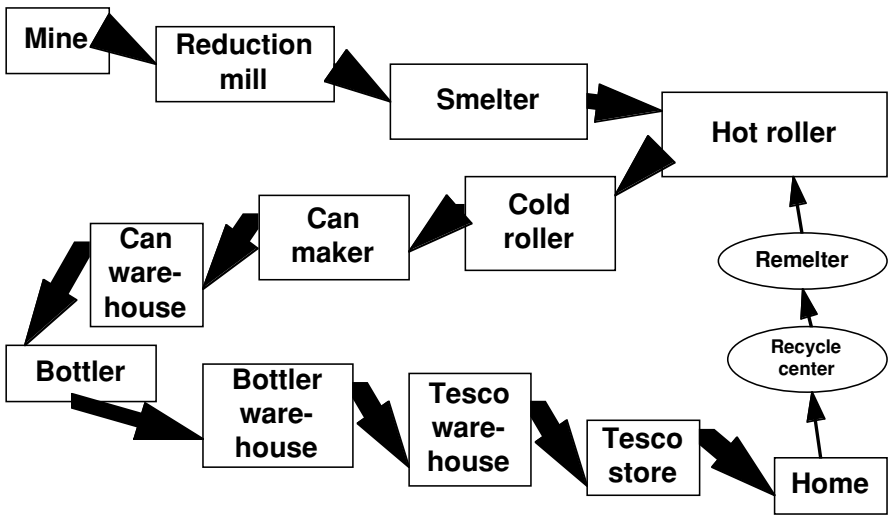
Even the mightiest river has modest headwaters. For cola one of these is literally water, supplied in the United Kingdom by the local Water Authorities. Other basic ingredients are the "essence" (in plain language, the taste) used in tiny amounts and supplied as a concentrate by the parent cola company,[5] beets for sugar, corn for caramels (to provide the "cola" color and additional taste), fir trees for cardboard to make the carton, and bauxite or recycled cans to create aluminum for the can.[6]

Because the can rather than the actual beverage is by far the most complex aspect of a carton of cola[7]—and the one with the longest production lead time—we'll initially focus our analysis on the flow of aluminum for the can,

treating sugar, caramels, essences, and cartons as tributaries joining the stream farther down the valley.

As shown in the value stream map in Figure 2.1, the first step is to mine bauxite in Australia. Although the ore could in principle be mined in small amounts and sent along to the next step within a few minutes of the receipt of an order, the mining machinery is truly massive and the actual process involves scooping out millions of tons of bauxite at a go in accord with a long-term production forecast. The mountain of ore is then transferred to massive trucks for shipment to a nearby chemical reduction mill where the bauxite is reduced to powdery alumina.

Figure 2.1: Value Stream for Cola Cans



This process, which turns four tons of bauxite into two tons of alumina, requires about thirty minutes. When enough alumina is accumulated to fill an ultralarge ore carrier (over two weeks or so; about 500,000 tons or enough for 10 million cans), it is shipped by sea—a four-week trip—to Norway or Sweden, countries with cheap hydroelectric power, for smelting.

After about a two-month wait at the smelter, the application of an enormous amount of energy (twenty times that needed to melt down and recycle old cans) reduces two tons of alumina to one ton of aluminum in about two hours. Again, scale in smelting dictates that large amounts of aluminum be created in each batch, with the molten aluminum poured into dozens of ingots one meter on each side and ten meters long. These are then carefully