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The Importance of Frugal Engineering

Providing new goods and services to "bottom of the pyramid" customers requires a radical rethinking of product development.

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A cell phone that makes phone calls — and does little else; a portable refrigerator the size of a small cooler; a car that sells for about US$2,200 (100,000 rupees). These are some of the results of "frugal engineering," a powerful and ultimately essential approach to developing products and services in emerging markets.

To get a handle on what frugal engineering is, it helps to understand what it is not. Frugal engineering is not simply low-cost engineering. It is not a scheme to boost profit margins by squeezing the marrow out of suppliers' bones. It is not simply the latest take on the decades-long focus on cost cutting.

Instead, frugal engineering is an overarching philosophy that enables a true "clean sheet" approach to product development. Cost discipline is an intrinsic part of the process, but rather than simply cutting existing costs, frugal engineering seeks to avoid needless costs in the first place. It recognizes that merely removing features from existing products to sell them cheaper in emerging markets is a losing game. That's because emerging-market customers have unique needs that usually aren't addressed by mature-market products, and because the cost base of developed world products, even when stripped down, remains too high to allow competitive prices and reasonable profits in the developing world.

Frugal engineering recalls an approach common in the early days of U.S. assembly-line manufacturing: Henry Ford's Model T is a prime example. But as industries grew and matured over the decades, and as consumers prospered to levels few would have predicted a century ago, product development processes became hardwired and standard operating procedures worked against frugality.

In addition, the profit structure in mature markets reduced incentives for major change. Constant expansion of features available to consumers in the developed world, frivolous or not, has provided many businesses with their richest profit margins. Mature-market customers continue to accept price premiums for new features, leading companies to over-engineer their product lines — at least from the point of view of emerging-market customers. The virtual extinction of manual car windows in the United States is just one example.

Frugal engineering, by contrast, addresses the billions of consumers at the bottom of the pyramid who are quickly moving out of poverty in China, India, Brazil, and other emerging nations. They are enjoying their first tastes of modern prosperity, and are shopping for the basics, not for fancy features. According to C.K. Prahalad, author of *The Fortune at the Bottom of the Pyramid*(Wharton School Publishing, 2005), these potential customers, "unserved or underserved by the large organized private sector, including multinational firms," total 4 to 5 billion of the 6.7 billion people on Earth. (See also Prahalad's "The Innovation Sandbox," *s+b*, Autumn 2006.) Although the purchasing power of any of these new consumers as an individual is only a fraction of a consumer's purchasing power in mature markets, in aggregate they represent a market nearly as large as that of the developed world.

Attracted by the size and rapid growth of emerging markets — concurrent with a growth slowdown in the developed world — companies in a range of industries are establishing distribution and manufacturing operations as well as research and development centers in these regions. However,

some of these companies may not fully grasp the challenges that competition in emerging markets entails. The prospect of high-volume profit streams may be enticing, but those profits must be earned in the face of lower prices, lower per-unit profits, and stringent cost targets.

In addition, too few companies realize how demanding emerging-market customers can be. They don't spend easily, because they don't have much to spend. They require a different set of product features and functions than their developed-world counterparts, but still insist on high quality. Global companies, therefore, must change the way they think about product design and engineering. Simply selling the cheapest products on hand or reusing technologies from higher-priced products will not cut costs enough and is unlikely to result in the kind of products these new customers will buy.

The central tenet behind every frugal engineering decision is maximizing value to the customer while minimizing nonessential costs. The term *frugal engineering*was coined in 2006 by Renault Chief Executive Carlos Ghosn to describe the competency of Indian engineers in developing products like Tata Motors' Nano, the pint-sized, low-cost automobile. Companies such as Suzuki paved the way for the development of low-cost automobiles, but there may be no better example of frugal engineering than the Nano, which will allow millions of people with modest means to reliably drive their own car. The Nano is not — like so many other low-cost vehicles — a stripped-down version of a traditional, more expensive car design. Like other newly engineered products selling well in emerging markets, ranging from refrigerators to laptop computers to X-ray machines, it is based on a bottom-up approach to product development.

Even global companies uninterested in the growth offered by the world's lowest-income consumers will have to pay attention to the lessons of frugal engineering: Products developed with this approach are beginning to compete with goods sold in developed countries, a trend that's likely to continue. Deere & Company, for example, designed and sold small, lower-powered tractors in the Indian market, but didn't begin selling such models in the U.S. until an Indian company, Mahindra & Mahindra Ltd., beat them to it. Mahindra & Mahindra has proven an able competitor to Deere in larger tractors as well. General Electric (GE), on the other hand, has been more proactive; for example, it has sold a revolutionary new low-cost handheld ultrasound scanner in developed markets by incorporating frugal engineering lessons learned in its Indian medical research and development lab. A low-cost GE electrocardiogram machine, developed at the same Indian lab for the local markets, is now being sold in the United States and Europe as well.

Meeting all these challenges will require a change in corporate culture. Some companies will be up to it; others companies will not. A successful approach to frugal engineering involves new ways of thinking about customers, innovation, and organization.

Understanding the Customer

The ultimate goal of frugal engineering couldn't be more basic: to provide the essential functions people need — a way to wash clothes, keep food cold, get to work — at a price they can afford. Critical attention to low cost is always accompanied by a commitment to maximizing customer value. The Tata Nano development team's decision not to include a radio on the standard model wasn't a simple move to avoid cost. The team understood that the typical Nano customer places far more value on extra storage space. Using what normally would be the radio slot for storage not only avoided a major cost, but also added value for the customer.

Such carefully calculated trade-offs, made at the product planning stage, serve the dual purpose of maintaining low costs and increasing the product's overall functionality and utility for the buyer. Assessment of those trade-offs requires close, careful observation on the part of planners if they are to arrive at a deep understanding of the ways a product fits (or doesn't fit) into customers' lives.

The Nokia 1100 cell phone is another example. Experience has shown that when low-income people in just about any country begin to enjoy a bit of economic prosperity, one of their first purchases is a cell phone. Many new cell phone customers in emerging markets are agricultural workers who spend their days outdoors. When Nokia developers watched field-workers using mobile phones in India, they noticed that the intense humidity made the phones slick and hard to hold or dial. So the phone was built with a nonslip silicon coating on its keypad and sides. The handset was also designed to resist damage from dust that is common in arid climates and some factory environments. The phones are otherwise basic: They can send and receive phone calls and text messages. The screens are monochrome. Because the phones lack fancy software, the power draw is smaller, so they can operate longer between charges. The only real extra is a tiny, energy-efficient flashlight that's proven popular in areas where power blackouts are common — in other words, in most rural villages and many emerging-market cities. At a price of $15 to $20, the Nokia 1100 is the best-selling cell phone ever.

Refrigerators provide another good example. Customers at the bottom of the pyramid can't afford traditional energy-sucking, compressor-driven refrigerators, not even the "small" floor models a Western business might have installed under the office credenza to keep drinks cold.

Rather than cut costs out of a bigger refrigerator, India's Godrej Appliances started with a clean sheet, closely observing the occupants of village huts. Most Indians, they noted, go to the grocery every day. They don't buy in bulk. A refrigerator that could hold just a few items would be plenty. So Godrej produced the ChotuKool, which translates into "Little Cool" in English.

The top-opening fridge measures 1.5 feet tall by 2 feet wide (roughly 46 by 61 centimeters) and has a capacity of only 1.6 gallons (6 liters). It has no compressor, instead using a cooling chip and fan similar to those that keep desktop computers from overheating. It can run on a battery during the power outages that are inevitable in rural villages. And since rural Indians change residences frequently, the ChotuKool also comes with a handle, making it easier to transport. By keeping the number of parts down to around 20 instead of the 200-plus used in conventional refrigerators, Godrej keeps the price low, too, at about $55. Spending time in people's homes and watching how they actually use products, rather than relying on focus groups or other secondary or tertiary research, was the key to determining consumer needs.

The frugal engineering approach is not limited to consumer products. Zhongxing Medical, a small medical devices company in China, developed an X-ray machine with a price tag one-twentieth that of the typical X-ray machines made by foreign companies. To achieve this, Zhongxing, a subsidiary of Beijing Aerospace, made a trade-off: Rather than engineer the machine to accommodate the wide range of sophisticated scans common in Western hospitals, the company focused on a machine that could perform only the most routine chest scans, which represent the vast majority of scans. By understanding the fundamental needs of its target hospitals — hospitals that cannot afford a conventionally priced X-ray machine but still hope to serve a majority of patients — Zhongxing has captured about 50 percent of the Chinese X-ray market.

Bottom-up Innovation

Typically, when a well-established automaker designs and builds an inexpensive car, the company's thinking is biased by decades of practices and procedures, and by its relationships with employees, customers, and suppliers. The approach reuses existing designs and relies on existing components. In essence, these companies start with a more expensive car and focus on ways to make it cheaper. That may count as a form of cost cutting, but it is not frugal engineering.

By contrast, when Tata Motors engineers began creating the Nano, they were inspired more by the three-wheeled vehicles known in India as auto-rickshaws than by any existing car models in Tata Motors' lineup. Building up from the bare minimum enabled the engineers to achieve their cost (and price) targets without compromising the essential functions of the car. If instead the Tata Nano had been designed on the platform of the then cheapest Tata car, it would have been twice the price.

Consider the conventional approach: Decades' worth of engineering value is built into even the least expensive of today's automobiles. Components, right down to the steel used, have steadily become more sophisticated, and often more expensive. The cost base, the design thinking, the very idea of what makes an automobile — all combine into a set of structural costs that simply go unquestioned. Reversing course is difficult, and few want to try. For example, if you asked Western designers to come up with a low-cost wiper system for cars, it's unlikely they would challenge the fundamental architecture of two wiper blades. But it would be cheaper to place one blade in the center that sweeps from end to end. India's auto-rickshaws have a single blade. Now, so does the Nano.

To achieve the drastically lower prices that emerging markets require, companies must be open to rethinking all aspects of the product. The Nano uses not only just one wiper, but also just one side-view mirror, and the seats are not adjustable. This represents a clear departure from the trends in conventional vehicles, and involves questioning the form and necessity of so-called standard features. Making these sorts of radical decisions is a form of innovation. Such choices are answers to questions that too few global companies are asking.

Organizational Agility

Frugal engineering requires that companies be open to organizational innovation, as well. Three areas are particularly important.

1. Cross-functional teams. The Tata Nano was developed by a team of 500 mostly young engineers, significantly smaller than the teams of 800-plus typically employed by Western automakers. In fact, a team for a new platform like the Nano at a U.S. or European car company would likely total more than 1,000. To make sure that the project got the attention it required, Tata created a separate unit, isolated from the rest of the company. In addition to its compact size, the Nano engineering team had another advantage over traditional engineering groups: It worked cross-functionally with other teams to maximize the chances of finding ways to keep costs low. When a legacy automaker like General Motors launches a car, its marketing group might be five times the size of the Nano's marketing team, which totaled three people.

The computer chip that replaced the compressor in Godrej's low-cost refrigerator represented such a radical move that it likely would not have made it to the final product had the development group started with the standard operating procedures of the refrigerator industry. The procurement team instead raced to identify a low-cost component supplier while the manufacturing team quickly reengineered the assembly line to handle chips instead of compressors.

Why would that kind of agility be difficult for a Western company? Typically, the more mature an organization, the more rigid the functional silos. There tends to be little coordination between functions without an explicit effort from top management, which must either create a new structure for the team or use brute force to encourage communication. That is happening more often, but it's still more the exception than the rule.

In mature industries, companies are optimized for their main customers. For emerging markets, a different organizational approach is required, both within and outside the organization.

2. A nontraditional supply chain. When reducing costs, most companies focus on getting better prices from their suppliers. The problem with this approach is that the reductions can go only so far; cut too deep, and the suppliers' margins are eliminated. Frugal engineering instead treats the suppliers as an extension of the enterprise. Such a lean manufacturing approach is not new, of course. But frugal engineering pushes the concept further, by demanding new levels of cost transparency, and by requiring that suppliers grant genuine authority to their representatives on the core product team.

A frugal development team must look beyond the usual, approved list of suppliers. The targets in frugal engineering projects are often so tight that conventional suppliers are unlikely to be able to meet the requirements for cost, quality, and timeliness of delivery.

At the same time, suppliers step up and become more involved in development projects. Traditionally, original equipment manufacturers (OEMs) dictate their requirements to suppliers; the suppliers ask few questions and compete on price. In frugal engineering, the game is different. OEMs and suppliers team up to set cost targets and a cost structure. Rather than focus on individual components, they work together to optimize entire

systems. For example, the Nano uses a simple motorcycle-style speedometer and forgoes a tachometer in the instrument cluster, but it includes a digital odometer. The costs saved on one were spent on the other, avoiding an analog odometer and a tachometer that few customers would use. By cooperating on developing the whole system, the supplier and Tata created a more appealing instrument cluster while still meeting the target cost.

Often, a higher-level commitment from suppliers has required a mandate from supplier CEOs. For example, Bosch CEO Bernd Bohr took on the cost-target challenge for the Nano and made sure Bosch came through by adapting a motorcycle starter motor to save weight and by finding a way to trim several ounces from the generator.

3. Top-down support. Nothing is more important to frugal engineering than commitment from the top — and not just from suppliers. The best examples of frugal engineering were championed by company founders. Ratan Tata, chairman of Tata, said, "I will design a car for $2,200. Period." (See "Too Good to Fail," by Ann Graham, *s+b*, Spring 2010.) The same happened at Mahindra & Mahindra, when Anand Mahindra, the managing director, publicly backed the cost-control plans of Pawan Goenka, the company's automotive chief. Mahindra's personal support proved essential to keeping costs low. A new automobile platform in the U.S. might cost anywhere from $700 million to $1 billion. Mahindra's Scorpio SUV was developed at a cost of $150 million. The car may lack the sophistication and status of other makers' luxury models. But it's right for its market. s+b

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