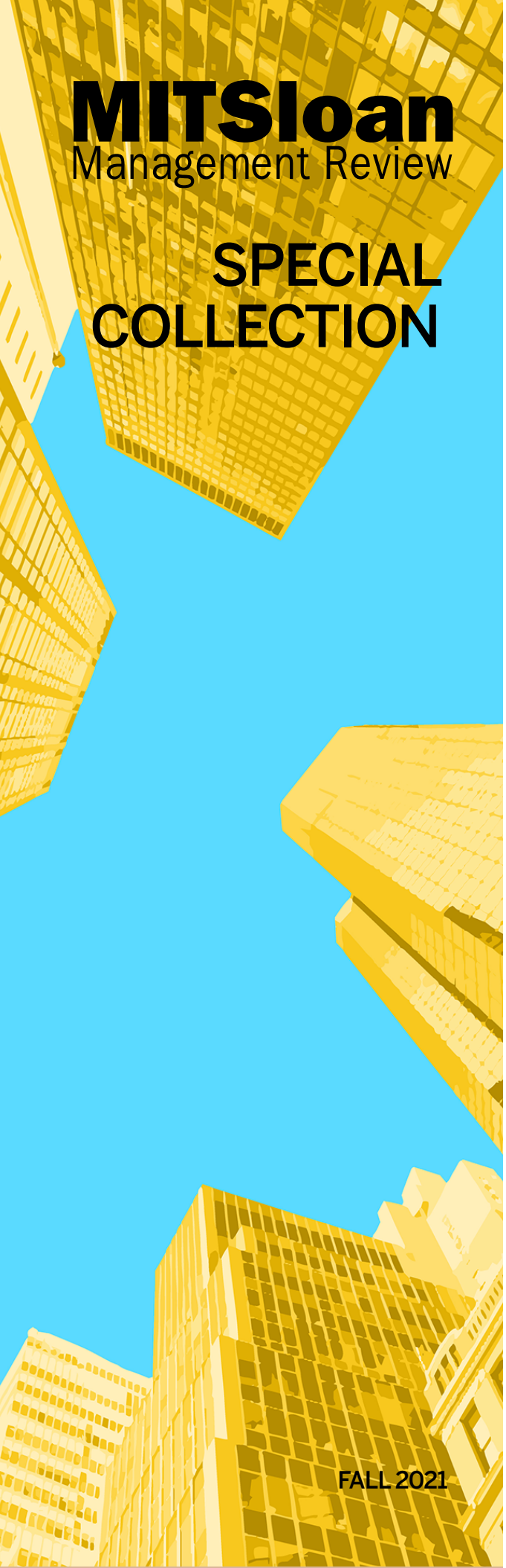


MITSloan Management Review

SPECIAL COLLECTION

CORPORATE SOCIAL RESPONSIBILITY

Sustainable Business

Creating value while doing right by people and the planet.

FALL 2021

SPECIAL REPORT

MANY BUSINESSES ARE SEEKING to be better corporate citizens by reducing their environmental impact and improving conditions for workers. While activist consumers have played a role in pushing companies to make positive changes, visionary leaders are themselves considering the growth opportunities that can come from pursuing such agendas.

Executing a business strategy that results in less damage to the environment and is equitable for all stakeholders doesn't have to mean sacrificing margins, say Marco Bertini, John Pineda, Amadeus Petzke, and Jean-Manuel Izaret. They argue that more creative thinking about both pricing mechanisms and cost mitigation can allow a company to do well by doing good.

Supply chain scholars Tim Kraft and Yanchong Zheng see efforts to improve transparency in the supply chain — and root out bad suppliers with poor environmental or labor practices — as a way for companies to stand out from competitors and appeal to customers who prefer to buy from socially responsible businesses. A particularly murky area of the supply chain is unauthorized subcontracting, but myth-busting research by Felipe Caro, Leonard Lane, and Anna Sáez de Tejada Cuenca demonstrates the power of analytics to predict — and curtail — this problem.

Finally, while some are pessimistic about the prospects for large-scale decarbonization of sectors such as industrial heat and heavy transport, Amory Lovins presents an alternative view: He sees a disruptive transformation on the horizon, in which new competitors will seize on the shift away from fossil fuels to renewable electricty to develop new business models — and bring us closer to the promise of a net-zero 2050.

— Elizabeth Heichler

SUSTAINABILITY STRATEGIES

CREATING VALUE WHILE DOING RIGHT BY PEOPLE AND THE PLANET

Can We Afford Sustainable Business?

Taking a creative approach to pricing can benefit society, the environment — and your company.

BY MARCO BERTINI, JOHN PINEDA, AMADEUS PETZKE, AND JEAN-MANUEL IZARET

"How are we going to pay for this?"

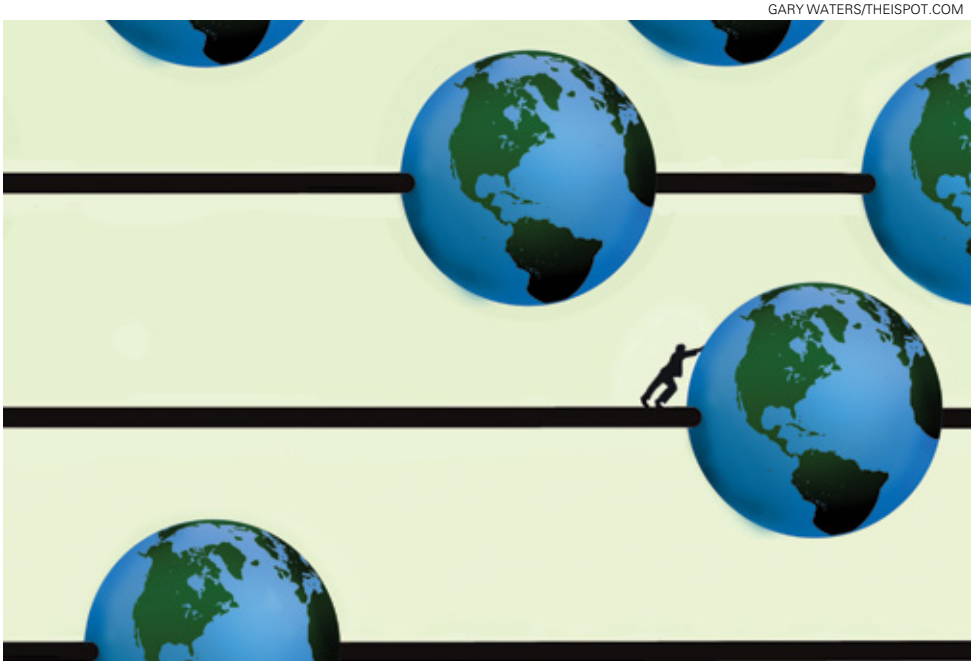
In that question lies the conundrum faced by the growing ranks of corporate leaders who recognize that business must, at the very least, stop contributing to the most urgent problems facing humanity and ought to, at best, help solve them. In mission statements and strategic plans, many companies are making commitments to improving sustainability and reducing inequity — but when it comes to meeting those goals, they are tripped up by the financial implications.

In reality, we have no shortage of ideas on how to provide greater and more equitable access to goods and services, use them conscientiously and more effectively, and leave the least amount of waste behind. But we are frequently held back in implementing those ideas because of the presumption that any sustainability initiative invariably leads to higher costs, higher taxes, higher fiscal deficits, and, ultimately, higher prices. "How are we going to pay for this?" becomes a killer question seemingly designed to stifle progress.

Overlooked in the debate, however, is one factor that unnecessarily limits the scope that leaders in all spheres — whether business, politics, or nonprofit — need to implement solutions that can scale to meaningful impact.

That factor is the price mechanism. We contend that it's possible to find creative solutions that rally all market actors around responsible behaviors that mitigate the negative externalities of commerce *before* businesses tally them up and price them in. In one sense, we argue that organizations act more as caretakers of markets than as simple producers, using the incentives and information embedded in the price mechanism to allocate the responsibility for broader and fairer access, for conscientious and effective consumption, and for handling waste more efficiently.

GARY WATERS/THEISPOT.COM



At the root of the problem is the premise that the only way companies can ease the burden of commerce on our society is to account for it properly and find someone to foot the bill. This premise corners businesses into what we call a *taboo trade-off*. A company can try to pass the incremental cost of environmentally or socially responsible practices onto customers, but they may not be willing or able to pay it and thus flee to cheaper competitors or leave the market entirely. Alternatively, the company can absorb this cost by sacrificing margin, cutting corners on quality, or making the supply chain "sweat" until the economics work out. In each case, the financial or reputational risk is such that the organization often sees "Do nothing" as the pragmatic solution. It dodges the trade-off instead of addressing it.

This conundrum is particularly frustrating for leaders who are committed to driving change. Emmanuel Faber led France's Danone for over six years and was widely seen as a prominent advocate for a more responsible capitalism that serves not only shareholders but also the environment, employees, and suppliers.[1] But in March 2021, Faber lost his job as chairman and CEO after activist shareholders voiced their displeasure with Danone's financial performance, strategy, and governance.

The dismissal of someone like Faber reflects an undercurrent of skepticism that still simmers behind the scenes at purpose-oriented businesses. One CEO of a European multinational reportedly said that if he made his company's environmental policy greener, "my profit margin would fall 3% per year, my stock price would fall 15%, and I would get fired."[2] Indeed, a recent study indicates that CEOs who enact greener or more sustainable policies are significantly more likely to get fired for poor performance than CEOs who do not.[3]

Capitalizing on Degrees of Freedom

The good news is that leaders have far more leeway with the price mechanism than they realize. This quickly becomes apparent when they stop thinking that "How are we going to pay for this?" is the only question and "Price in the externalities" is its only answer. In fact, every price decision builds on the answers to three basic questions:

- *What* are customers paying for?
- *Who* is going to pay?
- *When* and *how* do we transact?

Most businesses take these questions for granted and believe the answers to be moot and immutable. However, rejecting that assumption and thinking more expansively about what, who, when, and how can lead to innovative solutions.

Rethinking *what* customers pay for matters because it determines the extent to which organizations generate revenue by delivering outcomes that customers desire rather than providing them with inputs (products and services). The traditional "make and sell" approach can put a financial and physical strain on access, because it forces customers to find a solution and purchase it outright. This approach neither motivates customers to think responsibly about consumption nor guarantees that they will be satisfied with the purchase. Finally, "make and sell" transfers ownership — and therefore the burden of disposal — from suppliers to customers who may not have the drive or expertise to dispose of goods responsibly.

Today, a host of novel commercial arrangements — such as subscriptions and memberships, pay-as-you-go models, collaborative consumption, revenue-sharing agreements, and performance-based contracting — can address these challenges without transferring ownership. Each of these

> Leaders have more leeway with the price mechanism than they realize — if they stop thinking that "How are we going to pay for this?" is the only question and "Price in the externalities" is its only answer.

alternatives can ease the access problem inherent in traditional transactions, because companies earn their revenue only when they provide customers with direct, unencumbered access to their offerings. Similarly, pay-as-you-go and sharing approaches encourage sensible consumption because customers pay at each consumption episode, and performance-based contracts ensure that companies get paid only when they deliver value, not when they promise it.

As they consider *who* pays, business leaders need to question whether it makes sense for all customers to pay the same price, or even to pay at all. This may seem potentially unfair. But whenever universal access is the target in a sector, businesses should consider varying prices based on people's ability or willingness to pay or, in the case of third-party payers, the value that an individual end user derives.

In certain situations, companies might think in terms of interconnected currencies such that customers might pay to satisfy their own basic needs in something other than money. One example is subsidizing the purchase of water filters in order to eliminate the need to boil water on wood fires to make it potable. The reduction in carbon emissions resulting from the decreased use of wood fires has a monetary value on the carbon market, and this can be used to fund the enterprise.[4] The key here is to ensure that the behavior tied to the intermediate currency (such as fewer wood fires) aligns with the benefit pursued by the user (such as access to clean water). Otherwise, focusing on the former to generate revenue can distract from achieving the latter, which is in fact the primary goal.

Likewise, in some sectors, certain behaviors are clearly desirable from a social or environmental perspective, such as purchasing soon-to-expire food to avoid waste or participating in physical activity to improve one's health. In those cases, businesses should consider varying prices not based on customers' ability or willingness to pay, but based on their readiness to act responsibly.

Companies should likewise reconsider *when* and *how* to collect payment. They can turn to micropayments to allow more granular access. If reasonable, they can also defer payments to ease the financial burden on customers or, importantly, to better align the timing of costs and benefits. Finally, one can think creatively about payment as an opportunity to engage people. For example, to fight against low donation rates in 2014, the relief organization Misereor deployed interactive billboards that enabled bystanders to offer 2 euros by swiping their credit cards over the screen. True to its principle of "playful, not pitiful," Misereor deployed technology such that the swipe activated an engaging interactive sequence depicting the credit card slicing a piece of bread to feed the hungry or freeing an imprisoned child.[5]

In the rest of this article, we show how a broader, more creative take on these three questions can alleviate the taboo trade-off and accelerate progress.

Scaling Solar Energy

The battle to mitigate the effects of climate change is widely seen as a race against time. This urgency was recognized by the 196 countries that signed on to the 2015 Paris Agreement, which committed to reaching zero carbon emissions by 2050.[6] Conducting business as usual will doom those efforts.

Making progress against this ticking clock requires a multitude of solutions aimed at improving equitable access to renewable energy sources, combined with more conscientious consumption. The circumstances and challenges vary greatly from market to market, but one common denominator is that traditional views on the price mechanism create a taboo trade-off that hinders the adoption of cleaner solutions. How can the energy sector transition from a profitable carbon-based market to one that is equally profitable but greener?

One of the biggest obstacles inhibiting the adoption of solar energy among households is the upfront investment required to install solar panels. In developed countries, a residential installation can cost tens of thousands of dollars, even though the price per watt for photovoltaic (PV) panels dropped by almost 80% between 2010 and 2020. After making this investment, homeowners must wait many years to break even and start to enjoy the financial benefits that solar energy provides. The discrepancy between the timing of payments and onset of cost savings is so large that no reasonable price concession can bridge it satisfactorily.

However, opportunities emerged when the suppliers of solar energy solutions reexamined the three core questions.

• **What are customers paying for?** Simply put, households want to pay for cleaner energy rather than the inputs to access that energy. Recognizing this, pioneering companies Sunrun and SolarCity (now known as Tesla Energy) began offering customers a power purchase agreement (PPA). Instead of selling panels or establishing a fixed set of loan payments, they sold customers the energy output from the panels installed on their roofs, reflected as a discount to their utility rates. They also guaranteed the system output for 20 to 30 years. This change of focus, from panel sales to the provision of clean energy, enabled PV manufacturers to offer an alternative to the traditional approach predicated on a large upfront payment.

• **Who is going to pay?** Homeowners still pay for energy, but, to a large extent, the U.S. federal government has also paid large amounts of money for the installation of solar panels, through a mixture of subsidies and tax credits. Another alternative to outright purchase, leasing, lessens the need for these extensive government payments as a means to bring down the large upfront cost and create a purchase incentive. Ideally, this shift can take the government (and its taxpayers) out of the equation entirely and change the "who" to the homeowners themselves.

• **When and how do we transact?** Let's assume that the upfront cost of a PV installation by Sunrun in the U.S. is $21,000, before tax benefits.[7] The majority of homeowners are still opting to pay for or finance that expense and draw the "free" solar energy. But around 35% of homeowners now opt to enter into a PPA, which eliminates this upfront expense in exchange for a guaranteed energy supply from day one at monthly payments below prevailing market rates. This agreement creates a dependable revenue stream for the supplier and also offers consumers an appealing alternative to paying or financing a significant upfront cost.

Combined with the overall decline in PV prices, the introduction of PPAs alongside traditional leasing agreements helped fuel exponential growth in the solar market. Take California as an example. Installed capacity increased from 163 megawatts (MW) in 2010 to 1,950 MW in 2015. Leasing accounted for 63% of the installations in 2015, versus just 10% in 2010.[8] For comparison, leasing historically accounts for around 30% of new car registrations in the U.S. each year.

It is interesting to note that the market for direct purchases grew impressively as well in the same period, from 147 MW to 720 MW. In other words, the lower prices for PV panels would have naturally driven growth.[9] The lesson is that products can become even more accessible — and progress toward ambitious environmental, social, and governance goals can be achieved even faster — when companies are willing to reconsider preconceived notions about their prices.

The problem of energy access is universal. In sub-Saharan African countries, it can be prohibitively expensive to extend existing grids to serve remote populations. This includes 22 million displaced people in the region who lack access to electricity. Solar home kits have therefore become an attractive alternative, because they can help most families meet their basic power needs and avoid relying on diesel generators (or going without power). The upfront retail cost of a basic solar home kit is around $180, but that is a large expense for a family that might earn $1 to $2 per day.[10] What has accelerated adoption of the kits is an approach similar to the one used by telcos: a deposit combined with a pay-as-you-go charge. Most people use their cellphones to make the micropayments directly. The overall benefits of the solar home kits are numerous, ranging from less pollution and greater safety to freeing up time for education or work. They also offer a more reliable source of energy, not only because of the abundant sunshine, but also because diesel fuel or other energy sources are subject to disruption.

Lifesaving Treatment for All

The hepatitis C virus (HCV) currently afflicts over 70 million people worldwide. It is a leading cause of cirrhosis and liver cancer; a Centers for Disease Control and Prevention study found that in 2013, it killed more people in the U.S. than the next 60 infectious diseases combined, including HIV and tuberculosis.[11]

What makes disease management challenging is the wide range of symptoms and the respective costs to treat them. It may cost only a few hundred dollars to treat patients with mild symptoms, whereas treatment costs can run as high as $300,000 for the roughly 10% of patients who require a liver transplant.

> Gilead and the state of Louisiana brought new thinking to the price mechanism for a hepatitis C treatment, resolving the taboo trade-off by rethinking what customers pay for, and how they transact.

This reality presented Gilead Sciences, maker of breakthrough HCV therapy Sovaldi, with a significant taboo trade-off. By curing an otherwise chronic disease in just 12 weeks, Sovaldi literally provides a lifetime benefit to patients. But the industry's standard pricing approach — which is to charge a price per treatment at the time of care — makes it prohibitively expensive to treat patients with mild symptoms. At a price tag well north of $50,000 for that 12-week course, Sovaldi makes economic sense only for that small minority of patients with severe complications.

A lower price point would broaden access and hasten the World Health Organization's goal of reducing deaths due to HCV by 65% by 2030.[12] But it would also make the cure far less profitable, creating a quandary for leaders in biopharma companies who have a mandate to recover substantial investments in R&D and yield returns to investors.

A novel approach to the price mechanism offered the health care ecosystem a way to resolve the taboo trade-off. Gilead worked with the state of Louisiana to rethink two of the fundamental questions outlined above:

- **What are customers paying for?** Instead of paying to treat only the most affected patients on the standard per-dose or per-therapy basis, health insurance payers could pay "per population cured." This would allow for a spreading out of total benefits at the population level, regardless of the extent of any individual's symptoms at the time of treatment.
- **When and how do we transact?** The payments are spread out over multiple years, rather than being due when treatment is administered, to better match the timing of the lifetime benefits to patients. This also benefits the Louisiana Medicaid system, which pays for fewer liver transplants and other expensive interventions. This approach allows funding to reach all patients where there is a clear clinical and economic rationale.

Spreading payments over time and benefits across the population yields better economics for all. This arrangement is aptly nicknamed the Netflix model, because it resembles a subscription to a streaming service. The buyer pays a fixed price for access to a catalog of content, rather than paying potentially much more for individual content streams a la carte. This model is similar to the concept of software vendors' enterprise license agreements, under which an entire population of employees gains access to a software catalog. The supplier secures a constant revenue stream and serves many more users than it would on a case-by-case basis. The buyer secures value over time for the entire population in a way that allows everyone to benefit, regardless of their consumption level.

In 2019, Louisiana paid a subsidiary of Gilead a lump sum in exchange for as much of its HCV regimen as warranted to treat patients in its Medicaid program and correction facilities through 2024.[13] The exact terms of the deal are not known, but the amount is estimated to be significantly less than the aggregate sum that would have been necessary to treat all HCV patients at the ongoing per-therapy price. If we assume roughly $35 million per year for the minimum 31,000 HCV patients mentioned in the news release, that amounts to about $1,130 per patient per year for population-level coverage, or approximately $5,600 per patient over the five years of the contract.[14] Later in 2019, the state of Washington entered into a similar deal with the drugmaker AbbVie.[15]

There is some skepticism about the willingness of different players in the health care ecosystem to come to the table on this type of arrangement versus the more familiar pay-per-treatment one. But several new trends are helping all parties become

accustomed to aligning prices with the timing of value delivery in a way that boosts efficiency. These trends include the increasing adoption of quality-adjusted life years as a generic measure of disease burden and a means to price treatments based on health outcomes, as evidenced by Roche's recent efforts on personalized reimbursement models.[16]

Driving Efficiency in Education

The cost of higher education in the U.S. is increasingly untenable for both students whose financial futures are hostage to crippling levels of debt and to the federal government, which backs over 90% of the more than $1.7 trillion in outstanding student loans.[17] At issue is how to prevent that pile of debt from rising further and, more broadly, how to ensure that spending on higher education actually leads to desired outcomes such as learning and employment.

One solution addresses the "who" and the "when and how" questions, and in some cases the "what" question as well. Known as an income-share agreement (ISA), the arrangement calls for the student to pay the educational institution only when they are earning an annual salary above a certain threshold. The payment is a percentage of their income until the tuition is paid in full. The difference between an ISA and a conventional loan is that there is no interest rate, nor are any payments required if the student remains unemployed or earns wages below the threshold. These programs may appeal to students in one- or two-year skill-certificate programs, but major universities such as Purdue have also launched ISA programs.[18]

The state of Tennessee has turned the principle of the ISA into a comprehensive program under the umbrella Drive to 55. The "55" refers to the target of having 55% of residents possess a college degree or technical certification by 2025. The program includes the Tennessee Promise, which offers scholarships for qualifying students to attend selected colleges or technical schools for free, and Tennessee Reconnect, which allows adults without a degree or certification to complete one at no out-of-pocket cost. The difference between the Tennessee programs and an ISA is that there is no repayment plan at all.

The program has worked for several years because it aligns the incentives for all parties. Students gain access to an education, while the state derives a return on its investment by creating taxpayers and also making the state more attractive to companies that need a large pool of workers with 21st-century skills. The state also gains because the Tennessee Promise program requires students to fulfill a community service commitment.

Closing the Loop in Fashion

If the fashion industry were a country, it would be the fourth-worst emitter of greenhouse gases in the world, trailing only China, the U.S., and India.[19] One estimate shows that players in the sector consume more energy than aviation and shipping combined.[20] At the same time, the dependence on cotton — and thus the corresponding dependence on irrigation and agrichemicals — has had considerable environmental impact: It can take as much as 2,700 liters of water to make one cotton T-shirt.[21] Even then, each American on average throws away 80 pounds of textiles every year, which adds up to around 12.8 million tons of trash.[22]

Consider a pair of "fast fashion" jeans that retails for, say, 40 euros (roughly $50). The Impact Institute estimates the "true price" of these jeans, or the sticker price factoring in the cost to society and the environment of bringing the product to market, at 73 euros (around $90).[23]

The taboo trade-off here is clear. On the one hand, consumers are likely to balk at paying almost twice as much for something intended to last one

> Income-share agreements are one solution to the crisis of higher education cost and student debt that addresses the "who" and the "when and how" questions, and in some cases the "what" question as well.

Companies are taking creative steps to reduce the waste inherent in the fashion pipeline. One way is to promote reusing or recycling clothes instead of trashing them, as a means to close the loop.

or two seasons. On the other hand, most producers and retailers do not have nearly enough margin to absorb the spike in costs. Faced with this prospect, turning a blind eye to the environmental impact is almost understandable.

The challenge, then, is to look for ways to mitigate the negative externalities rather than pricing them in. To that end, companies are taking creative steps to reduce the waste inherent in the fashion pipeline. One of the most far-reaching steps is to promote reusing or recycling clothes instead of trashing them, as a means to close the loop. As Karl-Johan Persson, then-CEO of H&M, explained, "We have to change how fashion is made. We have to go from a linear model to a circular model, and we have to do it at scale."[24]

This is exactly where rethinking the "what" question is critically important. The fashion industry's traditional "make and sell" model, where the ownership of an item of clothing transfers from the retailer to the customer at the point of sale, puts the responsibility for closing the loop squarely on the shoulders of each individual. This is not efficient, given that people differ in their desire to do good and, even if sold on the idea of recycling, may not have the means or opportunity to do so.

One way to motivate people to be more responsible is to pay them for it. For example, as part of its Worn Wear program, popular outdoor clothing company Patagonia offers customers store credit when they trade in old items. However, the industry as a whole may not advance on circularity at the speed we need unless it embraces a means of generating revenue that is *not* predicated on the transfer of ownership — one that does not rely on individual customers to do the right thing.

For example, fashion labels should think seriously about introducing leasing and subscriptions, where customers buy access to apparel and accessories rather than the items themselves. This shift in the "what" does away with having to rely on the conscientiousness of individuals and puts reuse and recycling back on the shoulders of manufacturers, which presumably can handle this task more efficiently and at scale. Returning to the example of jeans, MUD Jeans from the Netherlands leases jeans to customers for 12 months, after which they can keep them or return them for recycling. Similarly, Rent the Runway lets people rent high-end clothes that would otherwise be prohibitively expensive to purchase, while Nuuly offers a clothing subscription that starts with six items for $88 per month.

As people grow more accustomed to renting clothes or subscribing to a wardrobe service, suppliers gain degrees of freedom to mitigate the taboo trade-off expressed in the true price of clothing.

Making Smarter Prices

Our own research and work with CEOs and other leaders have convinced us that organizations must rethink the three critical questions we have described if they want to strike a healthier balance between their sustainability goals and their more immediate obligations to customers, employees, and shareholders. The following recommendations — which run from the initial thought process through to implementation — should guide leaders to find creative new answers to the what, who, when, and how questions.

Make the "green premium" transparent and actionable. The root cause of the taboo trade-off is what Bill Gates dubbed the "green premium." When an environmentally friendly product costs twice as much as the conventional "dirty" version, few customers or businesses are willing to foot the bill. But when managers have greater visibility into what is driving higher costs, they can make more informed decisions on where to direct their

attention as they reconsider both how prices are set and the decisions in the supply chain that can reduce the footprint of business as usual.

Focus on outcomes, not products. This mind shift forces a broader scope that brings externalities into sharper focus. Some apparel companies, for example, are reorienting from "selling garments" to "clothing people" and are incorporating tailoring, repair, and recycling programs into their consumer engagement. Similarly, shifting from "selling cars" to "providing mobility" may reduce materials consumption and waste while providing vehicle makers and new competitors with new opportunities to meet customer needs. Offering true solutions to customer problems will remain aspirational as long as companies focus too much on the means rather than the end.

Align payments and benefits. For many solutions, the biggest hurdle is the clear misalignment between the timing of payments (usually upfront) and the onset of benefits (usually over time). For example, the sticker price on an electric vehicle such as the Chevrolet Bolt is about 40% higher than a comparable gas-fueled car, but the lifetime operating costs are significantly lower for the former, never mind the environmental benefit from lower emissions.[25] Alternatives to paying upfront, such as subscriptions, leasing, pay-as-you-go models, and even performance-based agreements, shift the timing of payments to align better with the timing of benefits perceived by customers. They also make access to products affordable to more people by spreading expenses over time.

Serve populations, not segments. Population-based pricing agreements make sense when a solution has broad applicability, but individual customers' willingness or ability to pay varies dramatically. In this case, the "what" shifts from a single dose or single product to coverage for an entire population. Optimal pricing based on target segments is exclusionary by definition, while population-based pricing aims to find a way to be inclusive. A salient example is the population-level agreements struck by Pfizer-BioNTech in the U.S. and Europe for its COVID-19 vaccine, which facilitated much lower price points than normal for such a breakthrough treatment.

Activate the ecosystem. Rethinking the company's solution or time-shifting this year's revenues into the future often creates opportunities that a single company cannot pursue on its own. Creative approaches to the price mechanism tend to involve multiple partners, such as financing partners for renewable energy and vehicles, and value-based health partners for migrating to health outcomes. Financing, support, and last-mile delivery are all common puzzle pieces in the ecosystem that require a company to look beyond its core business.

Create a shareholder tailwind. While tension may always exist between sustainability and profitability, more and more stakeholders are seeing the former as part of long-term value creation rather than a threat to it. Turning shareholder headwinds into tailwinds is an important factor. The leverage of powerful investors is now providing support for viable sustainability actions. For example, BlackRock has made a commitment to sustainable investing as a path to long-term value creation, and the California Public Employees' Retirement System has recently pushed for more accountability on climate risk in oil and gas. In our experience, significant changes to the price mechanism requires dedicated communication and engagement with all stakeholders.

THE WAY THAT MOST companies currently understand the price mechanism does not bode well for their ability to help address the world's most pressing social and environmental challenges. The narrow focus on price points — what we can refer to simply as the "How much?" question — imposes constraints on an organization's ability to achieve the scale that its sustainability solutions deserve.

Indeed, the now-popular notion of green premiums is, at its essence, a redefinition of that narrow "How much?" question. But business leaders need to stop thinking about pricing simply as a bar that they can prod up or down to get customers to buy less or more. Every pricing decision comprises additional, more strategic choices that can mitigate the negative externalities of commerce before companies price them in.

The urgency to act is increasing. Businesses are facing growing pressure to translate commitments into action and impact, or they risk jeopardizing their relationships with their increasingly conscientious, dollar-voting customers and investors.

We obviously are not claiming that rethinking the price mechanism is the ultimate answer — but we

Businesses are facing growing pressure to translate commitments into action and impact, or risk jeopardizing relationships with their increasingly conscientious, dollar-voting customers and investors.

are asserting that a more efficient price mechanism is among the necessary means to accelerate progress. Broader thinking on prices will help catalyze the search for innovative and enduring solutions that are profitable, scalable, and palatable to customers.

Marco Bertini *is a professor of marketing at Esade Ramon Llull University and a visiting professor at Harvard Business School. He is also a senior adviser at BCG.* ***John Pineda*** *is a partner and director in BCG's San Francisco office.* ***Amadeus Petzke*** *is a partner and associate director in BCG's Berlin office.* ***Jean-Manuel Izaret*** *is the global leader of the marketing, sales, and pricing practice at Boston Consulting Group (BCG). Comment on this article at https://sloanreview.mit.edu/x/63127.*

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How Supply Chain Transparency Boosts Business Value

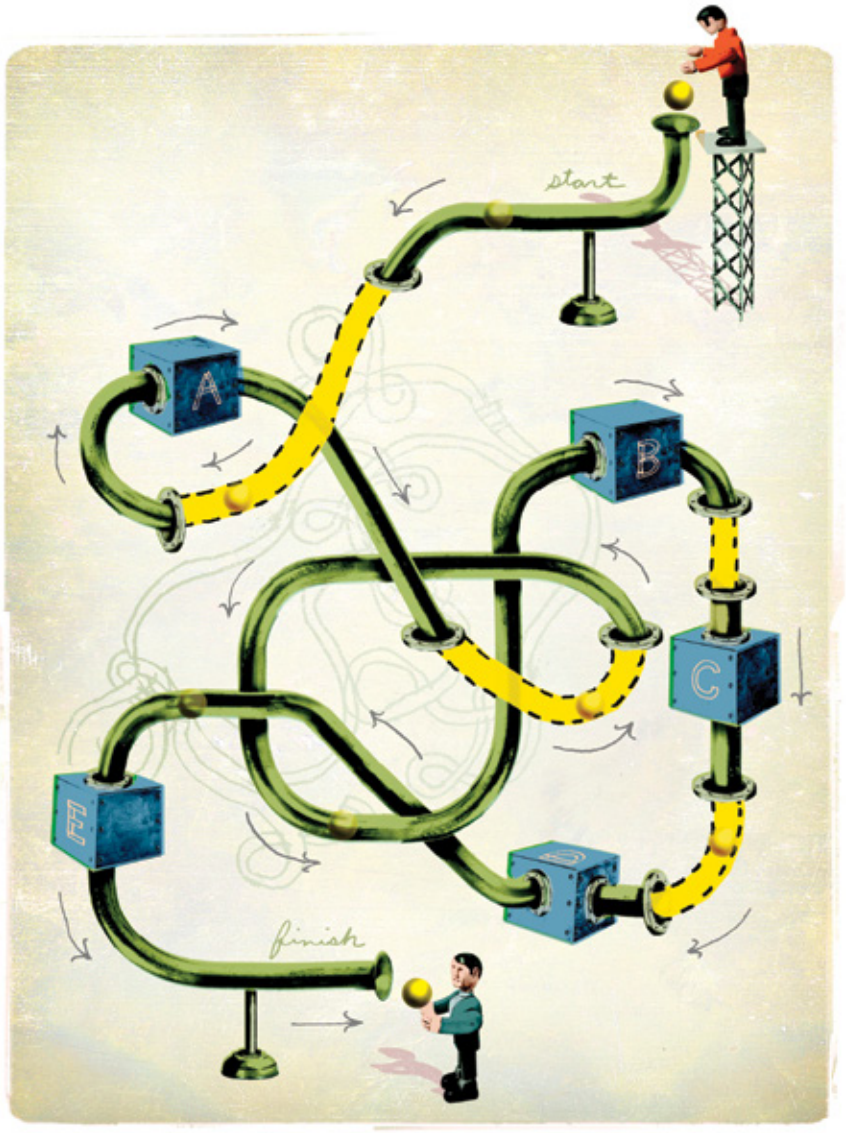
Increasing visibility into suppliers' practices takes work but can lead to new market opportunities.

BY TIM KRAFT AND YANCHONG ZHENG

In November 2020, executives from Amazon, Ikea, Nike, and other high-profile companies were called before the U.K. Parliament to address claims that their suppliers might be using forced labor.[1] Members of the House of Commons' Business, Energy and Industrial Strategy Committee were investigating the potential exploitation of Uyghur Muslims from the Xinjiang region of China.[2] They directly challenged company representatives on how their organizations maintain visibility into and combat modern slavery within their supply chains.

With businesses' sourcing practices under such scrutiny, supply chain transparency has become an imperative in many industries. Emerging regulations such as the U.K. Modern Slavery Act and the California Transparency in Supply Chains Act are not the only drivers of this trend, however. In industries such as apparel, consumer electronics, and food and beverage, companies are facing pressures from all sides to demonstrate better environmental and social practices in their supply chains.

Consumers increasingly want to know more about where and how the products they purchase are being made. They are actively rewarding companies that provide visibility into their



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supply chains and punishing companies that do not. Meanwhile, advocates for reform, such as Fashion Revolution and the Clean Clothes Campaign, are pressuring brands to be more transparent by grading and publicizing their levels of transparency. Investors are also increasingly critical of incidents that violate acceptable environmental, social, and corporate governance practices: In the U.S., it is estimated that such incidents erased almost half a trillion dollars' worth of value from public companies from 2015 to 2019.[3]

In practice, creating a transparent supply chain is not simply a matter of determining what information to disclose to consumers; businesses must first gain visibility into their own supply chains. However, the level of effort and resources needed to monitor first-tier suppliers, let alone upper-tier ones, can be very costly and time consuming. Furthermore, such efforts are often not required by regulation and thus are viewed as necessary only if "something bad" has happened, so getting management buy-in to proactively commit the necessary resources can be difficult.

Companies must find efficient and effective ways to gain visibility into their supply chains, given the increasing demands for greater transparency from regulators, consumers, activists, and investors, and the vast amount of resources such a commitment entails. In this article, we present innovative methods for making such improvements and provide evidence of the business value that greater transparency can enable.

Audits Are Only a Starting Point

Traditionally, companies have relied on audits to monitor their immediate suppliers and ensure that responsible practices are being followed in their supply chains. However, audits alone are not sufficient for truly gaining visibility into one's supply chain. To begin with, audits are only snapshots of supplier practices at the time the audits occur. There is evidence that suppliers often find ways to game audits and hide what they don't want an auditor to see.[4] Furthermore, audits require a significant commitment of time and resources, the cost of which often limits their frequency and narrows their scope to only first-tier or key suppliers. But the reality is that the more severe social and environmental incidents typically occur in the upper tiers of a supply chain. For example, a recent study of 3,922 supplier relationships found that second-tier suppliers committed, on average, 18% more instances of noncompliance per audit than first-tier suppliers, and the third tier committed 27% more.[5]

To increase the effectiveness of audits, companies must find ways to expand their reach for greater impact. For example, to increase oversight of its suppliers, Patagonia reduced its supplier count by 50% in the late 2000s. As a result, the company is able to annually audit 100% of its first-tier suppliers as well as a subset of second-tier suppliers that accounts for 80% of its total material costs. These changes have resulted in stronger and more collaborative relationships with suppliers, which helped the company increase its visibility into its supply chain and enhance its reputation among consumers.

Although many brands and manufacturers may not have the resources or capabilities of a company like Patagonia to extend their auditing influence beyond first-tier suppliers, they can increase their reach in other ways. One approach is to partner with independent auditors, local trade unions, or nongovernmental organizations that work within a supplier's region. For example, as a collaboration between the United Nations' International Labor Organization and the World Bank Group's International Finance Corporation, the Better Work program is actively performing independent, external assessments of 1,700 garment factories employing over 2.4 million workers in nine countries. In addition, it works closely with local governments to improve labor laws and advise unions on how to strengthen workers' voices. Through frequent, unannounced audits and on-the-ground actions such as working with local unions and governments, these efforts can often uncover region-specific issues that overseas brands cannot.

Another approach is to conduct joint audits, where multiple companies pool their resources to audit common suppliers. After the 2013 Rana Plaza collapse in Bangladesh, in which over 1,100 workers died, it became evident that many brands and retailers in the apparel industry lacked visibility into their supply chains. The resulting pressure placed on the industry to improve working conditions helped shift European retailers' compliance focus from

self-certification to more collaborative certification efforts. As a result, retailers and brands signed on to the Accord on Fire and Building Safety in Bangladesh, a legally binding five-year agreement that aimed to improve and better monitor the country's working conditions.[6] As part of the accord, retailers collaborated on conducting audits and shared the cost.

Also gaining traction is the practice of sharing audit information through trustworthy third parties. Service providers such as Sedex and nonprofit organizations such as the Fair Factories Clearinghouse are offering online tools and platforms to help buyers and suppliers share audit results more easily and efficiently. Such data sharing can help minimize duplicative efforts and reduce potential audit fatigue for suppliers, which often must satisfy multiple, similar audit requests from their buyers. The ability to demonstrate such efficiency gains is key to motivating brands and suppliers to participate in these innovative platforms.

There are still hurdles to making collaborative efforts such as these work. Manufacturers and brands may be hesitant to fully share audit information due to potential intellectual property (IP) risks and the fear of leaking commercially sensitive information to competitors. Many companies believe that their suppliers give them a competitive advantage and should remain undisclosed. In our conversations with Sedex leaders, they acknowledged that overcoming such resistance remains a challenge and ultimately requires building trust among the participating companies. Having large buyers on board can help demonstrate to others the credibility of collaboration around audits.

Another challenge to collaboration is the fact that audit information is often interpreted and measured differently across companies. To address the lack of a common audit language for assessing social and labor conditions in the apparel industry, brands, government organizations, and nonprofits have come together to form the Social and Labor Convergence Program (SLCP). This multistakeholder initiative is aimed at creating a common framework and language for assessing social and labor conditions. Uniquely, the SLCP's emphasis is on data collection and information sharing, not on interpretation of the data, which is still in each brand's hands. By creating a way to generate and share comparable data at the industry level, the initiative has the potential to move the conversation forward from monitoring and compliance toward factory improvements.

While these new approaches to auditing can provide better insights into supply chain compliance, we believe they are only part of the solution.

Overcoming Barriers to Supply Chain Visibility

Many would argue that technologies like the internet of things and blockchain are key to improving visibility into supply chains. IoT devices and sensors provide a way to collect granular, high-frequency environmental and social performance data throughout a supply chain to monitor key considerations, such as a product's carbon footprint, during each stage of production. Blockchain protects the integrity of data with immutable ledgers so that users of the data can trust it (such as confirming that fair trade certification requirements have been met).

The enhanced collection and sharing of data enabled by these technologies has the potential to offer unprecedented supply chain insights compared with those afforded by infrequent audits. But they cannot ensure transparency on their own. Other obstacles — namely, infrastructure limitations and stakeholder misalignment — must first be addressed.

Infrastructure barriers. Many supply chains originate in underdeveloped regions where technical infrastructure, good management practices, and even awareness of environmental and social issues are lacking or nonexistent. Trying to gain visibility into these regions and improve production practices is a major hurdle for many companies.

Consider Goodio Chocolate, a Finnish craft chocolatier that aims to provide "radical transparency" into the supply chain behind its products. The company experimented with using blockchain technology to trace raw materials and wages in its cacao supply chain but failed for two main reasons. First, the smallholder cacao farmers from whom Goodio sources do not have the knowledge and capabilities to operate a technology as advanced as blockchain. Second, trade deals with these farmers are often on the basis of verbal agreements rather than formal contracts that could be tracked through the blockchain.

Given such constraints, companies are finding innovative ways to extend their supply chain visibility using existing, common technologies such as cellphones. For example, Sedex (in partnership with IT provider &Wider) and Elevate (through its Laborlink mobile platform) are creating solutions to crowdsource insights into potential labor and safety issues on the factory floor by building safe communication channels for workers to call or text to report incidents. These platforms provide workers with a voice while providing suppliers and downstream buyers with a means to quickly gain extensive insights into their supply chains without having to rely solely on resource-intensive audits.

Another powerful but admittedly less simple approach to improving supply chain visibility that is gaining attention is the use of predictive analytics and data triangulation. For example, by partnering with Elevate and using large-scale worker voice data, the Global Fund to End Modern Slavery is creating predictive tools to help buyers detect unauthorized subcontracting and forced labor in informal garment factories in Bangladesh and India. Similarly, Sedex is developing data triangulation methods that integrate multiple data sources (such as audit reports and worker voice data) to help uncover a truer picture of factory practices. Analytics is one of the ways we see the conversation on supply chain monitoring shifting from reactive to more proactive management.

Stakeholder misalignment. Many companies lack a culture of data sharing, and incentives are not well aligned across stakeholders in their supply chains. When supply chain partners' objectives don't align, it creates another major roadblock to supply chain visibility. Large supply chains or ones where the flow of information is poor are particularly susceptible to misalignment. While downstream retailers and brands may feel the need to be more transparent about what is occurring in their supply chains due to regulatory, consumer, activist, and investor pressures, upstream suppliers may not have the same sense of urgency. Many upstream suppliers view their sourcing practices and own supply chains as part of the value proposition that they offer to downstream buyers. From their perspective, being more transparent could decrease their leverage and lead to them being squeezed out of the supply chain. Furthermore, providing the necessary data is often seen as extra work solely for the purpose of fulfilling their buyers' compliance requirements.

A variety of carrots and sticks can be used to encourage supplier transparency. This is especially true for small, informal suppliers that historically may not have paid attention to environmental and social issues. For example, Sourcemap, a provider of supply chain mapping and traceability tools, often relies on the market power of its large, corporate customers (including Hershey and H&M) to influence suppliers to share information. Similarly, many suppliers initially joined the Sedex platform based on requests from their buyers. While such incentives represent important first steps to attaining supplier buy-in, we contend that solely relying on such "sticks" is not a sustainable approach.

To gain suppliers' trust, it's important to show them the "carrots." These can be in the form of granting preferred-supplier status, offering more attractive contract terms, or jointly investing in capacity building. But it's even more effective to educate suppliers to see the long-term benefit of transparency. As Simon McCalla, CEO of Sedex, notes, "Our theory of change is to empower suppliers to change their mentality from seeing transparency as yet another requirement for compliance to viewing it as a way to achieve cost savings and, eventually, an opportunity to create

The practice of sharing audit information through trustworthy third parties can help minimize duplicative efforts and reduce potential audit fatigue for suppliers, which often must satisfy multiple, similar audit requests from their buyers.

business values," such as winning more contracts and attracting new buyers. While the education process can take time due to suppliers' lack of resources and procedures, the long-term benefit is a shift in mindset throughout the supply chain, from risk mitigation to proactive improvement. It's important to note that there is often a need for education on the buyer's side as well, particularly among upper management, given that some intangible and long-term benefits of investments in transparency may not immediately translate to the bottom line.

Interestingly, transparency can sometimes be the carrot itself to improve performance. Studies in health care and energy usage have shown that revealing relative performance against a peer group can be a powerful tool to drive positive behavior change.[7] Relatedly, in our discussions with Sedex leaders, they commented that they are investigating how relative performance transparency may be used to nudge suppliers on its platform to further share information and improve practices. An important consideration in the design of such relative performance schemes is to ensure that the introduction of competition does not lead to unethical practices, with suppliers taking shortcuts to demonstrate certification and win business.

Misalignment can also be caused by IP concerns. Consider GreenBlue, an environmental nonprofit dedicated to increasing visibility into the chemicals and substances used in products and supply chains. Suppliers are often reluctant to disclose their products' chemical and material makeup to buyers, worrying that they will reveal trade secrets and lose their competitive advantage. To overcome such concerns, GreenBlue built an innovative platform called Material IQ (MiQ) that allows upstream suppliers and downstream buyers to share sensitive chemical-toxicity information without divulging closely guarded information. Suppliers submit sample products to Scivera, a GreenBlue partner and third-party chemical safety assessment provider, which then evaluates and scores a product's chemical makeup and the associated risks. This information becomes part of MiQ, so buyers that subscribe to the platform can view the potential hazards of the product but not enough information to reverse engineer it.

Transparency Can Create New Business Opportunities

Gaining visibility into your supply chain enhances your ability to monitor and improve suppliers' environmental and social practices, but the potential benefits don't stop there. Improved visibility can also create new market opportunities. Consider, for example, the number of small businesses and start-ups whose business models are based on the concept of transparency. In the chocolate and coffee industries, where poor labor practices and low wages in the upper tiers of supply chains are common, companies such as Goodio Chocolate and Moyee Coffee are creating value propositions centered on the idea of end-to-end visibility. Similarly, in the cosmetics industry, which has long been criticized for a lack of transparency regarding products' potential health risks, companies such as Beautycounter are building their brands on the idea of "clean beauty."

For companies such as these, one way to capture the market value of improved supply chain visibility is to better communicate the environmental and social performance of their supply chains to the public. As consumers increasingly consider sustainability to be an integral part of their purchase criteria, better communication can lead to market advantages. Take, for example, Alta Gracia Apparel, a manufacturer of officially licensed collegiate apparel whose products are sold in university bookstores and by online retailers. Alta Gracia guarantees that the workers making its apparel in the Dominican Republic receive wages and benefits to cover the cost of a family's needs — wages that are 340% higher than what is required by law. To test the value of transparency in the market, Alta Gracia and its research partners ran a field experiment at a university bookstore. They found that when video clips describing Alta Gracia's practice of paying living wages to workers were displayed, the company's product sales increased significantly.[8]

In our own research, we consistently observe that companies benefit from providing increased visibility into the social responsibility practices of their supply chains. For example, improved visibility strengthens customers' trust in a company and can result in revenue benefits, especially when customers are generally skeptical of businesses'

corporate social responsibility (CSR) claims. Furthermore, greater visibility can induce consumers who are less socially minded to increase their valuations of a company's social responsibility efforts. Companies serving a global market can positively influence consumer preferences by tailoring their CSR communications in a way that best aligns with the cultural values in different market regions. For example, a culture that values competition and personal achievement (such as that in the U.S.) may be more readily persuaded by fact-based statements, whereas a culture that emphasizes caring for others and quality of life (such as Finland) may be more strongly affected by stories from beneficiaries.[9]

A second business opportunity comes from enhanced efficiency. Improved visibility helps companies to target their environmental and social responsibility efforts more efficiently and to accurately evaluate the associated outcomes. That is, companies can now direct resources where they are needed most to address environmental and social issues in their expansive supply chains, as well as identify the right set of suppliers with which to forge collaborative relationships. This can then support capacity building, which is important for improving practices, particularly in developing countries. For example, Goodio sources cacao for its chocolates directly from a small number of cacao cooperatives in Peru. By leveraging its close relationships with these cooperatives, Goodio gains visibility into its supply chain and works with these farmers to ensure both the quality of the cacao beans and the responsible treatment of the farmers, including fair pricing. In the long run, strengthening these cooperatives can help improve the farmers' practices and provide them with leverage in the marketplace to receive better prices and access a wider range of buyers.

A third potential benefit arises from creating opportunities to take a leadership position within an industry. Consider, for example, Taylor Guitars. In the early 2010s, high demand and low supply of ebony wood led to widespread illegal logging, which exposed many guitar manufacturers to compliance and reputation risks. Taylor sourced its ebony from the Crelicam mill in Cameroon, which in turn sourced its raw wood from several small suppliers in the region. During a 2011 trip to Cameroon, Taylor executives discovered some disturbing facts about the ebony sourcing process. For example, wood suppliers, on average, had to cut down 10 trees to find one tree with the desired pure black color. Furthermore, they observed poor labor practices at the Crelicam mill. These discoveries motivated Taylor to purchase the mill and vertically integrate its ebony supply chain. The company also established labor practice standards at the mill comparable with those found in the U.S. The mill began to accept wood with stripes of color from the wood suppliers at prices equal to those for pure black wood, and Taylor started to sell wood to its competitors. Using its position as both a supplier and a producer, the company helped reeducate the market — both consumers and competitors — to accept guitars made with striped ebony wood, thus significantly improving the sustainability of ebony forests.

Taylor Guitars is not an isolated example of a company playing a positive role in shaping industry standards and behavior around supply chain transparency. For example, in the apparel industry, Patagonia and Nike have helped set the expectation that large brands should disclose their supplier lists and share public maps of where their products are sourced and made. Similarly, Starbucks launched the Coffee and Farmer Equity (CAFE) Practices in 2004, establishing one of the first sets of ethical sourcing standards in the coffee industry. A central

> One way to capture the market value of improved supply chain visibility is to better communicate the environmental and social benefits to consumers, who increasingly consider sustainability to be an integral part of their purchase criteria.

component of CAFE Practices is transparency, requiring suppliers to provide information on where coffee beans are sourced and the prices paid to farmers. CAFE Practices allow Starbucks to develop deep working relationships with coffee suppliers and promote ethical sourcing practices in the industry. While the company sources only about 3% of the world's coffee, over 18% is now grown under CAFE Practices.

The Path Forward

Supply chain transparency has become a critical component in consumers' purchasing criteria, and companies now must decide how transparent they want to be. But they must gain visibility into their own supply chains before they can make them more transparent to consumers and partners. This increased visibility can help mitigate supply chain risks — to workers, the environment, consumers, and a company's production capabilities and reputation — and ensure compliance with social and environmental standards. It's also crucial to the next stages in the evolution of sustainable supply chains, which include increased knowledge sharing, deeper collaboration with partners and competitors, and greater ownership by downstream retailers and brands regarding what occurs in their supply chains.

Although audits are a necessary tool for managing compliance, truly increasing supply chain transparency requires companies to both innovate and expand their toolboxes by introducing new methods for gaining visibility into suppliers' practices. They must also bear in mind that the process is not just about making technology investments — it also requires business innovation that addresses infrastructure and incentive alignment barriers. To realize the true benefits of transparency, however, a change in mindset is needed. By educating supply chain partners on the value of transparency, companies throughout the supply chain can benefit from both improved efficiency and more collaborative relationships and capture potential revenue opportunities. And by leading transparency efforts in their respective industries, companies can place themselves in an advantageous position to proactively address regulatory and activist requirements, shape new market trends, and create new business opportunities for themselves.

Tim Kraft *is an associate professor of operations and supply chain management and the associate research director of the Supply Chain Resource Cooperative at the Poole College of Management, North Carolina State University.* ***Yanchong Zheng*** *is the George M. Bunker Professor and an associate professor of operations management at the MIT Sloan School of Management. Comment on this article at https://sloanreview.mit.edu/x/63105.*

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Four Myths About Unauthorized Subcontracting

Organizations that want to improve supply chain visibility — and reduce diverted orders — must use analytics and think beyond price.

BY FELIPE CARO, LEONARD LANE, AND ANNA SÁEZ DE TEJADA CUENCA

BRIAN STAUFFER/THEISPOT.COM

It has never been more important for a brand to know who, exactly, is making its products.

A case in point: A summer 2020 *Sunday Times* investigation revealed that during the COVID-19 pandemic, workers making clothes for "ultrafast" fashion brand Boohoo toiled for less than minimum wage in cramped conditions, with lax safety measures in place.[1] Though Boohoo claimed that the factory was not a direct supplier, it lost more than 1.5 billion euros ($2 billion U.S.) in market value in the immediate aftermath of the *Times* report.[2]

As Boohoo discovered, suppliers can pose serious risks to a company's reputation and finances, and the nature of the modern supply chain — global, complex, and frequently opaque — only increases the dangers. Companies that outsource manufacturing often discover that their suppliers rely in turn on layers of subcontractors, often without the buyer's knowledge or approval. Making matters worse, these unauthorized subcontractors are more likely to operate unsafe workplaces, engage in unfair labor practices, and violate health and environmental laws.

Unauthorized subcontracting is the bane of businesses that are working to improve visibility into their supply chains. The 2013 collapse of Rana Plaza, an eight-story commercial building in Bangladesh, killed more than a thousand apparel workers and drew worldwide attention to the problem. Workshops in the building made clothing for several prominent brands, including Italian fashion company Benetton and Irish retailer Primark, but many of the companies claimed to be unaware that their orders had been farmed out. These problems aren't limited to Bangladesh and go beyond building compliance: Companies have come under fire in many other

THE RESEARCH

The authors set out to investigate the factors that can lead suppliers to engage in unauthorized subcontracting, using data (provided by a global supply chain manager) on 32,000 orders, of which 36% were subcontracted without authorization.

They identified the key drivers of unauthorized subcontracting and found that it could be predicted correctly for 82% of the orders in out-of-sample tests and for 75% of suppliers.

parts of the world for using subcontractors that employed children and exploited forced labor.[3]

The pandemic has made the need to address supply chain visibility even more urgent by exposing the terrible working conditions in plants producing essential goods. A notorious example is the meatpacking industry. In Germany, 180 workers at one slaughterhouse tested positive for the coronavirus; a senior union official blamed "a sick system" and a meat industry that has long relied on "dubious subcontractors."[4]

In response to the workplace problems in their supply chains, companies have adopted codes of conduct, conducted regular audits, and required that suppliers adhere to international health and safety rules. However, if they want to demonstrate their commitment to the well-being of the people who make their products and to the communities in which they live, they'll need to get a grip on the problem of unauthorized subcontracting.

One major challenge is that data on unauthorized subcontracting is hard to come by. We collaborated with a large supply chain intermediary that, in the aftermath of the Rana Plaza disaster, kept records of orders that went to subcontractors that were not on buyers' authorized lists. In our analysis, more than a third of the 32,000 orders — placed by 30 brands with 226 apparel factories — involved an unauthorized supplier.[5]

Through our research findings, we can debunk four common misunderstandings or myths about the practice of unauthorized subcontracting — and offer specific guidance for companies seeking greater visibility into these opaque links in their supply chains.

MYTH 1: All Factories (in Developing Countries) Are Doing It

Because the problem is so widespread and the practice has been going on for so long, it's easy to imagine that all factories in developing countries have dealings with unauthorized and substandard workshops. But the data suggests that impression is incorrect.

In fact, we found that manufacturers vary widely in their use of unauthorized factories. Only a small fraction (11%) *always* send their orders to a noncompliant subcontractor, while a majority (57%) never engage in the practice. The rest farm out orders occasionally, depending on the circumstances. (See Myth 2.)

What's even more revealing is that the factories that are prone to using unauthorized subcontractors share some common characteristics. For one thing, they tend to be less specialized and make items in a greater number of different product categories — pants, sweaters, and overcoats, for example. (See "More Product Categories, More Problems.")

This suggests that when factories make commitments to deliver products but lack the specialized know-how needed to produce them, they are more likely to turn to unauthorized subcontractors to fill those orders.

Unauthorized subcontracting also varies by country. On average, Vietnam had the highest level of incidence, closely followed by Cambodia and China. This doesn't necessarily mean that all of those subcontractors have substandard operations, however. In fact, many of the unauthorized factories in China meet higher safety standards than the average workshop in Bangladesh. But paradoxically, these plants are not on authorized-subcontractor lists because they lack the resources to complete all the paperwork and obtain the necessary approvals, even though they could successfully do so.

MYTH 2: Unauthorized Subcontracting Is Mostly Driven by Price

Not surprisingly, price pressure — when a buyer offers a price lower than that paid for a similar order in the past — can make it more likely that the supplier will turn to an unauthorized subcontractor. For instance, prices that were 25% lower increased the chance of unauthorized subcontracting by 9%. This fits with the conventional wisdom: Subcontracting is a way for a manufacturer to cut corners and save money. But while price is important, it's not always the main driver.

More important is whether a factory is running close to capacity when a new order comes in. At some point, the factory can't fulfill all of its contracts, and farming them out becomes a way to manage the overflow and keep its customers satisfied.

We found that in periods of high factory utilization, unauthorized subcontracting frequently happens in batches. Once the queue of factory orders exceeds the plant's capacity and is sent to a

subcontractor, it's likely that the next order will also exceed the threshold and be farmed out. In fact, when a plant sends one order to an unapproved subcontractor, the chance that it will divert the next order *almost doubles*. Batching had a bigger effect than price or any other driver that we studied.

Factories might have several reasons for running so close to capacity. More orders mean more business and potentially higher earnings, especially if a supplier can subcontract out the work profitably. A supplier might fear, not unreasonably, that rejecting an order will mean that the buyer won't return with future purchases. And some plant managers lack more sophisticated planning tools and instead schedule production on an ad hoc basis.

A related misconception is the belief that a supplier is more likely to subcontract out rush orders than those with longer lead times. We found the opposite to be true: While only 24% of rush orders were dispatched to an unapproved contractor, 38% of those with a lead time of more than two months were farmed out.

The reason? Short lead times are more common with orders for fashion items, but it takes more sophisticated operations to make them — something that is lacking in the informal factories that receive the bulk of the subcontracted orders.

In contrast, basic apparel items, such as plain pullovers, typically change less often and can be ordered far in advance. They are also easier to make and can be more easily farmed out to other nearby factories. However, these are often makeshift workshops that may not meet the customer's compliance standards.

MYTH 3: Consumer Advocacy Doesn't Work

Fashion consumers are typically far removed from the working conditions in distant, largely invisible, informal factories. Therefore, it's easy to imagine that pressure from those shoppers, when it can be mustered at all, would be largely ineffective. The reality is that global consumers have more power to effect change than might be assumed.

After the Rana Plaza disaster, widespread consumer protests pushed brands and retailers to compensate victims of the building collapse and to crack down on poor workplace conditions in their supply chains. In response, retailers and fashion brands adopted the Bangladesh Accord on Fire and Building Safety and signed on to the Alliance for Bangladesh Worker Safety initiative, which required stepped-up factory inspections and worker safety training. The groups provided grants to pay for plant upgrades and set up worker-safety committees and hotlines to receive complaints about violations.

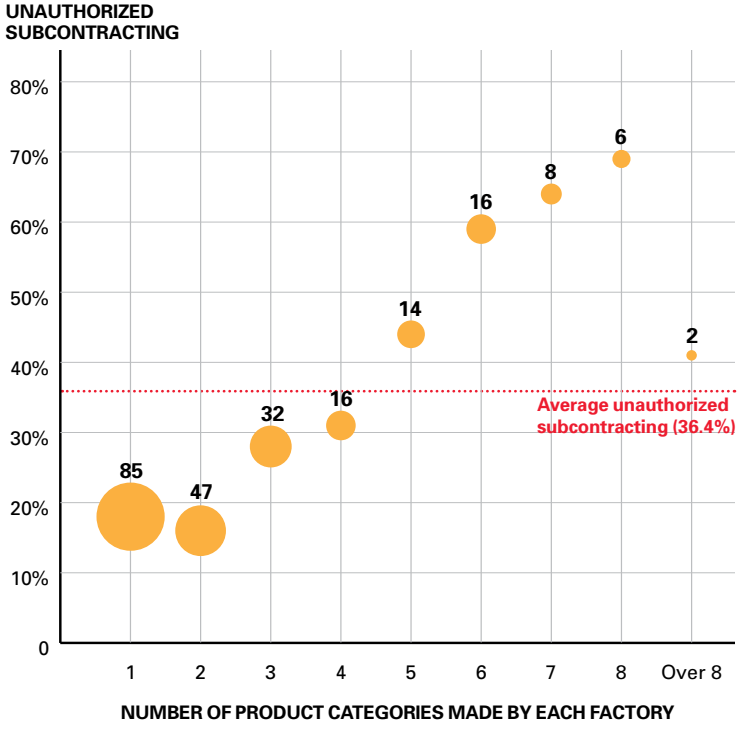
Consumers are increasingly demanding greater transparency in the apparel supply chain through advocacy groups like Fashion Revolution and the Clean Clothes Campaign, and via social media movements such as #WhoMadeMyClothes, which is aimed at making brands accountable for the working conditions at their factories.

It's frequently the largest, best-known brands that are the focus of these campaigns, and they have proved to be the most sensitive to public pressure. H&M, a Swedish fashion retailer, was the largest exporter of clothing from Bangladesh and received the brunt of attention after the Rana Plaza disaster.[6] It was among the first companies to sign the Bangladesh Accord.

This is consistent with our study results. We found

MORE PRODUCT CATEGORIES, MORE PROBLEMS

Unauthorized subcontracting is above the average (represented by the dotted line) for most factories that produce more than four product categories. The size of each circle indicates the number of factories.



that the chance of unauthorized subcontracting is 22% lower for orders placed by well-known brands. Specialty retailers like H&M are more exposed to consumer backlash than lesser-known, private-label brands. As a result, they are more likely to exercise greater oversight over their suppliers.

MYTH 4: Companies Can't Do Much

The long list of subcontracting horror stories might suggest that there is little companies can do to identify unauthorized suppliers and prevent their abuses. However, based on our research, buyers can use analytics and big data to discover with high levels of accuracy when manufacturers are most likely to use subcontractors. They can even predict which orders will probably be farmed out.

Using our analysis of the supply chain intermediary's orders, we trained a model to do just that. With information already in the hands of an intermediary, the model can predict with more than 82% accuracy when an order will be diverted to a subcontractor. A similar model can identify suppliers that use unapproved factories and those that don't with 75% accuracy.

The model can be plugged into a brand's existing decision support systems to monitor pending orders, the workload at each supplier's factories, and the average price per category and then flag those orders most likely to be farmed out. It could even suggest alternative factories. Brands — working with governments and nongovernmental organizations (NGOs) such as the Sustainable Apparel Coalition — could use this information to put pressure on factories with abusive labor policies and substandard living and working conditions.

Ours is a fairly simple model, and its purpose is mainly to show that such forecasting is possible. With more data, advanced machine learning techniques such as artificial neural networks could deliver even more accurate results.

Lessons for Supply Chain Leaders

Our findings can help businesses increase their visibility into what goes on in their supply chains. There's no silver bullet, but companies can minimize the problem by working with suppliers closely and continuously. We suggest that they take the following actions.

Get rid of the worst actors. The first step is the simplest: Weed out those factories that constantly use unauthorized subcontractors. Only a small fraction of factories are "serial offenders," according to our findings. Industry insiders we talked to described these suppliers as "mock factories" — plants that have passed buyers' audits but don't actually produce anything. Instead, they simply transfer their orders to factories that haven't been approved by the buyer.

One warning sign is if the supplier claims that it can produce essentially anything. Our evidence indicates that factories that produce many different categories of goods are more likely to rely on unauthorized suppliers. When a brand's demand for variety requires more versatile suppliers, it at least needs to have a solid understanding of the supplier's actual skills.

New Balance has on occasion taken this step. When it reported on its 2017 audit of 96% of its first-tier suppliers, the company said that it terminated relationships with three suppliers, two of them for reasons related to sourcing.[7] Gap Inc. explicitly addresses unauthorized subcontracting on its corporate website and warns that the practice is grounds for terminating the supplier relationship.[8]

Help suppliers manage workloads. "Unauthorized subcontracting happens at factories in moments of duress, so you must know your factories' capacity," a former Nike executive told us. The athletic apparel maker holds regular supplier conferences just for that purpose. Other brands could follow suit.

Nike also gains insight into suppliers' perspectives via the Better Buying Institute, which provides a tool for suppliers to anonymously rank companies' purchasing practices. It focuses on seven areas where buyers can help — or hurt — a supplier's ability to meet contractual obligations profitably while providing a safe work environment.

By working jointly with supply chain partners from the beginning of the design process, a business will be able to anticipate demand and plan factory capacity in advance, leading to a sustainable supply chain without resorting to subcontracting. Moreover, data-based models can be used to improve production schedules and reduce costly and time-wasting changes to orders.

Be willing to pay. While low prices aren't the main reason suppliers divert orders, it is a factor; the Ethical Trading Initiative lists aggressive price negotiation among poor purchasing practices that put pressure on supplier capacity, working hours, and labor costs.[9] A brand can reduce unauthorized subcontracting by guaranteeing that its payments are in line with what it has paid in the past. Indeed, companies that value transparency and compliance might be willing to pay a slight premium to ensure that they know where their goods are made. This is especially true for the large specialty brands that can be easy targets for consumer and labor advocates.

Be more diligent. Too often, brands focus only on their first-tier suppliers, but greater attention to those in the second tier can pay big dividends. That should include visits to facilities that aren't on a brand's list of approved suppliers. They should also work toward bringing more of those subcontractors into the authorized fold. We heard of one informal factory in China that was quite advanced but wasn't on the compliant list because the process of becoming certified was too burdensome. Streamlining the certification process can help expand the base of approved suppliers. NGOs can also help nudge buyers and suppliers in the right direction by gathering information and exposing problems.

Patagonia is among those companies going beyond the first tier: It has extended its monitoring to tier 2 of its supply chain, specifically looking at the largest suppliers of raw materials. It employs an audit and remediation process similar to what it uses for tier 1 factories.[10] HP engages its tier 1 suppliers in outreach to the next tier: It trains the first rank directly on its code of conduct and then involves them in jointly training the second tier.[11]

Buyers that prefer having an arm's-length relationship with their suppliers can at least collect data and use predictive analytics to flag which suppliers or orders are risky. One source of tools and services to help with this is Elevate, which provides analytics on unauthorized subcontracting.

CRITICS OF corporate social responsibility initiatives say that they are just window dressing used to adorn annual reports. However, in the case of unauthorized subcontracting, businesses have the means for these efforts to have a real impact. The time is right: The disruption caused by the coronavirus pandemic and the resulting economic shutdowns has accelerated already trending changes, such as shifts to online shopping and remote work. The same should happen with tackling unauthorized subcontracting to increase supply chain visibility.

Felipe Caro *is a professor of decisions, operations, and technology management at the UCLA Anderson School of Management.* ***Leonard Lane*** *is a senior lecturer of strategy at the University of California, Irvine's Paul Merage School of Business.* ***Anna Sáez de Tejada Cuenca*** *(@annasdtc) is an assistant professor of production, technology, and operations management at IESE Business School. Comment on this article at https://sloanreview.mit.edu/x/63121.*

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Decarbonizing Our Toughest Sectors — Profitably

Cutting carbon emissions from harder-to-abate sectors like heavy transport and industrial heat will create new strategic opportunities for business.

BY AMORY LOVINS

ALEX NABAUM/THEISPOT.COM

To avert runaway climate change, we must eliminate global carbon emissions by 2050. While much of the focus has been on the main culprits — power plants, buildings, and cars — more than one-third of emissions come from heavy transport such as trucks and planes and the heat-intensive manufacture of materials such as steel and cement. We can't reach our goal without addressing these sectors, too. But how? They're widely considered hard to abate — stubbornly resistant to decarbonization, which many believe would be slow, costly, and unprofitable.

But abatement is not only feasible — it will be amply rewarded, if done strategically. In this decade, a rich stew of new technologies, materials, design methods, financial techniques, and business models, along with smart policies and aggressive investments, could revitalize, relocate, or displace some of the world's most powerful industries. By the 2030s, trucking, aviation, and shipping could be decoupling from climate. Steel, aluminum, cement, and plastics could take new forms, be used more sparingly, and be made in new ways, in unexpected places, under novel business models.

In this article and a companion technical paper[1], I examine business strategies that can help make all this possible and generate trillions of dollars in the process. While the strategies are distinct, they share a common thread: Increasingly competitive and abundant renewable electricity is undercutting and displacing fossil

fuels. Outpaced and outcompeted, coal and gas plants are being starved of revenue while their fixed costs per kilowatt-hour rise. Electrified heavy transport and industrial manufacturing heat powered by renewables will likewise undercut, devalue, and strand their fossil-fueled rivals, siphoning off the old technologies' revenues to fund their own expansion. The growing arguments for making and using renewable electricity will reinforce one another, accelerating the demise of fossil fuels and propelling one of the greatest disruptions in business history.

Let's now explore the five business innovation strategies that will speed this transformation. Each is described as it applies to key sectors where it can bring early wins. But many of these will apply across sectors and can be even more powerful in synergistic combinations.

1 REPLACE

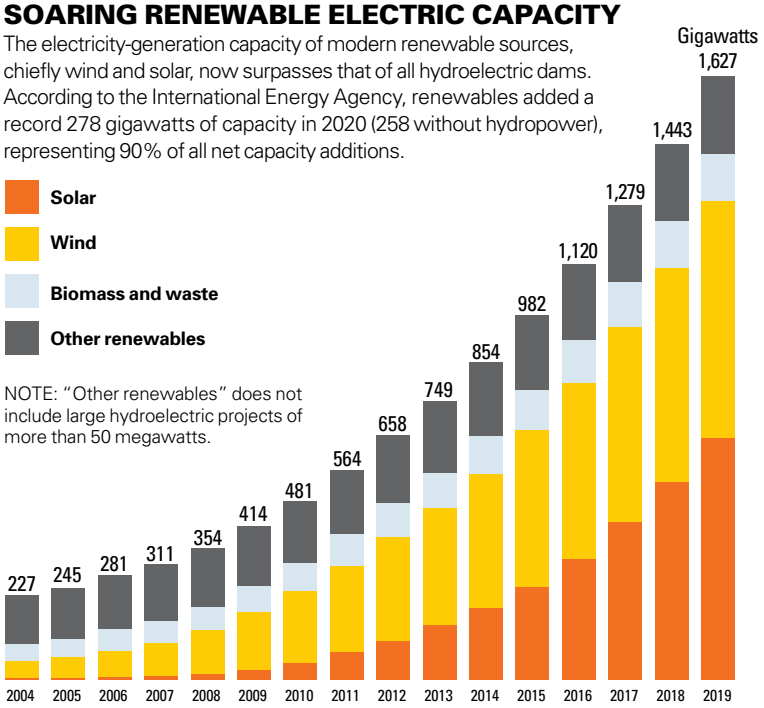
Rapidly scale green technologies to outcompete legacy rivals and supplant obsolete technology assets.

Heavy road vehicles, chiefly 18-wheel class 8 trucks, average just 6 miles per U.S. gallon and emit nearly 4% of global CO_2 — over half of the carbon produced by heavy road transport. This dirty technology is vulnerable to competition, as Elon Musk knew when he unveiled Tesla's all-electric Semi prototype in 2017. The Semi, designed to displace diesel 18-wheelers, gets over 17 miles per gallon equivalent[2] and, if charged with renewable electricity, emits nothing. It can accelerate from 0 to 60 mph in 20 seconds pulling a typical payload (versus diesel trucks' 1 minute or so), climbs a 5% grade 15 to 20 mph faster than a diesel, and with the latest batteries has a range of about 600 miles — comparable to a diesel truck's daily range. After a half-hour recharge, it can then go another 400 miles. Tesla expects to deliver the first units in late 2021. While the Semi will initially cost 50% more than a diesel 18-wheeler, Tesla says owners will recoup that premium from saved operating costs in two years and enjoy a million-mile warranty.[3] And Tesla has company: In the U.S. alone, at least 14 manufacturers expect to be producing electric heavy trucks by 2023.

While there were just over 2,000 electric trucks of all sizes on U.S. roads in 2019, by some estimates that

SOARING RENEWABLE ELECTRIC CAPACITY

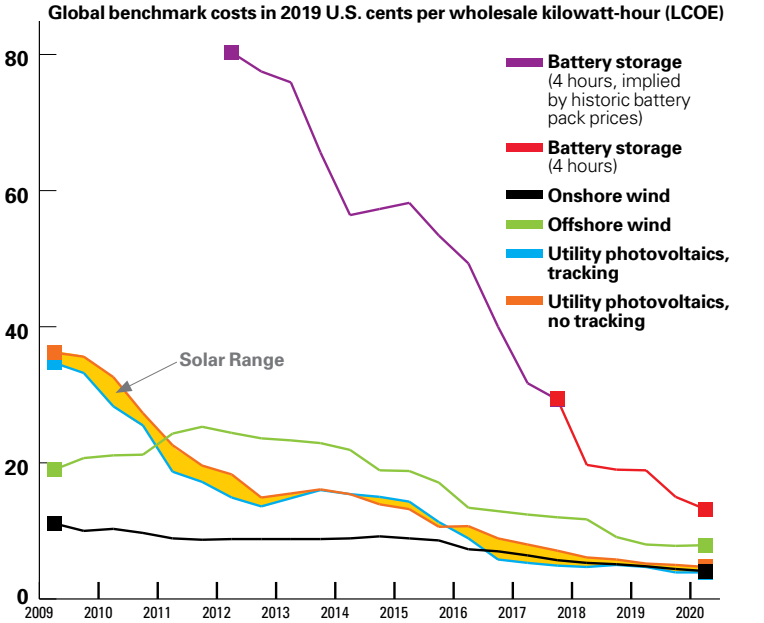
The electricity-generation capacity of modern renewable sources, chiefly wind and solar, now surpasses that of all hydroelectric dams. According to the International Energy Agency, renewables added a record 278 gigawatts of capacity in 2020 (258 without hydropower), representing 90% of all net capacity additions.



SOURCES: Frankfurt School-UNEP Collaborating Centre for Climate & Sustainable Energy Finance and BloombergNEF

PLUMMETING RENEWABLE ELECTRICITY COSTS

Solar power costs have fallen as much as 89% in the past decade, onshore wind power costs have dropped by 63%, and battery storage costs have dropped by 89%. Solar and wind costs are now competitive with fossil fuels'. Further innovation will push these costs even lower in the coming decades.



The global benchmark is a country-weighted average using the latest annual capacity additions. The storage levelized cost of energy (LCOE) is reflective of a utility-scale Li-ion battery storage system with four-hour duration running at a daily cycle and includes charging costs. All LCOE calculations are unsubsidized.

SOURCE: BloombergNEF

number could grow to more than 54,000 by 2025. McKinsey forecasts that e-truck demand across China, Europe, and the U.S. could reach 11 million units by 2030. To get a glimpse of electric trucks' future, consider e-cars' recent trajectory: Driven by falling battery prices, low life-cycle costs, high performance, and improvements in range, global sales of plug-in autos rose 43% in 2020, reaching 4.2% market share, while total auto sales fell 14%.

Fueled autos are now in their fourth year of shrinking sales. But because battery costs fall 18% with each doubling of cumulative production, electric autos should soon be as cheap to buy as fueled ones. I expect e-truck sales and prices to track e-cars' trajectory, driven by these same factors. Indeed, Europe's biggest truck makers are so bullish on e-trucks that they plan to deliver their last fueled truck in 2040, 10 years ahead of schedule.

All of this will require an extensive recharging infrastructure. Until that's in place, e-trucks will be limited to major transit corridors or to fixed-base (out-and-back) operations — both important markets. Ultimately, e-trucks' ability to outcompete remaining diesel rigs will depend on a far-flung infrastructure supporting irregular long routes. Although the cost of building it will be high, so is the revenue potential. Truck stops will be motivated to install charging stations to recoup lost diesel revenues, and utility companies will have an incentive to join with (or compete against) truck-stop operators in supporting infrastructure development. Utilities may also chase new revenues by leasing truck batteries separately (with the ripple effect of helping to lower e-truck prices, speeding the trucks' adoption).

E-truck penetration will also be supported by "smart recharging" and other opportunities to cut costs and generate revenues from charging and storage technologies. Solar and wind power operators can accurately predict their output, revealing when electricity is likely to be abundant and cheap — hence when charging parked trucks' batteries can cost the least and when selling stored electricity back to the grid can earn the most. Haulers can then add recharging schedules to the variables they optimize. As long-haul drivers sleep, their trucks can earn money, exploiting the trucks' fast charging and big batteries to sell valuable services back to the grid while preserving the next day's needed range. Proof of concept: For every e-car battery it manages, the European system integrator The Mobility House earns 1,000 euros annually from exchanging electricity and a dozen other services between the battery and the grid. Each Tesla Semi can exploit a storage capacity that is five to 10 times that of an e-car.

Other innovative incentives and financing strategies include automotive "feebates" — fees on high-emission cars, and rebates on low-emission cars — now provided by many countries.[4] Feebates could be effectively extended to trucks. In addition, e-trucks' fuel savings could be used to pay into leases, enabling small, independent diesel-fueled truckers, who haul most U.S. freight, to replace their inefficient rigs promptly with e-trucks rather than wait years for used hand-me-downs. Because e-trucks are cheaper to own and can last far longer than diesel trucks, we can expect them increasingly to supplant dirtier, more costly, and less durable diesel laggards.

2 TRANSFORM
Create novel incentives and business models that reward innovative competitors challenging incumbent industries with breakthrough technologies.

Like trucking, the more complex and risk-averse aviation sector will need clean-energy and efficiency innovations to reduce emissions. Jetliners using 65% to 80% less fuel than today's fleet were designed over a decade ago by the likes of Boeing, NASA, and MIT but would take a lifetime to emerge if efficiency keeps rising just 2% per year. But novel incentives and business models could rapidly bring established-but-underused innovations to the marketplace — and do so even faster if the latest aviation-efficiency advances are applied.

Consider Otto Aviation's 2020 Celera 500L prototype, a super-aerodynamic, multifueled long-range air taxi that can expand from carrying six to seating more than 20 passengers. The company didn't just put a fuel-sipping engine into an existing airframe. It built the 500L from scratch for unprecedented efficiency. The result: The plane has twice the range, eight times better fuel economy, one-sixth the operating cost, and one-fifth the carbon emissions of a comparably fast (but more cramped) business jet. It's a formidable competitor and an

ideal candidate for electrification — the greatest aviation innovation since jets appeared in numbers in the 1950s.

The same battery and efficiency improvements that are driving the explosion in e-cars and e-trucks will allow the first electric short-haul commuter planes from over 100 startups to enter the market in the next few years. E-plane prototypes are already being flight-tested, and United Airlines plans to purchase 200 electric planes worth $1 billion that are expected to enter service in 2024. While short-haul electric flights (those under about 900 miles) will establish the business beachhead, mid-haul flights should become possible with continued improvements. Even long-haul flights might become possible, particularly with the advances in electric flight powered by hydrogen fuel cells that some companies are now pursuing.

Currently, fuel is a dominant and volatile aviation cost. Superefficient-and-electric planes will eliminate this cost and uncertainty. With their far lower operating costs, fleets of smaller and more flexible e-planes could offer frequent, convenient, clean, quiet, and economical point-to-point flights serving 5,000 U.S. airports and tens of thousands of international ones. The vertical takeoff and landing capability some startups are developing could enable planes to bypass airports entirely. Thus, we can expect e-planes to challenge traditional airline and commuter-jet business models that are built around less flexible, affordable, and convenient hub-and-spoke route architectures and are dependent on liquid fuels. Electric air taxis could push traditional short-haul planes out of service, stranding the incumbents' assets and — if these legacy carriers don't get on board — hastening their decline.

While investors and some buyers are already putting money into e-plane startups, cash-short airplane buyers and builders are understandably cautious. How do we encourage further radical, seemingly risky efficiency improvements? One approach is to de-risk makers' development investments through "golden carrot" purchase commitments. Long used to elicit efficiency gains for smaller products such as refrigerators, these may work with planes, too (or trucks, trains, or

FIVE BUSINESS STRATEGIES FOR A NET-ZERO 2050

The growing arguments to make and use renewable electricity will reinforce one another. Here are five strategies for businesses to drive and benefit from the transformation.

REPLACE	Rapidly scale green technologies to outcompete legacy rivals and supplant obsolete technology assets.	**Example:** Replace diesel-fueled 18-wheelers with efficient electric trucks such as Tesla's Semi, financed from fuel savings by haulers big and small.
TRANSFORM	Create novel incentives and business models that reward innovative competitors challenging incumbent industries with breakthrough technologies.	**Example:** Fleets of smaller, superefficient, and often electric planes flying point-to-point can offer a more convenient, flexible alternative to planes tied to hub-and-spoke routes, transforming aviation.
REDESIGN	Integrate new design methods, technologies, materials, and manufacturing techniques to disrupt legacy industrial ecosystems.	**Example:** Carbon-fiber composites used for the body of BMW's i3 electric city car reduce its weight, so it requires fewer batteries; this, combined with savings from simplified manufacturing, offsets the cost of its pricier materials.
MIGRATE	Relocate basic materials industries using cheaper production unlocked by clean energy.	**Examples:** Steel producers are co-locating production with iron ore and locally abundant renewable energy rather than shipping ore to fossil-fueled plants far away.
ALIGN	Harmonize customers' and providers' incentives by rewarding frugal structural design and "servitizing" basic materials.	**Example:** An alliance might redesign a bridge to use far fewer tons of materials and get paid for the traffic that the bridge safely carries — not for the physical asset or its materials.

ships, for that matter). In short, big customers collectively commit to buy X units a year for Y years at price Z from whatever vendor first achieves, say, a fourfold efficiency gain while meeting all standard requirements. (The runner-up gets a smaller slice.) Such a big prize isn't just a bigger bulk buy; it provides an incentive for both the development and purchase of innovative vehicles, rewards gutsy innovation over timid incrementalism, and has the potential to transform makers' and buyers' cultures by raising their innovation tempo, performance expectations, and appetite for strategic risk-taking.

3 REDESIGN
Integrate new technologies, materials, and manufacturing methods to disrupt legacy industrial ecosystems.

Energy-efficiency efforts traditionally seek to optimize isolated parts of larger technical devices or systems, like a diesel or jet engine. But optimizing the efficiency of vehicles, buildings, and factories as whole systems can double or triple energy savings at lower cost.[5] Such integrative design, which combines new technologies, materials, manufacturing methods, and business models, will help disrupt vast, slow, overly mature industrial ecosystems.

Let's focus on a key element of many new integrative vehicle designs: advanced materials. Carbon fiber is far stronger and lighter than steel but also costs more per pound. You might conclude, therefore, that replacing a car's or truck's ton or more of steel with carbon fiber would increase its cost. But with integrative design, it needn't. The body of BMW's 2013-22 i3 electric city car is made entirely from carbon-fiber composites. But because this saves weight, the i3 needs fewer batteries, offsetting the carbon-fiber cost. Further, its radically simplified manufacturing process uses two-thirds less capital and space and half the water, energy, and time, and it doesn't require a conventional body or paint shop (where the two hardest and costliest parts of traditional automaking are done). All of this makes the i3's valuable weight reduction approximately free — so the quadrupled-efficiency car was profitable from the first unit made.[6]

Likewise, a radically simplified 95% carbon-fiber fighter plane designed by Lockheed Martin's Skunk Works in the 1990s was one-third lighter and two-thirds cheaper than its 71% metal predecessor. Its lead engineer went on to design a carbon-fiber sport utility vehicle that was half the previous weight and four to six times more efficient. Now China plans to cut its flagship cars' steel use by 80% in this decade by substituting light metals and carbon fiber. Ultimately the average U.S. car could shed over a ton of iron and steel, replaced by lighter but higher-value polymers. Carbon-fiber ships and trains, too, are starting to move beyond prototypes and specialty applications and into the mainstream. These examples foretell other lighter, more fuel-efficient, more easily electrifiable and lower-cost heavy-duty vehicles displacing steel ones. And since carbon fiber doesn't rust and scarcely dents or fatigues, combining it with ultrareliable electronics and electric motors could also make light or heavy vehicles last far longer, favoring leasing over sales and the manufacture of fewer vehicles with greater value.

Other advances in materials, combined with integrative design, hold particular promise for planes, where every pound cut can save $1,000 worth of fuel — and related emissions — over the plane's lifetime. NASA and several universities, for example, have demonstrated a plastic lattice structure for building aircraft. It's as strong and tough as the flexible polymer membrane surrounding it but 98% lighter than a metal structure. Like a bird's wing, its shape can morph in real time to cut drag, boost lift, and save energy. If the air is evacuated from the lattice, such crush-resistant structures could form a "vacuum balloon" whose buoyancy could help offset the weight of electric airplanes' batteries — a promising if, as of yet, only theoretical bit of engineering.

Ultimately, ultralight, superefficient electric cars and even planes could become partly or wholly solar powered. Later this year, two startups aim to begin selling electric Hypercars — vehicles that are so efficient, they need little or no plug-in recharging. Aptera's composite NeverCharge is a two-seat three-wheeler with less air drag than the side mirrors of the most popular pickup truck. Parked outdoors, its topside solar cells can power it for a conservative estimate of up to 11,000 miles per year. Its daily solar-only range is only around 40 miles, but plugging it in recharges the battery for a range

> Australia and Brazil ship iron ore to Chinese coal-fired blast furnaces, which make half the world's steel. Such dirty process heat will give way to clean heat generated by renewables — or clean-heat processes will shift abroad altogether.

of up to 1,000 miles. Dutch startup Lightyear's five-seat sedan similarly blends solar power with efficient operation, gaining 8 miles of range per hour in the sun. Both examples are proofs of concept that superefficient solar-powered or -assisted vehicles, including trucks and even ships and planes, could join our future zero-carbon transportation mix — and complement the faster expansion of a smaller recharging infrastructure.

To ride this wave of change, incumbent automakers must invest in belated asset, technical, and cultural transformation while living on revenues from the obsolete fueled products that their new offerings are meant to squash. Few are well positioned for the upheaval to come: A recent KPMG report on electric-vehicle trends concluded that "old empires may fall" in the transition and "massive structural change" of the industry could doom some major companies. Preparing for the inevitable, several manufacturers have announced plans to build their last fueled vehicles within a decade or two, among them Volvo by 2030 and General Motors by 2035. Next, the integrative design, electrification, lightening, and other efficiency advances coming swiftly to cars will surely reconfigure all of heavy transport, supplanting fueled vehicles. Business model innovations supported by superefficient integrative design, such as Otto Aviation's ambition to leapfrog incumbents with its fuel-efficient point-to-point air taxi, show the way for upstart competitors.

4 MIGRATE
Relocate basic materials industries using cheaper production unlocked by clean energy.

Let's shift gears now (a phrase that will become an anachronism as electrification eliminates transmissions) to innovations that can decarbonize industrial heat — the thermal energy needed to make steel, cement, and other basic materials. Coal-fired steel-making blast furnaces, coal- or gas-fired cement kilns, ethylene plants, and the like emit one-fourth of global carbon dioxide, including 7% to 8% each for cement and steel, 3% for chemicals (mainly fertilizers and plastics), and 1% for aluminum.

Those emissions from burning fossil fuels could be eliminated by instead generating heat directly from renewable electricity or delivering it via hydrogen, infrared radiation, microwaves, or superhot gaseous plasmas. (Nine percent of the world's heat needs, from low-temperature space heating to high-temperature industrial heating, already are met directly by solar and geothermal sources or burning biomass.) Some existing manufacturing plants will switch to renewable heat. Others will be replaced by purpose-built plants in regions with cheap renewable electricity. That creative destruction could strand trillions of dollars of fossil-fuel-based heavy-industry investments and produce trillions of dollars' worth of new ones.

Making metals was always about location — good ore near cheap energy. From 12th century Song dynasty China and Industrial Revolution England and Germany to 20th century America's Upper Midwest, the proximity of coal to iron ore spawned massive iron and steel industries. Today, ore is often shipped from afar to hungry markets; Australia and Brazil, for example, ship iron ore to Chinese coal-fired blast furnaces, which make half the world's steel. Such dirty process heat will give way to clean heat generated by renewables — elsewhere in China or imported — or clean-heat processes will shift abroad altogether.

That's why Sweden's steel industry plans to build a renewably powered mill in the Arctic iron-mining town of Gällivare. Foreseeing demand for "green steel," this year Swedish joint venture Hybrit's pilot plant in Luleå began using hydrogen made from hydroelectricity to turn local ore into CO_2-free

steel that Volvo plans to start putting into truck parts next year. Rival H2GreenSteel's industrial-scale production is due to begin in 2024, aiming for 5 million tons of steel per year before 2030.

Australia's Fortescue Metals is likewise planning to build a green-steel pilot plant this year that taps the country's abundant sun and wind to produce hydrogen. It then plans to build a commercial plant in Western Australia's Pilbara region, co-locating production with iron ore and locally abundant renewable energy rather than shipping ore to dirty steel mills far away. Such green steel should beat many fossil-fueled mills' prices and ultimately strand their assets. Combining cheap local renewables with growing demand (and perhaps a price premium) for green steel could bring its production not just to places rich in iron ore, like Australia, India, and South Africa, but also to areas with modest ore deposits, like North Africa and Chile, or none, like the Middle East. Along the same lines, the United Arab Emirates' solar-powered smelter turns Guinean bauxite into green aluminum for German cars.

Renewable energy itself can also be exported: Saudi Arabia is building a $5 billion sun- and wind-powered plant to produce "green hydrogen" and, starting in 2025, ship it in the form of liquid ammonia (NH_3) to join the projected $700 billion annual hydrogen market. BloombergNEF just announced that with solar electricity's 2050 price now predicted to be 40% below 2019's forecasts, green hydrogen will beat natural-gas-based hydrogen in this decade and become stunningly cheap — ideal for use in heavy industries like steel.[7]

Fossil-fueled cement-making is another rich target for renewable industrial heat. Currently, over half the world's cement is made in China using coal for heat. Solar-superheated air could soon become competitive with coal or gas for this purpose (and would also have to compete with green hydrogen). To test the concept, global cement giant Cemex and ETH Zurich spinoff Synhelion are building a solar-heated pilot cement kiln. And U.S. startup 247Solar's prototype concentrators (competing with Heliogen's) can heat air to 1,800 degrees Fahrenheit, at a gas-competitive cost, and provide overnight storage so it can deliver process heat whether the sun is shining or not. Processes that need milder heat, like most chemical plants, can already use solar steam or electric heat pumps at lower cost than burning natural gas.

If run as planned for their lifetimes, just the world's most carbon-intensive $22 trillion worth of 2018 electricity, transport, and industrial assets would break the world's total carbon budget. And just a fourth of those assets will emit three-fourths of that CO_2 if not retired sooner. But if, hypothetically, the world's entire coal power plant fleet were replaced today by renewables plus storage, that swap could be cost-neutral within two years and by 2025 could return over $100 billion annually, even with side benefits to climate and health valued at zero.[8] Energy, transport, and industry are all awash in imminently stranded assets and in opportunities to realign asset portfolios and remobilize trapped capital. As trillions of dollars rush in to fund both "out with the dirty" and "in with the clean" initiatives, Warren Buffett's sage advice applies: When horseless carriages enter the market, don't overanalyze which newcomer will win; short the horses.

5 ALIGN

Harmonize customers' and providers' incentives by rewarding frugal infrastructure design and "servitizing" basic materials.

As we've seen, traditional processes for manufacturing cement, steel, and other energy-intensive materials are expensive and dirty and generate billions of tons of CO_2 annually. Manufacturers and their customers have a common interest in reducing these costs. For both, squeezing waste out of the system represents one of the biggest business opportunities on the planet — and over 99% of the materials the world mines or grows are now wasted.

The giant industries that make and use basic materials are developing low- or no-carbon substitutes, and manufacturers are switching to more efficiently used, milder, or cleaner process heat. All of that is part of the solution. So is providing incentives for materials reuse, remanufacturing, and recycling: A more circular economy could save up to 37% of steel, 34% of cement, 40% of aluminum, and 56% of plastics, cutting materials-related CO_2 by 40%.[9] And making buildings durable in the first place and then maintaining them can help; while cement-intensive Chinese buildings erected in recent decades have average life spans of just 30 years, well-tended concrete

buildings can last for centuries. Rome's Pantheon dome, the world's largest unreinforced concrete structure, has stood for nearly 2,000 years.

These approaches to improving materials productivity are important but overlook the vast opportunity presented by reducing the amounts of cement, steel, and other structural materials that buildings need. Authoritative analyses suggest that 11% of cement and 9% of steel could be profitably and practically saved by simply using fewer tons more efficiently.[10] But with new designs that make frugal use of materials, and the transformation of materials into services, the potential savings seem far larger.

These design methods and business models will lead to a reduction in the extraction, processing, and transport of materials, allowing less capital to deliver more profit with less risk. That financial white space, I believe, holds the promise of redefining or displacing much of current extraction and materials-manufacturing industry. Many businesses based on selling tons rather than outcomes must either leap that chasm or vanish into it.

Frugal Design

Certainly, fixing innumerable little wastages across the complex value chain of construction can save gigatons of materials each year. However, novel designs that confer the same structural integrity with less material appear to be able to save at least as many tons and could halve builders' bills for steel and concrete, profitably and without compromise.

For example, airy single-tower suspension bridges and soaring cable-suspended stadium roofs can weigh 80% to 90% less than traditional structures. Pouring concrete not into flat box-like forms but into curving fabric forms, thinner where less strength or stiffness is needed and bulging where more is needed, can save at least half the concrete and steel needed to make traditional beams. The massive design of conventional concrete bridges mostly exists to support their own weight, but 3D printing can make bridges so strong and slender, supported by myriad delicate-looking branches, that their design is mostly directed toward carrying the payload.

Floor slabs account for about half the total weight of a typical mid- or high-rise building, and hefty concrete and steel beams, columns, and foundations to support all that weight make up much of the rest. But folding a thin, carbon-fiber reinforced floor slab into a structure like corrugated cardboard's makes it as stiff and strong as a solid slab six times thicker and four times heavier. Another strength-through-geometry solution, saving up to 70% of materials, is a thin and shallow shell rounded as a curving vault and extended to a flat top by thin stiffening ribs — perhaps making modern civil works as materials-efficient as a 13th century Gothic cathedral.

Servitizing

Such a focus on increasing materials productivity — using less to do more — enables a new business model for cement and steel companies: not selling by the ton, but rather leasing the structural services that these materials provide. When providing a ton of cement becomes a cost in a service model rather than a source of sales revenue, the fewer tons needed to deliver the same or better service, the more money the provider and customer both save. Thus, frugal design combined with a service model can be richly rewarded as both provider and customer profit by doing more and better with less for longer. And providers benefit from a steady stream of lease payments, which replace episodic payments that fluctuate with volatile commodity prices. You want the use, the outcome — not the stuff. You can enjoy a fine meal without owning the restaurant.

Selling services derived from products rather than the products themselves — what lean gurus

A focus on increasing materials productivity — using less to do more — enables a new business model for cement and steel companies: not selling by the ton, but rather leasing the structural services that these materials provide.

Jim Womack and Dan Jones dubbed the "solutions economy" around 2005 — is now called *servitizing* or *servitization* by the World Economic Forum.[11] The sale of jet-engine thrust as a service, known as Power-by-the-Hour, was pioneered by Bristol Siddley in 1962 and refined by Rolls-Royce in 2002; Xerox started selling copying by the page, not the machine; and Dow and Safety-Kleen switched from selling solvents to delivering "dissolving services." This model has spread across sectors from indoor climate control, lighting, elevators, and roofing to digital media, pallets, truck tires, and personal mobility. Why not structures, too? For example, when smart design can use a ton of concrete and steel at least twice as productively as normal practice, a cement or steel company — or, ideally, both together — could form an alliance to offer "bridge services." Such an alliance could design an advanced bridge using a fraction of the usual materials, pay its structural engineers for elegant frugality, arrange for careful construction and maintenance, and get paid for the traffic that the bridge safely carries — not for the physical asset or its materials. When I proposed this solutions-economy model to the head of a large cement maker years ago, he replied, "Good idea. I have 200 people working on that."

Copper likewise could be servitized. Where is the world's richest copper deposit — under Papua New Guinea? Chile? Or perhaps Manhattan, buried in wires and cables? Had copper miners not sold tons of metal to makers of wire and cable, which was then sold to Con Edison and AT&T (which then buried it), a conductance-services provider — let's call it "ConductCo" — could instead have installed its durable copper retrievably. That way, as it researched and developed alternatives like efficient electricity use, distributed generation, and broadband wireless, ConductCo could readily recover its copper and re-release its services to new clients. As steel, copper, gold, lithium, and other metals become servitized, mining companies may evolve into metal-services financiers and brokers — and remote ore deposits can keep on quietly holding up the ground.

Despite the vast profit potential in servitizing construction materials industries, there are daunting obstacles, chief among them that these are highly risk-averse, innovation-resistant sectors. In addition, most clients neither request nor reward materials efficiency and in fact tolerate or even extol huge overdesign margins.[12] Progress will depend on the work of outstanding, trusted civil and structural engineers who think differently and prefer brave rigor to timid groupthink. Structural service providers that partner early with these top designers, reward their performance, help grow and apply their talent, and assemble an alliance of suppliers, designers, and builders delivering better, cheaper buildings could beat laggards stuck with inferior designers and commodity businesses. Reforming client and designer cultures will be slow and hard, but the sharpness of both these players' competitive spears should help pierce tough layers of encrusted habit.

THESE FIVE STRATEGIC INNOVATIONS all depend on new business models and financial products to speed the graceful retirement of dirty industrial assets (blast furnaces, diesel fleets, coal-fired power stations, and more), finance their clean replacements, and speed capital flight from obsolete to advantageous assets and industries. I've touched on some of them here — servitization of materials, clean electricity arbitrage, feebates, golden-carrot purchase agreements, and early asset retirement among them. These, combined with focused and comprehensive efforts to improve efficiency — via conventional savings, integrative design savings, materials savings from frugal

> Turning fossil fuels' gentle slide into a mighty avalanche is a worthy goal for a future that makes sense, makes money, proceeds from applied hope, and creates a richer, fairer, cooler, safer world worth being hopeful about.

design, and others — will squeeze fossil fuels out of power generation, buildings, industry, and vehicles. This would more efficiently allocate capital, make more money, do more good, and be more fun (for insurgents, if not incumbents).

Getting this done requires investment in energy and materials efficiency whenever it's cheaper than inefficiency; rewarding utilities for cutting energy bills rather than selling energy; rewarding designers for what they save, not what they spend; prioritizing barrier busting in policy, not only proper energy pricing; and refocusing public policy and private-sector strategies to enable the new, not protect the old. Who won't like that? Corporate socialists masquerading as free marketeers. Who will? Serious conservatives, entrepreneurs, smart investors, and everyone who understands that roasting the planet is bad for business and for all beings.

Don't assume that these changes will wait until after you retire. Visionaries like futurist Tony Seba argue that the world is "on the cusp of the fastest, deepest, most profound disruption of the energy sector in over a century" — a phase change leading to a new system with very different rules and outcomes. BloombergNEF's deeply empirical analyses broadly concur.[13]

Even in the short run, capital flight from fossil fuels to renewables and efficiency is accelerating. Last year, despite the pandemic, the growth of renewables accelerated 45% — briskly enough to meet all future demand growth, condemning fossil fuels to permanent decline from their likely 2019 peak.[14] This triggered a self-reinforcing capital stampede from fossil fuels to their fast-growing replacements, sped by some targeted pandemic recovery investments, including 1 trillion euros in Europe. My five strategies could further pick up the pace. Turning fossil fuels' gentle slide into a mighty avalanche is a worthy goal for a future that makes sense, makes money, proceeds from applied hope[15], and creates a richer, fairer, cooler, safer world worth being hopeful about.

Amory Lovins *is cofounder and chairman emeritus of RMI and an adjunct professor at Stanford. He advises major corporations and governments around the world on energy issues. Comment on this article at https://sloanreview.mit.edu/x/63108.*

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