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Author
Posner, M

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See No Evil
Miriam Posner

Trawling a hotel minibar one night while on a work trip to Amsterdam, I found a piece of chocolate with an unusual name: Tony's Chocolonely. I giggled at how apt the name was—who eats minibar chocolate unless they are, indeed, a little lonely?—and, on a whim, plugged it into Google.

The results were more sobering than I'd expected. The founder of Chocolonely, Tony Van de Keuken, founded the company with the goal of making the first (the "lonely only") chocolate bar produced without labor exploitation. According to the company, this goal actually landed them in legal trouble: Bellissimo, a Swiss chocolatier, sued Chocolonely in 2007, allegedly claiming that "slave-free chocolate is impossible to produce."

I had heard similar claims about other industries. There was the Fairphone, which aimed at its launch in 2013 to be the first ethically produced smartphone, but admitted that no one could guarantee a supply chain completely free from unfair labor practices. And of course one often hears about exploitative labor practices cropping up in the supply chains of companies like Apple and Samsung: companies that say they make every effort to monitor labor conditions in their factories.

Putting aside my cynicism for the moment, I wondered: What if we take these companies at their word? What if it is truly impossible to get a handle on the entirety of a supply chain?

The thing that still confused me is how *reliable* supply chains are, or seem to be. The world is unpredictable—you've got earthquakes, labor strikes, mudslides, every conceivable tragedy—and yet as a consumer I can pretty much count on getting what I want whenever I want it. How can it be possible to predict a package's arrival down to the hour, yet know almost nothing about the conditions of its manufacture?

In the past twenty years, popular and academic audiences have taken a growing interest in the physical infrastructure of global supply chains. The journalist Alexis Madrigal's "Containers" podcast took on the question of how goods travel so far, so quickly. The writer Rose George traveled the world on a container ship for her book *Ninety Percent of Everything*. And Marc Levinson's *The Box* startled Princeton University Press by becoming a national bestseller. Most recently, Deborah Cowen's *The Deadly Life of Logistics* offered a surprisingly engrossing history of that all-important industry.

These books help us visualize the physical infrastructure that makes global capitalism possible. But the *data* infrastructure has yet to be explored. How does information travel through the

supply chain in such a peculiar way, so that I know to wait impatiently at my door at the exact moment my new iPhone will arrive—but no one really seems to know how it has gotten to me?

I set out to find the answer, and what I found surprised me. We consumers are not the only ones afflicted with this selective blindness. The corporations that make use of supply chains experience it too. And this partial sight, erected on a massive scale, is what makes global capitalism possible.

A Network of Waterways

The industry of supply-chain management (or SCM, to its initiates) is both vast and secretive. It's one of the most rapidly growing corporate fields, and the subject of reams of books, journal articles, and blog posts. You can even get a degree in it.

But most companies are leery about revealing too much about their own logistics operations. It's not only because they are afraid of exposing what dark secrets might lurk there. It's also because a reliable, efficient supply chain can give a company an invaluable edge over its competitors.

Take Amazon: it's not so much a retailer as a supply chain incarnate. Its advantage lies in the high speed and the low price with which it can get a set of bath towels to your door. No wonder the retailer is famously tight-lipped about its supply-chain infrastructure. Few people outside of Amazon know much about the software that Amazon uses to manage its logistics operations.

In the supply-chain universe, there are large, tech-forward companies like Amazon and Apple, which write and maintain their own supply-chain software, and there's everyone else. And most everyone else uses SAP. SAP (the name stands for Systems, Applications and Products) is a behemoth, less a single piece of software than a large, interlocking suite of applications, joined together through a shared database. Companies purchase SAP in "modules," and the supply-chain module interlocks with the rest of the suite. Among people who've used SAP, the reaction to hearing its name is often a pronounced sigh—like all large-scale enterprise software, SAP has a reputation for being frustrating.

Nevertheless, SAP is ubiquitous, with modules for finance, procurement, HR, and supply-chain management. "A very high percentage of companies run SAP for things like finance," says Ethan Jewett, an SAP consultant and software developer who helps companies implement SAP modules. "And so, if you're running it for one part of your business, you'll default to running it for another part of your business."

Leonardo Bonanni is the founder and CEO of a company called Sourcemap, which aims to help companies map their own supply chains. Bonanni suspects that companies' inability to visualize their own supply chain is partly a function of SAP's architecture itself. "It's funny, because the DNA of software really speaks through," said Bonanni. "If you look at SAP, the database is still

actually written in German. The relations in it are all one-link. They never intended for supply chains to involve so many people, and to be interesting to so many parts of the company."

This software, however imperfect, is crucial because supply chains are phenomenally complex, even for low-tech goods. A company may have a handle on the factories that manufacture finished products, but what about their suppliers? What about the suppliers' suppliers? And what about the raw materials?

"It's a staggering kind of undertaking," said Bonnani. "If you're a small apparel company, then you still might have 50,000 suppliers in your supply chain. You'll have a personal relationship with about 200 to 500 agents or intermediaries. If you had to be in touch with everybody who made everything, you would either have a very small selection of products you could sell or an incredible margin that would give you the extra staff to do that."

We call them "supply chains," but that image is misleading. They really look more like a network of waterways, with thousands of tiny tributaries made up of sub-suppliers trickling into larger rivers of assembly, production, and distribution.

Bonanni explained that while workplace abuses get a lot of attention when they take place in the supply chains of large, prestigious companies like Apple and Samsung, working conditions are actually most opaque and labor abuse is most rampant in other industries, like apparel and agriculture. "Apparel, every quarter they have 100% turnover in the clothing that they make, so it's a whole new supply chain every season. And with food, there's millions of farmers involved. So in these places, where there's way too many nodes for anyone to see without a computer, and where the chain changes by the time you've monitored it-—those are the places where we see a lot of problems and instability."

The picture that many of us have of supply chains involve state-of-the-art factories like Foxconn. In reality, the nodes of most modern supply chains look much less impressive: small, workshop-like outfits run out of garages and outbuildings. The proliferation and decentralization of these improvisational workshops help explain both why it's hard for companies to understand their own supply chains, and why the supply chains themselves are so resilient. If a fire or a labor strike disables one node in a supply network, another outfit can just as easily slot in, without the company that commissioned the goods ever becoming aware of it.

It's not like there's a control tower overseeing supply networks. Instead, each node has to talk only to its neighboring node, passing goods through a system that, considered in its entirety, is staggeringly complex. Supply chains are robust precisely because they're decentralized and self-healing. In this way, these physical infrastructures distributed all over the world are very much like the invisible network that makes them possible: the internet.

Gold Must Be Gold

By the time goods surface as commodities to be handed through the chain, purchasing at scale demands that information about their origin and manufacture be stripped away. Ethan Jewett explained the problem to me in terms of a theoretical purchase of gold:

> In some sense all gold is the same, so you just buy the cheapest gold you can get. But if you look at in another way, it matters how it was mined and transported. And then all of the sudden, every piece of gold is a little bit different. And so it becomes very difficult to compare these things that, in terms of your actual manufacturing process, are almost exactly the same.

To be traded as a commodity, in other words, gold must be gold.

As Jewett described this state of affairs to me, I felt a jolt of recognition. The system he was outlining was, in a word, *modular*: a method of partitioning information that's familiar to every computer programmer and systems architect. Modular systems manage complexity by "black-boxing" information; that is, they separate code or information into discrete units. A programmer need only know about the module with which she is working, because managing the complexity of the entire system would be too much to ask of any single individual. Modularity is the method we've devised to manage complexity at a time when we're drowning in information.

The computing historian Andrew Russell told me that "black-boxing reduces all kinds of cognitive and informational overhead, because you just know what the box spits out; you don't need to know anything about what's going on in there." Modularity, as Russell has documented, emerged as a term in architecture, and then spread to the military, where it was picked up to describe Project Tinkertoy, a post-World War II program to design interchangeable, self-contained parts for electronics. From there, the notion of modularity proliferated wildly, as a way of thinking about and structuring everything from organizations to economics to knitting. "It's kind of a characteristic of modernity," Russell said.

Supply chains are highly modular by design. Think of the shipping container. It wasn't revolutionary because it was a box; it was revolutionary because it was a standardized, interchangeable box that could be locked in and transported It makes globalization possible—it makes global *scale* possible—because of what it obscures. One doesn't need to know what's in the box, just where it needs to go.

How do you manage the complexity of a system that procures goods from a huge variety of locations? You make it modular: when you black-box each component, you don't need to know anything about it except that it meets your specifications. Information about provenance, labor conditions, and environmental impact is unwieldy when the goal of your system is simply to procure and assemble goods quickly. "You could imagine a different way of doing things, so that you *do* know all of that," said Russell, "so that your gaze is more immersive and continuous. But what that does is inhibit scale." And scale, of course, is key to a globalized economy.

On the one hand, this all seems very logical and straightforward: to manage complexity, we've learned to break objects and processes into interchangeable parts. But the consequences of this decision are wide-ranging and profound.

It helps explain, for one thing, why it's so hard to "see" down the branches of a supply network. It also helps explain why transnational labor organizing has been so difficult: to fit market demands, workshops have learned to make themselves interchangeable. It sometimes seems as though there's a psychological way in which we've absorbed the lessons of modularity—although the world is more connected than ever, we seem to have trouble imagining and articulating how we're linked to the other denizens of global manufacturing networks.

Put It On the Blockchain

If technology enables a selective blindness that makes the scale of global supply chains possible, can technology also cure the problem of disavowal? Can software, having created the black box, help crack it open?

Recently, there's been a lot of buzz about blockchain and the Internet of Things (IoT) among SCM practitioners. IoT technology would attach transmitters to components, so that their locations could be traced and monitored. With blockchain technology, each component that passes through a supply chain could have a unique, traceable ID number, and a log that registers every time it changes hands. Their proponents say that these technologies could bring radical transparency and unprecedented safety to global supply chains.

Blockchain is the technology that underlies bitcoins. The idea is that at each "stop" along a chain of users, a database associated with a particular coin (or component) updates to register the change of hands. The identity of each user could be cryptographically concealed, or it could be recorded transparently. Either way, the record of transactions is available to everyone along the chain, and it's near-impossible to forge.

Blockchain is security for the age of decentralization, and it could, in theory, make it possible for companies to verify the safety, composition, and provenance of manufactured goods. *Supply Chain 24/7*, an industry newsletter, calls blockchain a "game-changer" that "has the potential to transform the supply chain."

IoT is a different technology that addresses a similar problem. A company somewhere along a supply chain embeds a small transmitter, like an active RFID tag, in a component, allowing a monitor to see its location and status in real time. With sensors, a company could also keep track of the component's environment, checking on things like temperature and humidity. It sounds like a solution custom-fitted for the problem at hand: with these tiny trackers, companies could finally get the visibility they say they're after.

But the supply-chain specialists I talked to were skeptical. To make blockchain meaningful, Bonnani told me, you'd need to get every vendor to agree to disclose information about its

practices; otherwise you'll just see a string in a database. "If you get suppliers to agree to be transparent, then blockchain is a way to verify that the thing you receive actually came from the person who sent it to you, and it's extremely valuable in that respect," said Bonnani. "But if you don't get them to opt in, then all you know is, you got what you asked for. They're not going to tell you who they got it from, or who that person got it from."

IoT lends itself to the same problems. Without genuine buy-in from suppliers, IoT "becomes one more technology to counterfeit," said Bonnani. "You're basically not improving the current problem, which is a lack of visibility." Given the pressure on suppliers to move quickly and flexibly, it's hard to imagine anyone volunteering more information than necessary.

One could imagine a system in which IoT and blockchain enable detailed information on labor conditions and safety, but the reality of global capitalism suggests that IoT is more likely to bring us smart toasters than socially responsible supply chains.

Making Better Bets

SCM innovation continues to thrive, but it's not trending toward the kind of visibility that Tony's Chocolonely is looking for. The newest technology that logistics professionals find exciting is machine learning, which involves creating algorithms that are capable of making predictions or decisions by "learning" from a set of data.

Machine learning is already in heavy use on the consumer side, where companies like Target use it to wager that a shopper who purchases unscented lotion, vitamins, hand sanitizer, and soft furniture might be getting ready to have a baby. But in the SCM world, machine learning could make it much easier to discover which suppliers and routes will deliver goods most quickly and reliably. A company could "predict the performance of each supplier, carrier, forwarder, port, lane, road, manufacturing facility, warehouse, etc. within the extended supply chain, under varying conditions," according to the SCM analytics company Transvoyant.

In a machine-learning scenario, companies could use historical data about manufacturers and goods to assign suppliers risk scores. Weather, changes in a supplier's political climate, or economic factors could all reassign risk scores, causing the supply network to automatically reconfigure itself to favor less-risky suppliers. It's a stunning idea: supply chain networks dynamically rerouting themselves in response to global risk factors, just the way Google Maps sends you down surface streets when the freeway is clogged.

This would increase efficiency, but at the cost of making it even more impossible to identify the supplier of your smartphone's LCD screen. It would aggravate, not alleviate, the problem of selective blindness that's already so deeply embedded in global supply chains.

In reality, the prospect of using machine learning on the manufacturing end of supply chains remains mostly speculative. When a company doesn't even know the most basic facts about its

suppliers, it's hard to imagine how it would assemble the data necessary to develop efficient machine learning models.

But its attraction for SCM specialists is notable, because it points to the kind of visibility that companies are talking about when they call for supply-chain transparency: not the kind of information that would help a consumer see where her candy comes from, but the kind of information that would get it into her hands faster and cheaper.

Visibility, in the SCM context, is itself highly selective.

Learning To See

The challenges are political as well as technical, in other words. And the political challenges are immense. In the absence of real efforts to create democratic oversight of supply chains, we've come to see them as operating autonomously—more like natural forces than forces that we've created ourselves.

In 2014, the *Guardian* reported that Burmese migrants were being forced into slavery to work aboard shrimp boats off the coast of Thailand. According to Logan Kock of Santa Monica Seafood, a large seafood importer, "the supply chain is quite cloudy, especially when it comes from offshore." I was struck by Kock's characterization of slavery as somehow climatological: something that can happen to supply chains, not just something that they themselves cause.

But Kock was right, supply chains are murky—just in very specific ways. We've chosen scale, and the conceptual apparatus to manage it, at the expense of finer-grained knowledge that could make a more just and equitable arrangement possible.

When a company like Santa Monica Seafood pleads ignorance of the labor and environmental abuses that plague its supply chains, I find myself inclined to believe it. It's entirely possible to have an astoundingly effective supply chain while also knowing very little about it. Not only is it possible: it may be the enabling condition of capitalism at a global scale.

It's not as though these decentralized networks are inalterable facts of life. They look the way they do because we built them that way. It reminded me of something the anthropologist Anna Tsing has observed about Wal-Mart. Tsing points out that Wal-Mart demands perfect control over certain aspects of its supply chain, like price and delivery times, while at the same time refusing knowledge about other aspects, like labor practices and networks of subcontractors. Tsing wasn't writing about data, but her point seems to apply just as well to the architecture of SAP's supply-chain module: shaped as it is by business priorities, the software simply cannot absorb information about labor practices too far down the chain.

This peculiar state of knowing-while-not-knowing is not the explicit choice of any individual company but a system that's grown up to accommodate the variety of goods that we demand,

and the speed with which we want them. It's embedded in software, as well as in the container ships that are globalization's most visible emblem.

We know so much about the kinds of things we can get and when we can get them. But aside from the vague notion that our stuff comes from "overseas," few of us can really pin down the stations of its manufacture. Is a more transparent—and more just—supply chain possible? Maybe. But, as the Chocolonely lawsuit demonstrates, it could mean assimilating a lot of information that companies have become very good at disavowing—a term that, in its Freudian sense, means refusing to see something that might traumatize us.