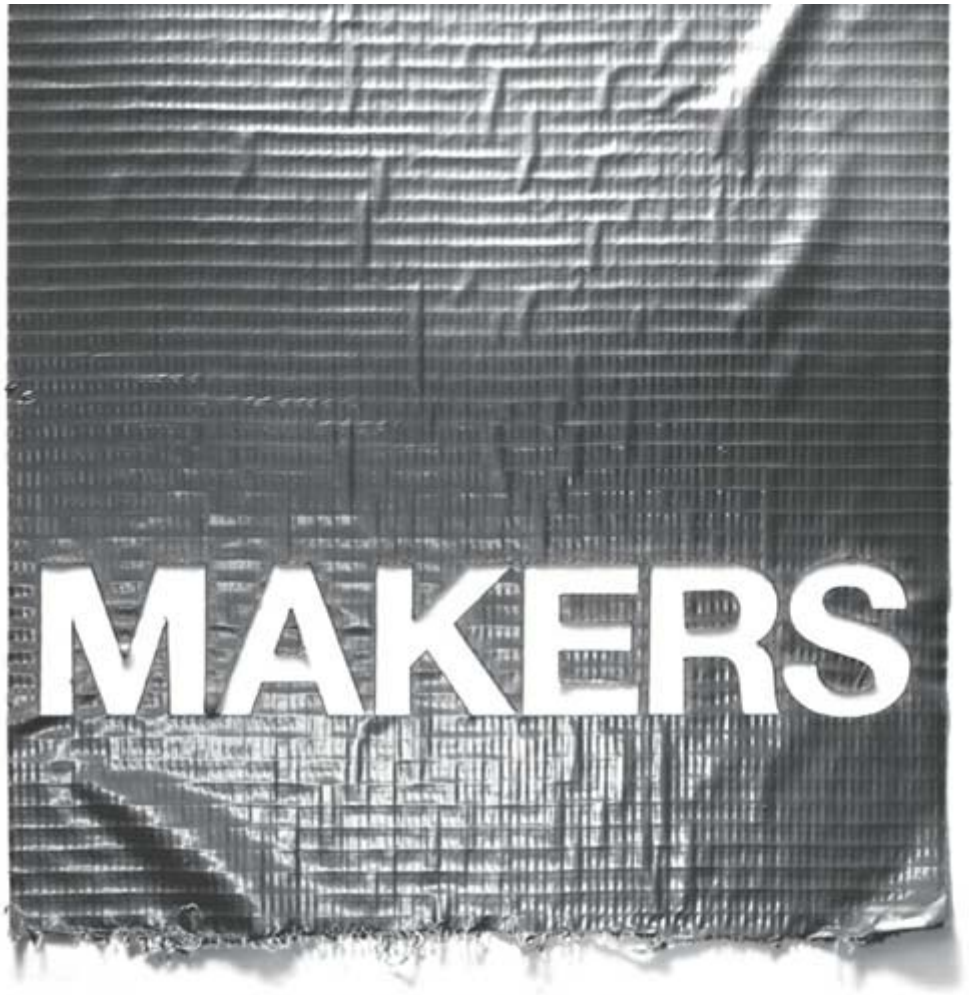

THE NEW INDUSTRIAL REVOLUTION

CHRIS ANDERSON

Author of the bestseller The Long Tail

MAKERS

The New Industrial Revolution

CHRIS ANDERSON

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Chapter 3

The History of the Future

What happened in Manchester and the cottage industries of England changed the world. It could happen again.

In 1766, James Hargreaves , a weaver in Lancashire, was visiting a friend when he saw a spinning wheel fall on its side. For some reason it kept spinning, and something about the contraption still working in the unfamiliar orientation triggered a vision in Hargreaves's mind: a line of spindles, side by side, spinning multiple threads of cotton from flax simultaneously. When he returned home, he started whittling up just such a machine from spare wood, with the spindles connected by a series of belts and pulleys. Many versions later, he had invented the spinning jenny, a pedal-powered device that could allow a single operator to spin eight threads at the same time (*jenny* was Lancashire slang for "machine").

The machine amplified the output of a single worker by a factor of eight at the start, and could easily be expanded beyond that. And this was just the beginning.

There was nothing new about textile-making machines themselves. The ancient Egyptians had looms, after all, and the Chinese had silk-spinning frames as early as 1000 BCE. The hand-powered spinning wheel was introduced in China and the Islamic world in the eleventh century, and the foot treadle appeared in the 1500s. You only have to look at illustrated fairy tales to see spinning wheels in widespread use.

But the earlier machines didn't launch an industrial revolution, while Hargreaves's invention, along with the steam engine and even more sophisticated power looms that came later, did. Why? Historians have been debating this for centuries, but they agree on a few reasons. First, unlike silk, wool, and hemp, which were used in many of the earlier machines, cotton was a commodity that could reach everyone. It was simply the cheapest and most available fiber in the world, even more so once the expanding British trade empire brought bales of the stuff from India, Egypt, and the New World.

Second, the spinning jenny, being driven by a series of belts and pulleys, was designed to distribute power from a central point to any number of mechanisms operating in parallel. Initially that was human muscle power, but the same principle could use much stronger motive forces—first water, then steam—to drive even more spindles. In other words, it was a scalable mechanism, able to take advantage of bigger sources of power than just arms and legs.

Finally, it arrived at the right time, in the right place. Britain in the 1700s was going through an intellectual renaissance, with a series of patent laws and

policies that gave artisans the incentive not only to invent but also to share their inventions.

As William Rosen put it in his 2010 book, *The Most Powerful Idea in the World*:

> Britain's insistence that ideas were a kind of property was as consequential as any idea in history. For while the laws of nature place severe limits on the total amount of gold, or land, or any other traditional form of property, there are (as it turned out) no constraints at all on the number of potentially valuable ideas.… The Industrial Revolution was, first and foremost, a revolution in *invention*. And not simply a huge increase in the number of new inventions but a radical transformation in the process of invention itself.[14]

In June 1770, Hargreaves submitted a patent application, number 962, for a version of the spinning jenny that could spin, draw, and twist sixteen threads simultaneously. The delay between this patent application and his first prototypes meant that others were already using the jenny by the time his patent was granted, making it difficult for him to enforce his patent rights. Even worse, the machine made enemies.

Starting in Hargreaves's native Lancashire, the spinning jenny's magical multiplication of productivity was initially, as you might expect, little welcomed by the local artisans, whose guilds had controlled production for centuries—they hated it. As yarn prices started to fall and opposition from local spinners grew, one mob came to his house and burned the frames for twenty new machines. Hargreaves left for Nottingham, where the booming cotton hosiery industry needed more cotton thread. He died a few years later, in 1778, having made a little money from his invention, but still far from rich.

While this was happening, the American colonies were declaring independence and war. James Watt invented the steam engine in 1776. Although the exact timing with the Declaration of Independence is a coincidence, the connection between the two is not. Britain was finding it increasingly difficult to support its empire on resource extraction from its colonies alone, especially as they became more difficult to manage. It needed to increase production at home, where the political and military costs were lower. Mechanized planting and harvesting tools were already hugely increasing the output of British farms. The arrival of machines to turn agricultural commodities into goods that could be sold around the world promised the opportunity to shift from a nation that commanded global power by force to one that used trade instead. But its greatest impact was initially at home, where the immediate effect was to both reshape the landscape and hugely elevate the living standard of millions of Britons.

What revolutions can do

What exactly is an "industrial revolution"? Historians have been debating this since the late eighteenth century, when they first noticed that something startling was happening to growth rates. It was already obvious that the

manufacturing and trade boom that came with the first factories had changed the economy, but the sheer magnitude of it wasn't immediately clear, in part because statistics were hard to find. But by the 1790s, the effects didn't need an accountant to observe them. Populations were simply exploding, and for the first time in history, wealth was spreading beyond landed gentry, royalty, and other elites.

Between 1700 and 1850, the population of Great Britain tripled. And between 1800 and 2000, average per capita income, inflation adjusted, grew *tenfold*. Nothing like this had ever happened before in recorded history. It seemed clear that this social revolution was connected somehow to the industrial quarters that were increasingly dominating England's fast-growing cities. But why mechanization led to population growth, to say nothing of the other booming quality of life measures, took longer to figure out.

There was, of course, more to it than just factories. Improved farming methods, including the fencing in of pastures that avoided the "tragedy of the commons" problem, had a lot to do with it. And more children were living to adulthood, thanks to the invention of the smallpox vaccine and other medical advances. But industrialization helped even more.

Although we think of factories as the "dark satanic mills" of William Blake's phrase, poisoning their workers and the land, the main effect of industrialization was to improve health. As people moved from rural communities to industrial towns, they moved from mud-walled cottages to brick buildings, which protected them from the damp and disease. Mass-produced cheap cotton clothing and good-quality soap allowed even the poorest families to have clean clothing and practice better hygiene, since cotton was easier to wash and dry than wool. Add to that the increased income that allowed a richer and more varied diet and the improved access to doctors, schools, and other shared resources that came with the migration to cities, and whatever ill effects resulted from working in the factories were more than compensated for by the positive effects of living around them. (To be clear, working in factories was tough, with long hours and poor conditions. But the statistics suggest that working on farms was even worse.)

The difference between life before and after this period is really quite amazing. Our modern expectation of continual growth and improving quality of life is just a few hundred years old. Before that, things stayed more or less the same, which is to say pretty bad, for thousands of years. Between 1200 and 1600, the average life span of a British noble (for whom records were best kept) didn't go up by so much as a single year. [15] Yet between 1800 and today, life expectancy for white males in the West doubled, from thirty-eight years to seventy-six. The main difference was the decline in child mortality. But even for those who survived childhood, life expectancy grew by about twenty years over that period, a jump of a magnitude never before seen.

The explanation for this had to do with all sorts of changes, from improvements in hygiene and medical care to urbanization and education. But the common factor is that as people got richer, they got healthier. And they got richer because their abilities were being amplified by machines, in particular

machines that made stuff. Of course, humans have been using tools since prehistory and one could argue that the "technologies" of fire, the plow, domesticated animals, and selective breeding were as defining as any steam engine. But agricultural technologies just allowed us to feed more people more easily. There was something different about the machines that allowed us to make products that improved our quality of life, from clothes to transportation.

For one thing, people around the world wanted such goods, so they drove trade. Trade, in turn, drove the engine of comparative advantage, so that countries did what they could do best and imported the rest, which improved everyone's productivity. And that, in turn, drove growth. As went the cotton mills of Manchester, so went the world economy.

The Second Industrial Revolution

The term *industrial revolution* itself was coined in 1799 by Louis-Guillaume Otto, a French diplomat, in a letter reporting that such a thing was under way in France (revolutions were much in vogue).[16] *Revolution* was also, perhaps unsurprisingly, the term used to describe the industrial changes by Friedrich Engels, whose capitalist critiques in the mid-1800s helped lead to Marxism. And it was popularized in the late 1800s by Arnold Toynbee, a British economic historian who gave a series of famous lectures on why this industrial movement had had such a profound impact on the world economy.

But at its core, *industrial revolution* refers to a set of technologies that dramatically amplify the productivity of people, changing everything from longevity and quality of life to where people live and how many there are of them.

For example, around 1850, the rise of the factory (from *manufactory*, as it was originally known) was joined by another technological wave, the development of steam-powered ships and railroads, which brought similar productivity gains to transportation. The invention of the Bessemer process for making steel in large quantities in the 1860s led to mass production of metal goods and eventually the assembly line.

Combined with the rise of the chemical industries, petroleum refining, and the internal combustion engine and electrification, this next phase of manufacturing transformation is called by many historians the "Second Industrial Revolution." They place it from 1850 to around the end of World War I, which includes Henry Ford's Model-T assembly line, with its innovations of stockpiles of interchangeable parts and the use of conveyer belts, where products being produced moved to stationary workers (who each did a single task), rather than the other way around.

Today, in a fully industrialized economy, we forget just how much the First and Second Industrial Revolutions changed society. We talk in terms of productivity enhancements, but consider what that means in terms of people's lives. When we moved from hunter-gatherers to farmers, one person could feed many. We were able to break out of the cycle of most other animals, where everyone's job is to feed themselves or their offspring, and pursue division of

labor, where we each do what we do best. This created spare time and energy, which could be invested in such things as building towns, inventing money, learning to read and write, and so on.

What the spinning jenny and its kin had created was an inflection point in the arc of history, a radical shift in the economic status quo. It elevated our species from one that was less about what we could do and more about what we knew. We became more valuable for our brains than for our muscles. And in the process, it made us richer, healthier, longer-living, and hugely more populous. Revolutions should be measured by their impact on people's lives, and as such the First Industrial Revolution is unparalleled.

The move from hand labor to machine labor freed up people to do something else. Fewer people in society were needed to create the bare essentials of food, clothing, and shelter, so more people could start working on the nonessentials that increasingly define our culture: ideas, invention, learning, politics, the arts, and creativity. Thus the modern age.

Writer Vankatesh Rao argues that the main effect of this was on time. Machines allow us to work faster, doing more in less time. That liberates those hours for other activities, whether productive or leisure. What the First Industrial Revolution did create, more than anything else, was a vast surplus of time, which was reallocated to invent practically everything that defines the modern world. Four hundred years ago, nearly everyone you'd know would be involved in producing the staples of existence: food, clothing, shelter. Today, odds are, almost none of them are. Rao writes:

> The primary effect of steam was not that it helped colonize a new land, but that it started the colonization of time. Many people misunderstood the fundamental nature of Schumpeterian growth [a reference to the innovation and entrepreneurship growth theories of the economist Joseph Schumpeter] as being fueled by ideas rather than time. Ideas fueled by energy can free up time which can then partly be used to create more ideas to free up more time. It is a positive feedback cycle.[17]

The Third Industrial Revolution?

There are those who argue that the Information Age is the Third Industrial Revolution. Computing and communications are also "force multipliers," doing for services what automation did for manufacturing. Rather than amplifying human muscle power, they amplify brain power. They can also drive productivity gains in existing industries and create new ones. And by allowing us to do existing jobs faster, they free us up to do new ones.

But in the same way that the first two Industrial Revolutions required a series of technologies to come together over many decades before their true impact was felt, the invention of digital computing is not enough by itself. The first commercial mainframes replaced some corporate and government accounting and statistics jobs; the first IBM PCs replaced some secretarial jobs. Neither changed the world.

Only when the computers were combined with networks, and ultimately the

network-of-all-networks, the Internet, did they really start to transform our culture. And even then the ultimate economic impact of computing may not be felt mostly in the services transformed by software (although there are a lot of them), but rather by how they transform the same domain as the first two Industrial Revolutions: the work of making stuff itself.

In short, the dawn of the Information Age, starting around 1950 and going through the personal computer in the late 1970s and early 1980s and then the Internet and the Web in the 1990s, was certainly a revolution. But it was not an *industrial* revolution until it had a similar democratizing and amplifying effect on *manufacturing*, something that's only happening now. Thus, the Third Industrial Revolution is best seen as the combination of digital manufacturing and personal manufacturing: the industrialization of the Maker Movement.

The digital transformation of making stuff is doing more than simply making existing manufacturing more efficient. It's also extending manufacturing to a hugely expanded population of producers—the existing manufacturers plus a lot of regular folk who are becoming entrepreneurs.

Sound familiar? It's exactly what happened with the Web, which was colonized first by technology and media companies, which used it to do better what they already did. Then software and hardware advances made the Web easier to use for regular folks (it was "democratized"), and they charged in with their own ideas, expertise, and energy. Today the vast majority of the Web is built by amateurs, semipros, and people who don't work for big technology and media companies.

We talk a lot about the "weightless economy," the trade in intangible information, services, and intellectual property rather than physical goods (the weightless economy consists of anything that doesn't hurt your foot if dropped upon it). Yet as big as the economy of bits may be, that dematerialized world of information trade is a small fraction of the manufacturing economy. So anything that can transform the process of making stuff has tremendous leverage in moving the global economy. That's the making of a real revolution.

Let's return to Manchester to consider how that might work in the real world.

Manchester, yesterday and tomorrow

Manchester is a city defined by its rapid rise long ago, and an agonizingly slow fall ever since. Today, in its manufacturing museum and crumbling warehouse districts, we see mostly the lost past: nostalgia for a time when Manchester was the world's greatest industrial city and the skyline was punctuated with the smokestacks of the world's clothes-makers. Every great city has its defining moment, and Manchester's can be seen in the architecture of the semirenovated Northern Quarter, which is still dominated by colossal Victorian brick warehouses and former factory buildings.

Why did the First Industrial Revolution take off in Manchester? There were other cities and regions that had early factories, including Birmingham and smaller towns in Lancashire. But Manchester had several key advantages. First,

it had plenty of free space and relaxed building laws, which made it possible to build factories and housing for the workers, something that would have been hard in the more built-up and restrictive port cities such as Liverpool. It was near rivers and streams that could provide waterpower for the early mill-driven factories. The largest of those rivers, the Mersey, extended all the way to the Atlantic, making it relatively easy to bring raw materials in and send finished goods out. And it was eventually well connected with rail lines, which brought coal from elsewhere in England and Wales.

In the mid-1800s, Manchester was at its peak. England grew hardly any cotton, but Manchester was called "Cottonopolis." Bales of raw cotton came in by sea from far-off lands and were transformed by miraculous machines—combing, tight weaving, and precision dyeing—into thread, cloth, and finally clothes. Then those goods were sent off through the same channels to markets around the world. It was a glimpse of the future: global supply chains, competitive advantage, and automation made a once-unremarkable city the center of the global textile trade.

Impressive as the new manufacturing machines were, the supply networks that fed them were equally important. Bigger, more efficient factories needed more and cheaper raw materials—not just cotton from Egypt and the Americas, but dyes and silk from Asia and eventually mineral resources such as iron ore and coal. That's why the steam engine's impact was felt as much in the evolution of sailing ships to steam freighters and the rise of steam locomotives as it was in the factory. Every step in the supply chain had to get more efficient for the impact of mechanized production to be felt.

At their height, Manchester's canals were the communications channels of the First Industrial Revolution. It was not enough to make stuff efficiently; it had to be distributed efficiently, too. Smaller canal projects eventually led to the Manchester Ship Canal in 1884, which allowed oceangoing freighters to sail right up to the Port of Manchester, forty miles inland. It was the perfect combination: an inland city with room for industrial expansion that, thanks to the big canal, could ship goods nearly as efficiently as a port city. Meanwhile, the railroads were doing the same on land: Manchester became one end of one of the world's first intercity rail lines, the Liverpool and Manchester Railway.

As a result, Manchester's manufacturing became the envy of the world, and companies everywhere sought to copy its model. Sadly for the local factories, they could. Along with selling clothing, Manchester firms started selling the machines that made them. Companies such as J&R Shorrocks and Platt Brothers, which were famed for their engineering skills, soon were exporting their machinery around the world, where it was copied, enhanced, and otherwise commoditized. By the 1900s, huge textile factories could be found from France to America. Manchester's mechanical advantages had been matched, and new industrial centers closer to agricultural sources of the raw cotton, especially in the American South, began to take over.

Manchester's factories went through the long-familiar quest to move upstream, with more-fashionable designs, higher quality, branded appeal, and further mechanical innovation. It certainly helped, and averted what might

have been an overnight implosion of an industry in the face of cheaper competitors. Instead, Manchester's textile decline stretched out over a century. But by the 1950s, there were more empty factories than full ones, and the city had become a symbol of Britain's lost industrial might.

By the 1980s, the city was better known for the raves held in empty warehouses than for what had once filled them. Not for nothing was the music label that was behind the UK's Manchester-based post-punk scene of the 1980s (Joy Division, New Order, Happy Mondays, and many others) called Factory Records—it started with a series of music clubs housed in former Victorian factories. Manchester had become a symbol of manufacturing decline. Young people with not enough to do created a thriving music scene, but their joblessness and existential despair also spoke to the vacuum left in the birthplace of the First Industrial Revolution.

In 1996, the IRA parked a truck packed with explosives in the city center. Although a warning call ensured that the area was evacuated before the bomb exploded, it badly damaged dozens of buildings. This became something of a turning point for Manchester. After years of decline and failed turnaround strategies, reconstruction became a catalyst. The tragedy focused national attention on the downtrodden city, and provided an opportunity to rethink the city center.

Today, that is well under way. In Manchester's center today is Spinningfields, which in the 1880s was a packed district of textile factory complexes, each employing as many as fifteen thousand women working power looms and sewing machines. Today, Spinningfields is a modern office and shopping district, with high-end boutiques and dramatic architecture. Its industrial past is reflected in the two-story windows of one clothing store, which displays an art installation matrix of hundreds of old Singer sewing machines. The clothes inside are mostly made in China, of course.

A few blocks north of Spinningfields is the Northern Quarter, where some of those original textile warehouses have been gutted and rearchitected as high-design workspaces, which are now filling with Web companies, game developers, and graphics studios. This is the showpiece of Manchester's hoped-for reinvention as a digital hub. Perhaps the design and engineering skills that powered the Industrial Age are still there, ready to be recast in media, entertainment, and marketing. (It's still too early to say; much of the space remains to be filled, and there is a fair amount of government money propping up what's there.)

But walk a few blocks farther north to the optimistically titled New Islington quarter (a reference to a posh district of London), and the reinvention of Manchester is more uncertain. Here lie mostly ruins: Victorian factories that are now empty shells, with caved-in roofs and long-gone windows. They are listed as historic buildings, so they cannot be bulldozed, but the cost and risk of rebuilding them with original façades intact (as the listing requires) as modern buildings are too high. So they are left to decay, reminders of empires lost. A few others did catch the eye of investors during the recent real-estate bubble, but it ended badly. Today they are fenced-in construction sites with very little

active construction actually going on, frozen between the past and the future, and in the protracted present they give the area the feel of a massive worksite without workers, all gravel and dust and no life.

Yet amid this postindustrial landscape are pockets of hope and growth. One of them is on a former factory site next to a former cholera hospital, on the banks of one of Manchester's many canals. Here a huge modern building stands, with stacks of floors, each angled a bit from the one below and painted with tastefully matched accent colors of pink, brown, and peach. Called Chips, supposedly because the architect piled up french fries ("chips") to brainstorm its shape, it was designed to be the model of a modern work/live/play space. The upper floors are built as condominiums. The lower floors are designed for restaurants and shops. And in the middle are floors for offices and workspaces.

Needless to say, the bursting of the real-estate bubble, which halted most of the construction in the area, pretty much put a halt to any restaurant and café plans around the building, and not many homeowners wanted to live among worksites. So rather than leave the building empty, the owners decided to try an experiment that evoked Manchester's beginning: they offered it to the regional manufacturing association as the site of a laboratory in the future of making stuff. Today it is the Manchester Fab Lab, the first Fab Lab in the United Kingdom.

Fab Labs are a special kind of makerspace. They are built on a model developed a decade ago by Neil Gershenfeld's Center for Bits and Atoms—the labs grew out of Gershenfeld's popular class at MIT called "How to Make (Almost) Anything." Each Fab Lab (as of this writing there are fifty-three of them, in seventeen countries around the world), has at least a minimal set of digital fabrication tools: a laser cutter, a vinyl cutter, a big CNC machine for furniture and a small one for circuit boards, basic electronics equipment, and sometimes a 3-D printer, too. They sometimes have more traditional machine shop tools such as metal lathes and drill presses, but typically they are focused on smaller-scale prototyping.

Fridays and Saturdays are free to all at the Fab Lab Manchester. On a typical Friday while I was there, there was a gentle hum of activity as students from local universities worked on architecture and furniture models, and the laser cutter was in constant use making art pieces and design-school classwork. Projects made on free days are supposed to be documented online so others can share them. On other days, members pay to use the facility, and those projects can be proprietary and closed.

It is, to be honest, a little hard to see this makerspace as the seed of a new British manufacturing industry. Most of the work is being done by local students, and is the sort of modest stuff you might expect to find in any design or shop class. No hot startups have been spawned here yet; unlike such makerspaces as TechShop in the United States, the place is not abuzz with entrepreneurship. But Haydn Insley, the lab manager, sees the experiment as more about liberating creativity. "It's about the ability for individuals to make —and, more importantly, modify—anything. Everyone here has an idea—we're trying to make it easier for them to realize it. What becomes important is the

designs, not the fabrication."

When you look at the UK manufacturing success stories that still exist today, you can see where Insley gets his optimism. Although textiles and flatware are long gone, the UK still has a major aerospace industry (British Aerospace, or BAE Systems as it is now called, is the world's second-largest defense contractor), and its car designs are still world renowned. And then there are innovative consumer product companies such as Dyson, which uses high design and superior engineering to get consumers to pay premium prices in previously stale and commoditized market segments such as vacuums and fans. Manchester's universities still produce more engineers than universities in any other city in the UK. The skills are there—they're just looking for new outlets.

Maybe one of the dreadlocked design students hovering over the laser cutter in the Manchester Fab Lab will be the next Dyson. Or maybe they're working on their own, using many of the same tools, now cheap enough for an individual to own. The Fab Lab has already created hundreds of projects, and it's just getting started. But here's what we do know: Manchester once made things that changed the world. It's in the water, in the air, woven into the fabric of its history. Whether it will happen again at the Fab Lab, it's now possible to dream of that again. The machines are running again on the Mersey.

But there are some significant differences between then and now. Whereas the First Industrial Revolution could have taken off only in a place like Manchester, with its natural resources and transport infrastructure, this new Maker Movement can occur anywhere. In part for historical resonance, the Manchester Fab Lab is located among the shells of old textile factories, but the tools and technologies within its walls could just as easily be in the offices of a London skyscraper or a converted barn in the countryside. Meanwhile, the Makers using them could be even more widely scattered, uploading design files from their homes. "Place" matters less and less in manufacturing these days—ideas trump geography.

What's more, you don't need a huge factory at all anymore—the days of belching smoke and steel pistons the size of boxcars are gone. Small-scale enterprises can thrive in the new world of distributed manufacturing. Ironically, this is almost a return to the very earliest days of the First Industrial Revolution. The spinning jenny changed the world not by creating the manufacturing plant, but by creating the cottage industry. And the cottage industry can be a very powerful economic force indeed.

What we now know as cottage industries (originally known as "the domestic system" or "outwork system") began with wooden-framed machines with foot pedals that could make many threads at the same time, essentially acting like many spinning wheels operating simultaneously. They were relatively easy to build or cheap to buy, and could be operated in a table-sized space. In a sense, they were the "desktop manufacturing" of the day.

The spinning jenny was used in the home, multiplying the work of one spinner manyfold, and for the first time making indoor work more lucrative than outdoor work for much of the population. By allowing both men and women to work within the home, it helped cement the nuclear family,

provided a better working environment for children, and broke the dependency on landowners. It was also a way for regular people to become entrepreneurs without having to go through the apprentice process of the guild system. Even as factories grew around the cottages, that sort of domestic entrepreneurship remained popular as a way for companies to outsource piecework to a network of highly skilled artisans whose output was multiplied by micro-manufacturing techniques.

The spread of these machines marked the end of the mostly agrarian era of British history. Rather than most people working in the fields, fewer people with better farming machines could plow and harvest, while the rest worked in the home in domestic workshops, with spinning soon joined by weaving and knitting with wooden looms.

Because such work wasn't tied to the land, it wasn't tied to landowners, either. The family members working in the home had more independence and control over their own economic future. But though they were liberated from a single landowner, they now had to deal with the market forces of supply and demand. They sold to big industrial buyers who were always seeking lower prices and would shift their buying to get them.

Wages were often no better than in farmwork, but at least the workers could set their own schedule. It was a step toward entrepreneurialism, but it fell short of creating truly differentiated innovation. Instead, most cottage industries were simply distributed labor for the big factories, compensating for their inferior machines by not requiring the factories to make capital investments in new production equipment or retooling for small or unusual orders. It was thatched-roof manufacturing, but not thatched-roof invention. The cottage workers were always at the mercy of the industrialists.

Nevertheless, the rise of cottage industries was an important part of the First Industrial Revolution that is often overshadowed by the image of the big "dark satanic mills." In a sense, they were closer to what a Maker-driven New Industrial Revolution might be than are the big factories we normally associate with manufacturing. Cottage industries were a distributed form of production, which complemented the centralized factories by being more flexible and making things in smaller batches than the big factories could gear up for.

They fit into and reinforced the family structure, finding work for all the family members (including, like it or not, lots of children, contributing to the population explosion that defined that period of British history). While big factories were drawing young adults to the cities to work and live in industrial compounds, cottage industries were growing the market towns. And they emphasized and preserved prized artisanal skills such as lacework, which at the time were difficult for machines or otherwise commanded a premium price.

Cottage industries were a thriving market well into the nineteenth century. In the late 1830s, for example, Dixons of Carlisle employed 3,500 handloom weavers scattered around neighboring counties, and a decade later Wards of Belper was recorded as providing work for four thousand scattered knitting frames. As late as the 1870s, Eliza Tinsley and Co. was putting out work to two thousand cottage nail and chain makers in the British Midlands. [18] Even at the

height of the First Industrial Revolution, the distributed labor of cottage industries ensured that there were far more small businesses than large ones.

Compare that with a typical Maker-ish small company today. Today's cottage industry is more typically an Etsy marketplace seller with a computer-controlled vinyl cutter making cool stickers for Mac-books or making and selling perfect replacement parts for vintage cars. Like their Industrial Age ancestors, they typically make the kinds of things big factories do not—they focus on niche markets of thousands, not mass markets of millions. They're distributed in a way that reflects the natural geography of ideas, not the hub-and-spoke logic of massive supply chains and cheap industrial land.

They're often run out of the Maker's garage or workshop, at least at the start, and often use family members as help. They make a virtue of their small-batch status, emphasizing handcrafted or artisanal qualities. And they are focused on desktop production tools, best suited for hundreds or a few thousand pieces.

That speaks to another key principle of the Maker Movement: As with the spinning jenny over two hundred years ago, the technology to create and design new products is available to anyone today. You don't need to invest in a massively expensive plant or acquire a vast workforce to turn your ideas into reality. Manufacturing new products is no longer the domain of the few, but the opportunity of the many.

Rather than selling to factories that control the path to market, today's Maker-style cottage industries sell directly to consumers around the world online, on their own websites or through marketplaces like Etsy or eBay. Rather than wait for orders from factories, as their nineteenth-century ancestors did, they invent their own products and seek to build their own microbrands. And rather than competing on price in a commodity market that favors cheap labor, they compete on innovation. They invent their own designs and can charge a premium to their discriminating consumers who are intentionally avoiding mass-produced goods.

So, back to the future. Today we are seeing a return to a new sort of cottage industry. Once again, new technology is giving individuals the power over the means of production, allowing for bottom-up entrepreneurship and distributed innovation. Just as the Web's democratization of the means of production in everything from software to music made it possible to create an empire in a dorm room or a hit album in a bedroom, so the new democratized tools of digital manufacturing will be tomorrow's spinning jennies. And the guilds they may break may be the very factory model that grew up in Manchester and dominated the past three centuries.