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THE iECONOMY | Part 1: An Empire Built Abroad

How the U.S. Lost Out on iPhone Work



Donald Chan/Reuters

People flooded Foxconn Technology with résumés at a 2010 job fair in Henan Province, China.

By CHARLES DUHIGG and KEITH BRADSHER Published: January 21, 2012 | 778 Comments

When Barack Obama joined Silicon Valley's top luminaries for dinner in California last February, each guest was asked to come with a question for the president.

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The iPhone Economy

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But as Steven P. Jobs of Apple spoke, President Obama interrupted with an inquiry of his own: what would it take to make iPhones in the United States?

Not long ago, Apple boasted that its products were made in America. Today, few are. Almost all of the 70 million iPhones, 30 million iPads and 59 million other products Apple sold last year were manufactured overseas.

Why can't that work come home? Mr. Obama asked.

Mr. Jobs's reply was unambiguous. "Those jobs aren't coming back," he said, according to another dinner guest.

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A production line in Foxconn City in Shenzhen, China. The iPhone is assembled in this vast facility, which has 230,000 employees, many at the plant up to 12 hours a day, six days a week.

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Thomas Lee for The New York Times

In China, Lina Lin is a project manager at PCH International, which contracts with Apple. "There are lots of jobs," she said. "Especially in Shenzhen."

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The president's question touched upon a central conviction at Apple. It isn't just that workers are cheaper abroad. Rather, Apple's executives believe the vast scale of overseas factories as well as the flexibility, diligence and industrial skills of foreign workers have so outpaced their American counterparts that "Made in the U.S.A." is no longer a viable option for most Apple products.

Apple has become one of the best-known, most admired and most imitated companies on earth, in part through an unrelenting mastery of global operations. Last year, it earned over \$400,000 in profit per employee, more than Goldman Sachs, Exxon Mobil or Google.

However, what has vexed Mr. Obama as well as economists and policy makers is that Apple — and many of its high-technology peers — are not nearly as avid in creating American jobs as other famous companies were in their heydays.

Apple employs [43,000 people in the United States and 20,000 overseas](#), a small fraction of the over 400,000 American workers at General Motors in the 1950s, or the hundreds of thousands at General Electric in the 1980s. Many more people work for Apple's contractors: an additional 700,000 people engineer, build and assemble iPads, iPhones and Apple's other products. But almost none of them work in the United States. Instead, they work for foreign companies in Asia, Europe and elsewhere, at factories that almost all electronics designers rely upon to build their wares.

"Apple's an example of why it's so hard to create middle-class jobs in the U.S. now," said Jared Bernstein, who until last year was an economic adviser to the White House.

"If it's the pinnacle of capitalism, we should be worried."

Apple executives say that going overseas, at this point, is their only option. One former executive described how the company relied upon a Chinese factory to revamp [iPhone](#) manufacturing just weeks before the device was due on shelves. Apple had redesigned the iPhone's screen at the last minute, forcing an assembly line overhaul. New screens began arriving at the plant near midnight.

A foreman immediately roused 8,000 workers inside the company's dormitories, according to the executive. Each employee was given a biscuit and a cup of tea, guided to a workstation and within half an hour started a 12-hour shift fitting glass screens into beveled frames. Within 96 hours, the plant was producing over 10,000 iPhones a day.

"The speed and flexibility is breathtaking," the executive said. "There's no American plant that can match that."

Similar stories could be told about almost any electronics company — and outsourcing has also become common in hundreds of industries, including accounting, legal services, banking, auto manufacturing and pharmaceuticals.

But while Apple is far from alone, it offers a window into why the success of some prominent companies has not translated into large numbers of domestic jobs. What's more, the company's decisions pose broader questions about what corporate America owes Americans as the global and national economies are increasingly intertwined.

"Companies once felt an obligation to support American workers, even when it wasn't the

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best financial choice,” said Betsey Stevenson, the chief economist at the Labor Department until last September. “That’s disappeared. Profits and efficiency have trumped generosity.”

Companies and other economists say that notion is naïve. Though Americans are among the most educated workers in the world, the nation has stopped training enough people in the mid-level skills that factories need, executives say.

To thrive, companies argue they need to move work where it can generate enough profits to keep paying for innovation. Doing otherwise risks losing even more American jobs over time, as evidenced by the legions of once-proud domestic manufacturers — including G.M. and others — that have shrunk as nimble competitors have emerged.

Apple was provided with extensive summaries of The New York Times’s reporting for this article, but the company, which has a reputation for secrecy, declined to comment.

This article is based on interviews with more than three dozen current and former Apple employees and contractors — many of whom requested anonymity to protect their jobs — as well as economists, manufacturing experts, international trade specialists, technology analysts, academic researchers, employees at Apple’s suppliers, competitors and corporate partners, and government officials.

Privately, Apple executives say the world is now such a changed place that it is a mistake to measure a company’s contribution simply by tallying its employees — though they note that Apple employs more workers in the United States than ever before.

They say Apple’s success has benefited the economy by empowering entrepreneurs and creating jobs at companies like cellular providers and businesses shipping Apple products. And, ultimately, they say curing unemployment is not their job.

“We sell iPhones in over a hundred countries,” a current Apple executive said. “We don’t have an obligation to solve America’s problems. Our only obligation is making the best product possible.”

#### **‘I Want a Glass Screen’**

In 2007, a little over a month before the iPhone was scheduled to appear in stores, Mr. Jobs beckoned a handful of lieutenants into an office. For weeks, he had been carrying a prototype of the device in his pocket.

Mr. Jobs angrily held up his iPhone, angling it so everyone could see the dozens of tiny scratches marring its plastic screen, according to someone who attended the meeting. He then pulled his keys from his jeans.

People will carry this phone in their pocket, he said. People also carry their keys in their pocket. “I won’t sell a product that gets scratched,” he said tensely. The only solution was using unscratchable glass instead. “I want a glass screen, and I want it perfect in six weeks.”

After one executive left that meeting, he booked a flight to [Shenzhen](#), China. If Mr. Jobs wanted perfect, there was nowhere else to go.

For over two years, the company had been working on a project — code-named Purple 2 — that presented the same questions at every turn: how do you completely reimagine the cellphone? And how do you design it at the highest quality — with an unscratchable screen, for instance — while also ensuring that millions can be manufactured quickly and inexpensively enough to earn a significant profit?

The answers, almost every time, were found outside the United States. Though components differ between versions, all iPhones contain hundreds of parts, an estimated 90 percent of which are manufactured abroad. Advanced semiconductors have come from Germany and Taiwan, memory from Korea and Japan, display panels and circuitry from Korea and Taiwan, chipsets from Europe and rare metals from Africa and Asia. And all of

it is put together in China.

In its early days, Apple usually didn't look beyond its own backyard for manufacturing solutions. A few years after Apple began building the Macintosh in 1983, for instance, Mr. Jobs bragged that it was "[a machine that is made in America.](#)" In 1990, while Mr. Jobs was running NeXT, which was eventually bought by Apple, the executive told a reporter that "[I'm as proud of the factory as I am of the computer.](#)" As late as 2002, top Apple executives occasionally drove two hours northeast of their headquarters to visit the company's iMac plant in Elk Grove, Calif.

But by 2004, Apple had largely turned to foreign manufacturing. Guiding that decision was Apple's operations expert, [Timothy D. Cook](#), who replaced Mr. Jobs as chief executive last August, six weeks before Mr. Jobs's death. Most other American electronics companies had already gone abroad, and Apple, which at the time was struggling, felt it had to grasp every advantage.

In part, Asia was attractive because the semiskilled workers there were cheaper. But that wasn't driving Apple. For technology companies, the cost of labor is minimal compared with the expense of buying parts and managing supply chains that bring together components and services from hundreds of companies.

For Mr. Cook, the focus on Asia "came down to two things," said one former high-ranking Apple executive. Factories in Asia "can scale up and down faster" and "Asian supply chains have surpassed what's in the U.S." The result is that "we can't compete at this point," the executive said.

The impact of such advantages became obvious as soon as Mr. Jobs demanded glass screens in 2007.

For years, cellphone makers had avoided using glass because it required precision in cutting and grinding that was extremely difficult to achieve. Apple had already selected an American company, [Corning Inc.](#), to manufacture large panes of strengthened glass. But figuring out how to cut those panes into millions of iPhone screens required finding an empty cutting plant, hundreds of pieces of glass to use in experiments and an army of midlevel engineers. It would cost a fortune simply to prepare.

Then a bid for the work arrived from a Chinese factory.

When an Apple team visited, the Chinese plant's owners were already constructing a new wing. "This is in case you give us the contract," the manager said, according to a former Apple executive. The Chinese government had agreed to underwrite costs for numerous industries, and those subsidies had trickled down to the glass-cutting factory. It had a warehouse filled with glass samples available to Apple, free of charge. The owners made engineers available at almost no cost. They had built on-site dormitories so employees would be available 24 hours a day.

The Chinese plant got the job.

"The entire supply chain is in China now," said another former high-ranking Apple executive. "You need a thousand rubber gaskets? That's the factory next door. You need a million screws? That factory is a block away. You need that screw made a little bit different? It will take three hours."

### **In Foxconn City**

An eight-hour drive from that glass factory is a complex, known informally as Foxconn City, where the iPhone is assembled. To Apple executives, Foxconn City was further evidence that China could deliver workers — and diligence — that outpaced their American counterparts.

That's because nothing like Foxconn City exists in the United States.

The facility has 230,000 employees, many working six days a week, often spending up to 12 hours a day at the plant. Over a quarter of Foxconn's work force lives in company barracks and many workers earn less than \$17 a day. When one Apple executive arrived during a shift change, his car was stuck in a river of employees streaming past. "The scale is unimaginable," he said.

Foxconn employs nearly 300 guards to direct foot traffic so workers are not crushed in doorway bottlenecks. The facility's central kitchen cooks an average of three tons of pork and 13 tons of rice a day. While factories are spotless, the air inside nearby teahouses is hazy with the smoke and stench of cigarettes.

[Foxconn Technology](#) has dozens of facilities in Asia and Eastern Europe, and in Mexico and Brazil, and it assembles an estimated 40 percent of the world's consumer electronics for customers like Amazon, Dell, Hewlett-Packard, Motorola, Nintendo, Nokia, Samsung and Sony.

"They could hire 3,000 people overnight," said Jennifer Rigoni, who was Apple's worldwide supply demand manager until 2010, but declined to discuss specifics of her work. "What U.S. plant can find 3,000 people overnight and convince them to live in dorms?"

In mid-2007, after a month of experimentation, Apple's engineers finally perfected a method for cutting strengthened glass so it could be used in the iPhone's screen. The first truckloads of cut glass arrived at Foxconn City in the dead of night, according to the former Apple executive. That's when managers woke thousands of workers, who crawled into their uniforms — white and black shirts for men, red for women — and quickly lined up to assemble, by hand, the phones. Within three months, Apple had sold one million iPhones. Since then, Foxconn has assembled over 200 million more.

Foxconn, in statements, declined to speak about specific clients.

"Any worker recruited by our firm is covered by a clear contract outlining terms and conditions and by Chinese government law that protects their rights," the company wrote. Foxconn "takes our responsibility to our employees very seriously and we work hard to give our more than one million employees a safe and positive environment."

The company disputed some details of the former Apple executive's account, and wrote that a midnight shift, such as the one described, was impossible "because we have strict regulations regarding the working hours of our employees based on their designated shifts, and every employee has computerized timecards that would bar them from working at any facility at a time outside of their approved shift." The company said that all shifts began at either 7 a.m. or 7 p.m., and that employees receive at least 12 hours' notice of any schedule changes.

Foxconn employees, in interviews, have challenged those assertions.

Another critical advantage for Apple was that China provided engineers at a scale the United States could not match. Apple's executives had estimated that about 8,700 industrial engineers were needed to oversee and guide the 200,000 assembly-line workers eventually involved in manufacturing iPhones. The company's analysts had forecast it would take as long as nine months to find that many qualified engineers in the United States.

In China, it took 15 days.

Companies like Apple "say the challenge in setting up U.S. plants is finding a technical work force," said [Martin Schmidt](#), associate provost at the Massachusetts Institute of Technology. In particular, companies say they need engineers with more than high school, but not necessarily a bachelor's degree. Americans at that skill level are hard to find, executives contend. "They're good jobs, but the country doesn't have enough to feed the demand," Mr. Schmidt said.

Some aspects of the iPhone are uniquely American. The device's software, for instance, and its innovative marketing campaigns were largely created in the United States. Apple recently built a \$500 million data center in North Carolina. Crucial semiconductors inside the iPhone 4 and 4S are manufactured in an Austin, Tex., factory by Samsung, of South Korea.

But even those facilities are not enormous sources of jobs. Apple's North Carolina center, for instance, has only 100 full-time employees. The Samsung plant has an estimated 2,400 workers.

"If you scale up from selling one million phones to 30 million phones, you don't really need more programmers," said Jean-Louis Gassée, who oversaw product development and marketing for Apple until he left in 1990. "All these new companies — Facebook, Google, Twitter — benefit from this. They grow, but they don't really need to hire much."

It is hard to estimate how much more it would cost to build iPhones in the United States. However, various academics and manufacturing analysts estimate that because labor is such a small part of technology manufacturing, paying American wages would add up to \$65 to each iPhone's expense. Since Apple's profits are often hundreds of dollars per phone, building domestically, in theory, would still give the company a healthy reward.

But such calculations are, in many respects, meaningless because building the iPhone in the United States would demand much more than hiring Americans — it would require transforming the national and global economies. Apple executives believe there simply aren't enough American workers with the skills the company needs or factories with sufficient speed and flexibility. Other companies that work with Apple, like Corning, also say they must go abroad.

Manufacturing glass for the iPhone revived a Corning factory in Kentucky, and today, much of the glass in iPhones is still made there. After the iPhone became a success, Corning received a flood of orders from other companies hoping to imitate Apple's designs. Its strengthened glass sales have grown to more than \$700 million a year, and it has hired or continued employing about 1,000 Americans to support the emerging market.

But as that market has expanded, the bulk of Corning's strengthened glass manufacturing has occurred at plants in Japan and Taiwan.

"Our customers are in Taiwan, Korea, Japan and China," said James B. Flaws, Corning's vice chairman and chief financial officer. "We could make the glass here, and then ship it by boat, but that takes 35 days. Or, we could ship it by air, but that's 10 times as expensive. So we build our glass factories next door to assembly factories, and those are overseas."

Corning was founded in America 161 years ago and its headquarters are still in upstate New York. Theoretically, the company could manufacture all its glass domestically. But it would "require a total overhaul in how the industry is structured," Mr. Flaws said. "The consumer electronics business has become an Asian business. As an American, I worry about that, but there's nothing I can do to stop it. Asia has become what the U.S. was for the last 40 years."

### **Middle-Class Jobs Fade**

The first time Eric Saragoza stepped into Apple's manufacturing plant in Elk Grove, Calif., he felt as if he were entering an engineering wonderland.

It was 1995, and the facility near Sacramento employed more than 1,500 workers. It was a kaleidoscope of robotic arms, conveyor belts ferrying circuit boards and, eventually, candy-colored iMacs in various stages of assembly. Mr. Saragoza, an engineer, quickly moved up the plant's ranks and joined an elite diagnostic team. His salary climbed to \$50,000. He and his wife had three children. They bought a home with a pool.

"It felt like, finally, school was paying off," he said. "I knew the world needed people who

can build things.”

At the same time, however, the electronics industry was changing, and Apple — with products that were declining in popularity — was struggling to remake itself. One focus was improving manufacturing. A few years after Mr. Saragoza started his job, his bosses explained how the California plant stacked up against overseas factories: the cost, excluding the materials, of building a \$1,500 computer in Elk Grove was \$22 a machine. In Singapore, it was \$6. In Taiwan, \$4.85. Wages weren't the major reason for the disparities. Rather it was costs like inventory and how long it took workers to finish a task.

“We were told we would have to do 12-hour days, and come in on Saturdays,” Mr. Saragoza said. “I had a family. I wanted to see my kids play soccer.”

Modernization has always caused some kinds of jobs to change or disappear. As the American economy transitioned from agriculture to manufacturing and then to other industries, farmers became steelworkers, and then salesmen and middle managers. These shifts have carried many economic benefits, and in general, with each progression, even unskilled workers received better wages and greater chances at upward mobility.

But in the last two decades, something more fundamental has changed, economists say. Midwage jobs started disappearing. Particularly among Americans without college degrees, today's new jobs are disproportionately in service occupations — at restaurants or call centers, or as hospital attendants or temporary workers — that offer fewer opportunities for reaching the middle class.

Even Mr. Saragoza, with his college degree, was vulnerable to these trends. First, some of Elk Grove's routine tasks were sent overseas. Mr. Saragoza didn't mind. Then the robotics that made Apple a futuristic playground allowed executives to replace workers with machines. Some diagnostic engineering went to Singapore. Middle managers who oversaw the plant's inventory were laid off because, suddenly, a few people with Internet connections were all that were needed.

Mr. Saragoza was too expensive for an unskilled position. He was also insufficiently credentialed for upper management. He was called into a small office in 2002 after a night shift, laid off and then escorted from the plant. He taught high school for a while, and then tried a return to technology. But Apple, which had helped anoint the region as “Silicon Valley North,” had by then converted much of the Elk Grove plant into an AppleCare call center, where new employees often earn \$12 an hour.

There were employment prospects in Silicon Valley, but none of them panned out. “What they really want are 30-year-olds without children,” said Mr. Saragoza, who today is 48, and whose family now includes five of his own.

After a few months of looking for work, he started feeling desperate. Even teaching jobs had dried up. So he took a position with an electronics temp agency that had been hired by Apple to check returned iPhones and iPads before they were sent back to customers. Every day, Mr. Saragoza would drive to the building where he had once worked as an engineer, and for \$10 an hour with no benefits, wipe thousands of glass screens and test audio ports by plugging in headphones.

### **Paydays for Apple**

As Apple's overseas operations and sales have expanded, its top employees have thrived. Last fiscal year, Apple's revenue topped \$108 billion, a sum larger than the combined state budgets of Michigan, New Jersey and Massachusetts. Since 2005, when the company's stock split, share prices have risen from about \$45 to more than \$427.

Some of that wealth has gone to shareholders. Apple is among the most widely held stocks, and the rising share price has benefited millions of individual investors, [401\(k\)'s](#) and pension plans. The bounty has also enriched Apple workers. Last fiscal year, in addition to their salaries, Apple's employees and directors received stock worth \$2 billion and

exercised or vested stock and options worth an added \$1.4 billion.

The biggest rewards, however, have often gone to Apple's top employees. Mr. Cook, Apple's chief, last year received [stock grants](#) — which vest over a 10-year period — that, at today's share price, would be worth \$427 million, and his salary was raised to \$1.4 million. In 2010, Mr. Cook's compensation package was valued at \$59 million, according to Apple's security filings.

A person close to Apple argued that the compensation received by Apple's employees was fair, in part because the company had brought so much value to the nation and world. As the company has grown, it has expanded its domestic work force, including manufacturing jobs. Last year, Apple's American work force grew by 8,000 people.

While other companies have sent call centers abroad, Apple has kept its centers in the United States. One source estimated that sales of Apple's products have caused other companies to hire tens of thousands of Americans. FedEx and United Parcel Service, for instance, both say they have created American jobs because of the volume of Apple's shipments, though neither would provide specific figures without permission from Apple, which the company declined to provide.

"We shouldn't be criticized for using Chinese workers," a current Apple executive said. "The U.S. has stopped producing people with the skills we need."

What's more, Apple sources say the company has created plenty of good American jobs inside its retail stores and among entrepreneurs selling iPhone and [iPad](#) applications.

After two months of testing iPads, Mr. Saragoza quit. The pay was so low that he was better off, he figured, spending those hours applying for other jobs. On a recent October evening, while Mr. Saragoza sat at his MacBook and submitted another round of résumés online, halfway around the world a woman arrived at her office. The worker, Lina Lin, is a project manager in Shenzhen, China, at PCH International, which contracts with Apple and other electronics companies to coordinate production of accessories, like the cases that protect the iPad's glass screens. She is not an Apple employee. But Mrs. Lin is integral to Apple's ability to deliver its products.

Mrs. Lin earns a bit less than what Mr. Saragoza was paid by Apple. She speaks fluent English, learned from watching television and in a Chinese university. She and her husband put a quarter of their salaries in the bank every month. They live in a 1,080-square-foot apartment, which they share with their in-laws and son.

"There are lots of jobs," Mrs. Lin said. "Especially in Shenzhen."

### **Innovation's Losers**

Toward the end of Mr. Obama's dinner last year with Mr. Jobs and other Silicon Valley executives, as everyone stood to leave, a crowd of photo seekers formed around the president. A slightly smaller scrum gathered around Mr. Jobs. Rumors had spread that his illness had worsened, and some hoped for a photograph with him, perhaps for the last time.

Eventually, the orbits of the men overlapped. "I'm not worried about the country's long-term future," Mr. Jobs told Mr. Obama, according to one observer. "This country is insanely great. What I'm worried about is that we don't talk enough about solutions."

At dinner, for instance, the executives had suggested that the government should reform visa programs to help companies hire foreign engineers. Some had urged the president to give companies a "tax holiday" so they could bring back overseas profits which, they argued, would be used to create work. Mr. Jobs even suggested it might be possible, someday, to locate some of Apple's skilled manufacturing in the United States if the government helped train more American engineers.

Economists debate the usefulness of those and other efforts, and note that a struggling



economy is sometimes transformed by unexpected developments. The last time analysts wrung their hands about prolonged American unemployment, for instance, in the early 1980s, the Internet hardly existed. Few at the time would have guessed that a degree in graphic design was rapidly becoming a smart bet, while studying telephone repair a dead end.

What remains unknown, however, is whether the United States will be able to leverage tomorrow's innovations into millions of jobs.

In the last decade, technological leaps in solar and [wind energy](#), semiconductor fabrication and display technologies have created thousands of jobs. But while many of those industries started in America, much of the employment has occurred abroad. Companies have closed major facilities in the United States to reopen in China. By way of explanation, executives say they are competing with Apple for shareholders. If they cannot rival Apple's growth and profit margins, they won't survive.

"New middle-class jobs will eventually emerge," said Lawrence Katz, a Harvard economist. "But will someone in his 40s have the skills for them? Or will he be bypassed for a new graduate and never find his way back into the middle class?"

The pace of innovation, say executives from a variety of industries, has been quickened by businessmen like Mr. Jobs. G.M. went as long as half a decade between major automobile redesigns. Apple, by comparison, has released five iPhones in four years, doubling the devices' speed and memory while dropping the price that some consumers pay.

Before Mr. Obama and Mr. Jobs said goodbye, the Apple executive pulled an iPhone from his pocket to show off a new application — a driving game — with incredibly detailed graphics. The device reflected the soft glow of the room's lights. The other executives, whose combined worth exceeded \$69 billion, jostled for position to glance over his shoulder. The game, everyone agreed, was wonderful.

There wasn't even a tiny scratch on the screen.

*David Barboza, Peter Lattman and Catherine Rampell contributed reporting.*

*This article has been revised to reflect the following correction:*

**Correction: January 24, 2012**

*An article on Sunday about the reasons iPhones are largely produced overseas omitted a passage immediately after the second continuation, from Page A22 to Page A23, in one edition. The full passage should have read: "Another critical advantage for Apple was that China provided engineers at a scale the United States could not match. Apple's executives had estimated that about 8,700 industrial engineers were needed to oversee and guide the 200,000 assembly-line workers eventually involved in manufacturing iPhones. The company's analysts had forecast it would take as long as nine months to find that many qualified engineers in the United States."*

A version of this article appears in print on January 22, 2012, on page A1 of the New York edition with the headline: How U.S. Lost Out On iPhone Work.

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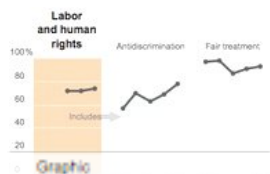
Color China Photo, via Associated Press

An explosion last May at a Foxconn factory in Chengdu, China, killed four people and injured 18. It built iPads.

By CHARLES DUHIGG and DAVID BARBOZA  
Published: January 25, 2012 | 1770 Comments

The explosion ripped through Building A5 on a Friday evening last May, an eruption of fire and noise that twisted metal pipes as if they were discarded straws.

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Two people were killed immediately, and over a dozen others hurt. As the injured were rushed into ambulances, one in particular stood out. His features had been smeared by the blast, scrubbed by heat and violence until a mat of red and black had replaced his mouth and nose.

"Are you Lai Xiaodong's father?" a caller asked when the phone rang at Mr. Lai's childhood home. Six months earlier, the 22-year-old had moved to Chengdu, in southwest China, to become one of the millions of human cogs powering the largest, fastest and most sophisticated

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**SAFETY PRECAUTIONS** After a rash of apparent suicide attempts, a dormitory for Foxconn workers in Shenzhen, China, had safety netting installed last May. Foxconn said it acted quickly and comprehensively to address employee suicides.

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Ryan Pyle for The New York Times

**A SHRINE FOR A SON** Lai Xiaodong was killed in a Foxconn factory explosion. His parents have built a memorial in their village.

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Ryan Pyle for The New York Times

**A JOB TURNS DEADLY** Aluminum dust from polishing iPads caused the blast at Foxconn's plant in Chengdu, left. Lai Xiaodong was among those killed. He had moved to Chengdu, bringing with him his college diploma, six months earlier.

manufacturing system on earth. That system has made it possible for [Apple](#) and hundreds of other companies to build devices almost as quickly as they can be dreamed up.

"He's in trouble," the caller told Mr. Lai's father. "Get to the hospital as soon as possible."

In the last decade, Apple has become one of the mightiest, richest and most successful companies in the world, in part by mastering global manufacturing. Apple and its high-technology peers — as well as dozens of other American industries — have achieved a pace of innovation nearly unmatched in modern history.

However, the workers assembling iPhones, iPads and other devices often labor in harsh conditions, according to employees inside those plants, worker advocates and documents published by companies themselves. Problems are as varied as onerous work environments and serious — sometimes deadly — safety problems.

Employees work excessive overtime, in some cases seven days a week, and live in crowded dorms. Some say they stand so long that their legs swell until they can hardly walk. Under-age workers have helped build Apple's products, and the company's suppliers have improperly disposed of hazardous waste and falsified records, according to company reports and advocacy groups that, within China, are often considered reliable, independent monitors.

More troubling, the groups say, is some suppliers' disregard for workers' health. Two years ago, 137 workers at an Apple supplier in eastern China were injured after they were ordered to use a poisonous chemical to clean [iPhone](#) screens. Within seven months last year, two explosions at iPad factories, including in Chengdu, killed four people and injured 77. Before those blasts, Apple had been alerted to hazardous conditions inside the Chengdu plant, according to a Chinese group that [published that warning](#).

"If Apple was warned, and didn't act, that's reprehensible," said Nicholas Ashford, a former chairman of the National Advisory Committee on Occupational Safety and Health, a group that advises the United States Labor Department. "But what's morally repugnant in one country is accepted business practices in another, and companies take advantage of that."

Apple is not the only electronics company doing business within a troubling supply system. Bleak working conditions have been documented at factories manufacturing products for Dell, Hewlett-Packard, I.B.M., Lenovo, Motorola, Nokia, Sony, Toshiba and others.

Current and former Apple executives, moreover, say the company has made significant strides in improving factories in recent years. Apple has a [supplier code of conduct](#) that details standards on labor issues, safety

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"These seductive products feed an egocentric population of must-have-the-latest-toy consumers who either ignore these stories or rationalize them away."

*Ex-New Yorker, undefined*  
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protections and other topics. The company has mounted a vigorous auditing campaign, and when abuses are discovered, Apple says, corrections are demanded.

And Apple's annual [supplier responsibility reports](#), in many cases, are the first to report abuses. This month, for the first time, the company [released a list](#) identifying many of its suppliers.

But significant problems remain. More than half of the suppliers audited by Apple have violated at least one aspect of the code of conduct every year since 2007, according to Apple's reports, and in some instances have violated the law. While many violations involve working conditions, rather than safety hazards, troubling patterns persist.

"Apple never cared about anything other than increasing product quality and decreasing production cost," said Li Mingqi, who until April worked in management at [Foxconn Technology](#), one of Apple's most important manufacturing partners. Mr. Li, who is suing Foxconn over his dismissal, helped manage the Chengdu factory where the explosion occurred.

"Workers' welfare has nothing to do with their interests," he said.

Some former Apple executives say there is an unresolved tension within the company: executives want to improve conditions within factories, but that dedication falters when it conflicts with crucial supplier relationships or the fast delivery of new products. Tuesday, [Apple reported](#) one of the most lucrative quarters of any corporation in history, with \$13.06 billion in profits on \$46.3 billion in sales. Its sales would have been even higher, executives said, if overseas factories had been able to produce more.

Executives at other corporations report similar internal pressures. This system may not be pretty, they argue, but a radical overhaul would slow innovation. Customers want amazing new electronics delivered every year.

"We've known about labor abuses in some factories for four years, and they're still going on," said one former Apple executive who, like others, spoke on the condition of anonymity because of confidentiality agreements. "Why? Because the system works for us. Suppliers would change everything tomorrow if Apple told them they didn't have another choice."

"If half of iPhones were malfunctioning, do you think Apple would let it go on for four years?" the executive asked.

Apple, in its published reports, has said it requires every discovered labor violation to be remedied, and suppliers that refuse are terminated. Privately, however, some former executives concede that finding new suppliers is time-consuming and costly. Foxconn is one of the few manufacturers in the world with the scale to build sufficient numbers of iPhones and iPads. So Apple is "not going to leave Foxconn and they're not going to leave China," said Heather White, a research fellow at Harvard and a former member of the Monitoring International Labor Standards committee at the National Academy of Sciences. "There's a lot of rationalization."

Apple was provided with extensive summaries of this article, but the company declined to comment. The reporting is based on interviews with more than three dozen current or former employees and contractors, including a half-dozen current or former executives with firsthand knowledge of Apple's supplier responsibility group, as well as others within the technology industry.

In 2010, Steven P. Jobs discussed the company's relationships with suppliers [at an industry conference](#).

"I actually think Apple does one of the best jobs of any companies in our industry, and maybe in any industry, of understanding the working conditions in our supply chain," said Mr. Jobs, who was Apple's chief executive at the time and who died last October.

"I mean, you go to this place, and, it's a factory, but, my gosh, I mean, they've got restaurants and movie theaters and hospitals and swimming pools, and I mean, for a factory, it's a pretty nice factory."

Others, including workers inside such plants, acknowledge the cafeterias and medical facilities, but insist conditions are punishing.

"We're trying really hard to make things better," said one former Apple executive. "But most people would still be really disturbed if they saw where their iPhone comes from."

### **The Road to Chengdu**

In the fall of 2010, about six months before the explosion in the iPad factory, Lai Xiaodong carefully wrapped his clothes around his college diploma, so it wouldn't crease in his suitcase. He told friends he would no longer be around for their weekly poker games, and said goodbye to his teachers. He was leaving for Chengdu, a city of 12 million that was rapidly becoming one of the world's most important manufacturing hubs.

Though painfully shy, Mr. Lai had surprised everyone by persuading a beautiful nursing student to become his girlfriend. She wanted to marry, she said, and so his goal was to earn enough money to buy an apartment.

Factories in Chengdu manufacture products for hundreds of companies. But Mr. Lai was focused on Foxconn Technology, China's largest exporter and one of the nation's biggest employers, with 1.2 million workers. The company has plants throughout China, and assembles an estimated 40 percent of the world's consumer electronics, including for customers like Amazon, Dell, Hewlett-Packard, Nintendo, Nokia and Samsung.

Foxconn's factory in Chengdu, Mr. Lai knew, was special. Inside, workers were building Apple's latest, potentially greatest product: the iPad.

When Mr. Lai finally landed a job repairing machines at the plant, one of the first things he noticed were the almost blinding lights. Shifts ran 24 hours a day, and the factory was always bright. At any moment, there were thousands of workers standing on assembly lines or sitting in backless chairs, crouching next to large machinery, or jogging between loading bays. Some workers' legs swelled so much they waddled. "It's hard to stand all day," said Zhao Sheng, a plant worker.

Banners on the walls warned the 120,000 employees: "Work hard on the job today or work hard to find a job tomorrow." Apple's supplier code of conduct dictates that, except in unusual circumstances, employees are not supposed to work more than 60 hours a week. But at Foxconn, some worked more, according to interviews, workers' pay stubs and surveys by outside groups. Mr. Lai was soon spending 12 hours a day, six days a week inside the factory, according to his paychecks. Employees who arrived late were sometimes required to write confession letters and copy quotations. There were "continuous shifts," when workers were told to work two stretches in a row, according to interviews.

Mr. Lai's college degree enabled him to earn a salary of around \$22 a day, including overtime — more than many others. When his days ended, he would retreat to a small bedroom just big enough for a mattress, wardrobe and a desk where he obsessively played an online game called Fight the Landlord, said his girlfriend, Luo Xiaohong.

Those accommodations were better than many of the company's dorms, where 70,000 Foxconn workers lived, at times stuffed 20 people to a three-room apartment, employees said. Last year, a dispute over paychecks set off a riot in one of the dormitories, and workers started throwing bottles, trash cans and flaming paper from their windows, according to witnesses. Two hundred police officers wrestled with workers, arresting eight.

Afterward, trash cans were removed, and piles of rubbish — and rodents — became a problem. Mr. Lai felt lucky to have a place of his own.

Foxconn, in a statement, disputed workers' accounts of continuous shifts, extended overtime, crowded living accommodations and the causes of the riot. The company said that its operations adhered to customers' codes of conduct, industry standards and national laws. "Conditions at Foxconn are anything but harsh," the company wrote. Foxconn also said that it had never been cited by a customer or government for under-age or overworked employees or toxic exposures.

"All assembly line employees are given regular breaks, including one-hour lunch breaks," the company wrote, and only 5 percent of assembly line workers are required to stand to carry out their tasks. Work stations have been designed to ergonomic standards, and employees have opportunities for job rotation and promotion, the statement said.

"Foxconn has a very good safety record," the company wrote. "Foxconn has come a long way in our efforts to lead our industry in China in areas such as workplace conditions and the care and treatment of our employees."

### **Apple's Code of Conduct**

In 2005, some of Apple's top executives gathered inside their Cupertino, Calif., headquarters for a special meeting. Other companies had created codes of conduct to police their suppliers. It was time, Apple decided, to follow suit. The code Apple published that year demands "that working conditions in Apple's supply chain are safe, that workers are treated with respect and dignity, and that manufacturing processes are environmentally responsible."

But the next year, a British newspaper, The Mail on Sunday, [secretly visited a Foxconn factory](#) in Shenzhen, China, where iPods were manufactured, and reported on workers' long hours, push-ups meted out as punishment and crowded dorms. Executives in Cupertino were shocked. "Apple is filled with really good people who had no idea this was going on," a former employee said. "We wanted it changed, immediately."

Apple audited that factory, the company's first such inspection, and ordered improvements. Executives also undertook a series of initiatives that included an annual audit report, first published in 2007. By last year, Apple had inspected 396 facilities — including the company's direct suppliers, as well as many of those suppliers' suppliers — one of the largest such programs within the electronics industry.

Those audits have found consistent violations of Apple's code of conduct, [according to summaries](#) published by the company. In 2007, for instance, Apple conducted over three dozen audits, two-thirds of which indicated that employees regularly worked more than 60 hours a week. In addition, there were six "core violations," the most serious kind, including hiring 15-year-olds as well as falsifying records.

Over the next three years, Apple conducted 312 audits, and every year, about half or more showed evidence of large numbers of employees laboring more than six days a week as well as working extended overtime. Some workers received less than minimum wage or had pay withheld as punishment. Apple found 70 core violations over that period, including cases of involuntary labor, under-age workers, record falsifications, improper disposal of hazardous waste and over a hundred workers injured by toxic chemical exposures.

Last year, the company conducted 229 audits. There were slight improvements in some categories and the detected rate of core violations declined. However, within 93 facilities, at least half of workers exceeded the 60-hours-a-week work limit. At a similar number, employees worked more than six days a week. There were incidents of discrimination, improper safety precautions, failure to pay required overtime rates and other violations. That year, four employees were killed and 77 injured in workplace explosions.

"If you see the same pattern of problems, year after year, that means the company's ignoring the issue rather than solving it," said one former Apple executive with firsthand knowledge of the supplier responsibility group. "Noncompliance is tolerated, as long as the suppliers promise to try harder next time. If we meant business, core violations would disappear."

Apple says that when an audit reveals a violation, the company requires suppliers to address the problem within 90 days and make changes to prevent a recurrence. "If a supplier is unwilling to change, we terminate our relationship," [the company says](#) on its Web site.

The seriousness of that threat, however, is unclear. Apple has found violations in hundreds of audits, but fewer than 15 suppliers have been terminated for transgressions since 2007, according to former Apple executives.

"Once the deal is set and Foxconn becomes an authorized Apple supplier, Apple will no longer give any attention to worker conditions or anything that is irrelevant to its products," said Mr. Li, the former Foxconn manager. Mr. Li spent seven years with Foxconn in Shenzhen and Chengdu and was forced out in April after he objected to a relocation to Chengdu, he said. Foxconn disputed his comments, and said "both Foxconn and Apple take the welfare of our employees very seriously."

Apple's efforts have spurred some changes. Facilities that were reaudited "showed continued performance improvements and better working conditions," the company wrote in its [2011 supplier responsibility progress report](#). In addition, the number of audited facilities has grown every year, and some executives say those expanding efforts obscure year-to-year improvements.

Apple also has trained over a million workers about their rights and methods for injury and disease prevention. A few years ago, after auditors insisted on interviewing low-level factory employees, they discovered that some had been forced to pay onerous "recruitment fees" — which Apple classifies as involuntary labor. As of last year, the company had forced suppliers to reimburse more than \$6.7 million in such charges.

"Apple is a leader in preventing under-age labor," said Dionne Harrison of Impactt, a firm paid by Apple to help prevent and respond to [child labor](#) among its suppliers. "They're doing as much as they possibly can."

Other consultants disagree.

"We've spent years telling Apple there are serious problems and recommending changes," said a consultant at BSR — also known as Business for Social Responsibility — which has been twice retained by Apple to provide advice on labor issues. "They don't want to pre-empt problems, they just want to avoid embarrassments."

### **'We Could Have Saved Lives'**

In 2006, BSR, along with a division of the World Bank and other groups, initiated a project to improve working conditions in factories building cellphones and other devices in China and elsewhere. The groups and companies pledged to test various ideas. Foxconn agreed to participate.

For four months, BSR and another group negotiated with Foxconn regarding a pilot program to create worker "hotlines," so that employees could report abusive conditions, seek mental counseling and discuss workplace problems. Apple was not a participant in the project, but was briefed on it, according to the BSR consultant, who had detailed knowledge.

As negotiations proceeded, Foxconn's requirements for participation kept changing. First Foxconn asked to shift from installing new hotlines to evaluating existing hotlines. Then Foxconn insisted that mental health counseling be excluded. Foxconn asked participants

to sign agreements saying they would not disclose what they observed, and then rewrote those agreements multiple times. Finally, an agreement was struck, and the project was scheduled to begin in January 2008. A day before the start, Foxconn demanded more changes, until it was clear the project would not proceed, according to the consultant and a 2008 summary by BSR that did not name Foxconn.

The next year, a Foxconn employee fell or jumped from an apartment building after losing an iPhone prototype. Over the next two years, at least 18 other Foxconn workers attempted suicide or fell from buildings in manners that suggested suicide attempts. In 2010, two years after the pilot program fell apart and after multiple suicide attempts, Foxconn created a dedicated mental health hotline and began offering free psychological counseling.

"We could have saved lives, and we asked Apple to pressure Foxconn, but they wouldn't do it," said the BSR consultant, who asked not to be identified because of confidentiality agreements. "Companies like H.P. and Intel and Nike push their suppliers. But Apple wants to keep an arm's length, and Foxconn is their most important manufacturer, so they refuse to push."

BSR, in a written statement, said the views of that consultant were not those of the company.

"My BSR colleagues and I view Apple as a company that is making a highly serious effort to ensure that labor conditions in its supply chain meet the expectations of applicable laws, the company's standards and the expectations of consumers," wrote Aron Cramer, BSR's president. Mr. Cramer added that asking Apple to pressure Foxconn would have been inconsistent with the purpose of the pilot program, and there were multiple reasons the pilot program did not proceed.

Foxconn, in a statement, said it acted quickly and comprehensively to address suicides, and "the record has shown that those measures have been successful."

### **A Demanding Client**

Every month, officials at companies from around the world trek to Cupertino or invite Apple executives to visit their foreign factories, all in pursuit of a goal: becoming a supplier.

When news arrives that Apple is interested in a particular product or service, small celebrations often erupt. Whiskey is drunk. Karaoke is sung.

Then, Apple's requests start.

Apple typically asks suppliers to specify how much every part costs, how many workers are needed and the size of their salaries. Executives want to know every financial detail. Afterward, Apple calculates how much it will pay for a part. Most suppliers are allowed only the slimmest of profits.

So suppliers often try to cut corners, replace expensive chemicals with less costly alternatives, or push their employees to work faster and longer, according to people at those companies.

"The only way you make money working for Apple is figuring out how to do things more efficiently or cheaper," said an executive at one company that helped bring the iPad to market. "And then they'll come back the next year, and force a 10 percent price cut."

In January 2010, workers at a Chinese factory owned by Wintek, an Apple manufacturing partner, went on strike over a variety of issues, including widespread rumors that workers were being exposed to toxins. Investigations by news organizations revealed that over a hundred employees had been injured by n-hexane, a toxic chemical that can cause nerve damage and paralysis.



Employees said they had been ordered to use n-hexane to clean iPhone screens because it evaporated almost three times as fast as rubbing alcohol. Faster evaporation meant workers could clean more screens each minute.

Apple commented on the Wintek injuries a year later. In its supplier responsibility report, Apple said it had “required Wintek to stop using n-hexane” and that “Apple has verified that all affected workers have been treated successfully, and we continue to monitor their medical reports until full recuperation.” Apple also said it required Wintek to fix the ventilation system.

That same month, a New York Times reporter interviewed a dozen injured Wintek workers [who said they had never been contacted](#) by Apple or its intermediaries, and that Wintek had pressured them to resign and take cash settlements that would absolve the company of liability. After those interviews, Wintek pledged to provide more compensation to the injured workers and Apple sent a representative to speak with some of them.

Six months later, trade publications reported that Apple significantly cut prices paid to Wintek.

“You can set all the rules you want, but they’re meaningless if you don’t give suppliers enough profit to treat workers well,” said one former Apple executive with firsthand knowledge of the supplier responsibility group. “If you squeeze margins, you’re forcing them to cut safety.”

Wintek is still one of Apple’s most important suppliers. Wintek, in a statement, declined to comment except to say that after the episode, the company took “ample measures” to address the situation and “is committed to ensuring employee welfare and creating a safe and healthy work environment.”

Many major technology companies have worked with factories where conditions are troubling. However, independent monitors and suppliers say some act differently. Executives at multiple suppliers, in interviews, said that Hewlett-Packard and others allowed them slightly more profits and other allowances if they were used to improve worker conditions.

“Our suppliers are very open with us,” said Zoe McMahon, an executive in Hewlett-Packard’s supply chain social and environmental responsibility program. “They let us know when they are struggling to meet our expectations, and that influences our decisions.”

### **The Explosion**

On the afternoon of the blast at the iPad plant, Lai Xiaodong telephoned his girlfriend, as he did every day. They had hoped to see each other that evening, but Mr. Lai’s manager said he had to work overtime, he told her.

He had been promoted quickly at Foxconn, and after just a few months was in charge of a team that maintained the machines that polished iPad cases. The sanding area was loud and hazy with aluminum dust. Workers wore masks and earplugs, but no matter how many times they showered, they were recognizable by the slight aluminum sparkle in their hair and at the corners of their eyes.

Just two weeks before the explosion, an advocacy group in Hong Kong published a report warning of unsafe conditions at the Chengdu plant, including problems with aluminum dust. The group, Students and Scholars Against Corporate Misbehavior, or Sacom, had videotaped workers covered with tiny aluminum particles. “Occupational health and safety issues in Chengdu are alarming,” [the report read](#). “Workers also highlight the problem of poor ventilation and inadequate personal protective equipment.”

A copy of that report was sent to Apple. “There was no response,” said Debby Chan Sze Wan of the group. “A few months later I went to Cupertino, and went into the Apple lobby,

but no one would meet with me. I've never heard from anyone from Apple at all."

The morning of the explosion, Mr. Lai rode his bicycle to work. The iPad had gone on sale just weeks earlier, and workers were told thousands of cases needed to be polished each day. The factory was frantic, employees said. Rows of machines buffed cases as masked employees pushed buttons. Large air ducts hovered over each station, but they could not keep up with the three lines of machines polishing nonstop. Aluminum dust was everywhere.

Dust is a known safety hazard. In 2003, an aluminum dust explosion in Indiana destroyed a wheel factory and killed a worker. In 2008, agricultural dust inside a sugar factory in Georgia [caused an explosion](#) that killed 14.

Two hours into Mr. Lai's second shift, the building started to shake, as if an earthquake was under way. There was a series of blasts, plant workers said.

Then the screams began.

When Mr. Lai's colleagues ran outside, dark smoke was mixing with a light rain, according to cellphone videos. The toll would eventually count four dead, 18 injured.

At the hospital, Mr. Lai's girlfriend saw that his skin was almost completely burned away. "I recognized him from his legs, otherwise I wouldn't know who that person was," she said.

Eventually, his family arrived. Over 90 percent of his body had been seared. "My mom ran away from the room at the first sight of him. I cried. Nobody could stand it," his brother said. When his mother eventually returned, she tried to avoid touching her son, for fear that it would cause pain.

"If I had known," she said, "I would have grabbed his arm, I would have touched him."

"He was very tough," she said. "He held on for two days."

After Mr. Lai died, Foxconn workers drove to Mr. Lai's hometown and delivered a box of ashes. The company later wired a check for about \$150,000.

Foxconn, in a statement, said that at the time of the explosion the Chengdu plant was in compliance with all relevant laws and regulations, and "after ensuring that the families of the deceased employees were given the support they required, we ensured that all of the injured employees were given the highest quality medical care." After the explosion, the company added, Foxconn immediately halted work in all polishing workshops, and later improved ventilation and dust disposal, and adopted technologies to enhance worker safety.

In its most recent supplier responsibility report, Apple wrote that after the explosion, the company contacted "the foremost experts in process safety" and assembled a team to investigate and make recommendations to prevent future accidents.

In December, however, seven months after the blast that killed Mr. Lai, another iPad factory exploded, this one in Shanghai. Once again, aluminum dust was the cause, according to interviews and Apple's most recent supplier responsibility report. That blast injured 59 workers, with 23 hospitalized.

"It is gross negligence, after an explosion occurs, not to realize that every factory should be inspected," said Nicholas Ashford, the occupational safety expert, who is now at the Massachusetts Institute of Technology. "If it were terribly difficult to deal with aluminum dust, I would understand. But do you know how easy dust is to control? It's called ventilation. We solved this problem over a century ago."

In its most recent supplier responsibility report, Apple wrote that while the explosions both involved combustible aluminum dust, the causes were different. The company declined, however, to provide details. The report added that Apple had now audited all

suppliers polishing aluminum products and had put stronger precautions in place. All suppliers have initiated required countermeasures, except one, which remains shut down, the report said.

For Mr. Lai's family, questions remain. "We're really not sure why he died," said Mr. Lai's mother, standing beside a shrine she built near their home. "We don't understand what happened."

### **Hitting the Apple Lottery**

Every year, as rumors about Apple's forthcoming products start to emerge, trade publications and Web sites begin speculating about which suppliers are likely to win the Apple lottery. Getting a contract from Apple can lift a company's value by millions because of the implied endorsement of manufacturing quality. But few companies openly brag about the work: Apple generally requires suppliers to sign contracts promising they will not divulge anything, including the partnership.

That lack of transparency gives Apple an edge at keeping its plans secret. But it also has been a barrier to improving working conditions, according to advocates and former Apple executives.

This month, after numerous requests by advocacy and news organizations, including The New York Times, [Apple released](#) the names of 156 of its suppliers. In the report accompanying that list, Apple said they "account for more than 97 percent of what we pay to suppliers to manufacture our products."

However, the company has not revealed the names of hundreds of other companies that do not directly contract with Apple, but supply the suppliers. The company's supplier list does not disclose where factories are, and many are hard to find. And independent monitoring organizations say when they have tried to inspect Apple's suppliers, they have been barred from entry — on Apple's orders, they have been told.

"We've had this conversation hundreds of times," said a former executive in Apple's supplier responsibility group. "There is a genuine, companywide commitment to the code of conduct. But taking it to the next level and creating real change conflicts with secrecy and business goals, and so there's only so far we can go." Former Apple employees say they were generally prohibited from engaging with most outside groups.

"There's a real culture of secrecy here that influences everything," the former executive said.

Some other technology companies operate differently.

"We talk to a lot of outsiders," said Gary Niekerk, director of corporate citizenship at Intel. "The world's complex, and unless we're dialoguing with outside groups, we miss a lot."

Given Apple's prominence and leadership in global manufacturing, if the company were to radically change its ways, it could overhaul how business is done. "Every company wants to be Apple," said Sasha Lezhnev at the Enough Project, a group focused on corporate accountability. "If they committed to building a conflict-free iPhone, it would transform technology."

But ultimately, say former Apple executives, there are few real outside pressures for change. Apple is one of the most admired brands. In a national survey conducted by The New York Times in November, 56 percent of respondents said they couldn't think of anything negative about Apple. Fourteen percent said the worst thing about the company was that its products were too expensive. Just 2 percent mentioned overseas labor practices.

People like Ms. White of Harvard say that until consumers demand better conditions in overseas factories — as they did for companies like Nike and Gap, which today have overhauled conditions among suppliers — or regulators act, there is little impetus for

radical change. Some Apple insiders agree.

“You can either manufacture in comfortable, worker-friendly factories, or you can reinvent the product every year, and make it better and faster and cheaper, which requires factories that seem harsh by American standards,” said a current Apple executive.

“And right now, customers care more about a new iPhone than working conditions in China.”

*Gu Huini contributed research.*

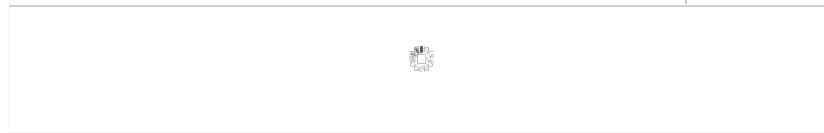
A version of this article appears in print on January 26, 2012, on page A1 of the New York edition with the headline: In China, the Human Costs That Are Built Into an iPad.

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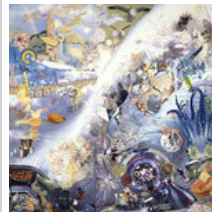
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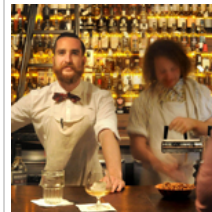
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THE iECONOMY | Part 3: Protecting Profits

## How Apple Sidesteps Billions in Taxes



David Calvert for The New York Times

Braeburn Capital, an Apple subsidiary in Reno, Nev., manages and invests the company's cash. Nevada has a corporate tax rate of zero, as opposed to the 8.84 percent levied in California, where Apple has its headquarters.

By CHARLES DUHIGG and DAVID KOCIEPIENSKI  
Published: April 28, 2012 | 1370 Comments

RENO, Nev. — [Apple](#), the world's most profitable technology company, doesn't design iPhones here. It doesn't run AppleCare customer service from this city. And it doesn't manufacture MacBooks or iPads anywhere nearby.

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GRAPHIC: Shrinking Corporate Tax Rates

DOCUMENT: Apple's Havens: A World of Subsidiaries

Yet, with a handful of employees in a small office here in Reno, Apple has done something central to its corporate strategy: it has avoided millions of dollars in taxes in California and 20 other states.

Apple's headquarters are in Cupertino, Calif. By putting an office in Reno, just 200 miles away, to collect and invest the company's profits, Apple sidesteps state income taxes on some of those gains.

California's corporate tax rate is 8.84 percent. Nevada's? Zero.

Setting up an office in Reno is just one of many legal methods Apple uses to reduce its worldwide tax bill by billions of dollars each year. As it has in Nevada, Apple has created subsidiaries in low-tax places like Ireland, the Netherlands, Luxembourg and the British Virgin Islands — some little more than a letterbox or an anonymous office — that help cut the taxes it pays around the world.

Almost every major corporation tries to minimize its taxes, of course. For Apple, the savings are especially alluring because the company's profits are so high. Wall Street analysts predict Apple could earn up to \$45.6 billion in its current fiscal year — which would be a record for any American business.

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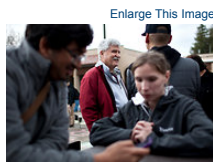
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**Reaction**

Apple's Response on Its Tax Practices (April 29, 2012)



Peter DaSilva for The New York Times  
Brian Murphy, center, head of De Anza College in Cupertino, Calif., says the big tech firms are "philosophically antitax, and it's decimating the state."

**Readers' Comments**

What do you think of Apple's tax strategy? Reporters responded to selected comments on the Business Day Live video on Monday at [nytimes.com/ieconomy](http://nytimes.com/ieconomy).

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Apple serves as a window on how technology giants have taken advantage of tax codes written for an industrial age and ill suited to today's digital economy. Some profits at companies like Apple, Google, Amazon, Hewlett-Packard and Microsoft derive not from physical goods but from royalties on intellectual property, like the patents on software that makes devices work. Other times, the products themselves are digital, like downloaded songs. It is much easier for businesses with royalties and digital products to move profits to low-tax countries than it is, say, for grocery stores or automakers. A downloaded application, unlike a car, can be sold from anywhere.

The growing digital economy presents a conundrum for lawmakers overseeing corporate taxation: although technology is now one of the nation's largest and most valued industries, many tech companies are among the least taxed, according to government and corporate data. Over the last two years, the 71 technology companies in the Standard & Poor's 500-stock index — including Apple, Google, Yahoo and Dell — reported paying worldwide cash taxes at a rate that, on average, was a third less than other S.& P. companies'. (Cash taxes may include payments for multiple years.)

Even among tech companies, Apple's rates are low. And while the company has remade industries, ignited economic growth and delighted customers, it has also devised corporate strategies that take advantage of gaps in the tax code, according to former executives who helped create those strategies.

Apple, for instance, was among the first tech companies to designate overseas salespeople in high-tax countries in a manner that allowed them to sell on behalf of low-tax subsidiaries on other continents, sidestepping income taxes, according to former executives. Apple was a pioneer of an accounting technique known as the "Double Irish With a Dutch Sandwich," which reduces taxes by routing profits through Irish subsidiaries and the Netherlands and then to the Caribbean. Today, that tactic is used by hundreds of other corporations — some of which directly imitated Apple's methods, say accountants at those companies.

Without such tactics, Apple's federal tax bill in the United States most likely would have been \$2.4 billion higher last year, according to a [recent study](#) by a former Treasury Department economist, Martin A. Sullivan. As it stands, the company paid cash taxes of \$3.3 billion around the world on its reported profits of \$34.2 billion last year, a tax rate of 9.8 percent. (Apple does not disclose what portion of those payments was in the United States, or what portion is assigned to previous or future years.)

By comparison, [Wal-Mart](#) last year paid worldwide cash taxes of \$5.9 billion on its booked profits of \$24.4 billion, a tax rate of 24 percent, which is about average for non-tech companies.

Apple's domestic tax bill has piqued particular curiosity among corporate tax experts because although the company is based in the United States, its profits — on paper, at least — are largely foreign. While Apple contracts out much of the manufacturing and assembly of its products to other companies overseas, the majority of Apple's executives, product designers, marketers, employees, research and development, and retail stores are in the United States. Tax experts say it is therefore reasonable to expect that most of Apple's profits would be American as well. The nation's tax code is based on the concept that a company "earns" income where value is created, rather than where products are sold.

However, Apple's accountants have found legal ways to allocate about 70 percent of its profits overseas, where tax rates are often much lower, according to [corporate filings](#).

Neither the government nor corporations make tax returns public, and a company's taxable income often differs from the profits disclosed in annual reports. Companies report their cash outlays for income taxes in their annual Form 10-K, but it is impossible from those numbers to determine precisely how much, in total, corporations pay to governments. In Apple's last annual disclosure, the company listed its worldwide taxes — which includes cash taxes paid as well as deferred taxes and other charges — at \$8.3 billion, an effective tax rate of almost a quarter of profits.

However, tax analysts and scholars said that figure most likely overstated how much the company would hand to governments because it included sums that might never be paid. "The information on 10-Ks is fiction for most companies," said Kimberly Clausing, an economist at Reed College who specializes in multinational taxation. "But for tech companies it goes from fiction to farcical."

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Apple, in a statement, said it "has conducted all of its business with the highest of ethical standards, complying with applicable laws and accounting rules." It added, "We are incredibly proud of all of Apple's contributions."

Apple "pays an enormous amount of taxes, which help our local, state and federal governments," the statement also said. "In the first half of fiscal year 2012, our U.S. operations have generated almost \$5 billion in federal and state income taxes, including income taxes withheld on employee stock gains, making us among the top payers of U.S. income tax."

The statement did not specify how it arrived at \$5 billion, nor did it address the issue of deferred taxes, which the company may pay in future years or decide to defer indefinitely. The \$5 billion figure appears to include taxes ultimately owed by Apple employees.

The sums paid by Apple and other tech corporations is a point of contention in the company's backyard.

A mile and a half from Apple's Cupertino headquarters is De Anza College, a community college that Steve Wozniak, one of Apple's founders, attended from 1969 to 1974. Because of California's state budget crisis, De Anza has cut more than a thousand courses and 8 percent of its faculty since 2008.

Now, De Anza faces a budget gap so large that it is confronting a "death spiral," the school's president, Brian Murphy, [wrote to the faculty](#) in January. Apple, of course, is not responsible for the state's financial shortfall, which has numerous causes. But the company's tax policies are seen by officials like Mr. Murphy as symptomatic of why the crisis exists.

"I just don't understand it," he said in an interview. "I'll bet every person at Apple has a connection to De Anza. Their kids swim in our pool. Their cousins take classes here. They drive past it every day, for Pete's sake.

"But then they do everything they can to pay as few taxes as possible."

#### **Escaping State Taxes**

In 2006, as Apple's bank accounts and stock price were rising, company executives came here to Reno and established a subsidiary named Braeburn Capital to manage and invest the company's cash. Braeburn is a variety of apple that is simultaneously sweet and tart.

Today, Braeburn's offices are down a narrow hallway inside a bland building that sits across from an abandoned restaurant. Inside, there are posters of candy-colored iPods and a large Apple insignia, as well as a handful of desks and computer terminals.

When someone in the United States buys an [iPhone](#), [iPad](#) or other Apple product, a portion of the profits from that sale is often deposited into accounts controlled by Braeburn, and then invested in stocks, bonds or other financial instruments, say company executives. Then, when those investments turn a profit, some of it is shielded from tax authorities in California by virtue of Braeburn's Nevada address.

Since founding Braeburn, Apple has earned more than \$2.5 billion in interest and dividend income on its cash reserves and investments around the globe. If Braeburn were located in Cupertino, where Apple's top executives work, a portion of the domestic income would be taxed at California's 8.84 percent corporate income tax rate.

But in Nevada there is no state corporate income tax and no capital gains tax.

What's more, Braeburn allows Apple to lower its taxes in other states — including Florida, New Jersey and New Mexico — because many of those jurisdictions use formulas that reduce what is owed when a company's financial management occurs elsewhere. Apple does not disclose what portion of cash taxes is paid to states, but the company reported that it owed \$762 million in state income taxes nationwide last year. That effective state tax rate is higher than the rate of many other tech companies, but as Ms. Clausung and other tax analysts have noted, such figures are often not reliable guides to what is actually paid.

Dozens of other companies, including Cisco, Harley-Davidson and Microsoft, have also set up Nevada subsidiaries that bypass taxes in other states. Hundreds of other corporations reap similar savings by locating offices in Delaware.

But some in California are unhappy that Apple and other California-based companies have moved financial operations to tax-free states — particularly since lawmakers have offered them tax breaks to keep them in the state.

In 1996, 1999 and 2000, for instance, the California Legislature increased the state's research and development tax credit, permitting hundreds of companies, including Apple, to avoid billions in state taxes, [according to legislative analysts](#). Apple has reported tax

savings of \$412 million from research and development credits of all sorts since 1996.

Then, in 2009, after an intense lobbying campaign led by Apple, Cisco, Oracle, Intel and other companies, the California Legislature reduced taxes for corporations based in California but operating in other states or nations. [Legislative analysts say](#) the change will eventually cost the state government about \$1.5 billion a year.

Such lost revenue is one reason California now faces [a budget crisis](#), with a shortfall of more than \$9.2 billion in the coming fiscal year alone. The state has cut some health care programs, significantly raised tuition at state universities, cut services to the disabled and proposed a \$4.8 billion reduction in spending on kindergarten and other grades.

Apple declined to comment on its Nevada operations. Privately, some executives said it was unfair to criticize the company for reducing its tax bill when thousands of other companies acted similarly. If Apple volunteered to pay more in taxes, it would put itself at a competitive disadvantage, they argued, and do a disservice to its shareholders.

Indeed, Apple's decisions have yielded benefits. [After announcing](#) one of the best quarters in its history last week, the company said it had net profits of \$24.7 billion on revenues of \$85.5 billion in the first half of the fiscal year, and more than \$110 billion in the bank, according to company filings.

### **A Global Tax Strategy**

Every second of every hour, millions of times each day, in living rooms and at cash registers, consumers click the "Buy" button on iTunes or hand over payment for an Apple product.

And with that, an international financial engine kicks into gear, moving money across continents in the blink of an eye. While Apple's Reno office helps the company avoid state taxes, its international subsidiaries — particularly the company's assignment of sales and patent royalties to other nations — help reduce taxes owed to the American and other governments.

For instance, one of Apple's subsidiaries in Luxembourg, named iTunes S.à r.l., has just a few dozen employees, according to corporate documents filed in that nation and a current executive. The only indication of the subsidiary's presence outside is a letterbox with a lopsided slip of paper reading "iTUNES SARL."

Luxembourg has just half a million residents. But when customers across Europe, Africa or the Middle East — and potentially elsewhere — download a song, television show or app, the sale is recorded in this small country, according to current and former executives. In 2011, iTunes S.à r.l.'s revenue exceeded \$1 billion, according to an Apple executive, representing roughly 20 percent of iTunes's worldwide sales.

The advantages of Luxembourg are simple, say Apple executives. The country has promised to tax the payments collected by Apple and numerous other tech corporations at low rates if they route transactions through Luxembourg. Taxes that would have otherwise gone to the governments of Britain, France, the United States and dozens of other nations go to Luxembourg instead, at discounted rates.

"We set up in Luxembourg because of the favorable taxes," said Robert Hatta, who helped oversee Apple's iTunes retail marketing and sales for European markets until 2007. "Downloads are different from tractors or steel because there's nothing you can touch, so it doesn't matter if your computer is in France or England. If you're buying from Luxembourg, it's a relationship with Luxembourg."

An Apple spokesman declined to comment on the Luxembourg operations.

Downloadable goods illustrate how modern tax systems have become increasingly ill equipped for an economy dominated by electronic commerce. Apple, say former executives, has been particularly talented at identifying legal tax loopholes and hiring accountants who, as much as iPhone designers, are known for their innovation. In the 1980s, for instance, Apple was among the first major corporations to designate overseas distributors as "commissionaires," rather than retailers, said Michael Rashkin, Apple's first director of tax policy, who helped set up the system before leaving in 1999.

To customers the designation was virtually unnoticeable. But because commissionaires never technically take possession of inventory — which would require them to recognize taxes — the structure allowed a salesman in high-tax Germany, for example, to sell computers on behalf of a subsidiary in low-tax Singapore. Hence, most of those profits would be taxed at Singaporean, rather than German, rates.

### **The Double Irish**

In the late 1980s, Apple was among the pioneers in creating a tax structure — known as the Double Irish — that allowed the company to move profits into tax havens around the



world, said Tim Jenkins, who helped set up the system as an Apple European finance manager until 1994.

Apple created two Irish subsidiaries — today named Apple Operations International and Apple Sales International — and built a glass-encased factory amid the green fields of Cork. The Irish government offered Apple tax breaks in exchange for jobs, according to former executives with knowledge of the relationship.

But the bigger advantage was that the arrangement allowed Apple to send royalties on patents developed in California to Ireland. The transfer was internal, and simply moved funds from one part of the company to a subsidiary overseas. But as a result, some profits were taxed at the Irish rate of approximately 12.5 percent, rather than at the American statutory rate of 35 percent. In 2004, Ireland, a nation of less than 5 million, was home to more than one-third of Apple's worldwide revenues, according to company filings. (Apple has not released more recent estimates.)

Moreover, the second Irish subsidiary — the “Double” — allowed other profits to flow to tax-free companies in the Caribbean. Apple has assigned partial ownership of its Irish subsidiaries to Baldwin Holdings Unlimited in the British Virgin Islands, a tax haven, according to documents filed there and in Ireland. Baldwin Holdings has no listed offices or telephone number, and its only listed director is Peter Oppenheimer, Apple's chief financial officer, who lives and works in Cupertino. Baldwin apples are known for their hardiness while traveling.

Finally, because of Ireland's treaties with European nations, some of Apple's profits could travel virtually tax-free through the Netherlands — the Dutch Sandwich — which made them essentially invisible to outside observers and tax authorities.

Robert Promm, Apple's controller in the mid-1990s, called the strategy “the worst-kept secret in Europe.”

It is unclear precisely how Apple's overseas finances now function. In 2006, the company reorganized its Irish divisions as unlimited corporations, which have few requirements to disclose financial information.

However, tax experts say that strategies like the Double Irish help explain how Apple has managed to keep its international taxes to 3.2 percent of foreign profits last year, to 2.2 percent in 2010, and in the single digits for the last half-decade, according to the company's corporate filings.

Apple declined to comment on its operations in Ireland, the Netherlands and the British Virgin Islands.

Apple reported in its last annual disclosures that \$24 billion — or 70 percent — of its total \$34.2 billion in pretax profits were earned abroad, and 30 percent were earned in the United States. But Mr. Sullivan, the former Treasury Department economist who today writes for the trade publication Tax Analysts, said that “given that all of the marketing and products are designed here, and the patents were created in California, that number should probably be at least 50 percent.”

If profits were evenly divided between the United States and foreign countries, Apple's federal tax bill would have increased by about \$2.4 billion last year, he said, because a larger amount of its profits would have been subject to the United States' higher corporate income tax rate.

“Apple, like many other multinationals, is using perfectly legal methods to keep a significant portion of their profits out of the hands of the I.R.S.,” Mr. Sullivan said. “And when America's most profitable companies pay less, the general public has to pay more.”

Other tax experts, like [Edward D. Kleinbard](#), former chief of staff of the Congressional Joint Committee on Taxation, have reached similar conclusions.

“This tax avoidance strategy used by Apple and other multinationals doesn't just minimize the companies' U.S. taxes,” said Mr. Kleinbard, now a professor of tax law at the University of Southern California. “It's German tax and French tax and tax in the U.K. and elsewhere.”

One downside for companies using such strategies is that when money is sent overseas, it cannot be returned to the United States without incurring a new tax bill.

However, that might change. Apple, which holds \$74 billion offshore, last year aligned itself with more than four dozen companies and organizations urging Congress for a “repatriation holiday” that would permit American businesses to bring money home without owing large taxes. [The coalition](#), which includes Google, Microsoft and Pfizer, has hired dozens of lobbyists to push for the measure, which has not yet come up for vote. The tax break would cost the federal government \$79 billion over the next decade, according to a Congressional report.

### Fallout in California

In one of his last public appearances before his death, Steven P. Jobs, Apple's chief executive, addressed Cupertino's City Council last June, seeking approval to build a new headquarters.

Most of the Council was effusive in its praise of the proposal. But one councilwoman, Kris Wang, had questions.

How will residents benefit? she asked. Perhaps Apple could provide free wireless Internet to Cupertino, she suggested, something Google had done in neighboring Mountain View.

"See, I'm a simpleton; I've always had this view that we pay taxes, and the city should do those things," Mr. Jobs replied, according to [a video of the meeting](#). "That's why we pay taxes. Now, if we can get out of paying taxes, I'll be glad to put up Wi-Fi."

He suggested that, if the City Council were unhappy, perhaps Apple could move. The company is Cupertino's largest taxpayer, with more than \$8 million in property taxes assessed by local officials last year.

Ms. Wang dropped her suggestion.

Cupertino, Ms. Wang said in an interview, has real financial problems. "We're proud to have Apple here," said Ms. Wang, who has since left the Council. "But how do you get them to feel more connected?"

Other residents argue that Apple does enough as Cupertino's largest employer and that tech companies, in general, have buoyed California's economy. Apple's workers eat in local restaurants, serve on local boards and donate to local causes. Silicon Valley's many millionaires pay personal state income taxes. In its statement, Apple said its "international growth is creating jobs domestically, since we oversee most of our operations from California."

"The vast majority of our global work force remains in the U.S.," the statement continued, "with more than 47,000 full-time employees in all 50 states."

Moreover, Apple has given nearby Stanford University more than \$50 million in the last two years. The company has also donated \$50 million to an African aid organization. In its statement, Apple said: "We have contributed to many charitable causes but have never sought publicity for doing so. Our focus has been on doing the right thing, not getting credit for it. In 2011, we dramatically expanded the number of deserving organizations we support by initiating a matching gift program for our employees."

Still, some, including De Anza College's president, Mr. Murphy, say the philanthropy and job creation do not offset Apple's and other companies' decisions to circumvent taxes. Within 20 minutes of the financially ailing school are the global headquarters of Google, Facebook, Intel, Hewlett-Packard and Cisco.

"When it comes time for all these companies — Google and Apple and Facebook and the rest — to pay their fair share, there's a knee-jerk resistance," Mr. Murphy said. "They're philosophically antitax, and it's decimating the state."

"But I'm not complaining," he added. "We can't afford to upset these guys. We need every dollar we can get."

*Additional reporting was contributed by Keith Bradsher in Hong Kong, Siem Eikelenboom in Amsterdam, Dean Greenaway in the British Virgin Islands, Scott Sayare in Luxembourg and Jason Woodard in Singapore.*

A version of this article appears in print on April 29, 2012, on page A1 of the New York edition with the headline: How Apple Sidesteps Billions in Taxes.

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What do you think of Apple's tax strategy? Reporters responded to selected comments on the Business Day Live video on Monday at [nytimes.com/ieconomy](http://nytimes.com/ieconomy).

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THE iECONOMY | *Part 4: Retailing's King*

## Apple's Retail Army, Long on Loyalty but Short on Pay



Justin Lane/European Pressphoto Agency

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Apple stores are renowned for design, service and revenues.

By [DAVID SEGAL](#)  
Published: June 23, 2012 | [1374 Comments](#)

Last year, during his best three-month stretch, Jordan Golson sold about \$750,000 worth of computers and gadgets at the [Apple Store](#) in Salem, N.H. It was a performance that might have called for a bottle of Champagne — if that were a luxury Mr. Golson could have afforded.

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“I was earning \$11.25 an hour,” he said. “Part of me was thinking, ‘This is great. I’m an Apple fan, the store is doing really well.’ But when you look at the amount of money the company is making and then you look at your paycheck, it’s kind of tough.”

America’s love affair with the smartphone has helped create tens of thousands of jobs at places like Best Buy and Verizon Wireless and will this year pump billions into the economy.

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Business Day Live | Apple Stores

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Within this world, the Apple Store is the undisputed king, a retail phenomenon renowned for impeccable design, deft service and spectacular revenues. Last year, the company's 327 global stores took in more money per square foot than any other United States retailer — wireless or otherwise — and almost double that of Tiffany, which was No. 2 on the list, according to the research firm RetailSails.

Worldwide, its stores sold \$16 billion in merchandise.

But most of Apple's employees enjoyed little of that wealth. While consumers tend to think of Apple's headquarters in Cupertino, Calif., as the company's heart and soul, a majority of its workers in the United States are not engineers or executives with hefty salaries and bonuses but rather hourly wage earners selling iPhones and MacBooks.

About 30,000 of the 43,000 Apple employees in this country work in Apple Stores, as members of the service economy, and many of them earn about \$25,000 a year. They work inside the world's fastest growing industry, for the most valuable company, run by one of the country's most richly compensated chief executives, Tim Cook. Last year, he received stock grants, which vest over a 10-year period, that at today's share price would be worth more than \$570 million.

And though Apple is unparalleled as a retailer, when it comes to its lowliest workers, the company is a reflection of the technology industry as a whole.

The Internet and advances in computing have created untold millionaires, but most of the jobs created by technology giants are service sector positions — sales employees and customer service representatives, repairmen and delivery drivers — that offer little of Silicon Valley's riches or glamour.

Much of the debate about American unemployment has focused on why companies have moved factories overseas, but only 8 percent of the American work force is in manufacturing, according to the Bureau of Labor Statistics. Job growth has for decades been led by service-related work, and any recovery with real legs, labor experts say, will be powered and sustained by this segment of the economy.

And as the service sector has grown, the definition of a career has been reframed for millions of American workers.

"In the service sector, companies provide a little bit of training and hope their employees leave after a few years," says Arne L. Kalleberg, a professor of sociology at the University of North Carolina. "Especially now, given the number of college kids willing to work for low wages."

By the standards of retailing, Apple offers above average pay — well above the minimum wage of \$7.25 and better than the Gap, though slightly less than Lululemon, the yoga and athletic apparel chain, where sales staff earn about \$12 an hour. The company also offers very good benefits for a retailer, including health care, [401\(k\)](#) contributions and the chance to buy company stock, as well as Apple products, at a discount.

But Apple is not selling polo shirts or yoga pants. Divide revenue by total number of employees and you find that last year, each Apple store employee — that includes non-sales staff like technicians and people stocking shelves — brought in \$473,000.

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"These are sales rates for a consulting company," said Horace Dediu, an analyst who [blogged about the calculation](#) on the site Asymco. Electronics and appliance stores typically post \$206,000 in revenue per employee, according to the latest figures from the National Retail Federation.

Even Apple, it seems, has recently decided it needs to pay its workers more. Last week, four months after The New York Times first began inquiring about the wages of its store employees, the company started to inform some staff members that they would receive substantial raises. An Apple spokesman confirmed the raises but would not discuss their size, timing or impetus, nor who would earn them.

But Cory Moll, a salesman in the San Francisco flagship store and a vocal labor activist, said that on Tuesday he was given a raise of \$2.82 an hour, to \$17.31, an increase of 19.5 percent and a big jump compared with the 49-cent raise he was given last year.

"My manager called me into his office and said, 'Apple wants to show that it cares about its workers, and show that it knows how much value you add to the company, by offering a bigger raise than in previous years,' " Mr. Moll recalled.

Though a significant increase, Mr. Moll's new salary of about \$36,000 puts him on the low side of the wage scale at the other large sellers of Apple products, AT&T and Verizon Wireless, both of which offer commissions to sales staff at their stores.

In other areas, Apple has been a leader. Stores in a variety of fields have adopted the company's retail techniques, like the use of roving credit-card swipers to minimize checkout lines, as well as the petting-zoo layout that encourages customers to test-drive products.

But Apple's success, it turns out, rests on a set of intangibles; foremost among them is a built-in fan base that ensures a steady supply of eager applicants and an employee culture that tries to turn every job into an exalted mission.

This is why Apple can do something unique in the annals of retailing: pay a modest hourly wage, and no commission, to employees who typically have college degrees and who at the highest performing levels can move as much as \$3 million in goods a year.

"When you're working for Apple you feel like you're working for this greater good," says a former salesman who asked for anonymity because he didn't want to draw attention to himself. "That's why they don't have a revolution on their hands."

These true believers skew young, as anyone who has ever set foot in an Apple Store knows. And the relative youth of this work force helps explain why people are likely to judge the company by a different set of standards when it comes to wages, says Paul Osterman, a professor at M.I.T.'s Sloan School of Management.

"It's interesting to ask why we find it offensive that Wal-Mart pays a single mother \$9 an hour, but we don't find it offensive that Apple pays a young man \$12 an hour," Mr. Osterman said. "For each company, the logic is the same — there is a line of people eager to take the job. In effect, we're saying that our value judgments depend on the circumstances of the employee, not just supply and demand of the labor market."

Twenty-two-year-olds also tend to be more tolerant of the Apple Store's noise and bustle, yet these days some former employees describe a work environment that was too hectic and stressful, thanks in large part to the runaway popularity of the [iPhone](#) and [iPad](#).

Managers often tell new workers that they hope to get six years of service, former employees say. "That was what we heard all the time," says Shane Garcia, a former Apple Store manager in Chicago. "Six years." But the average tenure is two and a half years, says a person familiar with the company's retention numbers, and as foot traffic has increased, turnover rates in many stores have increased, too. Internal surveys at stores have also found surprising dissatisfaction levels, particularly among technicians, or "geniuses" in

Apple's parlance, who work at what is called the Genius Bar. Apple declined requests for interviews for this article. Instead, the company issued a statement:

"Thousands of incredibly talented professionals work behind the Genius Bar and deliver the best customer service in the world. The annual retention rate for Geniuses is almost 90%, which is unheard-of in the retail industry, and shows how passionate they are about their customers and their careers at Apple."

That 90 percent figure sounds accurate to Mr. Garcia, who quit last July after four years with the company, overwhelmed by the work and unable to mollify employees and customers alike. Plenty of technicians do, in fact, like their jobs, which vary around the country, and which pay in the range of \$40,000 a year in the Chicago area. Many technicians, though, wanted to leave but were unable to find equivalent work, according to Mr. Garcia and other former managers, in part because of the weak economy.

The problem for Apple Store employees, they said, wasn't just the pace. It was the lack of upward mobility. There are only a handful of different jobs at Apple Stores and the most prestigious are invariably sought after by dozens of candidates. And a leap to the company headquarters is highly unusual.

Apple prohibits its staff from talking to the media, but several former employees who spoke for this article said they had fond memories of their jobs, and regarded them as ideal for people in their early 20s who aren't ready for a full-on dive into the white-collar world.

And "Apple" can be a strong credential to have on a résumé, these people said. Technicians often move on to higher-paying jobs in information technology, they said, and sales staff have a leg up on the competition if they stay in retailing because "people know how grueling the job is," as one former manager put it.

But other former employees have struggled to find work, or have moved into lateral jobs at other companies. And even those who used Apple as a launching pad described a gradual evolution, from team player to skeptic, as they discovered that there was a gap between what the job appeared to be (kind of hip) and what it was (frenetic and in many cases a dead end).

Kelly Jackson, who was a technician at an Apple Store in Chicago, was thrilled when she was hired two years ago. But she said she was even happier when she quit a year later, having found the work too relentless and the satisfactions too elusive.

"When somebody left, you'd be really excited for them," says Ms. Jackson, who now works at Groupon. "It was sort of like, 'Congratulations. You've done what everyone here wants to do.'"

### **Recruiting the Devoted**

Skeptics outnumbered believers when Steven P. Jobs, then Apple's chief, pitched the Apple Store concept to his board in 2000. Ultimately, approval was given for just four stores.

Mr. Jobs hired a Target executive named Ron Johnson to help design and oversee the stores. He in turn hired eight people, one of whom was Denyelle Bruno, then an executive at Macy's West. When she was first approached, she said, she was told next to nothing about the work.

That did not daunt Ms. Bruno, now an executive at Peet's Coffee.

"I had grown up using Macs, and if it involved Apple and I could be involved," she said, "it made me feel important."

Ms. Bruno was one of the first hard-core Apple fans hired for the nascent chain. Many others would follow, and part of her job was to help recruit them. Initially, that involved walking into stores, including those operated by Sprint and AT&T, and scouting out

promising employees.

Such solicitations were unnecessary after the first two stores opened, on May 19, 2001, in McLean, Va., and Glendale, Calif. Soon, so many people wanted to work at the stores that Mr. Johnson would compare applicants-to-openings ratios and boast that it was harder to land a job at an Apple Store than to get into Stanford, his alma mater.

Those applicants have for years submitted résumés through the company's site. The time-intensive part, former managers say, is finding the right people amid the pile, and the candidates of choice are affable and self-directed rather than tech-savvy. (The latter can be taught, is the theory, while the former is innate.) The vetting has not changed much. It often starts with an invitation to a seminar, held in a conference room at a hotel.

The culling begins before the seminar starts.

"They turn away people who are three minutes late," says Graham Marley, who attended his seminar in a hotel in Dedham, Mass., in 2009. "My dream my whole life was to work for Apple and suddenly, you can," he said. "You've always been an evangelist for Apple and now you can get paid for it."

One manager said it was common for people offered jobs to burst into tears. But if the newly hired arrive as devotees, Apple's training course, which can range from a few days to a few weeks, depending on the job and locale, turns them into disciples.

Training commences with what is known as a "warm welcome." As new employees enter the room, Apple managers and trainers give them a standing ovation. The clapping often bewilders the trainees, at least at first, but when the applause goes on for several lengthy minutes they eventually join in.

"My hands would sting from all the clapping," says Michael Dow, who trained Apple employees for years in Providence, R.I.

There is more role-playing at Core training, as it's known, this time with pointers on the elaborate etiquette of interacting with customers. One rule: ask for permission before touching anyone's iPhone.

"And we told trainees that the first thing they needed to do was acknowledge the problem, though don't promise you can fix the problem," said Shane Garcia, the one-time Chicago manager. "If you can, let them know that you have felt some of the emotions they are feeling. But you have to be careful because you don't want to lie about that."

The phrase that trainees hear time and again, which echoes once they arrive at the stores, is "enriching people's lives." The idea is to instill in employees the notion that they are doing something far grander than just selling or fixing products. If there is a secret to Apple's sauce, this is it: the company ennobles employees. It understands that a lot of people will forgo money if they have a sense of higher purpose.

That empowerment is important because aspiring sales employees would clearly be better off working at one of the country's other big sellers of Apple products, AT&T and Verizon Wireless, if they were searching for a hefty paycheck. Both offer sales commissions.

"It's not at all common but there are sales agents at Verizon who earn six figures," says Jonathan Jarboe, who managed Verizon Wireless stores in Oklahoma until last summer. Several former Verizon Wireless managers said that annual pay ran from \$35,000 up to \$100,000 in rare cases, with the sweet spot in the \$50,000 to \$60,000 range.

At Apple, the decision not to offer commissions was made, Ms. Bruno said, before a store had opened. The idea was that such incentives would work against the company's primary goals — finding customers the right products, rather than the most expensive ones, and establishing long-term rapport with the brand. Commissions, it was also thought, would foster employee competition, which would undermine camaraderie.

Tellingly, Apple doesn't use the word "sales" to describe members of its sales team. They're called "specialists."

By minimizing the profit motive among employees, Apple does more than just filter out people interested primarily in money. It also reduces the number of middle-aged and older people on the payroll, said former managers. This isn't about age discrimination, they said, so much as self-selection. Generally, an Apple employee is someone who can afford to live cheaply, is not bothered by the nonstop commotion of an Apple Store and is comfortable with technology.

People who fit that bill tend to be in their early or mid-20s, the former managers said. They typically don't have children and many don't have spouses, which means they are relatively inexpensive to cover with health insurance.

There is no shortage of college graduates eager to dedicate themselves to Apple's vision, on Apple's terms. That includes people like Asher Perlman, another former technician from a store in Chicago, who joined Apple three years ago, when he was 22.

"I'm happy with my time at Apple and where it landed me," says Mr. Perlman, who now works in information technology. "I wouldn't recommend it for my 35-year-old friend with a kid, but it works for someone who is 22 years old and doesn't want to enter the business world yet."

### **When Work Piles Up**

The iPhone, which arrived in 2007, brought unprecedented crowds to Apple Stores. The company tried to hang on to its culture, but naturally it changed, and in many ways, say some former employees, for the worse.

Arthur Zarate, who joined Apple in 2004 and later worked as a technician at the store in Mission Viejo, Calif., says his training left him with a sense of ownership and pride. For a while, he loved the job, in large part because it delivered the simple and gratifying sense that he was helping people. There were time constraints on technicians — 20 minutes per customer — but because the store was rarely swamped, he usually had more time than that.

"My customers knew me by name," he said. "That was a big deal."

He had already begun to sour on the job when in 2007, he said, his store began an attendance system whereby employees accumulated a point for every day they did not come to work; anyone with four points in a 90-day period was at risk of termination.

"It was a perfectly good idea, but the thing that was terrible is that it didn't matter why you couldn't come to work," Mr. Zarate said. "Even if you had a doctor document some medical condition, if you didn't come to work, you got a point."

Mr. Zarate, a former heavy smoker, said he was once out for two and a half weeks with severe bronchitis and was on the verge of dismissal when he e-mailed Ron Johnson, then the retail chief, who intervened on his behalf.

"I just wrote and said, 'This isn't fair. They don't look at why you were out,'" he recalls. "And he saved my job."

To meet the growing demand for the technicians, several former employees said their stores imposed new rules limiting on-the-spot repairs to 15 minutes for a computer-related problem, and 10 minutes for Apple's assortment of devices. If a solution took longer to find, which it frequently did, a pileup ensued and a scrum of customers would hover. It wasn't unusual for a genius to help three customers at once.

Because of the constant backlog, technicians often worked nonstop through their shift, instead of taking two allotted 15-minute breaks. In 2009, Matthew Bainer, a lawyer, filed a class action alleging that Apple was breaking California labor laws.



"State law mandates two 10-minute breaks a day," Mr. Bainer said. "But geniuses had these lengthy queues of customers that made it all but impossible for them to stop even for a few minutes."

The lawsuit was denied class certification in June of last year. Mr. Bainer pursued the matter in separate lawsuits and achieved what he described as "very favorable settlements" for 10 plaintiffs.

Not long after the class-action lawsuit was filed, a technician named Kevin Timmer who worked at the Woodland Mall store in Grand Rapids, Mich., noticed an added step when he logged onto a computer to punch out of work.

"This window popped up and it said something like, 'By clicking this box I acknowledge that I received all my breaks,'" Mr. Timmer recalled. "The rumor was that was because some guy in California had sued."

Mr. Timmer said he and other technicians in the store clicked the box even when they didn't take any breaks. It wasn't because management insisted they stick around. It was that any down time would slam already overburdened colleagues with even more work.

"We were all in the trenches together," he said. "Nobody wanted to leave."

With time limits, several former employees said, came another change at their stores. Technicians had always been able to spend a few hours of their shift in the repair room, providing a little away-from-customers time. In many stores, that ended. Walk-in demand for tech help was so great that when the bar was open, management at these stores decreed, it was to be staffed by any technician in the building. Repairs that could not be done at the bar would wait. As a result, the late shift in the repair room at these stores ended not at 10 p.m., but at midnight.

The pressure didn't faze everyone. Multitasking, for instance, did not bother Asher Perlman.

"I'm a low stress kind of person to begin with and I didn't find it unmanageable," he said. "I know others did."

As the crowds grew, the company's "thank you" gestures started to seem a little tin-eared. Jordan Golson, who now blogs at [MacRumors](#), a site that keeps tabs on all things Apple, said that for Christmas 2010, he and others at the store were given a fleece blanket and an insulated coffee thermos.

Mr. Zarate fared no better at one quarterly meeting for employees. Mr. Johnson made a videotaped appearance and referred to a wonderful surprise that managers were about to spring on everyone in the room. Free iPads for everyone was the expectation. "Then the lights went down, and we had a party in the store, with games and dancing," Mr. Zarate said. "And we all got two tacos from a taco truck. That was our surprise. Two tacos."

### **Rising to the Top**

Like many who spoke for this article, Shane Garcia, the former Chicago manager, talked about Apple with a bittersweet mix of admiration and sadness. When he joined the company in 2007, he considered it a place, as he said, that "wanted you to be the best you could be in life, not just in sales."

Three years later, his work life seemed tense and thankless. He had little expectation that upper management would praise or even notice his efforts.

Sales employees, Mr. Garcia and others noted, deal with stresses all their own. Though commissions are not offered, many managers keep close tabs on sales of warranties, known as Apple Care, and One to One, which is personal tutoring for a fee. Employees often had goals for "attachments" as these add-ons are called — 40 percent of certain products should include One to One, and 65 percent should include Apple Care.

For a sales employee who wanted to climb Apple's in-store ladder — to technician or manager, for instance — those numbers were important. And in terms of keeping employees invested and striving, so were the rungs on that ladder, something that is true across retailing.

"There was always something being dangled in terms of different positions," says Danielle Draper, a former manager at a store in Hingham, Mass. "You'll need to do this if you want to become a creative, that kind of thing. There was never perfection. You could always tell someone they needed to work on something."

At some point, employees either realize they won't rise, or rise as high as they can.

"The disillusionment settles in not because of pay," says Graham Marley, the former part-time salesman, "though pay is part of it. What happens is you realize that they want you to spend years there, but there is no actual career path."

An exception is the job of manager, and Apple is often diligent about elevating from within its ranks of high achievers. Though not always. After the great influx that started with the iPhone, the company started plucking managers from stores like the Gap and Banana Republic. From employees who were around in the pre-2007 era, you can hear occasional laments about the gradual "Gapification of Apple."

In recent years, the level of unhappiness at some stores was captured by an employee satisfaction survey known in the company as NetPromoter for Our People. It's a variation of a questionnaire that Apple has long given to customers, and the key question asks employees to rate, on a scale of one to 10, "How likely are you to recommend working at your Apple Retail Store to an interested friend or family member?" Anyone who offers a nine or 10 is considered a "promoter." Anyone who offers a seven or below is considered a "detractor."

Kevin Timmer said the internal survey results last year at the Grand Rapids store were loaded with fives and sixes.

"We discussed it in a monthly meeting and our manager had tears in her eyes," Mr. Timmer recalled. "She said something about how humbling these results were, that they want to fix any problems, that her door is always open, and so on."

Similar figures were found in Chicago.

"By then," Mr. Garcia said, "it wasn't a surprise to upper management because it was clear that many geniuses wanted to leave. There was a ceiling. It wasn't a glass ceiling because everyone could see it."

Mr. Garcia would eventually quit Apple, and walk away from a job that paid a little more than \$40,000 a year, when stress-related health issues sidelined him long enough to put his job at risk. He had no doubts that the company would easily find a replacement.

"There was never a shortage of résumés," he said. "People will always want to work for Apple."

A version of this article appears in print on June 24, 2012, on page A1 of the New York edition with the headline: Apple's Retail Army, Long on Loyalty but Short on Pay.

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In Pursuit of Nissan, a Jobs Lesson for the Tech Industry?



Josh Anderson for The New York Times

Workers assemble cars on the trim line at the Nissan manufacturing plant in Smyrna, Tenn., in June. More Photos »

By BILL VLASIC, HIROKO TABUCHI and CHARLES DUHIGG Published: August 4, 2012 | 331 Comments

SMYRNA, Tenn. — The dairy farms that once draped the countryside here were paved over so the Japanese carmaker Nissan could build its first American assembly plant. Eighty miles to the south, another green pasture was replaced by a Nissan engine factory, and across Tennessee about 100 Nissan suppliers dot the landscape, making steel in Murfreesboro, air conditioning units in Lewisburg, transmission parts in Portland.

Three decades ago, none of this existed. The conventional wisdom at the time was simple: Japanese automakers would not build many cars anywhere but Japan, where supply chains were in place, costs were tightly controlled and the reputation for quality was unparalleled.

“They were very unfamiliar doing anything outside Japan,” said Senator Lamar Alexander, a Republican who was governor of Tennessee when Nissan opened its factory here in 1983. “They were tentative and awkward even discussing

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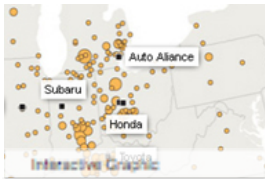
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Ana Ottoni for The New York Times

**A RECENT RECHRISTENING**  
Alongside this road in Jundiaí, Brazil, is a Foxconn factory that makes iPhones and iPads. [More Photos](#) »

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Lamar Alexander of Tennessee and Marvin Runyon of Nissan in 1984. [More Photos](#) »

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it.”

Today, echoes of that conventional wisdom can be heard within the American technology industry. For years, high-tech executives have argued that the United States cannot compete in making the most popular electronic devices. Companies like [Apple](#), Dell and Hewlett-Packard, which rely on huge Asian factories, assert that many types of manufacturing would be too costly and inefficient in America. Only overseas, they have said, can they find an abundance of educated midlevel engineers, low-wage workers and at-the-ready suppliers.

But the migration of Japanese auto manufacturing to the United States over the last 30 years offers a case study in how the unlikeliest of transformations can unfold. Despite the decline of American car companies, the United States today remains one of the top auto manufacturers and employers in the world. Japanese and other foreign companies account for more than 40 percent of cars built in the United States, employing about 95,000 people directly and hundreds of thousands more among parts suppliers.

The United States gained these jobs through a combination of public and Congressional pressure on Japan, “voluntary” quotas on car exports from Japan and incentives like tax breaks that encouraged Japanese automakers to build factories in America. Pressuring technology companies to move manufacturing here would pose different challenges. For one thing, Apple and many other technology giants are American, not foreign, and so are viewed differently by politicians and the public. But it is possible and the benefits might be worth it, some economists say.

“The U.S. has a long history of demanding that companies build here if they want to sell here, because it jump-starts industries,” said Clyde V. Prestowitz Jr., a senior trade official in the Reagan administration who helped negotiate with Japan in the 1980s. The government could also encourage domestic production of technologies, including display manufacturing and advanced semiconductor fabrication, that would nurture new industries. “Instead, we let those jobs go to Asia, and then the supply chains follow, and then R&D follows, and soon it makes sense to build everything overseas,” he said. “If Apple or Congress wanted to make the valuable parts of the [iPhone](#) in America, it wouldn't be hard.”

One country has recently succeeded at forcing technology jobs to relocate. Last year, Brazilian politicians used subsidies and the threat of continued high tariffs on imports to persuade [Foxconn](#) — which makes smartphones and computers in Asia for dozens of technology companies — to start producing iPhones, iPads and other devices in a factory north of São Paulo. Today, the new plant has 1,000 workers, and could employ many more. Apple and Foxconn declined to comment about the specifics of their Brazilian manufacturing.

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However, a developing country like Brazil can adopt trade policies that would be difficult for the United States to do. Taking a hard line to reduce imports of technology goods and encourage domestic manufacturing could violate international trade agreements and set off a trade confrontation. "We're a long way from even talking about limits on imported iPhones or iPads," said a former high-ranking Obama administration official who did not want to be named because he was not authorized to speak.

Protectionism is bad policy in today's globalized world, many economists argue. Countries benefit most when they concentrate on what they do best, and trade barriers harm consumers by driving up prices and undermine a nation's competitiveness by shielding industries from market forces that spur innovation. The United States needs to create new jobs, economists say, but it should not chase low-paid electronics assembly work that at some point may be replaced by robots. Instead, it should focus on higher-paying jobs.

"Closing our border is a 20th-century thought, and it will only weaken the economy over the long term," said Andrew N. Liveris, president of Dow Chemical and co-chairman of the Advanced Manufacturing Partnership, a group of executives and academics convened by the White House who have studied ways to encourage domestic manufacturing.

The debate is not just economic, however. Increasingly, it is political. With high unemployment, the question of how to create jobs has taken a role in the presidential race between [President Obama](#) and Mitt Romney, and both have traded barbs on outsourcing by American companies.

Although the car and technology industries are different, and the eras are separated by 30 years, the resurgence of American auto manufacturing in the 1980s is an example of how one industry created tens of thousands of good jobs. Since its first pickup truck rolled off the line here on June 16, 1983, Nissan has produced more than seven million vehicles in the United States. It now employs 15,000 people in this country. It makes more than a half-million cars, trucks and S.U.V.'s a year, with the plant in Smyrna building six models, including the soon-to-be-produced, all-electric Nissan Leaf.

Other foreign carmakers settled in America — Honda, Toyota, Hyundai, BMW, Mercedes-Benz and, most recently, Volkswagen — after a failed attempt decades ago. And some of those factories have become among the best in the world. The Nissan engine plant in Decherd, Tenn., for instance, exports engines to Japan. "We have 14 companies now that produce light vehicles here, and that is enormous," said Thomas Klier, a senior economist at the Federal Reserve Bank in Chicago. "There is no major market in the world that compares to it."

### **Tennessee?**

"Where is Tennessee?"

It was a blunt question, posed by Takashi Ishihara, president of Nissan, to Mr. Alexander, then the state's governor.

Mr. Alexander, who had journeyed to Tokyo in 1979 to pitch Nissan on building a plant in his state, was ready with his answer: "I said, 'It's right in the middle.'" To help out, he displayed a satellite photograph of the United States at night, showing the bright lights shining on the East and West Coasts and the relative darkness of Tennessee.

"We were the third-poorest state in the nation back then," Mr. Alexander said. "President Carter had told all the U.S. governors to go to Japan and persuade the Japanese to make in the U.S. what they sell in the U.S."

Mr. Alexander recalled that the Nissan executives were "incredibly anxious" about testing their homegrown production systems abroad. Could the Japanese car companies achieve the same quality using American workers?

Despite the concerns, pressures were growing for Nissan to break out of its manufacturing

cocoon in Japan, including currency fluctuations that made exporting more expensive. The final push came from American anger as imports grabbed one-fourth of the United States market.

“Japanese automakers had achieved rapid growth by exporting to America,” said Hidetoshi Imazu, a senior manufacturing executive at Nissan in Tokyo who led the development of the plant here in its early years. “But it was clear that model would no longer work.”

In the fall of 1980, Congress held hearings to limit Japanese imports. With tensions running high, Nissan announced plans for the \$300 million assembly plant in Smyrna. That gave the company a head start in circumventing looming restrictions. In May 1981, Japan agreed to limit exports to America to 1.68 million cars annually, a 7 percent reduction from a year earlier. In addition, the United States imposed a 25 percent tax on imported pickup trucks.

“The pressure put on the Japanese was absolutely critical for them to agree to export restraints,” said Stephen D. Cohen, a professor emeritus of international studies at American University.

Rural Tennessee may not have seemed a likely place to build a giant automotive factory, but its location was actually a selling point. It was far from Detroit and the United Auto Workers — and the Japanese wanted to work without what they saw as union interference.

Nissan's choice of Tennessee was not popular with everyone. On a 20-degree February morning in 1981, trade unionists jeered Mr. Alexander and Nissan executives as they turned the first shovelfuls of dirt for the factory, protesting nonunion construction crews. An airplane circled overhead, urging a boycott of Japanese vehicles.

Standing nearby was Marvin Runyon, a 37-year veteran of Ford who had been recruited as Nissan's first American plant manager. In [a later interview](#) with The New York Times, Mr. Runyon was asked what his old colleagues in Detroit thought of his new job. “They wish me luck,” he said. “But not too much.”

Success did not come overnight. Many Japanese were skeptical of their new colleagues. Americans, they had heard, were soft, lazy and incapable of mastering the precision manufacturing that had made Nissan great.

To train its new American engineers, Nissan flew workers to its Zama factory in eastern Japan. There the Nissan officials, assisted by English-speaking Japanese workers called “communication helpers,” imparted the intricacies of the company's production techniques to the Americans.

### **Beginnings at Nissan**

Early on, Nissan guarded against quality concerns by not relying on parts from American suppliers. Most components were either shipped from Japan or produced by Japanese companies that set up operations nearby. “We felt sourcing parts in the U.S. wouldn't allow us to make cars in our own way,” said Mr. Imazu, the Nissan manufacturing executive.

By 1985, Nissan was confident enough about the quality that it added passenger cars to Smyrna's assembly lines. Gradually, American parts makers were allowed to bid on supply contracts. Even that came amid arm-twisting by Congress, which passed a law in 1992 requiring auto makers to inform consumers of the percentage of parts in United States-made cars that came from North America, Asia or elsewhere.

Calsonic Kansei of Tokyo opened its first plant in Tennessee in the mid-1980s, and now employs about 2,600 Americans making instrument panels, exhaust systems, and heating and cooling modules for Nissan. “The Japanese suppliers were encouraged to localize production,” said Matt Mulliniks, vice president for sales and marketing at Calsonic

Kansei in Tennessee.

Nissan's early doubts are reflected in recent debates over whether American workers can compete with overseas laborers. Within the technology industry, workers in Asia are viewed as hungrier and more willing to tolerate harsh work schedules to achieve productivity. The numbingly repetitive jobs of assembling cellphones and tablet computers, executives say, would be scorned here; they worry that many Americans would not make the sacrifices that success demands, and want too much vacation time and predictable work schedules.

In the auto industry, the belief that American workers could not match Japanese workers has long since faded. "A big part of the reluctance of Japanese automakers to come to the U.S. was the belief that their manufacturing systems could only work with loyal Japanese employees," said Dr. Cohen, the American University professor. "Everybody was surprised how quickly the systems were adopted here."

This year, Nissan held an internal competition to decide where to produce a new Infiniti-brand luxury sport utility vehicle. The plant in Smyrna was vying against one in Japan.

The surprising winner: Smyrna.

"All my life I've heard about how great luxury brands like Lexus and BMW are," said Richard Soloman, a 20-year veteran at the Smyrna plant. "Now we will be building a vehicle of that standard right here in Tennessee."

The Japanese presence has rippled through the South. But no place has benefited to the extent of Tennessee, which counts more than 60,000 jobs related to automobile and parts production. The state's jobless rate, which exceeded the national average by a significant margin in 1983 when Nissan opened its plant, is now lower — 8.1 percent in June versus 8.2 percent nationwide.

### **Brazil's Breakthrough**

Earlier this year, when Apple's chief executive, Tim Cook, took the stage at a technology conference, he was asked if his company — which once made computers in America, but now locates most assembly in China and other countries — would ever build another product in the United States.

"I hope so," Mr. Cook replied. "One day."

That day came recently for Brazil.

In Jundiaí, an hour's drive from São Paulo, a strip of asphalt has recently been rechristened Avenida Steve Jobs, or Steve Jobs Avenue. Alongside is a factory where workers make iPhones and iPads. Brazil got these jobs through tactics the United States once used to persuade Nissan and other foreign carmakers to build plants in America: it cajoled Apple and Foxconn with a combination of financial incentives and import penalties.

Like the United States, Brazil is a big market — the third largest for computers after China and the United States. It has long imposed tariffs on imported technology products to encourage domestic manufacturing. Those fees mean that smartphones and laptops often cost consumers more in Brazil, and that domestic manufacturers can be at a disadvantage if their products require imported parts.

In April 2011, Brazil's president, Dilma Rousseff, traveled to Asia with a pitch, much as Mr. Alexander did in 1979. The federal government would give Foxconn tax breaks, subsidized loans and special access through customs and lower tariffs for imported parts if it started assembling Apple products in Brazil, where Foxconn was already producing electronics for Dell, Sony and Hewlett-Packard.

Foxconn agreed. Within months, new Brazilian engineers were flying to China for training. By year's end, Foxconn was making iPhones in Jundiaí, and it began making iPads there in early 2012, according to Evandro Oliveira Santos, director of the Jundiaí Metalworkers Union, whose members work at the plant. Stores now carry Apple products with the inscription "Fabricado no Brasil" — "Made in Brazil."

Apple products remain expensive; the latest [iPad](#), for instance, costs about \$760 in Brazil, compared with \$499 in the United States. But because those devices are made in Brazil and lower tariffs are charged on parts used to assemble them, Foxconn and Apple are pocketing larger shares of the profits, analysts say, offsetting the increased costs of building outside China.

Foxconn declined to discuss specific customers, but said that the Brazilian government's incentive programs had influenced its decisions and that the company expected to generate more Brazilian jobs and aid the government's goal of furthering the country's technology industries.

Indeed, Brazil hopes that compelling Foxconn to assemble iPhones and iPads domestically will help set off a technology explosion. Ms. Rousseff has said that Foxconn could invest \$12 billion more in Brazil. And as an electronics supply chain develops within the country, as it has in China, the expectation is that other manufacturers will build factories.

The government also hopes to use consumer electronics as a springboard for more advanced manufacturing. Targeting high-tech parts like computer displays and semiconductors could help Brazil reduce its trade deficit in these products and develop a robust homegrown industry, said Virgilio Almeida, information technology secretary at the Ministry of Science and Technology. "They are deemed high priority in the Brazilian industrial policy and are part of the Greater Brazil Plan," he said. "Brazil has developed specific policies that grant incentives to foment research, development and industrial production."

### **America's Gap**

Throughout his term, Mr. Obama has regularly gathered advisers to discuss manufacturing, according to former high-ranking White House officials. As one meeting was breaking up, Mr. Obama casually tapped an aide's iPhone to raise a point. Since the device is designed domestically, he said, it should be possible to make it in this country as well.

But it became clear at the meetings that there were differences of opinion over how best to bring manufacturing home, according to people familiar with the discussions who did not want to be named because the sessions were private. Everyone shared the same goal: establishing a level playing field and creating as many jobs in America as possible. But the debate centered, in part, on choosing among different tactics the American government has used in the past: penalties like tariffs against foreign countries that do not play by the rules or incentives like tax breaks to encourage more domestic manufacturing. On one side were officials like Ron Bloom, until earlier this year the president's senior counselor for manufacturing policy, who favored more aggressive stances to counter policies used by Asian countries. He argued that the United States should fight China's efforts to keep its currency weak. If China's currency were stronger, American companies might find it costlier to make their goods in China and could have greater incentive to manufacture more in this country.

Aligned on the other side at times were two powerful voices: [Lawrence H. Summers](#), the top economic adviser to Mr. Obama until 2010, and Treasury Secretary [Timothy F. Geithner](#). Along with many economists, Mr. Summers argued that an overly aggressive trade stance could hurt manufacturing — by, for instance, pushing up the price of imported steel used by carmakers — and over time, drive companies away.

Mr. Geithner thought diplomacy was more effective than confrontational tactics like



labeling China a currency manipulator. "He told us, 'It's going to be a trade war if we go there,'" according to a person who attended the meetings. But this person countered that China would respond only to pressure. "What doesn't work is the quiet stuff," he said.

Mr. Summers, in a recent interview, declined to discuss his role at the White House. But speaking more broadly, he said that [protectionist](#) measures might incite new domestic manufacturing in the short run, but that it would come at a high price. "People will pay more for the product because it's produced in a place that can't make it at the lowest cost," he said. "It burdens exporters because they pay more for their inputs. And it removes the spur of competition."

A spokeswoman for Mr. Geithner said, "A multidimensional approach to tough yet smart engagement with China is the most effective way to level the playing field." This strategy has had some success in persuading China to increase the value of its currency, she noted.

One of the president's economic advisers also said that, despite some differences, Mr. Obama's team, including Mr. Geithner and Mr. Summers, united to preserve manufacturing jobs in a critical area by bailing out the auto industry in the wake of the financial crisis.

But the divisions within the White House have often frustrated those who wanted a sharper focus on manufacturing. "The critics would say we didn't really fight for manufacturing policy," said another former high-ranking official who took part in many of those meetings and who did not want to be named because the discussions were confidential. "They have a strong point."

Now, with unemployment high and a growing debate over outsourcing of jobs, manufacturing is on the political agenda. In March, Gene B. Sperling, director of the White House's National Economic Council, outlined initiatives — including tax breaks for building factories here, infrastructure investments and going after "unfair trade practices" — to reinvigorate manufacturing. In May, the Commerce Department announced tariffs on Chinese solar panels for selling below fair-market value. The White House has challenged China's trade practices on tires and rare-earth metals, and has established an "interagency trade enforcement center" to combat unfair trade.

Washington, however, has generally shied from addressing the protectionist measures of countries like China with countermeasures, as politicians once did against Japan.

After the Senate passed legislation last year imposing tariffs on nations whose currency is undervalued — a salvo aimed at China — the bill went nowhere in the House of Representatives, and the White House indicated it did not like the proposal.

However, champions of "in-sourcing" legislation — which takes away benefits from companies moving jobs abroad and provides incentives for those bringing jobs back — said the tenor of the debate was changing. "The public by and large has been betrayed by large American corporations that outsource. I think Congress is catching on to that," said Senator Sherrod Brown, Democrat of Ohio.

Still, he does not advocate tariffs or quotas. Senator Debbie Stabenow, Democrat of Michigan, also favors tax breaks, rather than penalties. "I love my iPad," she said. "And I want it made in America."

One reason for the difference today: Unlike in the 1980s, when Japanese auto imports upset many voters, there has been little public outcry over imported cellphones and computers.

Back then, American workers were losing jobs as imports from Japanese companies cut into sales of the Big Three automakers.

But consumer electronics are different. Though some jobs have moved to Asia, many were never here to begin with. And the biggest technology importers — like Apple, Hewlett-

Packard, Dell and Microsoft — are American companies.

Today, many consumers do not know or care where their smartphones are made. "Where it was built, what it means for politics, how it affects the economy," said Raymond Stata, a founder of Analog Devices, one of the largest semiconductor manufacturers, "that's not something people think about when they buy."

*Bill Vlasic reported from Smyrna, Tenn., Hiroko Tabuchi from Tokyo and Charles Duhigg from New York. Lis Horta Moriconi contributed from Rio de Janeiro.*

A version of this article appears in print on August 5, 2012, on page A1 of the New York edition with the headline: An American Model for Tech Jobs?.

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THE iECONOMY | Part 6: Artificial Competence

# Skilled Work, Without the Worker



Paul Sakuma/Associated Press

While the many robots in auto factories typically perform only one function, in the new Tesla factory in Fremont, Calif., a robot might do up to four: welding, riveting, bonding and installing a component.

By JOHN MARKOFF  
Published: August 18, 2012 | 558 Comments

DRACHTEN, the Netherlands — At the Philips Electronics factory on the coast of China, hundreds of workers use their hands and specialized tools to assemble electric shavers. That is the old way.

**THE iECONOMY**  
A series examining challenges posed by increasingly globalized high-tech industries.

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At a sister factory here in the Dutch countryside, 128 robot arms do the same work with yoga-like flexibility. Video cameras guide them through feats well beyond the capability of the most dexterous human.



The Robot Factory Future

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One robot arm endlessly forms three perfect bends in two connector wires and slips them into holes almost too small for the eye to see. The arms work so fast that they must be enclosed in glass cages to prevent the people supervising them from being injured. And they do it all without a coffee break — three shifts a day, 365 days a year.

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Lianne Milton for The New York Times  
A robot stacking solar panels at a factory in Milpitas, Calif.

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Adept Technology  
Robot arms like those at a Philips Electronics factory in the Netherlands can perform the same tasks as hundreds of low-skill workers.

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Ym Yik/European Pressphoto Agency  
The Foxconn plant in Shenzhen, China.

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Erik Brynjolfsson and Andrew McAfee, economists at the Massachusetts Institute of Technology, made the case for a rapid transformation. “The pace and scale of this encroachment into human skills is relatively recent and has profound economic implications,” they wrote in their book, [“Race Against the Machine.”](#)

In their minds, the advent of low-cost automation foretells changes on the scale of the revolution in agricultural technology over the last century, when farming employment in the United States fell from 40 percent of the work force to about 2 percent today. The analogy is not only to the industrialization of agriculture but also to the electrification of manufacturing in the past century, Mr. McAfee argues.

“At what point does the chain saw replace Paul Bunyan?” asked Mike Dennison, an executive at [Flextronics](#), a manufacturer of consumer electronics products that is based in Silicon Valley and is increasingly automating assembly work. “There’s always a price point, and we’re very close to that point.”

But Bran Ferren, a veteran roboticist and industrial product designer at Applied Minds in Glendale, Calif., argues that there are still steep obstacles that have made the dream of the universal assembly robot elusive. “I had an early naïveté about universal robots that could just do anything,” he said. “You have to have people around anyway. And people are pretty good at figuring out, how do I wiggle the radiator in or slip the hose on? And these things are still hard for robots to do.”

Beyond the technical challenges lies resistance from unionized workers and communities

All told, the factory here has several dozen workers per shift, about a tenth as many as the plant in the Chinese city of Zhuhai.

This is the future. A new wave of robots, far more adept than those now commonly used by automakers and other heavy manufacturers, are replacing workers around the world in both manufacturing and distribution. Factories like the one here in the Netherlands are a striking counterpoint to those used by [Apple](#) and other consumer electronics giants, which employ hundreds of thousands of low-skilled workers.

“With these machines, we can make any consumer device in the world,” said Binne Visser, an electrical engineer who manages the Philips assembly line in Drachten.

Many industry executives and technology experts say Philips’s approach is gaining ground on Apple’s. Even as Foxconn, Apple’s [iPhone](#) manufacturer, continues to build new plants and hire thousands of additional workers to make smartphones, it plans to install more than a million robots within a few years to supplement its work force in China.

Foxconn has not disclosed how many workers will be displaced or when. But its chairman, Terry Gou, has publicly endorsed a growing use of robots. Speaking of his more than one million employees worldwide, he said in January, according to the official Xinhua news agency: “As human beings are also animals, to manage one million animals gives me a headache.”

The falling costs and growing sophistication of robots have touched off a renewed debate among economists and technologists over how quickly jobs will be lost. This year,

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worried about jobs. The ascension of robots may mean fewer jobs are created in this country, even though rising labor and transportation costs in Asia and fears of intellectual property theft are now bringing some work back to the West.

Take the cavernous solar-panel factory run by Flextronics in Milpitas, south of San Francisco. A large banner proudly proclaims "Bringing Jobs & Manufacturing Back to California!" (Right now China makes a large share of the solar panels used in this country and is automating its own industry.)

Yet in the state-of-the-art plant, where the assembly line runs 24 hours a day, seven days a week, there are robots everywhere and few human workers. All of the heavy lifting and almost all of the precise work is done by robots that string together solar cells and seal them under glass. The human workers do things like trimming excess material, threading wires and screwing a handful of fasteners into a simple frame for each panel.

Such advances in manufacturing are also beginning to transform other sectors that employ millions of workers around the world. One is distribution, where robots that zoom at the speed of the world's fastest sprinters can store, retrieve and pack goods for shipment far more efficiently than people. Robots could soon replace workers at companies like C & S Wholesale Grocers, the nation's largest grocery distributor, which has already deployed robot technology.

Rapid improvement in vision and touch technologies is putting a wide array of manual jobs within the abilities of robots. For example, [Boeing's](#) wide-body commercial jets are now riveted automatically by giant machines that move rapidly and precisely over the skin of the planes. Even with these machines, the company said it struggles to find enough workers to make its new 787 aircraft. Rather, the machines offer significant increases in precision and are safer for workers.

And at Earthbound Farms in California, four newly installed robot arms with customized suction cups swiftly place clamshell containers of organic lettuce into shipping boxes. The robots move far faster than the people they replaced. Each robot replaces two to five workers at Earthbound, according to John Dulchinos, an engineer who is the chief executive at Adept Technology, a robot maker based in Pleasanton, Calif., that developed Earthbound's system.

Robot manufacturers in the United States say that in many applications, robots are already more cost-effective than humans.

At an automation trade show last year in Chicago, Ron Potter, the director of robotics technology at an Atlanta consulting firm called Factory Automation Systems, offered attendees a spreadsheet to calculate how quickly robots would pay for themselves.

In one example, a robotic manufacturing system initially cost \$250,000 and replaced two machine operators, each earning \$50,000 a year. Over the 15-year life of the system, the machines yielded \$3.5 million in labor and productivity savings.

The Obama administration says this technological shift presents a historic opportunity for the nation to stay competitive. "The only way we are going to maintain manufacturing in the U.S. is if we have higher productivity," said Tom Kalil, deputy director of the White House Office of Science and Technology Policy.

Government officials and industry executives argue that even if factories are automated, they still are a valuable source of jobs. If the United States does not compete for advanced manufacturing in industries like consumer electronics, it could lose product engineering and design as well. Moreover, robotics executives argue that even though blue-collar jobs will be lost, more efficient manufacturing will create skilled jobs in designing, operating and servicing the assembly lines, as well as significant numbers of other kinds of jobs in the communities where factories are.

And robot makers point out that their industry itself creates jobs. A report commissioned

by the [International Federation of Robotics](#) last year found that 150,000 people are already employed by robotics manufacturers worldwide in engineering and assembly jobs.

But American and European dominance in the next generation of manufacturing is far from certain.

“What I see is that the Chinese are going to apply robots too,” said Frans van Houten, Philips’s chief executive. “The window of opportunity to bring manufacturing back is before that happens.”

### **A Faster Assembly Line**

Royal Philips Electronics began making the first electric shavers in 1939 and set up the factory here in Drachten in 1950. But Mr. Visser, the engineer who manages the assembly, takes pride in the sophistication of the latest shavers. They sell for as much as \$350 and, he says, are more complex to make than smartphones.

The assembly line here is made up of dozens of glass cages housing robots made by Adept Technology that snake around the factory floor for more than 100 yards. Video cameras atop the cages guide the robot arms almost unerringly to pick up the parts they assemble. The arms bend wires with millimetric accuracy, set toothpick-thin spindles in tiny holes, grab miniature plastic gears and set them in housings, and snap pieces of plastic into place.

The next generation of robots for manufacturing will be more flexible and easier to train.

Witness the factory of [Tesla Motors](#), which recently began manufacturing the Tesla S, a luxury sedan, in Fremont, Calif., on the edge of Silicon Valley.

More than half of the building is shuttered, called “the dark side.” It still houses a dingy, unused Toyota Corolla assembly line on which an army of workers once turned out half a million cars annually.

The Tesla assembly line is a stark contrast, brilliantly lit. [Its fast-moving robots, bright Tesla red](#), each has a single arm with multiple joints. Most of them are imposing, 8 to 10 feet tall, giving them a slightly menacing “Terminator” quality.

But the arms seem eerily human when they reach over to a stand and change their “hand” to perform a different task. While the many robots in auto factories typically perform only one function, in the new Tesla factory a robot might do up to four: welding, riveting, bonding and installing a component.

As many as eight robots perform a ballet around each vehicle as it stops at each station along the line for just five minutes. Ultimately as many as 83 cars a day — roughly 20,000 are planned for the first year — will be produced at the factory. When the company adds a sport utility vehicle next year, it will be built on the same assembly line, once the robots are reprogrammed.

Tesla’s factory is tiny but represents a significant bet on flexible robots, one that could be a model for the industry. And others are already thinking bigger.

Hyundai and Beijing Motors recently completed a mammoth factory outside Beijing that can produce a million vehicles a year using more robots and fewer people than the big factories of their competitors and with the same flexibility as Tesla’s, said Paul Chau, an American venture capitalist at WI Harper who toured the plant in June.

### **The New Warehouse**

Traditional and futuristic systems working side by side in a distribution center north of New York City show how robotics is transforming the way products are distributed, threatening jobs. From this warehouse in Newburgh, C & S, the nation’s largest grocery wholesaler, supplies a major supermarket chain.

The old system sprawls across almost half a million square feet. The shelves are loaded and unloaded around the clock by hundreds of people driving pallet jacks and forklifts. At peak times in the evening, the warehouse is a cacophony of beeping and darting [electric vehicles](#) as workers with headsets are directed to cases of food by a computer that speaks to them in four languages.

The new system is much smaller, squeezed into only 30,000 square feet at the far end of the warehouse and controlled by just a handful of technicians. They watch over a four-story cage with different levels holding 168 “rover” robots the size of go-carts. Each can move at 25 miles an hour, nearly as fast as an Olympic sprinter.

Each rover is connected wirelessly to a central computer and on command will race along an aisle until it reaches its destination — a case of food to retrieve or the spot to drop one off for storage. The robot gathers a box by extending two-foot-long metal fingers from its side and sliding them underneath. It lifts the box and pulls it to its belly. Then it accelerates to the front of the steel cage, where it turns into a wide lane where it must contend with traffic — eight robots are active on each level of the structure, which is 20 aisles wide and 21 levels high.

From the aisle, the robots wait their turn to pull into a special open lane where they deposit each load into an elevator that sends a stream of food cases down to a conveyor belt that leads to a large robot arm.

About 10 feet tall, the arm has the grace and dexterity of a skilled supermarket bagger, twisting and turning each case so the final stack forms an eight-foot cube. The software is sophisticated enough to determine which robot should pick up which case first, so when the order arrives at the supermarket, workers can take the cases out in the precise order in which they are to go on the shelves.

When the arm is finished, the cube of goods is conveyed to a machine that wraps it in clear plastic to hold it in place. Then a forklift operator summoned by the computer moves the cube to a truck for shipment.

Built by [Symbotic](#), a start-up company based in the Boston area, this robotic warehouse is inspired by computer designers who created software algorithms to efficiently organize data to be stored on a computer’s hard drive.

Jim Baum, Symbotic’s chief executive, compares the new system to a huge parallel computer. The design is efficient because there is no single choke point; the cases of food moving through the robotic warehouse are like the digital bits being processed by the computer.

### **Humans’ Changing Role**

In the decade since he began working as a warehouseman in Tolleson, Ariz., a suburb of Phoenix, Josh Graves has seen how automation systems can make work easier but also create new stress and insecurity. The giant facility where he works distributes dry goods for Kroger supermarkets.

Mr. Graves, 29, went to work in the warehouse, where his father worked for three decades, right out of high school. The demanding job required lifting heavy boxes and the hours were long. “They would bring in 15 guys, and only one would last,” he said.

Today Mr. Graves drives a small forklift-like machine that stores and retrieves cases of all sizes. Because such workers are doing less physical labor, there are fewer injuries, said Rome Aloise, a Teamsters vice president in Northern California. Because a computer sets the pace, the stress is now more psychological.

Mr. Graves wears headsets and is instructed by a computerized voice on where to go in the warehouse to gather or store products. A centralized computer the workers call The Brain dictates their speed. Managers know exactly what the workers do, to the precise minute.

Several years ago, Mr. Graves's warehouse installed a German system that automatically stores and retrieves cases of food. That led to the elimination of 106 jobs, roughly 20 percent of the work force. The new system was initially maintained by union workers with high seniority. Then that job went to the German company, which hired nonunion workers.

Now Kroger plans to build a highly automated warehouse in Tolleson. Sixty union workers went before the City Council last year to oppose the plan, on which the city has not yet ruled.

"We don't have a problem with the machines coming," Mr. Graves told city officials. "But tell Kroger we don't want to lose these jobs in our city."

Some jobs are still beyond the reach of automation: construction jobs that require workers to move in unpredictable settings and perform different tasks that are not repetitive; assembly work that requires tactile feedback like placing fiberglass panels inside airplanes, boats or cars; and assembly jobs where only a limited quantity of products are made or where there are many versions of each product, requiring expensive reprogramming of robots.

But that list is growing shorter.

### Upgrading Distribution

Inside a spartan garage in an industrial neighborhood in Palo Alto, Calif., a robot armed with electronic "eyes" and a small scoop and suction cups [repeatedly picks up boxes and drops them onto a conveyor belt](#).

It is doing what low-wage workers do every day around the world.

Older robots cannot do such work because computer vision systems were costly and limited to carefully controlled environments where the lighting was just right. But thanks to an inexpensive stereo camera and software that lets the system see shapes with the same ease as humans, this robot can quickly discern the irregular dimensions of randomly placed objects.

The robot uses a technology pioneered in [Microsoft's](#) Kinect motion sensing system for its Xbox video game system.

Such robots will put automation within range of companies like Federal Express and United Parcel Service that now employ tens of thousands of workers doing such tasks.

The start-up behind the robot, Industrial Perception Inc., is the first spinoff of Willow Garage, an ambitious robotics research firm based in Menlo Park, Calif. The first customer is likely to be a company that now employs thousands of workers to load and unload its trucks. The workers can move one box every six seconds on average. But each box can weigh more than 130 pounds, so the workers tire easily and sometimes hurt their backs.

Industrial Perception will win its contract if its machine can reliably move one box every four seconds. The engineers are confident that the robot will soon do much better than that, picking up and setting down one box per second.

"We're on the cusp of completely changing manufacturing and distribution," said Gary Bradski, a machine-vision scientist who is a founder of Industrial Perception. "I think it's not as singular an event, but it will ultimately have as big an impact as the Internet."

A version of this article appears in print on August 19, 2012, on page A1 of the New York edition with the headline: Skilled Work, Without the Worker.

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THE iECONOMY | Part 7: A System in Disarray

# The Patent, Used as a Sword



J. Emilio Flores for The New York Times

1 2 3 4

A display of giant iPhones at the Los Angeles County Fair that show some of Apple's patents.

By CHARLES DUHIGG and STEVE LOHR  
Published: October 7, 2012 | 277 Comments

When [Apple](#) announced last year that all iPhones would come with a voice-activated assistant named Siri, capable of answering spoken questions, Michael Phillips's heart sank.

## THE iECONOMY

A series examining challenges posed by increasingly globalized high-tech industries.

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For Software, Cracks in the Patent System

For three decades, Mr. Phillips had focused on writing software to allow computers to understand human speech. In 2006, he had co-founded a voice recognition company, and eventually executives at Apple, Google and elsewhere proposed partnerships. Mr. Phillips's technology was even integrated into Siri itself before the digital assistant was absorbed into the [iPhone](#).

But in 2008, Mr. Phillips's company, Vlingo, had been contacted by a much larger voice recognition firm called Nuance. "I have patents that can prevent you from practicing in this market," Nuance's chief executive, Paul Ricci, told Mr. Phillips, according to executives involved in

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that conversation.

Mr. Ricci issued an ultimatum: Mr. Phillips could sell his firm to Mr. Ricci or be sued for patent infringements. When Mr. Phillips refused to sell, Mr. Ricci's company filed the first of six lawsuits.

Soon after, Apple and Google stopped returning phone calls. The company behind Siri switched its partnership from Mr. Phillips to Mr. Ricci's firm. And the millions of dollars Mr. Phillips had set aside for research and development were redirected to lawyers and court fees.

When the first lawsuit went to trial last year, Mr. Phillips won. In the companies' only courtroom face-off, a jury ruled that Mr. Phillips had not infringed on a broad voice recognition patent owned by Mr. Ricci's company.

But it was too late. The suit had cost \$3 million, and the financial damage was done. In December, Mr. Phillips agreed to [sell his company](#) to Mr. Ricci. "We were on the brink of changing the world before we got stuck in this legal muck," Mr. Phillips said.

Mr. Phillips and Vlingo are among the thousands of executives and companies caught in a software patent system that federal judges, economists, policy makers and technology executives say is so flawed that it often stymies innovation.

Alongside the impressive technological advances of the last two decades, they argue, a pall has descended: the marketplace for new ideas has been corrupted by software patents used as destructive weapons.

Vlingo was a tiny upstart on this battlefield, but as recent litigation involving Apple and Samsung shows, technology giants have also waged wars among themselves.

In the smartphone industry alone, according to a Stanford University analysis, as much as \$20 billion was spent on patent litigation and patent purchases in the last two years — an amount equal to eight Mars rover missions. Last year, for the first time, spending by Apple and Google on patent lawsuits and unusually big-dollar patent purchases exceeded spending on research and development of new products, according to public filings.

Patents are vitally important to protecting intellectual property. Plenty of creativity occurs within the technology industry, and without patents, executives say they could never justify spending fortunes on new products. And academics say that some aspects of the patent system, like protections for pharmaceuticals, often function smoothly.

However, many people argue that the nation's patent rules, intended for a mechanical world, are inadequate in today's digital marketplace. Unlike patents for new drug formulas, patents on software often effectively grant ownership of concepts, rather than tangible creations. Today, the patent office routinely approves patents that describe vague algorithms or business methods, like a software system for calculating online prices, without patent examiners demanding specifics about how those calculations occur or how the software operates.

As a result, some patents are so broad that they allow patent holders to claim sweeping ownership of seemingly unrelated products built by others. Often, companies are sued for violating patents they never knew existed or never dreamed might apply to their creations, at a cost shouldered by consumers in the form of higher prices and fewer choices.

"There's a real chaos," said Richard A. Posner, a federal appellate judge who has helped shape patent law, in an interview. "The standards for granting patents are too loose."

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Almost every major technology company is involved in ongoing patent battles, but the most significant player is Apple, industry executives say, because of its influence and the size of its claims: in August in California, the company won [a \\$1 billion patent infringement judgment](#) against Samsung. Former Apple employees say senior executives made a deliberate decision over the last decade, after Apple was a victim of patent attacks, to use patents as leverage against competitors to the iPhone, the company's biggest source of profits.

Apple has filed multiple suits against three companies — HTC, Samsung and Motorola Mobility, now part of Google — that today are responsible for more than half of all smartphone sales in the United States. If Apple's claims — which include ownership of minor elements like rounded square icons and of more fundamental smartphone technologies — prevail, it will most likely force competitors to overhaul how they design phones, industry experts say.

HTC, Samsung, Motorola and others have filed numerous suits of their own, also trying to claim ownership of market-changing technologies.

While Apple and other major companies have sometimes benefited from this war, so have smaller partners. In 2010, Apple acquired Siri Inc., the company behind the software of the same name. The stock price of Mr. Ricci's company, Nuance, which had by then become Siri's partner, rose by more than 70 percent as iPhone sales skyrocketed. Some former executives at Vlingo, Nuance's old rival, remain bitter.

"We had spent \$3 million to win one patent trial, and had five more to go," said a former Vlingo executive who spoke on condition of anonymity because he had signed confidentiality agreements. "We had the better product, but it didn't matter, because this system is so completely broken."

Mr. Ricci declined to be interviewed. Others at Nuance said they were simply protecting their intellectual property.

"Our responsibility is to follow the law," said Lee Patch, a vice president at Nuance. "That's what we do. It's not our fault if some people don't like the system."

Today, Nuance is a giant in voice recognition. Apple is the most valuable company in the world. And the iPhone is wrapped in thousands of patents that keep companies in numerous court battles.

"Apple has always stood for innovation," the company wrote in a statement in response to questions from The New York Times. "To protect our inventions, we have patented many of the new technologies in these groundbreaking and category-defining products. In the rare cases when we take legal action over a patent dispute, it's only as a last resort.

"We think companies should dream up their own products rather than willfully copying ours, and in August a jury in California reached the same conclusion," the statement said.

At a technology conference this year, Apple's chief executive, Timothy D. Cook, said patent battles had not slowed innovation at the company, but acknowledged that some aspects of the battles had "kind of gotten crazy."

"There's some of this that is maddening," he said. "It's a waste; it's a time suck."

The evolution of Apple into one of the industry's patent warriors gained momentum, like many things within the company, with a terse order from its chief executive, Steven P. Jobs.

### **A Patent Warrior's Education**

It was 2006, and Apple was preparing to unveil the first iPhone. Life inside company headquarters, former executives said, had become a frenzy of programming sessions and meetings between engineers and executives. And, increasingly, patent lawyers.

Just months earlier, Apple [reluctantly agreed](#) to pay \$100 million to Creative Technology, a Singapore-based company. Five years before, Creative applied for a broad software patent for a “portable music playback device” that bore minor similarities to the iPod, an Apple product that had gone on sale the same year. Once the patent was granted to Creative, it became a license to sue.

Apple settled three months after Creative went to court. “Creative is very fortunate to have been granted this early patent,” Mr. Jobs said in a statement announcing the settlement in 2006.

Privately, Mr. Jobs gathered his senior managers. While Apple had long been adept at filing patents, when it came to the new iPhone, “we’re going to patent it all,” he declared, according to a former executive who, like other former employees, requested anonymity because of confidentiality agreements.

“His attitude was that if someone at Apple can dream it up, then we should apply for a patent, because even if we never build it, it’s a defensive tool,” said Nancy R. Heinen, Apple’s general counsel until 2006.

Soon, Apple’s engineers were asked to participate in monthly “invention disclosure sessions.” One day, a group of software engineers met with three patent lawyers, according to a former Apple patent lawyer who was at the meeting.

The first engineer discussed a piece of software that studied users’ preferences as they browsed the Web.

“That’s a patent,” a lawyer said, scribbling notes.

Another engineer described a slight modification to a popular application.

“That’s a patent,” the lawyer said.

Another engineer mentioned that his team had streamlined some software.

“That’s another one,” the lawyer said.

“Even if we knew it wouldn’t get approved, we would file the application anyway,” the former Apple lawyer said in an interview. “If nothing else, it prevents another company from trying to patent the idea.”

The disclosure session had yielded more than a dozen potential patents when an engineer, an Apple veteran, spoke up. “I would like to decline to participate,” he said, according to the lawyer who was at the meeting. The engineer explained that he didn’t believe companies should be allowed to own basic software concepts.

It is a complaint heard throughout the industry. The increasing push to assert ownership of broad technologies has led to a destructive arms race, engineers say. Some point to so-called patent trolls, companies that exist solely to sue over patent violations. Others say big technology companies have also exploited the system’s weaknesses.

“There are hundreds of ways to write the same computer program,” said James Bessen, a legal expert at Harvard. And so patent applications often try to encompass every potential aspect of a new technology. When such applications are approved, Mr. Bessen said, “the borders are fuzzy, so it’s really easy to accuse others of trespassing on your ideas.”

The number of patent applications, computer-related and otherwise, filed each year at the United States patent office has increased by more than 50 percent over the last decade to more than 540,000 in 2011. Google has received 2,700 patents since 2000, according to the patent analysis firm M-CAM. Microsoft has received 21,000.

In the last decade, the number of patent applications submitted by Apple each year has risen almost tenfold. The company has won ownership of pinching a screen to zoom in, of using magnets to affix a cover to a tablet computer and of the glass staircases in Apple

stores. It has received more than 4,100 patents since 2000, according to M-CAM.

And as patent portfolios have expanded, so have pressures to use them against competitors.

In March 2010, Apple sued HTC, a Taiwanese smartphone manufacturer that had partnered with Google. Apple did not talk to HTC before suing. Negotiations were not part of the strategy, according to a former executive. "Google was the enemy, the real target," the executive said.

It was one of seven major smartphone and patent-related lawsuits Apple has initiated since 2006. The suits have focused on two large companies, HTC and Samsung, both Google partners, which together account for 39 percent of American smartphone sales. Apple has also filed countersuits against Nokia, as well as against Motorola Mobility, which is now owned by Google and accounts for 12 percent of sales.

In addition, the company has filed two declaratory judgment actions asking the courts to rule on the provenance and validity of patents. Over the same period, Apple itself has been sued 135 times, mostly by patent trolls interested in its deep pockets.

Apple is not alone. The number of patent lawsuits filed in United States district courts each year has almost tripled in the last two decades to 3,260 in 2010, the last year for which federal data is available. Microsoft has sued Motorola; Motorola has sued Apple and Research in Motion; Research in Motion has sued Visto, a mobile technology company; and in August, Google, through its Motorola unit, sued Apple, contending that Siri had infringed on its patents. (Google dropped the suit last week, leaving open the possibility of refileing at a later date.) All of those companies have also been sued numerous times by trolls.

Patents for software and some kinds of electronics, particularly smartphones, are now so problematic that they contribute to a so-called patent tax that adds as much as 20 percent to companies' research and development costs, according to a study conducted last year by two Boston University professors.

Supporters of suits initiated by Apple say that the litigation is vital to the company's success and that Apple is sued far more often than it sues, as do all major tech firms.

"If we can't protect our intellectual property, then we won't spend millions creating products like the iPhone," a former Apple executive said, noting that some of Apple's patents, like the "slide to unlock" feature on the iPhone, took years to perfect. The concept "might seem obvious now, but that's only after we spent millions figuring it out," the executive said. "Other companies shouldn't be able to steal that without compensating us. That's why the patent system exists."

But others challenge that logic, given the huge profits the technology industry enjoys. Apple collects more than \$1 billion a week in iPhone and related sales. "I am skeptical whether patents are needed in the software industry to provide adequate incentives," Judge Posner wrote in an e-mail.

One consequence of all this litigation, policy makers and academics say, is that patent disputes are suffocating the culture of start-ups that has long fueled job growth and technological innovation.

"Think of the billions of dollars being flushed down the toilet," said Ms. Heinen, the former Apple general counsel, who left the company and [paid \\$2.2 million](#) in connection with a federal investigation of stock option backdating. "When patent lawyers become rock stars, it's a bad sign for where an industry is heading," she said, adding that she had no issue with the lawyers themselves.

There are some indications that the big companies themselves are growing weary of this warfare.

In its response to The Times, Apple addressed “standards-essential” patents, which companies are obligated to license to competitors at reasonable rates, and wrote that it was “deeply concerned by the rampant abuse of standards-essential patents by some of our competitors.”

“Standards-essential patents are technologies which these companies have volunteered to license to anyone for a reasonable fee,” the statement said, “but instead of negotiating with Apple, they’ve chosen to sue us.” Samsung, Motorola, Nokia and HTC have sued Apple, claiming it violated standards-essential patents.

Another sign of fatigue is the frequency with which executives and lawyers from Apple and Google speak to one another about patent disputes. Earlier this year, Google proposed a cease-fire, according to people familiar with the conversations. And when Google withdrew its Motorola suit last week, it was widely seen as a peace gesture.

But Apple has been hard to pin down, said one person from Google who was not authorized to speak publicly. “Sometimes they’re asking for money. Then they say we have to promise to not copy aspects of the iPhone. And whenever we get close to an agreement, it all changes again.

“Our feeling is they don’t really want this to end. As long as everyone is distracted by these trials, the iPhone continues to sell.”

Apple declined to comment on the negotiations.

### **The Patent Bureaucracy**

The application by Apple that eventually became patent 8,086,604 first crossed desks at the Patent and Trademark Office on a winter day in 2004.

In the next two years, a small cast of officials spent about 23 hours — the time generally allotted for reviewing a new application — examining the three dozen pages before recommending rejection. The application, for a voice- and text-based search engine, was “an obvious variation” on existing ideas, a patent examiner named Raheem Hoffler wrote. Over the next five years, Apple modified and resubmitted the application eight times — and each time it was rejected by the patent office.

Until last year.

On its 10th attempt, Apple got patent 8,086,604 approved. Today, though the patent was not among those Vlingo and Nuance fought over, it is known as the Siri patent because it is widely viewed as one of the linchpins of Apple’s strategy to protect its smartphone technologies.

In February, the company deployed this new patent in a continuing lawsuit against Samsung that could radically reorder the \$200 billion smartphone business by giving Apple effective ownership of now-commonplace technologies, software experts say.

Patent 8,086,604’s path to approval “shows there’s a lot wrong with the process,” said Arti K. Rai, [an intellectual property](#) expert at Duke University School of Law who reviewed the patent application for The Times. That patent, like numerous others, is an example of how companies can file an application again and again until they win approval, Ms. Rai said.

When Apple submitted the first application for 8,086,604, the iPhone and Siri did not exist. The application was aspirational: it described a theoretical “universal interface” that would allow people to search across various mediums, like the Internet, corporate databases and computer hard drives, without having to use multiple search engines. It outlined how such software might function, but it did not offer specifics about how to build it. It suggested that some people might speak a search phrase rather than use a keyboard.

The ideas contained in the application would blossom at Apple, Google, Microsoft,

Nuance, Vlingo and dozens of other companies. All the while, the application traveled quietly through the patent office, where officials rejected it twice in 2007, three times in 2008, once in 2009, twice in 2010 and once in 2011.

The patent office has a reputation for being overworked, understaffed and plagued by employee turnover, and employees concede that some of their work is subjective.

“When I get an application, I basically have two days to research and write a 10- to 20-page term paper on why I think it should be approved or rejected,” said Robert Budens, a 22-year patent examiner and president of the examiners’ labor union. “I’m not going to pretend like we get it right every time.”

To receive a patent, an invention must be novel (substantially different from what exists), not obvious (one can’t patent a new toaster simply by expanding it to handle five slices of bread), and useful (someone can’t patent an invisibility machine if invisibility is impossible).

“If you give the same application to 10 different examiners, you’ll get 10 different results,” said Raymond Persino, a patent lawyer who worked as an examiner from 1998 to 2005.

After patent 8,086,604 was first rejected in 2007, Apple’s lawyers made small adjustments to the application, changing the word “documents” to “items of information” and inserting the phrase “heuristic modules” to refer to bits of software code. A few years later, the inclusion of the word “predetermined” further narrowed Apple’s approach.

These changes had little substantial impact, said experts who reviewed the application for The Times. But the patent office slowly began to come around to Apple’s point of view.

Though submitting an application repeatedly can incur large legal fees, it is often effective. About 70 percent of patent applications are eventually approved after an applicant has altered claims, tinkered with language or worn down the patent examiners.

One consequence is that patents are sometimes granted for ideas that already exist.

In 1999, for instance, two men received a patent for a crustless, sealed peanut butter and jelly sandwich. (The J. M. Smucker company acquired the patent and used it to sue other food makers. In 2007, after press scrutiny, federal officials canceled the patent.)

A year earlier, the patent office had awarded an Illinois company effective ownership of many of the basic systems that power the Internet. That firm sued a number of tech giants, persuading many to sign multimillion-dollar settlements, until a jury declared some of the patents invalid last year.

For Apple’s 8,086,604, the examiners finally relented last December and issued a patent.

“Apple got another warhead in its arsenal, but there’s no big invention here,” said David J. Pratt, president of M-CAM, the patent analysis firm, who analyzed the application for The Times.

The patent office declined to discuss 8,086,604. Officials pointed out that the agency’s 7,650 examiners received more than half a million applications last year, and the numbers have kept climbing.

By all accounts, there have been improvements in the patent office since David J. Kappos took over as director in 2009. In an interview, Mr. Kappos said the lengthy back-and-forth between examiners and Apple was evidence that the system worked.

“It’s called the patent office,” he said, noting that issuing patents is the agency’s job. In a statement, the agency said it had spent the last three years strengthening policies to improve patent quality. Besides, Mr. Kappos said, “we realize that only a handful of these patents will be really important.”

However, patent 8,086,604 has proved very important. In February, Apple sued Samsung

in a California court, arguing that 17 of Samsung's smartphones and tablets violated 8,086,604. In June, a judge [banned sales](#) of Samsung's Galaxy Nexus phone, validating 8,086,604 and ruling that the phone infringed on Apple's patent because it featured a "Google quick search box" that allowed users to enter one search term, either typed or spoken, that returned results simultaneously from the Internet, contacts stored on the phone and recently visited Web sites. (The ban has been stayed while under appeal.)

### Searching for Fixes

Some experts worry that Apple's broad patents may give the company control of technologies that, over the last seven years, have been independently developed at dozens of companies and have become central to many devices.

"Apple could get a chokehold on the smartphone industry," said Tim O'Reilly, a publisher of computer guides and a software patent critic. "A patent is a government-sanctioned monopoly, and we should be very cautious about handing those out."

Others say the system works fine.

"Intellectual property is property, just like a house, and its owners deserve protection," said Jay P. Kesan, [a law professor](#) at the University of Illinois. "We have rules in place, and they're getting better.

"And if someone gets a bad patent, so what?" he said. "You can request a re-examination. You can go to court to invalidate the patent. Even rules that need improvements are better than no rules at all."

Five years ago, Congress was debating how to fix the patent system when an inventor named Stephen G. Perlman went to Capitol Hill.

Mr. Perlman worked at Apple in the 1980s. Today, he runs a start-up incubator called Reararden in San Francisco. He holds 100 patents — including for the software behind the reverse aging in the film "The Curious Case of Benjamin Button" — and has about 100 more applications pending.

Patents are crucial to his business, Mr. Perlman said, particularly in raising money from venture capitalists and deterring large companies from copying his innovations. "When we file a patent application, it's a big deal," he said.

When Mr. Perlman went to Congress, he brought ideas to protect small inventors. He wasn't alone in suggesting solutions. Thousands of companies, from start-ups like Vlingo to large technology firms, have argued that a well-functioning patent system is essential to their success. The problems with the current system are so pervasive, they say, that the courts, lawmakers and Silicon Valley must find their own fixes.

One option is judicial activism. This year, Judge Posner, in an Illinois federal court, tossed out patent arguments made by both Apple and Motorola Mobility in [a 38-page opinion](#) that dismissed a lawsuit between the two companies. Cleaning up the patent mess, Judge Posner said in an interview, might also require reducing the duration of patents on digital technologies, which can be as long as 20 years. "That would make a big difference," he said. "After five years, these patents are mainly traps for the unwary."

Ideas have also come from policy experts and Silicon Valley. The Federal Reserve Bank of St. Louis recently published [a working paper](#) calling for the abolition of patents, saying they do more harm than good.

Another idea is to create different classes of patents, so that some kinds of inventions, like pharmaceuticals, would receive 20 years of ironclad protection, while others, like software, would receive shorter and more flexible terms.

A third suggestion was made by the Internet company Twitter, which released an ["Innovator's Patent Agreement"](#) this year intended to give software engineers some control



over how their creations are used. Under the terms of the agreement, companies pledge that patents will be used only for defensive purposes.

“We’re just trying to do something modest,” said Benjamin Lee, Twitter’s legal counsel.

Similarly, law school faculty at the University of California, Berkeley, have proposed a [“Defensive Patent License”](#) in which companies would contribute patents to a common pool that shielded participants from litigious aggressors. Companies would be allowed to participate as long as they did not become first-strike plaintiffs. The benefit is that “you don’t have to worry about your patent being weaponized” and used to attack competitors, said Jason M. Schultz, [an assistant professor](#) who helped design the license.

But to really make a difference, such ideas require the participation of large technology companies, and the incentives to cooperate are small. So some frustrated engineers have become outspoken advocates for reform.

Mr. Perlman, the independent inventor, for instance, was hopeful his voice would be heard on Capitol Hill. But alongside Mr. Perlman were hundreds of lobbyists from high-tech corporations and the pharmaceutical industry, which often push conflicting proposals. Big technology companies, in general, want to limit the financial damages juries can award for minor patent violations, while drug makers want to make sure they can sue for billions of dollars if a single patent is violated.

These and dozens of other narrow battles have paralyzed Congress’s ability to make real changes, lawmakers and lobbyists say. The last attempt, the America Invents Act, which was passed last year, achieved mostly administrative fixes, like making it easier for outsiders to challenge a patent’s validity.

The new law did make one fundamental change. Since the patent system was overseen by Thomas Jefferson, the United States has awarded ownership of an innovation to whoever created the first prototype, a policy known as “first to invent.” Under the America Invents Act, ownership will be awarded to whoever submits the first application, or “first to file.”

The shift, inventors like Mr. Perlman say, makes life harder for small entrepreneurs. Large companies with battalions of lawyers can file thousands of pre-emptive patent applications in emerging industries. Start-ups, lacking similar resources, will find themselves easy prey once their products show promise.

That is the concern of people like Mr. Phillips, the voice recognition specialist and one-time Siri partner who founded Vlingo. “Start-ups are where progress occurs,” he said in an interview. “If you spend all your time in court, you can’t create much technology.”

In June, Mr. Phillips started work at his new employer, and former courtroom adversary, Nuance. Theoretically, his job was to help manage the companies’ integration and find new technological frontiers to explore. With a background at M.I.T. and Carnegie Mellon, he is widely acknowledged as one of the most innovative thinkers in computer speech.

But he spent much of the summer on vacation, recuperating from the last six bruising years. And in September, he quit. He plans to leave voice recognition altogether, he has told friends, and find an industry with less treacherous patent terrain.

A version of this article appears in print on October 8, 2012, on page A1 of the New York edition with the headline: The Patent, Used as a Sword.

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THE iECONOMY | *Part 8: Writing the Software*

# As Boom Lures App Creators, Tough Part Is Making a Living



Daniel Rosenbaum for The New York Times

Shawn and Stephanie Grimes's efforts have cost \$200,000 in lost income and savings, but their apps have earned less than \$5,000 this year.

By DAVID STREITFELD  
Published: November 17, 2012 | [185 Comments](#)

ROSEDALE, Md. — Shawn and Stephanie Grimes spent much of the last two years pursuing their dream of doing research and development for [Apple](#), the world's most successful corporation.

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But they did not actually have jobs at Apple. It was freelance work that came with nothing in the way of a regular income, health insurance or retirement plan. Instead, the Grimeses tried to prepare by willingly, even eagerly, throwing overboard just about everything they could.

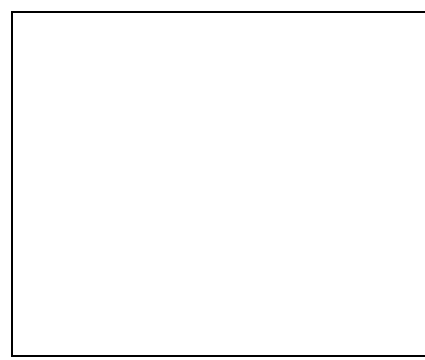
They sold one of their cars, gave some possessions to relatives and sold others in a yard sale, rented out their six-bedroom house and stayed with family for a while. They even cashed in Mr. Grimes's 401(k).

"We didn't lose any sleep over it," said Mr. Grimes, 32. "I'll retire when I die."

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What It Takes to Be an App Developer (November 18, 2012)

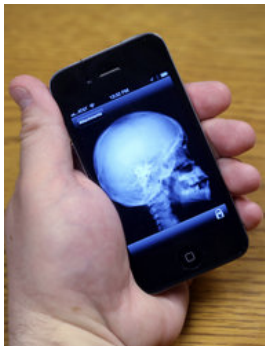
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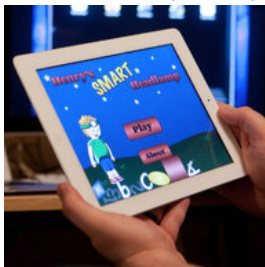
Béatrice de Géa for The New York Times  
Ethan Nicholas has made more than \$1 million on an artillery game.

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disappearing.

The couple's chosen field is so new it did not even exist a few years ago: writing software applications for mobile devices like the [iPhone](#) or [iPad](#). Even as unemployment remained stubbornly high and the economy struggled to emerge from the recession's shadow, the ranks of computer software engineers, including app writers, increased nearly 8 percent in 2010 to more than a million, according to the latest available government data for that category. These software engineers now outnumber farmers and have almost caught up with lawyers.

Much as the Web set off the dot-com boom 15 years ago, apps have inspired a new class of entrepreneurs. These innovators have turned cellphones and tablets into tools for discovering, organizing and controlling the world, spawning a multibillion-dollar industry virtually overnight. The iPhone and iPad have about 700,000 apps, from Instagram to Angry Birds.

Yet with the American economy yielding few good opportunities in recent years, there is debate about how real, and lasting, the rise in app employment might be.

Despite the rumors of hordes of hip programmers starting million-dollar businesses from their kitchen tables, only a small minority of developers actually make a living by creating their own apps, according to surveys and experts. The Grimeses began their venture with high hopes, but their apps, most of them for toddlers, did not come quickly enough or sell fast enough.

And programming is not a skill that just anyone can learn. While people already employed in tech jobs have added app writing to their résumés, the profession offers few options to most unemployed, underemployed and discouraged workers.

One success story is Ethan Nicholas, who earned more than \$1 million in 2009 after writing a game for the iPhone. But he says the app writing world has experienced tectonic shifts since then.

"Can someone drop everything and start writing apps? Sure," said Mr. Nicholas, 34, who quit his job to write apps after iShoot, an artillery game, became a sensation. "Can they start writing good apps? Not often, no. I got lucky with iShoot, because back then a decent app could still be successful. But competition is fierce nowadays, and decent isn't good enough."

The boom in apps comes as economists are debating the changing nature of work, which technology is reshaping at an accelerating speed. The upheaval, in some ways echoing the mechanization of agriculture a century ago, began its latest turbulent phase with the migration of tech manufacturing to places like China. Now service and even white-collar jobs, like file clerks and data entry specialists or office support staff and mechanical drafters, are

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“Technology is always destroying jobs and always creating jobs, but in recent years the destruction has been happening faster than the creation,” said Erik Brynjolfsson, an economist and director of the M.I.T. Center for Digital Business.

Still, the digital transition is creating enormous wealth and opportunity. Four of the most valuable American companies — Apple, Google, Microsoft and I.B.M. — are rooted in technology. And it was Apple, more than any other company, that set off the app revolution with the iPhone and iPad. Since Apple unleashed the world’s freelance coders to build applications four years ago, it has paid them more than \$6.5 billion in royalties.

Last year, federal statisticians changed the title and the exact composition of a jobs subcategory to reflect the new prominence of apps. And the tech industry has begun making claims about how apps are contributing to the broader economy.

A study commissioned by the tech advocacy group TechNet [found that](#) the “app economy” — including Apple, Facebook, Google’s Android and other app platforms — was responsible, directly and indirectly, for 466,000 jobs. The study used a methodology that searched online help-wanted ads.

Using the same methodology, Apple [said this month](#) that its app business had generated 291,250 jobs for the American economy, as varied as developers and U.P.S. drivers. That number rose 39 percent in less than a year. During that time, the number of United States developers paying the \$99 annual fee to register with Apple rose 10 percent to 275,000. Some of these registered developers have other full-time jobs and write apps in their spare time.

Apple has become increasingly assertive in promoting the economic benefits of apps as its own wealth and prominence have grown and its employment and other business practices have come under scrutiny. The company issued a statement for this article saying it was “incredibly proud of the opportunities the App Store gives developers of all sizes,” but declined to answer questions.

At the company’s annual meeting this spring, the chief executive, Timothy D. Cook, noted that just a few years ago “mobile app” wasn’t even in people’s vocabulary. “Now there’s this enormous, entirely new job segment that didn’t exist before,” he said. “Apple has become a jobs platform.”

Michael Mandel, the economist who conducted the TechNet study, said it was problematic to slice the jobs data as Apple had done. “The guy who writes an Apple app one day will write an Android app the next day,” he said. “You can’t add up all the numbers from every study to get the total number of jobs.”

For many of the developers not working at traditional companies, moreover, “job” is a misnomer. Streaming Color Studios, a game developer, did a survey of game makers late last year. The 252 respondents, while not a scientifically valid sample and restricted to one segment of the app market, indicated what many people had suspected: the app world is an ecology weighted heavily toward a few winners.

A quarter of the respondents said they had made less than \$200 in lifetime revenue from Apple. A quarter had made more than \$30,000, and 4 percent had made over \$1 million.

A few apps have made it extremely big, including Instagram, the photo-sharing app that [was bought](#) by Facebook in April for \$1 billion. When app developers dream, they dream of triumphs like that.

Most developers, however, make their money when someone buys or upgrades their app from Apple’s online store, the only place consumers can buy an iPhone or iPad app.

Apple keeps 30 percent of each app sale. While its job creation report trumpets the \$6.5 billion the company has paid out in royalties, it does not note that as much as half of that money goes to developers outside the United States. The pie, while growing rapidly, is

smaller than it seems.

“My guess is that very few developers make a living off their own apps,” said Jeff Scott, who runs the Apple app review site [148Apps.com](http://148Apps.com) and closely tracks developments in the field.

### **The Struggling Entrepreneur**

Like many computer experts, Shawn Grimes started experimenting with apps almost as soon as Apple opened its doors for the iPhone. He wrote an Internet security program as well as a tool for studio photographers to manage portrait sessions. Those amateur apps pulled in more than \$5,000 from Apple.

Late last year, Mr. Grimes was laid off as a computer security specialist by Legg Mason, the Baltimore financial firm. The dismissal shook his confidence. “I worked really hard,” he said. “I did my best. But ultimately my career was not in my hands.”

The layoff, a result of Legg Mason’s decision to eliminate the jobs of 300 tech support workers, had been in the works for more than a year, which gave Mr. Grimes and his wife, Stephanie, plenty of time to contemplate their future. They have strong family roots in the Baltimore area but would have moved for a position with a Silicon Valley giant.

Google, which receives two million applications a year, interviewed Mr. Grimes, but he did not make it past the preliminary stages.

With direct employment out of reach, he decided to work independently by writing apps. He had no illusion that he was likely to become rich. Mostly, he hoped to find satisfying work that paid enough to provide a middle-class living and some shelter from a shifting economy.

But with hundreds of new apps introduced every day in Apple’s store, the field is overcrowded — something the Grimeses learned quickly and painfully.

Ms. Grimes, 32, quit her job teaching kindergartners to join the couple’s new venture, [Campfire Apps](#). They downsized to a two-bedroom apartment. “We either succeed and it’s awesome, or we fail and it was awesome while it lasted,” she said.

They worked steadily on apps that revolved around children. Henry’s Smart Headlamp was a learning game for preschoolers, a hunt for hidden objects that the Grimeses hoped iPhone-wielding parents would think was worth \$2 for a moment of distraction. A free version called Henry’s Spooky Headlamp got 5,409 downloads during Halloween 2011.

The couple aimed for one new app a month, but progress was slow and sales were slower. In March, with the apps bringing in only about \$20 a day, they cashed in Mr. Grimes’s 401(k), which yielded \$30,000 after taxes and penalties. They had already spent the severance from his job at Legg Mason.

One thing they never scrimped on was technology, especially Apple technology. At one point they owned a 24-inch iMac, a Mac Mini, a 24-inch cinema display screen, two 13-inch MacBook Airs, a 15-inch MacBook Pro, two iPad 2s, two Apple TVs, two iPhone 4s and an iPhone 3GS. “We justify buying new models by saying we need them to test out the apps,” Mr. Grimes said.

Soon, though, it got to the point where Mr. Grimes needed to take on freelance work, which brought in crucial income but took time away from Campfire Apps. By the beginning of summer, troubled by several persistent health care issues, he surrendered to the need for a full-time job.

Mr. Grimes now works as an app developer for ELC Technologies, an Oregon company that allowed him to stay in Baltimore. Ms. Grimes is still working on Campfire Apps.

While Mr. Grimes was angry at Legg Mason for laying him off, Apple delivered little — but

it also made no promises. "People used to expect companies to take care of them," he said. "Now you're in charge of your own destiny, for better or worse."

The Grimeses' quest cost them more than \$200,000 in lost income and savings. So far this year, their eight apps have earned \$4,964. When the newest iPhone came out at the end of September, the couple immediately bought two.

### Success Beyond Dreams

Ethan Nicholas was a Sun Microsystems programmer, a games enthusiast and a father of two very young boys, and he needed some extra cash. So in late 2008 he wrote an artillery game that could be played on the iPhone, which was still relatively new. There were about 11 million in circulation — certainly a large number, but nothing like the 270 million that have now been sold.

Mr. Nicholas wrote iShoot in six weeks, in his spare time. It sold 17,000 copies at \$2.99 each on a single day, Jan. 11, 2009. That was a Sunday. On Monday, he quit his job. By March, he had earned more than \$1 million. "Sheer dumb luck and being in the right place at the right time," he said.

Mr. Nicholas and a friend, Brent Miller, were inspired to form a company. "We were going to make another million or two," said Mr. Miller, 38. But when none of their new games sold like iShoot, the pair moved in an entirely new direction. They founded [echoBase](#), a start-up with 14 employees that is developing apps to allow doctors and nurses to view and update medical records across different computer systems. They brought in Mr. Miller's father, Rod, a former I.B.M. sales manager, as chief executive.

EchoBase has raised about \$4 million. Most of that has come from dozens of small investors, but Mr. Nicholas and the Millers have contributed about \$1 million. "All of my savings and retirement account are gone," Brent Miller said. His father took out a second mortgage. Revenue is now coming in, with 3,200 doctors signed up, but the company is a long way from making a profit. Rod Miller forecast that it would become self-sustaining in 2013.

Mr. Nicholas has cautioned his new colleagues about easy money. "The time for that has passed," he said.

EchoBase markets its service to medical records software providers and hospitals, whose doctors download the app free. Apple makes no money here, but it gets a long-term benefit: start-ups that succeed will embed the iPad and the iPhone more thoroughly into society.

The company is, in a sense, another arm of Apple's research and development program. "The applications are what sells the hardware," Rod Miller said. "Without us, and thousands of others like us, Apple has limited appeal."

On one level, it was a strange move for Apple to open its devices to people like Mr. Grimes, Mr. Nicholas and the Millers. Imagine a violinist's horror at letting a toddler play with his Stradivarius and you would have some idea of Apple's reluctance to let anyone outside of its walls fool with any of its technology. This is a company that sealed batteries into its devices so people could not replace them.

Apple's brilliant but mercurial chief executive, Steven P. Jobs, agreed to unlock the gates of the fledgling iPhone only after much internal argument, and he made sure that Apple would retain strict oversight of every app. In retrospect, it might have been the smartest decision ever made by a company that prides itself on creating the future.

The App Store opened in July 2008 with 500 apps. [In an interview](#), Mr. Jobs laid bare the company's goal: "Sell more iPhones."

And so, thanks in large part to the multitude of apps, it came to pass. More iPhones — nearly seven million — were sold in the next three months than in the entire previous year,

and that was just the beginning of the ascent.

“Apps changed the iPhone from a simple phone into a mobile computer,” said Mr. Scott of [148Apps.com](http://148Apps.com).

Apple’s financial documents show just how crucial app inventors are. If the developers stop developing, the company warned again last month, “customers may choose not to buy the company’s products.”

So far, there has not been much risk of revolt. Developers have expressed flickers of grumpiness at Apple’s 30 percent cut of each app sale. A shadowy group calling itself the [App Developer Union](#) briefly posted a petition online this summer asking for “something more equitable.” Apple declined to comment about the union, which disappeared from the Web as mysteriously as it had arrived.

Mr. Nicholas has the same philosophy about Apple now as he did when he wrote iShoot. “I’d rather get 70 percent of a large pie than all of a small pie,” he said.

A version of this article appears in print on November 18, 2012, on page A1 of the New York edition with the headline: As Boom Lures App Creators, Tough Part Is Making a Living.

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THE iECONOMY

# Signs of Changes Taking Hold in Electronics Factories in China



**The iEconomy: Factory Upgrade:** Change comes to factories in China.

By KEITH BRADSHER and CHARLES DUHIGG  
Published: December 26, 2012 | 176 Comments

CHENGDU, China — One day last summer, Pu Xiaolan was halfway through a shift inspecting iPad cases when she received a beige wooden chair with white stripes and a high, sturdy back.

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Factory Conditions in China

At first, Ms. Pu wondered if someone had made a mistake. But when her bosses walked by, they just nodded curtly. So Ms. Pu gently sat down and leaned back. Her body relaxed.

The rumors were true.

When Ms. Pu was hired at this [Foxconn](#) plant a year earlier, she received a short, green plastic stool that left her unsupported back so sore that she could barely sleep at night. Eventually, she was promoted to a wooden chair, but the backrest was much too small to lean against. The managers of this 164,000-employee factory, she surmised, believed that comfort encouraged sloth.

But in March, unbeknown to Ms. Pu, a critical meeting had occurred between Foxconn's top executives and a

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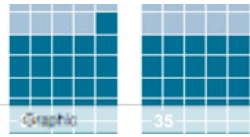
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Improving Working Conditions at Foxconn

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**ON THE LINE** Workers assembling Hewlett-Packard computers at a plant in Chongqing, China, operated by Foxconn of Taiwan. [More Photos](#) »

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high-ranking [Apple](#) official. The companies had committed themselves to a series of wide-ranging reforms. Foxconn, China's largest private employer, pledged to sharply curtail workers' hours and significantly increase wages — reforms that, if fully carried out next year as planned, could create a ripple effect that benefits tens of millions of workers across the electronics industry, employment experts say.

Other reforms were more personal. Protective foam sprouted on low stairwell ceilings inside factories. Automatic shut-off devices appeared on whirring machines. Ms. Pu got her chair. This autumn, she even heard that some workers had received cushioned seats.

The changes also extend to California, where Apple is based. Apple, the electronics industry's behemoth, in the last year has tripled its corporate social responsibility staff, has re-evaluated how it works with manufacturers, has asked competitors to help curb excessive overtime in China and has reached out to advocacy groups it once rebuffed.

Executives at companies like [Hewlett-Packard](#) and Intel say those shifts have convinced many electronics companies that they must also overhaul how they interact with foreign plants and workers — often at a cost to their bottom lines, though, analysts say, probably not so much as to affect consumer prices. As Apple and Foxconn became fodder for “[Saturday Night Live](#)” and [questions during presidential debates](#), device designers and manufacturers concluded the industry's reputation was at risk.

“The days of easy globalization are done,” said an Apple executive who, like many people interviewed for this article, requested anonymity because of confidentiality agreements. “We know that we have to get into the muck now.”

Even with these reforms, chronic problems remain. Many laborers still work illegal overtime and some employees' safety remains at risk, according to interviews and reports published by advocacy organizations.

But the shifts under way in China may prove as transformative to global manufacturing as the [iPhone](#) was to consumer technology, say officials at over a dozen electronics companies, worker advocates and even longtime factory critics.

“This is on the front burner for everyone now,” said Gary Niekerk, a director of corporate social responsibility at Intel, which manufactures semiconductors in China. No one inside Intel “wants to end up in a factory that treats people badly, that ends up on the front page.”

The durability of many transformations, however, depends on where Apple, Foxconn and overseas workers go from here. Interviews with more than 70 Foxconn employees in multiple cities indicate a shift among the people on iPad and iPhone assembly lines. The once-anonymous millions assembling the world's devices are drawing lessons from the changes occurring around them.

As summer turned to autumn and then winter, Ms. Pu began to sign up for Foxconn's newly offered courses in knitting and sketching. At 25 and unmarried, she already felt old. But she decided that she should view her high-backed chair as a sign. China's migrant workers are, in a sense, the nation's boldest risk-takers, transforming entire industries by leaving their villages for far-off factories to power a manufacturing engine that spans the globe.

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Ms. Pu had always felt brave, and as this year progressed and conditions inside her factory improved, she became convinced that a better life was within reach. Her parents had told her that she was free to choose any husband, as long as he was from Sichuan. Then she found someone who seemed ideal, except that he came from another province.

Reclining in her new seat, she decided to ignore her family's demands, she said. The couple are seeing each other.

"There was a change this year," she said. "I'm realizing my value."

### **An Inspector's Push**

"This is a disgrace!" shouted Terry Gou, founder and chairman of Foxconn, the world's largest electronics manufacturer and Apple's most important industrial partner.

It was March of this year and Mr. Gou — seen by activists as a longtime obstacle to improving conditions inside his factories — was meeting with his top deputies in Shenzhen, China. In 2011, The New York Times began sending Apple and Foxconn extensive questions about working conditions in factories manufacturing Apple products. [The resulting articles](#) in late January detailed problems ranging from excessive overtime and under-age workers to sometimes deadly hazards, such as workers' using a poisonous chemical to clean iPhone screens at another manufacturer, and an explosion in Ms. Pu's Foxconn plant that killed four workers.

In January, Apple publicly released the names of many of its suppliers for the first time. Additionally, the company made the unusual move of joining the [Fair Labor Association](#), one of the largest workplace monitoring groups. Auditors from that association were soon inspecting Apple's partners in China, starting with Foxconn.

Now, Mr. Gou was learning the results of those examinations. Foxconn was still failing to stop illegal overtime, the association's lead inspector told Mr. Gou and his lieutenants, according to multiple people with knowledge of the meeting. The company was failing to keep student interns off night shifts. Foxconn had not put sufficient safety policies into practice and had exposed potentially hundreds of thousands of workers to at least 43 violations of Chinese laws and regulations.

"The world is watching!" Mr. Gou yelled, according to multiple people. "We are going to fix this, right here!"

But the inspector was not done.

He turned to the only Apple executive in the room, the senior vice president for operations, Jeff Williams. Apple needed to change as well, the inspector said. Apple, to its credit, had been working for years to improve conditions in overseas factories, but the company was treating such problems too much like engineering puzzles, the inspector said.

"Long-term solutions require a messier, more human approach," that inspector, Auret van Heerden of the Fair Labor Association, told Mr. Williams. Instead of concentrating on writing more policies, Apple needed to listen better to workers' complaints and advocacy groups' recommendations.

Some of those suggestions surprised Mr. Williams, say people who worked with him. Since 2007, Apple had built one of the most extensive auditing programs in the electronics industry, inspecting over 800 facilities. It was a point of pride for both Mr. Williams and the company's top leadership.

When Mr. Williams, who declined to comment for this article, returned from that March meeting to California, changes began. Among them, say people with firsthand knowledge, was the hiring of roughly 30 professionals into Apple's social responsibility unit in the last year, which tripled the size of that division and brought high-profile corporate activists into the company. Two widely respected former Apple executives — Jacky Haynes and Bob

Bainbridge — were recruited back to help lead the unit, reporting ultimately to Mr. Williams and the chief executive, Timothy D. Cook.

“Everyone knows Bob and Jacky,” said a former Apple executive. “It sends a message that Jeff and Tim expect everyone to get on board.”

Moreover, the company has reached out to advocates it once rebuffed. In late April, Apple allowed the first in a series of pollution audits by [Ma Jun](#), a Chinese environmental advocate who works closely with dozens of other multinationals but whom Apple had refused to speak with until last year, according to Mr. Ma. In September, the company joined the [Sustainable Trade Initiative](#), an advocacy group based in the Netherlands.

“They know now if they don’t participate, it is the same as saying nothing,” Mr. Ma said.

Foxconn has also shifted. After the meeting with the Fair Labor Association, Foxconn announced that by July 2013, no employee would be allowed to work more than an average of 49 hours a week — the limit set by Chinese law. Previously, some Foxconn employees worked schedules that approached 100 hours a week. No other major manufacturer has pledged to abide by China’s work-hour laws in such a public manner. Foxconn, which is based in Taiwan, also promised to increase wages, so employees’ total pay would not decline despite fewer hours — the equivalent of a 50 percent raise for many workers, analysts say.

With 1.4 million employees in China — the most of any private company — Foxconn is setting a bar that all manufacturers will be judged against, say executives at other companies.

“When the largest company raises wages and cuts hours, it forces every other factory to do the same thing whether they want to or not,” said Tony Prophet, a senior vice president at Hewlett-Packard. “A firestorm has started, and these companies are in the glare now. They have to improve to compete. It’s a huge change from just 18 months ago.”

Foxconn, in a statement, said that it was “committed to ensuring that we provide a safe and healthy working environment for all our employees,” and that the company had regularly increased wages over the last three years.

### **Secrecy and Transparency**

Despite those reforms, however, worker advocates inside Apple and with outside groups say the electronics industry’s problems will not genuinely diminish until Apple — the world’s most valuable company — starts filling a public leadership role similar to that of companies in other industries with overseas problems, like Nike in footwear manufacturing and Patagonia in apparel.

Such public leadership and transparency can run counter to a culture of secrecy that pervades Apple. Employees often don’t know what their lunch companions or next-door office mates are working on. This secrecy has helped Apple stay ahead of competitors, but has been a problem when it spills into the broader corporate culture, say past executives.

“It’s remarkable how the paranoia in Silicon Valley prevents companies from cooperating, even on something like corporate social responsibility,” said Mr. van Heerden of the Fair Labor Association, who added that his work with Apple, Foxconn and other companies was confidential.

While Apple is the only electronics company to join Mr. van Heerden’s monitoring group, it has not opened up in some other ways. Apple has declined to release audit reports on the hundreds of facilities the company has inspected. After two factory explosions last year, Apple did not share investigative reports with other companies so they might avoid similar accidents. Apple does not, in general, publicly identify terminated suppliers or factories that have violated Apple’s supplier code of conduct.

Moreover, Apple’s growing team of safety and corporate responsibility experts are

typically prohibited from sharing their findings at conferences, in academic journals or other forums where their insights could be absorbed by other companies, according to former members of that team.

“Apple is scared that if we open the kimono too wide, it will ruin what has made Apple special,” said one former company official. “But that’s the only way to really improve things. If you don’t share what you know, then no one else gets a chance to learn from your mistakes and discoveries.”

Apple declined requests for interviews. In a statement, it said the company embraced its “unique position to lead” and had taken working conditions very seriously for a long time. “No one in our industry is doing as much as we are, in as many places, touching as many people as we do. Through years of hard work and steadfast commitment, we have set workplace, dormitory and safety standards, sought help from the world’s leading experts, and established groundbreaking educational programs for workers.”

“We have been upfront about the challenges we face and are attacking issues aggressively,” the statement continues. “We believe deeply in transparency and have demonstrated this through reporting our shortcomings and exposing violations.”

At a conference in May, Mr. Cook, the chief executive, said that the company was “going to double down on secrecy on products.”

He added, however, that “there’s going to be other things that we do that we’re going to be the most transparent company in the world on. Like social change. Supplier responsibility. On what we’re doing for the environment. We’re going to be the most transparent, because we think that transparency is so important in these areas, and that if we are, other people will copy what we’re doing.”

This year, Apple began publishing [monthly summaries](#) of suppliers’ compliance with overtime standards. In October, Apple hosted other technology companies for a private discussion on responses to excessive work hours overseas. While Apple’s [annual supplier responsibility reports](#) do not contain details on specific factories, they are still among the most thorough in the electronics business.

But Apple has not sought the high-profile leadership opportunities that have set off transformations in other industries. Nike, for instance, has convened public meetings of labor, human rights, environmental and business leaders to discuss how to improve overseas factories. The clothing retailer Gap Inc. has invited outside organizations to critique its purchasing practices and publish their findings. Patagonia shares its factory audits with competitors and has been a vocal supporter of a centralized audit report clearinghouse that lets companies share information.

“That’s the standard Apple has to meet,” said a former Apple executive. “That’s how a leader transforms an industry.”

### **A More Human Touch**

Almost 200 miles southeast of the factory where Ms. Pu received her new chair is another plant that is experimenting with improving workers’ quality of life — and shows the trade-offs of such gains.

The factory, in Chongqing, makes computers for Hewlett-Packard, a company with little of Apple’s glamour. It is operated by Quanta, a little-known Taiwanese manufacturer.

Inside the plant, amid thousands of workers in bright white uniforms, are occasional flashes of pink worn by people like Zhang Xuemei, a bubbly 19-year-old with glinting earrings whose sole job is to chat with co-workers.

For eight hours a day, Ms. Zhang collects complaints about the factory’s free meals and dorms. She listens to workers who are divorcing, homesick or arguing with managers. When she finds someone suffering, she refers them to the company’s full-time doctor or

professional counselors.

Quanta's 10-story dormitories feel like a college campus. There is a free movie theater, television rooms, a large martial arts gym, two spacious karaoke bars, a huge cafeteria and an aerobics hall playing a Chinese remix of "Gangnam Style."

Neither Quanta nor Hewlett-Packard claims it has solved every labor woe. And the amenities are partly selfish: one of the biggest problems for Chinese factories is that workers are constantly leaving. Hewlett-Packard hopes that by improving living conditions, turnover and training costs will fall.

"You can tweak the line and get one second out of the process, but if the people turn over every three months, think what that does to your quality," said Mr. Prophet, the Hewlett-Packard executive.

Last year, a worker advocacy group criticized another Quanta plant, in Shanghai, for harsh working conditions found at many factories, including extensive overtime and poor food. In Chongqing, Hewlett-Packard has agreed to pay slightly higher prices initially so that Quanta can offer workers a better quality of life. Such payments are the price all companies should bear for more humane factories, say Hewlett-Packard executives.

There are costs for workers, too. Quanta's employees earn slightly less than their peers at Foxconn. What's more, Quanta's emphasis on hours that are easier on employees means they are prohibited from overtime shifts that advocates say are abusive, but which some workers insist they want.

Zhang Jiang, a slim 21-year-old, previously assembled laptop computers at another company in Shanghai. Each week, he sent the bulk of his pay home so his younger brother could stay in school. Overtime was like a blessing, he said.

But last summer, fed up with the 25-hour train trip to see his family, Mr. Zhang moved to Chongqing and joined Quanta. He enjoys the better facilities and dorms. He frequently visits his parents' home. But his take-home pay has fallen by nearly a third and the thought that his brother may have to drop out of school so he can help the family gnaws at Mr. Zhang. Instead of working in the factory each night, he spends hours playing an online game, *Dungeon Fighter*.

"I'd like to work 80 hours a week," he said.

### **Change Is Hard**

Hewlett-Packard also makes products at Foxconn factories, as does almost every major electronics firm. Foxconn, more than any other company, has proved that Chinese plants can deliver obsessive attention to quality. The company has helped make China into a manufacturing juggernaut through strict discipline that is visible everywhere, even in the salutes managers give visiting executives.

That discipline, say former Apple executives, is one reason every iPhone is put together so well.

It is also one reason the reforms enjoyed by employees like Ms. Pu — who received the new chair — have not spread quickly. Though Foxconn has trained managers to treat employees more gently, foremen still use profanity and intimidation, workers say.

"The managers speak in a manner that often feels like a threat," said Mou Kezhang, who works in iPad quality assurance at the Foxconn factory in Chengdu.

Foxconn, in a statement, said it had "always been among the fastest to adopt change and reform." Its policy, the company said, is "to treat employees with respect and if we find any transgressions, they are immediately investigated and addressed."

In the last two years, Hewlett-Packard has increasingly moved its manufacturing to

Quanta. Foxconn has not fought particularly hard to win that business back, according to Hewlett-Packard officials. Often, the quality-of-life improvements requested by Western electronics executives come at the cost of a supplier's bottom line. Even within Apple, tensions erupt because executives often believe improvements should be financed by suppliers, whereas suppliers say changes are not feasible unless Apple pays more.

And ultimately, some workers themselves resist reforms. In March, when Foxconn announced that workers' hours would be reduced to China's legal limits, employees began complaining. "Absolutely I'd like to do overtime to work more than 60 hours, but now there's a ceiling on it," said Ma Changqiao, a 23-year-old at Foxconn's Chongqing factory.

Change is hard, say officials at multiple companies. Reforming labor conditions in a country as large as China will probably take decades, and labor abuses are an ever-evolving problem without just one right answer.

In September, six months after Foxconn agreed to a Fair Labor Association request for new internship rules, two worker advocacy groups found that students in nonmanufacturing courses were being improperly forced to work at a Foxconn plant in north central China. One student studying preschool education said she was prohibited from quitting her internship and was compelled to work night shifts. Afterward, Mr. Gou of Foxconn issued apologies to wronged interns and the responsible official was fired.

Today, Foxconn's internship program continues — a testament, executives say, to Foxconn's commitment to a program that can benefit thousands of students, even when making improvements is hard and stumbles are inevitable. Changing the company's culture is slow going. But the needed reforms, executives at Apple and Foxconn hope and believe, are falling into place.

*Keith Bradsher reported from Chengdu and Chongqing, and Charles Duhigg from New York. Yadan Ouyang contributed reporting from Chengdu and Chongqing.*

A version of this article appears in print on December 27, 2012, on page A1 of the New York edition with the headline: Signs of Changes Taking Hold in Electronics Factories in China.

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