

MAKING IT HERE

The Future of Manufacturing in New York City

MAKING IT HERE: THE FUTURE OF MANUFACTURING IN NEW YORK CITY. Researched and written by Charles Euchner. Edited by Eli Dvorkin and Jonathan Bowles. Additional research support from Natalia Khosla, Kathleen Gorman, and Zoë Kleinfeld. Design by Rob Chabebe.

Center *for an* Urban Future

CENTER FOR AN URBAN FUTURE

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Center for an Urban Future (CUF) is a catalyst for smart and sustainable policies that reduce inequality, increase economic mobility, and grow the economy in New York City. An independent, nonpartisan policy organization, CUF uses fact-based research to elevate important and often overlooked issues onto the radar of policymakers and advance practical solutions that strengthen New York and help all New Yorkers participate in the city's rising prosperity.

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Cover: A bank of 3D printers at Voodoo Manufacturing in Brooklyn

CONTENTS

| | |
|---|-----------|
| INTRODUCTION | 3 |
| 3D PRINTING: GUTENBERG IN THE FACTORY | 6 |
| New York City has emerged as a major hub of 3D printing, launching a wave of new businesses and transforming traditional manufacturing in the process. | |
| FABRICATION: BUILDING WITH WOOD AND METAL | 14 |
| From museum exhibitions to gut-renovated brownstones, fabricators fuse age-old techniques and new technology to build complex environments from wood and metal. | |
| FOOD MANUFACTURING: A TASTE OF DISRUPTION | 18 |
| Artisanal producers are making everything from chocolate to hot sauce in New York kitchens, creating a movement that is shaping consumer tastes worldwide. | |
| BARRIERS TO MANUFACTURING GROWTH | 24 |
| Manufacturing is growing again after decades of decline, but New York City companies face major obstacles in the struggle to scale up. | |
| RECOMMENDATIONS | 27 |
| Ten ways to support New York City's new wave of manufacturing | |

MAKING IT HERE

New York City's manufacturing sector received another dose of bitter news in January when Cumberland Packing, the maker of Sweet'N Low, announced it was shutting down its Brooklyn factory and eliminating all 300 of its jobs in the borough. The decision was only the latest example of a large New York City-based manufacturer opting to close its doors or relocate operations out of the city, following recent exits by pita manufacturer Damascus Bakery, jewelry maker Frederick Goldman, Inc., matzo baker Streits, and adhesives manufacturer AP&G.

But unlike years past, the departure of traditional manufacturers like Cumberland is now being counteracted by a new wave of modern manufacturing companies that are adding jobs in the five boroughs and breathing new life into a sector that was all but presumed dead as recently as five years ago.

The city lost an average of 8,370 manufacturing jobs a year between 2001 and 2011, bringing the sector's employment total below 75,000 jobs for the first time since the rise of the industrial city. But since then, from April 2011 to April 2016, the city's manufacturing sector has grown by 3,900 jobs, including 1,100 jobs in the last twelve months. This hardly makes manufacturing one of the city's leading growth industries. Manufacturing accounted for just 0.8 percent of the 513,500 new private sector jobs added citywide over the past five years and the sector now makes up just 2.1 percent of all private sector jobs in the city, down from 5.7 percent in 2000 and 9.1 percent in 1990. But it represents the city's longest period of sustained manufacturing growth in several decades and a much-needed shot in the arm for a sector that still provides a crucial source of middle-class jobs.

This report examines whether this growth can continue and which segments of the city's manufacturing sector offer the greatest promise. The report—the latest publication of the Center for an Urban Future's Middle Class Jobs Project, a research initiative funded by Fisher Brothers and Winston C. Fisher—also assesses what obstacles might inhibit additional job creation in the sector and what government policies could help ensure that the city's manufacturing revival continues.

We conclude that there is clear potential for additional manufacturing growth in the five boroughs. However, our research suggests that some parts of the city's manufacturing ecosystem offer significantly more promise than others. In particular, we find that three sectors are well positioned for future growth: 3D printing, metal and wood fabrication, and food manufacturing.

For this report, we asked dozens of industry experts—including company owners, leaders of industry associations and local development corporations, investors, economists, and academics—where they are seeing the most manufacturing growth in the city and which sectors are best positioned for future growth.

The broad consensus is that the city's recent industrial growth is being driven by a new kind of manufacturing: small, entrepreneurial companies that are making specialty products mainly for individual consumers and businesses in the region. These makers and manufacturers are producing in small batches with quick turnaround times, investing in new technologies, capitalizing on connections to the city's thriving creative industries—including design, fashion, and film—and taking advantage of powerful demographic, economic, and consumer trends. For instance, some are tapping into New York's status as a leading center in the back-to-local movement, where a large

and growing mass of consumers are demanding locally made, artisanal products. Others are benefiting from the city’s rapid growth in affluent residents, many of whom are willing to pay a premium for custom-made products.

Even the most optimistic manufacturing experts that we interviewed caution that many traditional manufacturers will continue to struggle. Indeed, even as employment in the sector has ticked up in recent years, the number of manufacturing firms citywide has declined from 5,976 in 2011 to 5,752 in 2015.

What we heard, again and again, is that New York’s competitive advantage in manufacturing today—and its best hope for growth in the future—is undoubtedly with small firms that operate in niche markets and take advantage of modern production processes. Labor market data supports this. In 2015, the average manufacturing company in the city had just 13.4 employees (down from 17.3 in 2000) and the average manufacturer in Brooklyn had 12 workers (down from 16.8 in 2000). In comparison, manufacturing companies in New York State employ 26.3 workers on average.

Small specialty producers are thriving in a variety of sectors, including fields where the overall employment trends have been negative, such as apparel manufacturing. With the right policies in place, opportunities exist to scale up companies in many of these sectors.

However, the experts we interviewed suggest that three of New York City’s manufacturing fields are particularly well positioned for growth in the years ahead: 3D printing, metal and wood fabrication, and food manufacturing.

3D Printing

There are no longer many manufacturing sectors where New York can boast a competitive advantage, but 3D printing is one of them. One of the industry’s leading online platforms, 3D Hubs, reported in July 2016 that New York “continues its reign as the 3D printing capital of the world.” According to its data, accessed in mid-July, New York is home to 3,739 makers and 516 3D printers, far ahead of second place Los Angeles (which has 2,557 makers and 410 printers), third place London (3,326 makers and 358 printers), and fourth place Paris (2,069 makers and 313 printers).

New York is widely known as the home base for 3D printing pioneers MakerBot and Shapeways. However, New York today is home to dozens of companies and thousands of makers in the 3D printing space. This includes companies that moved here from elsewhere—including Matter, a firm founded at MIT that relocated to Brooklyn in 2014—

Manufacturing Employment in NYC (Thousands), 2001–2016

| | |
|------|-------|
| 2001 | 158.6 |
| 2002 | 140.7 |
| 2003 | 128.2 |
| 2004 | 120.8 |
| 2005 | 114.9 |
| 2006 | 106.9 |
| 2007 | 101.8 |
| 2008 | 96.8 |
| 2009 | 82.3 |
| 2010 | 76.5 |
| 2011 | 74.9 |
| 2012 | 75.9 |
| 2013 | 76.2 |
| 2014 | 75.8 |
| 2015 | 77.7 |
| 2016 | 78.8 |

Source: New York State Labor Department, Current Employment Statistics. Data is for April of every year.

as well as a growing number of start-ups that were established by former staffers of MakerBot and Shapeways.

Although New York’s 3D printing industry has undoubtedly suffered setbacks in the past year—MakerBot recently announced that it would be outsourcing production and eliminating 200 Brooklyn jobs—the industry experts we interviewed are optimistic that the city is poised for additional growth. Indeed, many of those experts say that the industry is entering a new phase of growth, going beyond the production of individual products to develop applications for a wide range of businesses, from aerospace to healthcare. Overall, the 3D printing industry is expected to grow from \$4.98 billion in 2015 to \$30.19 billion by 2022, according to private research firm MarketsandMarkets. As we detail in this report, New York is well positioned to capture some of this growth.

Fabrication

Metal and wood product fabrication is hardly the best known industrial sector, but it is the city’s third-largest manufacturing industry, and one of a handful that has experienced employment growth in recent years. From 2011 to 2015, employment in the sector increased by 6 percent, from 6,570 to 6,980 jobs.

The city’s metal and wood fabrication companies have benefited from growing demand for high-end interiors, finishes, and furniture. Much of this has been fueled by the city’s sharp rise in affluent residents, whose luxury condos and second homes in the Hamptons often include custom furniture, metal railings, contemporary chandeliers, spiral staircases, and other handcrafted wood and metal furnishings. The explosion in high-end retail stores and restaurants has created additional market opportunities for New York’s skilled fabricators, as has the booming office market, the thriving film and television production sector, and a healthy museum and gallery sector.

As the city’s massive luxury consumer market continues to grow, there are ample opportunities for New York’s metal and wood fabricators to expand further.

| Average Number of Employees in Manufacturing Companies | | |
|--|------|------|
| | 2000 | 2015 |
| NYC | 17.3 | 13.4 |
| Brooklyn | 16.8 | 12.0 |

Source: New York State Labor Department, Quarterly Census of Employment and Wages

Food

Of the twenty largest American cities, only two experienced a greater percentage increase in food manufacturing employment between 2005 and 2015 than New York. In the five boroughs, employment in the sector increased by 27 percent during this period, from 13,929 jobs in 2005 to 17,682 in 2015. That’s a faster rate of growth than Houston (where food manufacturing jobs increased by 15 percent), Seattle (+10 percent), San Francisco (-3 percent), Los Angeles (-11 percent), Chicago (-11 percent) and every other large U.S. city other than Phoenix (+45 percent) and San Jose (+28 percent).

Also benefiting from a growing luxury market, food became the city’s largest manufacturing sector, as measured by jobs, surpassing the apparel manufacturing industry in 2014. Food now comprises 28 percent of all manufacturing jobs in Brooklyn, 27 percent in the Bronx, 26 percent in Staten Island, 21 percent in Queens, and 16 percent in Manhattan.

A growing number of the city’s food and beverage manufacturers have succeeded in distributing their niche products beyond the five boroughs. However, there are clear op-

portunities to scale up more of the city’s food production companies.

Each of the three manufacturing sectors profiled in this report—3D printing, metal and wood fabrication, and food—have the potential to add hundreds if not thousands of additional jobs in the years ahead. There are also opportunities for growth in other manufacturing sectors, especially among small-batch manufacturers that cater to the local market and invest in technology.

But as we heard in our interviews, none of this growth is certain. Given that so many of the most successful manufacturers in the city are making products for consumers and businesses in the region, a slowing local economy could easily erase many of the recent employment gains. At the same time, manufacturing firms in the city face enormous hurdles. Some of the barriers—such as the diminishing availability of affordable industrial space—have plagued local companies for years. But other obstacles are fairly new. For instance, many of the manufacturing company executives interviewed for this report—particularly in 3D printing and fabrication, but also in apparel manufacturing and other sectors—cited challenges finding employees who have the advanced skills required for the kinds of jobs that are currently growing.

To its credit, the de Blasio administration has taken several important steps to address some of these barriers and support manufacturing. But more could be done. This report lays out ten recommendations to strengthen and support the kinds of manufacturing that have the strongest growth potential in the years ahead.

With the right support, New York can benefit from ongoing job growth in manufacturing—a sector that continues to provide New Yorkers from a range of backgrounds with a crucial pathway to the middle class.

3D PRINTING: GUTENBERG IN THE FACTORY

New York City has emerged as a major hub of 3D printing, launching a wave of new businesses and transforming traditional manufacturing in the process.

New York City is a global hub for 3D printing today. What began with a handful of New York-based companies, such as MakerBot and Shapeways, is now a growing industry that includes dozens of companies, hundreds of jobs, and thousands of makers. A method of producing whole products or parts with one machine, 3D printing has emerged as a potent force in the manufacturing sector over the past decade, affecting industries from aerospace to medicine. MarketsandMarkets, a private research firm, reports that the industry is expected to grow from \$4.98 billion in 2015 to \$30.19 billion by 2022. As 3D printing expands into new territory, moving beyond the production of individual products to include design services and integrated manufacturing, the industry shows significant potential for future growth.

As the technology develops and applications multiply, 3D printing is bringing major changes to a wide range of businesses. The aerospace and automotive industries are using 3D printing to produce parts that do not justify large-scale cast-and-mold production. Design firms are able to print prototypes before committing to costly production runs. The comedian Jay Leno uses a \$300,000 3D printer to produce parts for his antique car collection that have been unavailable for decades. Manufacturing and service businesses now have the ability to customize machine tools and parts, appliances, jewelry, clothing, food, electronics, medical devices and procedures, and even organ transplants.

New York is currently a center for the industry, leading the world in both 3D printers and the makers who use them. The website 3D Hubs, which provides connections between buyers and producers of 3D-printed objects, reported in July 2016 that New

York “continues its reign as the 3D printing capital of the world,” having grown 2.9 percent over the previous month to 524 3D printers. Experts say 3D printing promises to be “the second industrial revolution” and will spark “a Gutenberg-like renaissance” in manufacturing, and New York City is poised to take advantage of this next wave. The city’s complex economy—which includes a dense concentration of investors, media outlets, maker movements, technologists, and educational and medical institutions—offers a fertile environment for further growth in 3D printing. The city is also attracting 3D printing activity from other parts of the country. For example, Matter, a company started at MIT, moved to Brooklyn in 2014.

“New York City,” says Zack Schildhorn, a partner at Lux Capital, “is probably the premier location for creating the technology at the moment. You probably have the most important companies here, especially when you compare the traditional technology industry to a place like Silicon Valley... Normally you have to cluster a tech factor that is predominantly based in Silicon Valley but in 3D printing at least it seems like it will be one of those unique cases where New York is really where it is at.”

New York’s 3D printing scene

Two companies, MakerBot and Shapeways, established New York as an early leader in the sector—a status that continues, despite some recent setbacks. MakerBot’s role was analogous to the first personal computer makers, like Commodore, IBM, and Apple. For the first time, 3D printers were available to consumers for the same price as a high-end computer. In 2016, Time magazine named MakerBot’s Replicator machine one of the most influential gadgets ever. Af-

WHAT IS 3D PRINTING?

Three-dimensional printing, also known as additive manufacturing, has been transforming heavy manufacturing for a generation. Since the expiration of patents in the early 2010s, the cost of machines has plummeted and software has grown dramatically, opening a wide range of applications for consumers and small businesses. The 3D printing process has become integrated into traditional product manufacturing, including dentistry, orthopedics, and jewelry. Other companies use 3D printing to update their machinery to respond to the shifting demands of their businesses.

To create physical products, 3D printing layers plastics and metals on a surface, just as standard printing creates documents by laying down tiny drops of ink on paper. In the 3D printing process, thousands of layers of materials accumulate over time; eventually, products ranging from phone cases to jet engine parts take shape. Software programs instruct the 3D printers to lay down materials in prescribed patterns and shapes.

The category of 3D printing also includes subtractive processes. Rather than applying successive layers of plastics or metals, the subtractive process uses lasers to cut away from blocks of plastic or metal. Industry insiders liken the subtractive process to a sculptor chipping a block of granite to uncover the form inside.

Three-D printing offers a number of advantages. Most important, the process can customize any object, such as vehicle and engine parts, clothing, devices from door handles to drones, medical and dental materials, body parts and organs, and food. Some architects have even begun to 3D print large structures such as homes. Each 3D copy is programmed to fit specified dimensions and material needs, and can be adjusted to perform better as often as required. For example, if an orthopedic insert does not perfectly fit a shoe, it can be instantly adjusted and remade. Three-D printing offers an ideal tool to iterate the designs of complex objects. As soon as an object is used, feedback can be used to tweak the design and improve its performance.

“This is definitely going to change the face of manufacturing, there’s no question about that,” says Kegan Schouwenberg, the founder and CEO of Sols, the Hudson Yards-based producer of customized, 3D printed insoles. “It will be a major driver for in-demand manufacturing. But to make it happen, we need to see 3D printing as a process and not as an end in itself. In the early days, companies like MakerBot and Shapeways focused on the consumer—giving them something to make whatever they wanted. But we need to think of it as a new manufacturing technique that can solve people’s problems.”

ter Minneapolis-based Stratasys acquired MakerBot in 2013 for \$403 million, MakerBot continued to operate in Brooklyn to maintain its local networks and access to high-level talent.

Since the deal, MakerBot has struggled to meet its projections. MakerBot laid off 200 of its 500 employees in 2014 and 2015. The company is now locked in a battle with South Carolina-based 3D Systems for pre-eminence in the consumer 3D printer market. Stratasys’ stock price fell from a high of \$134.70 in late 2014 to \$19.74 in May 2016. Still the company was valued at \$1.2 billion and was projected to produce \$711 million in sales in 2016. Then, in April 2016, MakerBot announced that it would move production to China by partnering with Jabil, a global contract manufacturer. That decision resulted in 200 more layoffs.

The news was a blow to New York’s 3D printing community. But experts say the decision to outsource production was an inevitable phase in the industry’s evolution. And even with the company’s presence di-

minished, it has left behind an impressive legacy. “MakerBot spawned a whole colony of offshoots,” says Alan Meckler, the founder of the New York-based Asimov Ventures, a firm dedicated exclusively to 3D printing and robotics, and creator of the trade show Inside 3D Printing and the online news site 3DPrint.com. “Think about Voodoo [Manufacturing]. That was started by MakerBot guys. There are dozens of companies in Brooklyn and Queens that trace their roots to working at MakerBot.”

The Dutch company Shapeways established its headquarters in New York in 2010 and developed a brisk business using 3D printers to produce objects for consumers and businesses. The print-on-demand facility in Brooklyn takes orders every month for thousands of customizable products, from trinkets to furnishings, although factory-level jobs will be limited because of the company’s use of far-flung partners to produce a number of their products. At the same time, company officials say they have adequate room to expand opera-

tions at their headquarters in Long Island City and expect to remain based in New York.

Determining the exact number of 3D printing jobs in New York City is impossible. Government agencies, like the U.S. Department of Labor, do not track the sector; jobs in 3D printing are included within a wide range of other jobs categories. Overall, the sector includes hundreds of jobs in New York City. “Those are jobs that didn’t exist just a few years ago,” says Euan Robertson, chief operating officer of the New York City Economic Development Corporation (NYCEDC). Although some jobs are within small- and medium-sized companies, many others are independent makers. They are, in essence, the freelancer class for 3D printing.

Investment money gives a good indication of the overall sector. Bryan Dow of Moreland Partners estimates that 3D printing companies raised just \$300 million between 1987 and 2010 in the United States; from 2011 to January 2015, 3D printing companies raised close to \$4 billion in all kinds of investment. New York firms, say Zack Schildhorn and other venture capitalists, are receiving a large share of the money.

Makers of all stripes

New York’s 3D printing industry came to prominence with MakerBot and Shapeways. Since the early 2010s, numerous other companies have opened shop in the city to provide 3D printing services.

The most prominent may be Voodoo Manufacturing, which manages a fleet of 125 machines via a proprietary computer system. The East Williamsburg-based company uses MakerBot machines and materials, which connect to a network of 3D printers. The software system also allows small companies to send orders from their websites to the Voodoo network, creating a seamless consumer experience. Voodoo has a number

of corporate clients and has produced everything from build-it-yourself robots to an adrenaline-sensing dress for New York Fashion Week. Voodoo has also connected with entrepreneurs on Etsy, a global marketplace of artisans and designers, to produce 3D printed products on demand.

Voodoo was founded in October 2015 by four MakerBot alumni with a simple idea: become the leading 3D printing manufacturer for consumers and small businesses. Even though 3D printers are now affordable for a wider market, many would-be users cannot justify spending even \$1,000 for one-off or spec projects. Voodoo was envisioned as the the FedEx Office of 3D printing—a “service bureau” that allows virtually anyone to experiment with the technology. The company, which now employs eight workers, expects to have a staff of 20 to 25 next year.

Jonathan Schwartz, one of the company’s cofounders, says Voodoo was determined to follow the market rather than create one. “Some companies bet on a product, but that’s the worst way,” he says. Voodoo’s approach is to make the technology accessible to a much wider audience, using networked machines to allow quick product turnaround. Voodoo’s biggest orders are for marketing and promotional items, functional end-use parts, prototypes and scale models, and film and TV content merchandizing for companies such as Mattel and Universal Studios. Most of the company’s business comes from one-off, high-volume orders.

“Our aim is to be a provider of small-batch manufacturing services, and we see our value being our ability to offer fast, affordable, full-service solutions to making physical products in sub-10,000 quantities,” says Schwartz. In addition, Voodoo is gathering massive data on its customers’ needs, helping the business evolve to meet shifts in demand.

Voodoo now has competition in the print-on-demand space. The Brooklyn-based company Matter invites makers to “turn your next big idea into a small-batch” without leaving the computer. The company employs eleven people, with plans for growth. Founded by Greg Tao and Dylan Reid and backed by former MIT Media Lab director Frank Moss, the company allows customers to come up with new designs or simply alter the designs of existing products.

The large-format printing company gCreate aims, according to founders Anna Lee and Gordon LaPlante,

Top global hubs for 3D printing

New York: 524 printers
Los Angeles: 420 printers
London: 363 printers
Paris: 313 printers
Milan: 309 printers

Source: 3D Hubs Printing Trends July 2016

“New York has a deeper pool of workers with experience in 3D printing than any other city in the world.”

to become the “premier one-stop source for 3D printing and fabrication,” with machines that can be customized by users to serve different needs. The company plans to expand from three employees to fifteen to twenty within the next year.

Adafruit, a \$33 million business that employs 85 people, supplies do-it-yourself electronics kits to children and hobbyists, with a special mission to get girls involved in science, technology, engineering, and math. The company’s SoHo factory makes use of 3D printers and supplies 3D printing tools to people interested in experimenting with the technology. Unlike companies with proprietary processes, Adafruit’s adoption of open-source technology offers makers the opportunity to learn about 3D printing, electronics, and manufacturing in its 16,000-square-foot facility. Limor Fried started the company in her apartment near MIT, where she was a graduate student, and later moved to New York to grow her business. Adafruit was named the fastest growing private company in New York by *Inc.* magazine in 2014.

Three-D printing is disrupting whole product lines, from insoles to jewelry to home appliances.

Traditional product lines are undergoing dramatic changes with the advent of 3D printing. With 3D printers, companies can produce small batches of products that once required large-scale manufacturing. They can also customize their products and rush orders to customers. Most important, experts say, 3D printing allows the production of shapes and materials that have never been possible with traditional manufacturing. This transformation allows for the creation of whole new products and the enhancement of old product designs.

A Hudson Yards-based company called Sols, for example, produces custom orthopedic insoles using 3D printing. The insoles, with prices starting at \$99—a fraction of the traditional cost—are being promoted by

a cadre of 1,200 medical professionals. The company plans to systematically expand its product offerings as it masters the 3D printing technology. By the end of 2016, founder and CEO Kegan Schouwenberg expects to ship 10,000 products per month. The company employs 56 people, having raised more than \$20 million from investors as of early 2016. The company expects to move into a larger production facility in the near future and is considering sites in Brooklyn, including the old Pfizer building.

Sols was created to solve a longstanding problem—offering custom products to improve active people’s footwear and to help people with physical problems with their feet. “When I started Sols, I was like, let’s find a problem and then let’s solve that problem,” says Schouwenberg. “For me, I had bad feet growing up. I used orthotics. The process is expensive and takes weeks. For \$600 you get a plastic cast on your foot. It’s old fashioned and inaccurate, a mom-and-pop, fragmented industry. So it’s a situation where you replace outdated technology with new technology that’s better, faster, cheaper, more accurate.”

American Pearl, operating in the diamond district since the 1950s, now uses 3D printing to customize rings, earrings, and pendants. The company’s 3D printer creates a mold, which is used to cast jewelry in gold, silver, or platinum. The process takes hours instead of weeks and cuts costs as much as one-quarter. Sales doubled after the introduction of the technology.

Another New York start-up, Normal Ears, also recognized the potential of 3D printing to customize existing products. Founded by Nikki Kaufman in 2013, the Chelsea-based company uses smartphone-generated images of customers’ ears to 3D print earphones that fit snugly while in motion. Custom-fitted earphones manufactured through traditional processes could cost hundreds of dollars and take weeks to produce; Normal charges \$199 and delivers within days.

“The route to growth lies in using the technology to offer extraordinary new value—either producing objects faster or better, providing new levels of customization, or manufacturing objects that cannot be produced any other way.”

The company adjusted its business model after selling 30,000 sets. “Now that we have experience with 30,000 ears, we see that most people’s ears fit [one of] seven sizes,” says Ben Kaufman, Nikki’s husband, who now runs the company. “So we mass manufacture those and have them in inventory. Then we 3D print earphones for people whose ears do not fall into those seven sizes.” With its simpler process, company is on schedule to match its 2015 revenues of \$2.5 million. Meanwhile, Normal continues to develop new products. Wireless earbuds, to be released in the fall of 2016, have generated \$500,000 in preorders.

With its 3D printers needed only for ears that do not match standard sizes, the company is shifting its focus. Under a new entity called the Auxiliary Creative Fund, other makers will be able to use Normal’s 12,000-square-foot facility for a daily fee of \$100 to \$200 plus the cost of materials.

“There is so much creative talent and we want to connect it. People have a million ideas—inflatable toys, new kinds of batteries, you name it. We want to give them a space to do it. Where in New York City can you make stuff? We’re going to pair them with someone who knows how to run the machines. Too often people learn how to use a machine and then spin their wheels getting started. We have two guys who know the machinery and can make it happen for people off the street.”

Other companies have decided to make 3D printing just one part of their manufacturing processes. Utley’s, a Woodside-based prototyping shop whose clients include Estée Lauder, Avon, and Victoria’s Secret, uses a

variety of tools and processes to build beauty products, medical devices, packing materials, store displays, and furniture. Among the processes the company uses is 3D printing. “We use 3D printing,” says owner John Utley, “but we also do things by hand and we use other machines. . . . [3D printing] is one of the tools in the toolbox. You have to know what tools are right and when.”

Some producers in the garment sector have also embraced 3D printing. The Brooklyn Fashion and Design Accelerator uses 3D printers to knit sweaters. The Fashion Institute of Technology teaches students the latest technology in body scanning and 3D printing. And Manufacture New York, a Brooklyn-based fashion incubator, has hired a full-time technology expert to oversee 3D printing and other cutting-edge design and manufacturing techniques for clothing and accessories. The idea, says Amanda Parkes, the organization’s head of R&D, is to foster innovation by combining activities from different fields. At the MIT Media Lab, where Parkes previously worked, she observed the effects of “proximity, where you put a robotics lab and a music lab next to each other. The idea is to combine these different elements and see what happens.”

The possibilities of 3D printing are reshaping high-cost services from design, to architecture, to civil engineering.

Companies that provide a wide range of products and services are beginning to use 3D printing for their equipment and logistics. These companies are leveraging the speed, accuracy, and customization afforded by

3D printing to improve their operations, even though they are not 3D printing companies per se.

Brooklyn-based Aerobo designs and prints its own drones to carry high-end video cameras into the sky, providing aerial footage for TV and film, broadcast news, and industrial inspection. After each job, Aerobo's programmers adjust the drones' designs to account for the conditions of flight. Aerobo plans to expand its drone service to anyone needing crisp images of hard-to-reach places, such as bridges and other infrastructure that requires regular inspection and maintenance. The company continues to invest in new 3D printed drone technology to fuel its growth. The ultimate goal is to "be the largest service provider of drone [video] in the world," says CEO Brian Stroom. "We believe that using proprietary, customized technology will get us there." The company now employs eight people, but Stroom expects to double that within a year or two. He also employs a vast network of drone operators around the country.

D-Shape, a British company, won a competition in 2012 to develop an innovative strategy to repair the city's decaying waterfront pilings. The company's method, dubbed "digital concrete," scans images of the pilings, which could rot if exposed to air, and then uses those images to fabricate casings for the pilings. These "piling jackets" use less than half the material of traditional casings and could cost 30 percent less—with estimated savings of \$2.9 billion, if the company's method were applied to all 565 miles of New York City's shoreline. Michael Simas, the executive vice president of the Partnership for New York City, says such applications of 3D printing could spark a whole new approach to infrastructure and public works, although D-Shape's proposal was not implemented.

A start-up called nTopology writes code for a distinctive lattice structure for 3D printing objects, with applications for everything from athletic shoes to parts for aerospace and military contractors. Spencer Wright, a cofounder, is overseeing the development of programs for the aerospace and medical industries. "Job shops are designed to print stuff," Wright says. "But what really matters is the design. We're trying to master the design that will get us into the high-level projects."

Doob-3D makes photo-quality 3D replicas. The company's current process transforms a full-body scan into a digital 3D model, which is printed into a statuette

the size of an action figure at the company's Brooklyn factory. But Doob CEO Michael Anderson says the figurines represent just one application of the proprietary scanning technology. Scanning can help create customized medical devices, for example, or high-performance clothing for athletes. The company is also pursuing partnerships with companies to develop supply-chain solutions. Anderson anticipates that the company's technology will play a disruptive role in several other industries, such as apparel, medicine, fitness, toys and video gaming, and advertising and marketing. In March 2016 Doob listed seven jobs on Indeed.com, including five with manufacturing functions.

Microscape spans the consumer and service markets with its scale models of New York. Using its own aerial scans of the city, the company produces programs that instruct 3D printers to create 5000-to-1 scale models. A Kickstarter campaign raised more than \$100,000 from consumers, turning a part-time hobby into a full-time job. Architects William Ngo and Alan Silverman, Microscape's founders, are developing plans to allow customers to buy a custom piece of New York online. They also sell custom models: one woman who moved to California has ordered a model of her New Jersey home to help her son deal with homesickness. But greater value lies in large-scale design and planning projects in New York and beyond.

Body Labs uses 3D body scans, which record all of the shapes and scales of the body down to skin wrinkles, to provide dimensions for clothing manufacturers, shoe makers, military equipment makers, and various other functions. Over the long term, Body Labs wants to create a comprehensive database of body shapes, called BodyKit, as a reference guide for nearly all wearable products. The company's website, BodyHub.com, already allows users to make scans at home using an app designed for Microsoft's Kinect motion controllers.

Prospects for a 3D Big Apple

As the industry matures, emerging applications are likely to reshape industries across New York City's economic spectrum. Investor Alan Meckler explains: "We tend to look at 3D printing as a product, but it's really a service and AI and software are going to spawn hundreds of businesses. Rather than everyone having a machine, companies are going to create products for people—and even more important, other companies

are going to integrate 3D printing into larger production processes. So it won't be 3D printing alone, but 3D printing as part of something else. That's where it's going to make a difference.

"This will create a whole new battery of jobs, people who are expert at this whole new way of manufacturing," says Meckler. "This follows the trail of other disruptive processes. There's no question that these skills and the needs in terms of personnel will evolve. New York has been a hotbed of 3D printing."

The sector's major question is how to produce the most value for a technology still in its nascent stages. Increasingly, experts say 3D printing will not thrive simply by offering technology to print objects that are readily available elsewhere. The route to growth lies in using the technology to offer extraordinary new value—either producing objects faster or better, providing new levels of customization, or manufacturing objects that cannot be produced any other way.

Three-D printing, says Zack Schildhorn of Lux, will disrupt long-established sectors such as household appliances. Lux has invested in a New York-based household products company that uses 3D printing. That start-up, which cannot be named until the deal is finalized, plans to create home goods with qualities—design uniqueness, strength, cost, weight, shape—that will allow a rate of return of 40 percent in a sector that typically sees rates of 1 to 2 percent. Not only is the quality of the goods dramatically greater than that of standard products, Schildhorn says, but the company can justify production runs as small as ten or as large as 10,000.

New York's leadership position, according to some insiders, depends on producing or attracting breakthrough companies analogous to Microsoft, Apple, or Amazon. Kegan Schouwenberg, the founder and CEO of Sols, says the region's leading role ultimately depends on producing dominant companies: "We need wins—companies that are IPOing or selling, creating wealth for entrepreneurs, who are starting new companies with that wealth and putting it back into the ecosystem."

New York's long history as a fashion, media, medical, and shopping city gives it an edge over other cities, Schouwenberg says. VC firms in Silicon Valley focus on blockbuster technology, whereas New York firms focus on physical products. "I don't think the Valley understands physical products like New York. They get

software and hardware companies. Physical consumer product companies, they don't get that. That's what New York does well. We get products. We get what people buy. We're watching every day."

The greatest advantage of 3D printing for New York, says Jack Plunkett of the Houston-based Plunkett Research, is the low barrier to entry.

"This is a business that's about to explode. It's not terribly capital intensive and the price of equipment is falling. It doesn't take a lot of space. It's perfect for just-in-time delivery, which is important to a lot of businesses in the city. If cost is the important factor, I'd rather make it in Tennessee and FedEx it up there. But if time is the key factor, then the ability to localize this technology is phenomenal." Policymakers, Plunkett says, should identify businesses that require instant turnaround on orders and encourage the development of 3D printing technology to serve those firms.

The greatest opportunity for 3D printing in New York may be with medical devices and other high-cost, advanced technologies.

New York's 3D printing sector will not compete in heavy manufacturing sectors such as aerospace or automotive. "Can New York manufacture aircraft engine parts?" asks the NYCEDC's Euan Robertson. "I doubt it."

More likely, suggests James Katz, chief of staff at the NYCEDC, New York will lead the way in forging links between 3D printing and biotech. New York's established medical institutions, alongside new research centers such as the Cornell Tech campus and BioLabs' coworking spaces, offer fertile territory for the development of new 3D printing applications.

At Columbia University and other research centers, 3D printing is paving the way for new methods of treating physical ailments. Medical researchers are devising 3D printed solutions for dental care, limbs and sinews, and even organ replacements. Dr. Jeremy Mao of Columbia is using 3D printing to develop scaffolding for a torn meniscus, the cartilage in the knee. Mao's 3D printed material would create the space for the cartilage to regenerate itself; after the cartilage is repaired, the scaffolding would dissolve. Mao is planning pre-clinical trials for the technique and has set up an independent company to produce the product.

New York research institutions are especially well positioned to develop new 3D printing applications

due to the city's vibrant community of early-stage investors. Strong universities are not enough to bring cutting-edge research to marketable uses, says Mao. To succeed, lab innovations, made possible with funds from the National Institutes of Health (NIH), need private investment to reach the next level. Mao explains, "The NIH does a fantastic job and has been, for decades, supporting fundamental research. What the NIH doesn't do well is [support applications of that research]. I get a nice grant that demonstrates that we can place a scaffold into a sheep and it regenerates the meniscus. If I write another grant and say, 'Hey, this works in sheep and I'd like to try it in patients,' chances are that I wouldn't get that grant because my colleagues will say, 'Actually, this [research money] is to support innovation. You have invented it already. What's new this time around?'"

Only three places—New York, Boston, and the San Francisco Bay Area—have an active enough venture capital (VC) sector needed to support high-level invention, such as the medical applications of 3D printing. Investors insist on being close to where the applications are being tested, to offer advice, make connections, and track progress.

In addition to the support VC firms offer, cutting-edge 3D printing businesses also benefit from New York City's growing tech and hacker networks. OpenBCI, for example, produces 3D printed devices that can track brainwaves and vital signs such as muscle and heart activity. Joel Murphy, the founder of OpenBCI, freely distributes the software for the equipment, which can be 3D printed by users themselves. "Once you have your device sized to your head, it's very easy to start measuring your brainwaves," says Murphy. The company's revenue comes from a mix of hardware sales and consulting services.

Keeping New York competitive as 3D printing grows

Despite the MakerBot setback, analysts say that New York maintains a premier position in the industry for a number of reasons. Perhaps most important, New York has a deeper pool of workers with experience in 3D printing than virtually any other city in the world, in large part because two of the early pioneers in the field—MakerBot and Shapeways—based their operations in New York. As these and other companies grew, they hired and trained workers, many of whom have since gone on to

work at other 3D printing firms—or, in many cases, to create new start-ups. New York also stands out among 3D printing hubs because of its rich network of investors, growing tech sector, and the intersection of other creative and scientific fields including education, medicine, media, jewelry, garments, and food, all of which can use 3D printing to improve traditional processes.

Taken together, all of these assets leave New York with what is arguably the nation's strongest 3D printing ecosystem, which gives the city an important edge for future growth.

The industry is still young. Across the United States and around the world, cities and regions are positioning themselves to capture 3D printing activity. Patrick McGibbon, vice president for strategic analytics at the Association for Manufacturing Technology (AMT), says other locations—including California, Ohio, Indiana, and Florida—have also established foundations for 3D printing. The industry remains at a nascent stage, he says. Companies like MakerBot "have stumbled and picked themselves up. They're taking the brunt of being first on the frontier. There's both a positive and a negative side to being first in the market."

"New York City has had for a long time an excess of people with design talent. Other cities do, too, but it is one of our competitive strengths," says Robertson. "And 3D printing is a new set of tools to which you can apply those talents."

Ultimately, says McGibbon of AMT, the industry will succeed where companies integrate 3D printing into large-scale manufacturing or where whole new products and applications are introduced. The central challenge, he says, is training a new generation of engineers to apply their engineering skills to 3D printed materials and processes.

"The challenge is the people," McGibbon says. "Almost all the [mechanical engineers] who have gone through schools in the last ten years have been taught to do the engineering and build process with parts that were made with casting and subtractive manufacturing. . . They run into difficulties, spending hundreds of hours using traditional process, or can't do it at all, whereas additive would make it faster and easier to do. One of the limitations is how fast can we get engineers who design parts to think about the possibility of [3D printing]. Most of the people I've met who are really good at this programming have been taught on the job."

FABRICATION: BUILDING WITH WOOD AND METAL

From museum exhibitions to gut-renovated brownstones, fabricators fuse age-old techniques and new technology to build complex environments from wood and metal.

Fabrication of wood and metal is growing in New York City, fueled by demand for high-end interiors, finishes, and furniture in building projects of all sizes. The construction cranes and scaffolding visible on nearly every block attest to the constant transformation of New York's streetscape. But it's the interiors of these structures that are creating work for New York's skilled fabricators. Amid the city's largest construction boom ever—with projects ranging from infill buildings in Greenwich Village to massive development in Hudson Yards—these wood and metal manufacturers are busier than ever, building everything from modular office spaces and high-end window displays to spiral staircases and chandeliers. Projects including Google's 2.9 million-square-foot building in Manhattan, thriving TV production facilities in Brooklyn, and the constant churn of trade shows and cultural activities all create demand for wood and metal fabrication.

Fabricated metal and wood product manufacturing is the third largest manufacturing sector in the five boroughs. With roughly 7,000 jobs citywide, the sector is behind only food manufacturing and apparel manufacturing in overall employment. It is also one of a small number of production sectors that has added jobs in recent years. Over the past four years, employment in the sector increased by 6 percent, from 6,570 jobs in 2011 to 6,980 in 2015. The actual employment total is likely much higher since those numbers do not include some forms of fabrication—like the production of steel scaffolding for building sites—that fall under the category of construction in government statistics.

“New York is a booming place [for fabricators] and I see it continuing for the next three years, at least,” says Barry Leistner, president and CEO of Koenig Iron-

| Fabricated Metal and Wood Product Manufacturing Employment in NYC, 2011–2015 | |
|--|-------|
| 2011 | 6,570 |
| 2012 | 6,940 |
| 2013 | 7,101 |
| 2014 | 7,176 |
| 2015 | 6,980 |

Source: New York State Labor Department, Quarterly Census of Employment and Wages.

works. “You never know, but the industry looks strong right now. There's lots of construction and we've got to ride it as far as it will take us.”

According to estimates from Hoover's, the business data provider, 147 companies in New York were created in the metal fabrication sector from 2010 to 2015. Of those, four had 40 or more employees, six had 20 to 39 employees, and eight had between 10 and 16 employees. The rest had under ten employees. These companies did a wide range of work, including many with a focus on high-end clients: fabricating metal sculptures for museums and galleries, building customized bars and furniture for restaurants, manufacturing lighting fixtures for the lobbies of new buildings, and making furniture for boutiques, offices, and homes. In that same span, 89 companies were created in wood production.

Two of these recent companies, AGL Industries (metalworking) and Core Home Inc. (woodworking), employed 50 or more people. The rest employed fewer than ten people. These companies provide a wide

range of services, including display furniture for shops and markets, mobile classrooms, hardwood flooring, custom tables and chairs, millwork, and various consumer products.

New York has even attracted fabrication businesses from outside the city. For example, the Egg Collective, a high-end furniture design and production company in Brooklyn, set up shop in New York because of the availability of coworking space with access to machinery. “That and the proximity to the market and other people interested in design brought us here,” says Crystal Ellis, one of three co-owners who met at Washington University. The company considered three other cities before locating in New York. Nine people now work at its shop in Industry City, where it moved in 2015.

By providing custom work on tight deadlines, fabricators make themselves indispensable, developing a broad range of skills and techniques that can evolve over time, says Leah Archibald, executive director of Evergreen, a local development corporation that works with manufacturers in north Brooklyn. “They’re doing custom doors for a restaurant or a home renovation or custom cabinetry for a museum or a high-end home. It’s not like they’re looking for a niche and if they could only bottle a sauce there would be tons more of it. Their niche is the ability to construct, with specific details from an architect or designer, stuff that goes in buildings. They’re not, like, ‘instead of making this one-off door, we’re going to make a million doors.’ Their benefit is being able to respond to what the market wants at a particular time.

“Because New York is this center of design and creativity, many of our small manufacturers are making things that are being installed in facilities all over the world. . . . Once designers and architects get comfortable with a fabricator, they become a pipeline.”

From raw materials to high-skilled specialists

New York’s metalworking and woodworking businesses range from small shops doing custom interiors for high-end clients to major suppliers in the construction industry.

Remains, a luxury lighting manufacturer based in Manhattan, produces lines of commercially available fixtures, but its big business is in custom reproduction work. Such high-level products are in demand far beyond the local economy. “The chandelier they make here goes into a hotel in Miami and in London, but it’s getting fabricated here,” says Leah Archibald. “The design talent is right here. The jobs are here. That’s good for New York.”

Woodworking companies create custom cabinetry for private homes, build furniture and display cases for museums and office buildings, and restore or replicate historic pieces from mantels to stairways. Metalwork includes the large-scale production of steel beams, building reinforcements, transmission towers, storage containers, industrial furniture, ornamental fencing, doors and grills, construction materials, tools, and novelties, as well as a wide variety of custom designs driven by demand from high-end construction projects.

Wood and metal fabrication—especially for niche markets—remain robust sectors, with projections of strong growth. These businesses face some of the same

| New Woodworking Companies | |
|-----------------------------------|----|
| Artisanal materials and furniture | 5 |
| Building materials | 6 |
| Consumer goods | 25 |
| Millwork and services | 53 |
| Larger structures | 3 |

| New Metal Fabrication Companies | |
|---------------------------------|----|
| Artisanal work | 8 |
| Consumer products | 56 |
| Large structures | 7 |
| Parts and tools | 26 |
| Raw materials | 25 |
| Services | 24 |

Source: Hoover’s, 2016

“New York is this center of design and creativity. Many of our small manufacturers are making things that are being installed all over the world.”

problems as other manufacturers, including finding viable leases for production facilities, negotiating a congested transportation network, scaling businesses, and coping with a costly tax and regulatory environment.

Growth in the woodworking and metalworking sectors is bolstered by two major developments—the increase in construction activity and the demand for custom products for affluent homes, restaurants, and businesses. “A lot depends on Wall Street, and how much money they have for art and redevelopment and custom interior work,” says Andrew Hunt of ATH Studios, a metal fabricator in Brooklyn.

Barry Leistner of Koenig Iron Works says the company “is busier than we have been since we were started in 1907.” The company has increased its workforce from 50 to 90 in the last few years and has made \$1 million in investments in new computerized fabrication equipment. The investments, Koenig’s largest ever, were essential for the company’s growth: “The changes in technology and software have gone up significantly in recent years. We had to do it to keep up.”

The industry can expect to see more growth in future years, says New York State Department of Labor Analyst James Brown, because of the high cost of transporting heavy materials. “Metal fabrication and to a lesser extent woodworking benefit from being close to the market,” he says. “It’s expensive to bring in products from outside.”

Ferra Designs, which specializes in precision architectural metal fabrication, increased its space from 7,000 to 25,000 square feet in the Brooklyn Navy Yard to handle major new projects and saw revenues increase from \$2.5 million to \$6 million from 2014 to 2015. One job—working on the offices of Time, Inc., in Industry City—accounted for much of the boost. Just as quickly, that work can disappear. The company has cut back its

staff since that job was completed, says Michelle Ferra, the company’s vice president for administration. The swings on the volume of work make it difficult to keep some workers on the job for long periods.

The competitive advantage of some wood and metal companies derives from their ability to iterate designs and products as they build them. Juniper Design, which began operations in Montreal and moved to New York in 2014, creates a line of high-end lamps and lighting systems and also does custom work for major corporate clients. In 2015, the company produced 6,000 units; this year it plans to produce 10,000 units, before scaling up to 20,000 units.

The company’s 5,000-square-foot assembly plant in Industry City now employs twelve people, as well as outside designers and other contractors. Within five years Juniper hopes to double its workforce.

Situ Studio also employs a design/build method to tackle major projects. The company, which previously designed and fabricated the New York Hall of Science’s Design Lab, is now building complex interior workspaces for a major tech company. Situ Studio is experimenting with different schemes by building pieces in its workshop and testing them in the tech company’s offices to see how well they work. “The standard approach is to make a sketch, then a model, and finally a prototype,” says Bradley Samuels, a principal at Situ Studio. “But we start with a prototype and go backward.” Over time, Situ designers are observing how the tech company’s employees respond to the built environment—and will make adjustments to the design in response.

Even though it produces wood and metal products, Situ considers itself a design studio first and foremost. Significantly expanding its workshop in New York would not make sense, Samuels says, because of space

availability and costs. For now the company has decided to fabricate wood and metal prototypes on a limited scale in its Brooklyn Navy Yard space to support its design work.

ATH Studios takes a similar approach in its work with corporate clients and artists. “We’re primarily involved with problem-solving as opposed to working strictly from plans,” says Andrew Hunt, the company’s owner. ATH has done major projects for the new Williamsburg Hotel, Time, Inc., and Industry City, where the company is located. ATH’s Brooklyn location creates new opportunities, he says. “The hotel wanted to make sure we were doing the work here, hiring local workers, not subbing it out.” The company now employs six people but expects to increase to ten by the summer as it begins work on a major new art project.

Urban Aesthetics, a wood and metal fabrication company, does historic preservation work and creates custom furniture and fixtures for high-end customers and businesses. Jobs include bars and tables for restaurants, a mantelpiece for a private residence at the Dakota, and the restoration of sculptures. The company has increased its workforce from twelve to fifteen over the past three years. Michael Smart, the owner, says he doubts the company can grow much faster in the future. New York’s high costs “are a double-edged sword,” he says. “I’ve definitely thought about moving” because of the high cost of rent, utilities, and labor, he says, “but where else can I do this work at this price level? Most people wouldn’t spend thousands of dollars on a chair, much less fixing a chair.”

Like other industries—from cars to computers—manufacturing often means assembly of materials produced by outside companies. Juniper Design, for example, sources its materials from elsewhere but assembles them in its Brooklyn factory. Shant Madjarian, the company’s owner, says the company’s distinctive value comes from the detail work that requires constant attention.

“The ultimate quality product depends on the last person to touch it,” Madjarian says. “For us to deal with customization for clients, we can’t buy things finished. We need to have control over that inventory.

“It’s very important that we become part of the process, understanding how our products work, how they are made, how they feel, the tolerances, the difference between this to this and that part to that part.

When we do the assembly, you can see how it all comes together and that’s very, very important.”

Because the products of wood and metal fabricators are so important to their clients, close collaboration between producers and clients gives local firms a powerful advantage, says Jack Plunkett of Plunkett Research. “It’s all about building the personal relationships,” he says. “They develop a level of trust and they like to be able to stop by the shop once in a while and see what’s going on.”

Wood and metal fabrication companies emphasize the importance of hands-on quality control, especially in the final stages of assembly and finishing. At every stage, the designer, manufacturers, assemblers, and clients collaborate. The ability to work closely with demanding clients plays a critical role in product development and can lead to viable new endeavors. Juniper, for example, spins off some consumer products from its corporate work.

Skills in wood and metal fabrication are always in demand, says Plunkett. “The guys who can run a machine make 80 grand, so that’s real money. And if you lose your job you can always bounce right back, get a job down the street. That’s the kind of thing the city can get behind, to analyze local need and where the just-in-time [products] are needed in the local economy.”

FOOD MANUFACTURING: A TASTE OF DISRUPTION

Artisanal producers are making everything from chocolate to hot sauce in New York kitchens, a movement that is shaping consumer tastes worldwide.

New York City's food sector has exploded in recent years, leading a nationwide shift in consumer tastes. Specialty foods are rapidly outpacing the growth of conventional products, and many of the goods leading the way are made in New York. Local companies are now manufacturing everything from beer and whiskey to high-end pickles, chocolate, hot sauce, coffee, and house-cured meats, driving food manufacturing to replace apparel as the largest manufacturing sector in the city.

Food is the city's only manufacturing sector to record an increase in jobs over the past ten years, with employment growing by 27 percent—from 13,929 jobs in 2005 to 17,682 in 2015. Much of the growth has occurred in the past five years, during which the sector added 3,329 jobs.

New York City's food manufacturing sector is also growing at a faster clip than in nearly every other major city. Of the twenty largest American cities, only two experienced a larger percentage increase in employment between 2005 and 2015 than New York: Phoenix, where food manufacturing jobs increased by 45 percent, and San Jose, which registered a 28 percent jump. New York City's rate of food manufacturing employment growth (27 percent) during the past decade topped cities as varied as Houston (+15 percent), Seattle (+10 percent), Charlotte (+7 percent), San Francisco (-3 percent), Los Angeles (-11 percent), Chicago (-11 percent), and Philadelphia (-31 percent).

Food recently surpassed apparel as the largest manufacturing employer in the city. This is evident throughout the five boroughs. Food now accounts for 28 percent of all manufacturing jobs in Brooklyn, 27 percent in the Bronx, 26 percent in Staten Island, 21 percent in Queens, and 16 percent in Manhattan. Hundreds of new companies are setting up shop in the five

boroughs and many existing companies are growing to meet surging demand.

Our research suggests that the city's food manufacturing sector undoubtedly has the potential for additional growth.

Arguably the food capital of the United States, New York is leading "a global disruption in the food industry," says Shen Tong, one of the leaders of the 1989 Tiananmen Square protests, who now directs Food Future, a New York-based incubator that offers funding, technical assistance, and workspaces to food entrepreneurs. The hunger for high-quality, locally produced food, with a diverse array of minimally processed products, could help wean people from the "Standard American Diet" that has led to both obesity and poor nutrition, according to Tong. "New York is at the center of the American food scene," Tong says. "New York could play a role in the next major pivot for the industry—on a scale nothing short of the Internet revolution."

A number of factors, experts say, are fueling the growth of the food sector in New York—especially small, artisanal products. First, the sheer size of the city's population—New York added more than 1 million residents between 1990 and 2015, growing from 7.22 million to 8.55 million—has boosted demand for food products in general. Second, the incredible growth in high-income earning individuals over the past decade has created an ever-expanding market for locally-made, specialty food and beverage products. In other words, there is now an abundant supply of consumers throughout the city who can afford to pay a premium for everything from artisanal chocolate to freshly cured meats. Third, the city's ethnic and cultural diversity not only increases the demand for exotic foods, but also feeds the process of creation. Fourth, the city's vast creative industries—from art to tech to design—offer

the elements needed for invention of new food products and services.

Of the three manufacturing sectors highlighted in this report, food manufacturing jobs come with the lowest median annual wages (\$34,396). But Nevin Cohen, an expert in urban food policy at CUNY’s School of Public Health, argues that a market for better food can lead to better jobs. “There is a real opportunity to make the sector one that produces better quality jobs and food. We have the population and the dense clusters of restaurants and food retailers and market to support smaller scale production. This can go on for years and years.”

As vibrant as small food manufacturing companies might be, however, New York is not likely to spawn

new companies that mass-produce food. The costs of doing business in the city are too high to allow large-scale manufacturing to thrive. To succeed, New York enterprises must produce products and services that are unique, commanding higher prices than the mass producers charge. “There are a lot of start-ups in New York that get tested in the city and then move on,” says Dom Gervasi, the owner and operator of the Made in Brooklyn Tours. “The best known are Häagen-Dazs ice cream and Arizona iced tea, but really any firm that reaches a certain size fits the description.”

The food industry has always been open to start-ups, says Jack Plunkett of Plunkett Research, a leading business and technology analysis firm. “The industries with the least barriers to entry and the lowest capital

Growth in Food Manufacturing Employment in Nation’s 20 Largest Cities, 2005–2015

| City | 2005 | 2015 | Change | % Change |
|---------------|--------|--------|--------|----------|
| Phoenix | 7,014 | 10,169 | 3,155 | 45.0% |
| San Jose | 2,797 | 3,572 | 775 | 27.7% |
| NYC | 13,936 | 17,683 | 3,747 | 26.9% |
| Indianapolis | 2,850 | 3,499 | 649 | 22.8% |
| Austin | 1,438 | 1,734 | 296 | 20.6% |
| Houston | 7,123 | 8,213 | 1,090 | 15.3% |
| Seattle | 10,461 | 11,526 | 1,065 | 10.2% |
| San Antonio | 5,175 | 5,663 | 488 | 9.4% |
| El Paso | 1,560 | 1,686 | 126 | 8.1% |
| Charlotte | 3,235 | 3,454 | 219 | 6.8% |
| San Francisco | 2,275 | 2,201 | -74 | -3.3% |
| Denver | 5,190 | 4,937 | -253 | -4.9% |
| Fort Worth | 5,839 | 5,514 | -325 | -5.6% |
| Columbus | 6,758 | 6,020 | -738 | -10.9% |
| Chicago | 35,269 | 31,331 | -3,938 | -11.2% |
| Los Angeles | 43,149 | 38,316 | -4,833 | -11.2% |
| Dallas | 14,744 | 10,698 | -4,046 | -27.4% |
| Jacksonville | 1,990 | 1,405 | -585 | -29.4% |
| Philadelphia | 6,004 | 4,126 | -1,878 | -31.3% |

Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages. Data for each city is based on the corresponding county: Maricopa County (Phoenix), Santa Clara County (San Jose), Marion County (Indianapolis), Travis County (Austin), Harris County (Houston), King County (Seattle), Bexar County (San Antonio), El Paso County (El Paso), Mecklenburg County (Charlotte), San Francisco County (San Francisco), Denver County (Denver), Tarrant County (Fort Worth), Franklin County (Columbus), Cook County (Chicago), Los Angeles County (LA), Dallas County (Dallas), Duval County (Jacksonville), and Philadelphia County (Philadelphia). NYC data is the total for all five boroughs.

expense have always been apparel and food,” he says. “And now the consumer-driven trends are for local fare. The consumer will pay a lot more for things that are locally crafted and have some local meaning. If I can get something unique, with a nutritional advantage, that’s a powerful trend all across the U.S. And it’s even better for New York.”

Pete Chatziplis, a private equity advisor at PriceWaterhouseCooper who studies the American food industry, says New York’s strength in food manufacturing comes from a new attitude toward food, one less oriented toward basic needs and more focused identity. “[Consumers] want to feel special,” he says. Gervasi agrees that the image of New York City’s new food man-

| Food Manufacturing Employment in NYC, 2005–2015 | |
|---|--------|
| 2005 | 13,929 |
| 2006 | 14,223 |
| 2007 | 14,389 |
| 2008 | 14,284 |
| 2009 | 14,016 |
| 2010 | 14,353 |
| 2011 | 14,405 |
| 2012 | 15,400 |
| 2013 | 15,471 |
| 2014 | 16,367 |
| 2015 | 17,682 |

Source: New York State Labor Department, Quarterly Census of Employment and Wages.

ufacturers feeds that desire. It’s no longer enough to just make a product. “Now you have to tell a story,” he says.

Food manufacturing is on the rise

New York City boasts three of the top ten U.S. counties with the most food manufacturing establishments: Brooklyn (No. 3, 401 establishments), Manhattan (No. 7, 277 establishments), and Queens (No. 8, 276 establishments). Los Angeles County leads with 1,063 establishments, the most in the United States.

When U.S. counties are ordered by the number of average employees in food manufacturing, however, New York City counties do not make the top ten. Brook-

lyn leads New York’s boroughs at the No. 25 position on the list with 5,781 employees. Los Angeles County’s 38,473 employees lead the nation. New York City excels at incubating start-ups and other small-scale companies, which often use innovative and efficient machinery that requires fewer employees per establishment. New York City’s food industry also focuses more on artisanal food production than large-scale production, creating higher-margin products at lower volumes.

From 2010 to 2015, across the city, 525 companies started businesses in the food manufacturing sector, according to data supplied by Hoovers. Four of those companies employed as many as 100 workers. Another five employed between 50 and 100, twelve from 20 to 28, and another twelve from 10 to 17. All the rest employed fewer than ten workers.

Meanwhile, the city’s breweries and distilleries have made Brooklyn the epicenter of small-batch drinks. Once the home of mass-market brands like Rheingold and Schaefer, the city now boasts more than a dozen breweries. The city has also launched almost two dozen nonalcoholic drink companies between 2010 and 2015, with thirteen new soft drink, six new noncarbonated beverage, and four water and ice companies.

More start-ups mean more jobs, and New York food-manufacturing companies are growing quickly. A search of the professional networking site LinkedIn in May 2016 yielded more than 25,000 food production jobs in New York City, ranging from tortilla manufacturers, to warehouse workers, to pastry chefs.

Long-term, large-scale growth in the food business, experts say, requires real estate, business consulting, and worker training. Scaling operations—moving from a dozen workers to 50 or 100—requires major investments in people, facilities, and capital improvements.

New York’s changing food world, from legacies to start-ups

New York has always been a major center for food manufacturing. Although the city once mass-produced a wide range of food staples, its distinctive advantage has long centered on ethnic and specialty foods. Those niche producers have been able to survive in the city despite the high costs of operation. To thrive, legacy firms need to achieve economies of scale while standing out as artisanal producers.

Russ & Daughters, a storied Jewish specialty food company, is undergoing its biggest expansion in its 102-year history. In just two years, the company is increasing its workforce from 25 to 120 as it moves its manufacturing facility to the Brooklyn Navy Yard and opens an eatery and retail space at the Jewish Museum. The new manufacturing site will include bakery operations, food production, a nationwide shipping center, catering services, training for company employees, and classes for the public, as well as ground-level retail operations.

As a longtime fixture on the Lower East Side with a loyal customer base among New York’s food and culture mavens, a new generation of family leadership is preparing for careful, long-term growth. “This [company] was started more than 100 years ago by my great grandfather, and we expect to be thriving 100 years from now,” says Niki Russ Federman, who now runs the company with her cousin.

Even legacy companies face a catch-22 with the mass production of goods. If they do not build their consumer brand, adopt higher-margin products, or launch a hip retail outlet, they could find their food manufacturing business in danger.

That’s the dilemma facing Sahadi’s, a 118-year-old family-owned company with two separate businesses—one a Middle Eastern grocery, the other a manufacturer and packager of Middle Eastern foods. The Sahadi family invested about \$10 million from 1999 to 2001 in a new production facility. The facility grosses \$45 million in annual business and now employs 45 workers, ten

more than two years ago. But the company’s narrow profit margins threaten its long-term viability.

“You’re not going to get another Chobani’s, and if you do, it’s going to leave,” says Pat Whelan, who runs Sahadi’s manufacturing operations. “What you’ve seen is a big bleed of the big guys. They can’t survive. We can’t survive. The growth belongs to the \$8 pickle guys.” Given the industry’s high rates of spoilage and notoriously low margins, Whelan sees the best opportunities among very small producers of high-end products. Sahadi’s maintains its production facilities in New York, Whelan says, because of its sunk costs in its facility. But he says moving to New Jersey would dramatically cut the costs of production and distribution and make the company more viable.

Narrow margins on mass production have put Sahadi’s in danger, Whelan says. High production costs and intense competition for mass-market producers combine to squeeze large-scale operators like Sahadi’s. “From a real manufacturing business standpoint, a scalable business, we don’t have a chance. We’re never going to survive here. And every large-scale manufacturer is facing the same thing. I know I have to adapt to a smaller scale, to become a more artisanal manufacturer.”

The success of Brooklyn Brewery suggests that high-end products can sometimes scale up in the city and become global brands. “You can’t just slap a name on it,” cautions Steve Hindy, the company’s cofounder. “You have to make a really great product.” The company is not only exporting its products at record numbers,

| Food Category | Number of Companies |
|--------------------------------|---------------------|
| Baked goods | 18 |
| Baked goods with retail | 273 |
| Coffee, tea, and drink powders | 12 |
| Condiments | 27 |
| Dairy | 6 |
| Dry goods | 24 |
| Fruit and vegetable products | 16 |
| Meat and fish | 13 |
| Miscellany | 25 |
| Prepared products | 35 |
| Sweet treats and snacks | 74 |

Source: Hoover’s, 2016

but also bringing jobs back to the city after years of manufacturing upstate. The company has decided to move its brewery from Utica, where it now makes most of the product, to a new \$70 million, 200,000-square-foot facility on Staten Island's west side, bringing the product much closer to the city's ports. "We came to be here for strategic and marketing reasons," Hindy says. "Being in Staten Island will save lots of money [on] transportation."

The new facility will be able to produce 1 to 1.2 million barrels of beer annually and employ 120 people. The brewery also plans to move its home base from Williamsburg to the Brooklyn Navy Yard, where it has signed a 40-year lease.

Other food and drink manufacturers have started off in Williamsburg before expanding to larger locations in other boroughs. In 2011, inspired by parents who declined to drink hot coffee at a school event for their children, Grady Laird saw an opportunity for bottled cold-brew coffee. Less than five years later, Laird employs twenty people in Williamsburg at the 6,000-square-foot facility manufacturing Grady's Cold Brew. The company is adding four to seven employees as it plans an April move to a 14,000-square-foot facility in Hunts Point in the Bronx. Sales outside the city have increased significantly, accounting for 30 to 40 percent of sales today, says Erin Chung, the company's director of communications and HR.

Most food start-ups remain small. Even when they scale up, they do so deliberately. Ends Meat is a case in point. Although the company is growing to meet demand and is developing additional retail locations, the owner says he plans to limit his company's growth even if it's successful. The year-old company cures Italian-style cold cuts in Brooklyn from locally sourced whole animals. Butcher John Ratliff cures and ages more than 10,000 pounds of salami for periods of up to six months at his facility in Industry City, which doubles as an eatery. Ratliff is planning to open a second retail outlet by the end of the year, expanding his payroll from five to ten employees. Eventually he plans to open four or five stores, employing another 10 to 20 employees, to sell his product directly to consumers.

For a growing number of companies, a social mission is the driver both for producers and customers. Ovenly proudly positions itself as a woman-owned business, producing baked goods with "a touch of

spice" from its kitchen in Greenpoint. In recent years the company has expanded to five new locations and now employs 45 people with full benefits. The company partnered with Getting Out Staying Out and the Ansoh Center for Refugees to develop a successful job training program for at-risk communities.

Massive waste in the bagged lettuce business, a \$4.4 billion industry, inspired Christopher Washington to create the Radicle Farm Company, which sells living lettuces for use in home kitchens. This New York-based start-up operates a greenhouse in New Jersey to grow lettuce plants, which are sold in recyclable trays, roots and all. The plants stay fresh for days, allowing customers to snip and eat as desired. The product aims to reduce the amount of waste in the fresh food industry, which is 28 percent for lettuce, according to industry studies.

Saucy by Nature, a condiment company, shifted its business from manufacturing to catering in 2013 after two years in business. "So many people are falling by the wayside because New York is so expensive," says Przemek Adolf, the company's founder. "New York says it loves small businesses, but it really loves large businesses that look small. The margins are so small. To survive you have to do tremendous volumes, but that requires tremendous resources. The companies that get the investors, like Grady's Cold Brew, are going to survive and grow."

A boom begins

For most New Yorkers, the first signs of an uptick in local food manufacturing came with visits to public food markets like the Brooklyn Flea and Smorgasburg in Brooklyn and the Union Square Greenmarket in Manhattan, where city-based producers showcase their goods.

New York's public markets have not only granted New Yorkers access to fresh and artisanal foods. They have also given food entrepreneurs unprecedented opportunities to gain exposure for their products, although the competition is fierce. "Everyone has a great tomato sauce," says Brian Todd of the Food Institute. "But try getting it on the supermarket shelf. Forget it. Local markets give producers a place to try it out. The problem is that the markets have gotten so competitive. Union Square is probably as competitive as a supermarket."

Finding space to actually produce these foods is a separate challenge. Building a commercial kitchen requires a major upfront investment, and home kitchens cannot be licensed for most wholesale or retail food production. Recognizing this surge in demand, Acumen Capital invested \$26 million in the old Pfizer Building in Brooklyn to create commercial kitchens for start-up manufacturers and the building has become a major hub of food entrepreneurship. Industry City also provides space for manufacturing and sales of local foods.

Food start-ups have been given a boost with the rise of incubators and coworking spaces around the city. The Hot Bread Kitchen incubator in Harlem, Hana Kitchens in Sunset Park, the Entrepreneur Space in Long Island City, and Brooklyn FoodWorks in Bedford-Stuyvesant provide coworking space for sole proprietors and small food companies, but space is limited.

An incubator in Long Island City shows the vast potential of coworking spaces and technical assistance—as well as the need to grow slowly but steadily in a volatile marketplace. The Organic Food Incubator provides space for 40 companies, which employ close to 100 people. Brian Schwartz, the founder of the incubator and operator of the company BAO Food and Drink, has received a city grant to help move to a bigger space.

When he started the incubator five years ago, Schwartz says, the food community in New York did not easily share business tips or connections. But the rise of small-scale manufacturers has changed the culture. “There is just such a groundswell of these small businesses, and people love to talk,” he says. “You call me up and immediately I’ll babble for an hour. You know people love to tell their stories.”

But if start-ups get more help than ever before, they also face more severe obstacles in scaling up, including expensive real estate, limited labor availability and high costs, and high-risk investments in capital equipment. New York’s challenge, then, is to determine what kinds of policies enable companies to grow and stay in the city.

The future of food

The success of New York’s growing food sector can be seen in every neighborhood of the city, from outdoor markets like Smorgasburg and the Union Square Greenmarket to incubators and coworking spaces, bus-

ting locavore restaurants, and even the home delivery of curated ingredients.

But start-up success does not assure growth over the long run. Most new companies begin with a creative idea but lack the sophisticated strategies and resources needed to expand operations. To take food manufacturing to the next level, says Brian Todd of the Food Institute, small companies need to develop smart approaches to manufacturing and marketing.

“There’s a lot of food manufacturers but no business model,” Todd says. “Most producers start out on a very small scale, they make some delicious yogurt or they make cookies and they sell it at a farmers’ market and all of a sudden there’s demand. But at a certain point, there needs to be an infrastructure for that business to take it to the next level. You can’t produce in your kitchen or even a shared incubator space. You reach a point where you need staff and space. You have to go from crawling to running in one move.”

Expansion of food companies beyond local markets, Todd warns, will rarely be viable. High production costs and clogged transportation networks make scaling up in New York a difficult proposition. “A lot of these companies can operate within the New York [regional] market. I think that’s sustainable. But if they try to expand too far from New York City, there would be many issues with that. The demand for a workforce, the logistics, and the low margins all make it hard to go too far.”

Expanding a food business carries a number of higher costs, including greater scrutiny by regulators. With the 2011 Food Safety Modernization Act (FSMA), the biggest overhaul of federal laws in seven decades, companies bear a heavier burden for insuring the safety of their products. As companies increase in size, they are subject to stricter regulations for “traceability.” Although companies in other parts of the United States also face these hurdles, New York companies will be especially affected, as these additional costs come on top of the city’s already burdensome, low-margin manufacturing environment.

As in other sectors, the most significant problem lies in real estate costs. Even if food poses low barriers to entry, it poses difficult choices when a company has to make investments in the hundreds of thousands of dollars and rent a facility at \$25 per square foot.

BARRIERS TO MANUFACTURING GROWTH

Manufacturing is growing again after decades of decline, but New York City companies face major obstacles in the struggle to scale up.

The new wave of manufacturing poses one overarching dilemma: Can New York companies scale up to employ dozens or even hundreds of workers? Both small-scale manufacturers and some legacy firms that employ dozens of workers have their doubts. But the city's culture of innovation offers cause for hope.

The dilemma turns on two questions. First, can New York tamp down the costs of manufacturing sites? Second, can New York offer other advantages—such as efficiencies from close proximity of talent, markets, and ports, and the creativity born of diversity—that cancel out higher costs for real estate and labor? If New York cannot offer an environment for scaling up, the alternative is to serve as a discovery zone that fosters innovation and incubates start-ups, while accepting that firms will leave the city in order to expand production capacity.

The biggest challenge, manufacturers say, is that scaling requires a “great leap forward,” incurring a host of new costs simultaneously. This leap might bring high reward, but it's also risky. Mike Schwartz of the Organic Food Incubator has been considering making new investments to automate production and packaging. But he hesitates due to doubts about finding enough workers with the right experience. Other manufacturers echo the concern.

Because of difficulties finding adequate industrial facilities and workers for scaled-up production, company owners say they are reluctant to invest in expensive new equipment. Even when they can access the capital required to get new machines, they hesitate because they do not know whether they will have a reliable workforce to run the machines.

Different companies hit the wall at different stages of growth. For some companies, expanding beyond a dozen workers poses major challenges; for others, the number is more like 50 or 100. Most company execu-

tives say the biggest problem arrives when the staff approaches 50 workers. That number triggers greater expenses for health care, insurance, and workers' compensation. John Utley, the owner of prototyping shop Utley's, currently employs 45 workers at his Queens facility but does not expect to hire more than a few more. “The government doesn't encourage you to hire more than 50 workers,” he says. “As soon as you have 50, you have to deal with all kinds of regulations for health care, family and medical leave. That makes it hard to go any bigger. [You] have to grow way beyond that to make it worthwhile.”

Bigger workforces also require more attention to training, logistics, and management. Manufacturers of big products—in wood and metal fabrication, for example—also require round-the-clock production and delivery truck traffic that often causes a backlash in neighborhoods, a problem that only increases as manufacturers scale up.

Jeff Smith, COO of Sols, says the company is looking for production space in Brooklyn for its next stage of growth. But if the company succeeds—and requires a bigger facility—it will look outside the city. “What happens after that?” Smith asks. “I can't say we're going to stay here forever. But if we ever leave, we'll leave behind all kinds of tech people, entrepreneurs who will take on the next generation of manufacturing.”

Complicating the whole process is uncertainty about the economy's boom-bust cycles. Over the past four decades, these cycles have tended to repeat every few years. The current boom, which began in the wake of the Great Recession, is now seven years old, and many economists anticipate another downturn before the end of the decade.

Because of the inherent risks of operating in a high-cost area, even successful start-ups struggle to get the resources they need to scale their operations. Even

when government agencies offer subsidies, tax breaks, and other targeted benefits, many small companies do not have the time or resources to pursue them. Company owners who have focused on production processes, branding, and distribution, says Kinda Younes of ITAC, often lack savvy at dealing with government agencies, financial institutions, and consulting companies. “You have to apply,” Younes says. “You have to figure out a way to get the resources. You need the technology. Otherwise these companies are not going to make it because the costs are just too high in New York.”

New York’s years as a global center of mass production are over. Companies can find cheaper production centers elsewhere, with easier access to transportation networks. Even low-wage factories, such as the Cumberland Packing Company—the manufacturer of Sweet’N Low sugar substitute—cannot afford New York’s high costs. The company recently announced plans to leave the city by the end of 2016.

“Our version of manufacturing is different from our fathers’ and grandfathers’ versions,” says Brian Coleman of GMDC. “People think of the Brooklyn Navy Yard when 2,000 people were leaving a big plant at the end of the day. Our producers are small, they do custom work, they focus on value-added, create a high-end product, and serve the local market.”

Real estate

Manufacturing space in the five boroughs comes in short supply, at high costs, and with little security of tenure. The cost of industrial space in the boroughs outside of Manhattan, per square foot, has increased from \$11.50 in 2011 to \$14.25, according to CoStar, a New York real-estate data company. In 2016, according to Jeffrey Marshall, a broker at Kaplon Belo Affiliates, manufacturing space rents for \$17 to \$18 per square foot. “I have buildings asking \$25 a foot and they’ll probably get \$20 or \$21,” he says.

Owners of industrial space can get as much as three times the rent from offices, residences, and retail as they can get from manufacturers. Manufacturers in all sectors have experienced escalating rents and, even more unnerving, uncertain leases.

The city has lost millions of square feet of manufacturing space to competing demands. The loosening of zoning controls over industrial zones during the past

two decades has led to a shortage of industrial space today.

In 2005, Mayor Michael Bloomberg attempted to address the problem when he created 16 Industrial Business Zones (IBZs) and one-time-only tax credits for businesses to relocate into them. Still, pressures against industrial activities remain strong. Even in IBZs, development pressures drive up real-estate prices. Many manufacturers struggle to operate in these zones because of inadequate trucking capacity. When non-manufacturing activities move into industrial zones, round-the-clock production and trucking raises the ire of residents. With few areas focused solely on manufacturing, the city’s potential to produce products at large scales diminishes.

An additional pressure comes from the growing movement to simplify and declutter. All along the Brooklyn-Queens Expressway, self-storage units consume millions of square feet of space in old industrial buildings. Some 2 to 3 million square feet of storage units are now in the development pipeline, according to Marc Nakleh, a senior director of real estate services at Cushman & Wakefield. Rents for these units have climbed 18.2 percent since 2012, according to Reis Inc., a commercial real estate data company. The monthly rent for a 10-by-10 unit was \$301.20 in the first quarter of 2016.

Bob Mason, who runs a Brooklyn furniture company, says he would like to expand operations—and that the market would support more production in New York—but space and costs hold him back. “People do it, but they don’t do it in New York City, they do it in Cleveland or Omaha, places where space is cheap,” he says. “You can start in a garage and expand [to] 10,000 square feet. Here, everything feels like you’re on an automatic payment to everybody. We’re going to do \$600,000 or \$700,000 worth of business this year. We did \$540,000 last year. That sounds like a lot, but it’s not.” Even with rising revenues, Mason says, he struggles to break even. Low margins make it difficult to get the resources to expand operations. Mason estimates he would need \$2 million to purchase new equipment and move to a bigger facility.

One trend works in favor of today’s manufacturing companies: A need for less space, at least for many niche, artisanal producers. “That brings lofts and other multi-story buildings back into play,” says Marshall of

Kaplon Belo Affiliates. “They’re not shoving big products down the elevators and they don’t need massive trucks. Let’s face it, 53-foot trucks don’t work well in this city.” Still, manufacturers of all sizes face intense competition for space within the sector, as well as creeping pressure from residential, office, and commercial demand.

Training and work preparedness

Employers continue to face difficulties finding the workers they need to operate their production facilities—especially as they scale operations and implement sophisticated computerized equipment that requires workers with critical thinking skills.

The labor problem has two dimensions. First, many workers lack the soft skills—punctuality, following directions, working with other employees, and solving problems—needed to succeed, according to many employers.

New technology has widened the divide. To achieve greater efficiencies and produce for high-end markets, companies need skilled workers to run cutting-edge equipment. “Everything will be tied to people that can run the machines,” says Amanda Parkes of Manufacture New York. “I’ve been to too many organizations where they have all these machines but don’t have people who know how to run them.”

Today’s manufacturing jobs, says Brian Coleman of the GMDC, require more educated workers. “That’s good but it’s bad, too,” he says. “In the old days the guy who finished high school could get a job at a factory, like Eagle or Bulova Watch. Having a good strong back, you could get a job that paid middle-class wages. Now having a good strong back can get you a job in just 20 percent of businesses.” Although job quality and retention may improve as a result, major investments in training will be required to cultivate the workforce that current manufacturing jobs require.

If New York manufacturers can train their workers well, leverage the city’s workforce development system, and invest in the right capital equipment, says Jack Plunkett, these business will create a unique opportunity for stable jobs accessible to thousands of workers. “If George in the Bronx can get a full-time job in a start-up candy factory instead of trying to hold down three part-time jobs, that’s real advancement,” he says.

“Maybe he could learn enough to climb the ladder and even start a business of his own.”

Management and logistics

To make big investments and scale up operations, companies need to develop new management and production processes. But expertise on large-scale manufacturing—including optimization of everything from purchasing to shop floor operations to distribution—is often hard to find at affordable prices.

The big challenge for growing companies, says Kinda Younes of ITAC, is “you’ve got to ‘rightsize’ the organization.” The layout of facilities, the process of making and assembling materials, loading merchandise onto trucks, and managing suppliers and customers all pose different challenges in operations both large and small. Benefits that come from buying materials at scale can be canceled out by higher costs of storage and the burden of unsold inventory. To manage these challenges, most growing companies need help.

Companies in all sectors lose as much as 30 percent of their inventory to inefficient company operations, according to research by Zeynep Ton of the Massachusetts Institute of Technology and other scholars. For low-margin companies that go into debt to expand operations, even minor inefficiencies can spell the difference between success and failure.

Businesses need to embrace technology like never before, says Younes. But to do so, they need company strategists and managers need to learn more about computerized equipment, 3D printing, robotics, and materials breakthroughs. “A lot of companies that are small and family-owned have been doing things for generations the same way,” Younes says. “They’re now finding it more difficult to compete with companies that are leaner, that can be more efficient because of new technologies. We need to be making them aware of the new opportunities.”

RECOMMENDATIONS

Ten ways to support New York City's new wave of manufacturing

The new wave of manufacturing in New York City looks very different than its predecessors. Old-style manufacturing produced goods in mass quantities for sale at low prices. But technology and globalization have pushed mass production out of the city. In its place, a smaller and more inventive manufacturing scene is growing, creating a dizzying variety of products in smaller batches for more discerning consumers.

The initial successes of manufacturing's new wave hold promise not just for creating thousands of new jobs, but also for incubating companies that take advantage of New York's growing diversity, exceptional creative industries, boutique financiers, and strategic location. To support and expand the new manufacturing, policymakers should focus on the demands of the twenty-first century rather than attempt to recover a lost age.

Refocus New York City's industrial strategy on the kinds of manufacturers poised to grow here.

If the future of manufacturing in New York City lies in small-scale companies making niche products, then city and state economic development officials should refocus its industrial toolkit to target these kinds of businesses. For example, the average manufacturing company in the city today has 13.1 employees, down from 17.4 employees in 2000. In Brooklyn, the average manufacturer has twelve workers. Unfortunately, city and state industrial programs are not always aimed at businesses of these sizes. Although city and state economic development agencies both have important programs to support local manufacturers, more could be done to reorient their industrial strategies to support small makers and manufacturers.

Revise the state's Excelsior Jobs Program to support small manufacturers.

In 2010, New York State replaced the much-maligned Empire Zone tax incentive program with the Excelsior Jobs Program, which is more focused on supporting high-growth companies in

manufacturing, tech, biotech, and clean-tech. Although the switch made sense in most respects, the Excelsior program has one huge downside: its requirements put city manufacturers at a big disadvantage.

Unlike the Empire Zones program, Excelsior requires participating manufacturing companies to create ten new jobs to qualify for tax credits. But most new manufacturing companies in the city cannot project that many new jobs at once. Even established manufacturers would struggle to qualify for the program. Excelsior's quarterly report for September 2015, for example, shows 753 companies that qualify for Excelsior benefits; only 133 are from the city, and of those only 30 are manufacturing companies.

Develop a scale-up strategy for city manufacturers.

In recent years, scores of new makers and manufacturers set up shop in the five boroughs. Today, there is a tremendous opportunity to help some of these entrepreneurial businesses, many of which have fewer than ten employees, to expand to a level where they have 15, 25, or even 50 employees. Growing beyond the start-up stage will not only increase the overall number of jobs, it will widen the opportunities for middle-income positions that are accessible to workers from low-income backgrounds.

A scale-up strategy should include new and expanded programs to help small manufacturers export their products to new markets, including cities in the United States with similar population dynamics to New York, as well as markets overseas. A support program could also target makers who primarily sell their products at food markets and street fairs by providing technical assistance and financing support to help them open permanent facilities or simply scale up their operations.

Pair local manufacturers with New York-based industrial designers and engineers.

The nation's largest manufacturers typically have in-house industrial design and operations teams that

help streamline and improve their production and distribution processes. But few of New York City's small manufacturers take advantage of industrial designers and engineers in this way. Given that so many manufacturers in the city operate on razor-thin profit margins and face increasingly intense competition, overlooking the opportunity to tap existing resources is a missed opportunity. These companies could greatly benefit from design-focused efforts to improve efficiency and productivity.

City economic development officials should consider launching a new program that pairs local manufacturers with New York-based industrial designers and engineers. Such a program would take advantage of the city's large and growing population of designers, and could be developed in partnership with the local chapter of the Industrial Design Society of America and design universities such as Pratt, School of Vision Arts, Parsons School of Design, Fashion Institute of Technology, and New York Institute of Technology, as well as the industrial engineering departments at Columbia University and New York University.

Invest in intermediaries that help strengthen local manufacturers.

In addition to design and engineering services, low-margin manufacturers could greatly benefit from technical assistance in areas such as technology, management, and logistics. The city already has an organization with this mission: the Industrial and Technology Assistance Corporation (ITAC). ITAC provides below-market consulting assistance to help companies create a growth plan, invest in innovative technologies, find reliable workers, improve the work culture, manage the supply chain for costs and agility, and use financing wisely.

The services ITAC offers are arguably more important than ever, given that the city's manufacturing sector is showing more promise than at any time in decades, but its funding has been cut in recent months. In January 2016, the state announced a 54 percent cut in its contribution to ITAC. After the cuts, the state now provides \$166 per manufacturer in the city, compared with \$800 per company statewide, according to Crain's New York. This disinvestment is a blow to New York's resurgent manufacturers.

Zeynep Ton of the Massachusetts Institute of

Technology argues that most companies are rife with inefficiencies that erode their competitive edge. By op-timizing operations manufacturers can significantly in-crease their margins with little additional investment. To boost manufacturing in the city, the state and city should restore ITAC's funding or create new providers of subsidized consulting to meet the needs of compa-nies with growth potential

Expand and improve job training programs that help New Yorkers develop the advanced skills needed by today's manufacturing firms.

Manufacturing has long provided opportunities for low-income New Yorkers with limited educational credentials or language skills to access decent paying jobs with career ladders. But many of the jobs being added in the sector today, in fields such as 3D printing and metal fabrication, require an advanced level of skills that many New Yorkers from low-income backgrounds are missing.

To ensure that a diverse mix of New Yorkers can access jobs in the sector—and that the city's manufacturing companies can find the skilled workers they need to grow—city and state economic development should invest in new and expanded workforce development programs. Policymakers should support workforce training programs whose curricula are informed by strong connections to employers in the field and programs that teach both soft skills and technical skills for jobs in specific sectors. In particular, these programs should expand on the intensive training centers established in recent years at industrial campuses such as the Brooklyn Navy Yard, Industry City, Brooklyn Army Terminal, and Liberty View Plaza.

To its credit, the de Blasio administration has already taken some important steps, including the creation of a new Workforce1 Industrial and Transportation Career (ITC) Center at the Brooklyn Army Terminal in Sunset Park. But policymakers should seize opportunities to expand these training initiatives and create similar workforce development programs at manufacturing hubs in other boroughs.

Build new career and technical programs that teach advanced manufacturing skills.

New York City should create and support hands-on training programs that prepare young people for careers in advanced manufacturing. Many school districts in upstate New York offer technical educa-

tion programs that train students for these jobs. For instance, a precision machining training program in Sullivan County trains students “to design, create, and machine creations using computers and high tech tools.” Class topics include shop math, precision measurement, blue-print reading, shop safety, bench tool skills, and layout skills. Then students learn how to use factory-level machines, often under the guidance of employees from local manufacturers. They also work in internships or apprenticeships with local companies.

New York City could benefit from programs like these that have strong buy-in from local manufacturers and teach young people in-demand skills that are portable in today’s technology-driven economy. One such program is on the way. The city’s Department of Education (DOE) is working with the Brooklyn Navy Yard to develop a promising model for job training called the STEAM Center. STEAM—Science, Technology, Engineering, Arts, and Math—will offer students from eight city schools hands-on learning and work-based opportunities at the Navy Yard. STEAM is developing advisory groups for six industry sectors: culinary arts, systems technology, computer science, structural engineering, engineering, and media design. The program will also provide after-school programs and professional development for teachers.

Pooling students from several schools into different programs, according to Navy Yard CEO David Ehrenberg, allows “better and more intensive resources” than school-based programs. “A lot of kids will graduate high school with a credential which will allow them to enter the workforce at a totally different level than a standard high school degree or one of the current CTE credential, which is improperly conceived for today’s industry,” says Ehrenberg.

Local educators and economic development officials should continue to support the development of the program at the Navy Yard, measure its outcomes, and consider the potential to replicate the model at other manufacturing campuses in the five boroughs. DOE and the Navy Yard should also commit to keeping open the STEAM center in the evenings, so that adults looking to upgrade their skills can take advantage of the facility’s equipment and teaching opportunities after work.

Expose students to new technologies.

City schools should introduce new technologies to students as early as middle school. Jack Plunkett of Plunkett Research argues: “Policymakers should show people that additive manufacturing can make a real difference. That means boosting education and training—skills like CAD-CAM and hands-on work. If you visit college libraries like Purdue University, they have two, three 3D printers in the library. College kids on well-funded campuses are getting their hands on it, so it’s not intimidating to them. I would make the experience possible all the way down to junior high school.”

To encourage skills development for all ages, the city might consider giving all learners a skills dossier—an electronic record that documents the skills students have demonstrated in classroom and on-the-job work. This dossier, which can be maintained by smartphone and via web-based apps, could help people share their abilities with employers throughout their careers. It could also indicate what new skills people need to learn to advance to new positions. With appropriate privacy filters, the dossier could be connected to the city’s municipal ID card.

City officials should offer platforms for employers to connect existing training programs and dossiers to companies searching for labor. By working with online jobs databases such as Indeed or Monster, the city can ensure that companies and workers find each other.

Clear unnecessary barriers to manufacturing.

New York’s multigenerational web of rules and codes makes navigating the city’s regulatory hurdles a difficult process. The de Blasio administration should establish a citywide commission, with members from all manufacturing sectors, to identify ways to eliminate and streamline unnecessary and duplicative regulations, particularly those that undermine start-ups and the scaling of enterprises both old and new. The commission should identify regulations that impose unnecessary costs and delays and propose specific ways to streamline and simplify processes for building facilities; installing power, water, heat, and other systems; investing in capital equipment; getting products to market; protecting the environment; and safeguarding workers’ health and rights.

The commission should undertake detailed analyses of the value chains for manufacturing businesses to

identify the bottlenecks that undermine competitiveness. The successful effort to modernize New Jersey's housing rehabilitation subcode offers a good model for this difficult work. Over several years, the state's code officials conferred with a wide range of stakeholders to develop simplified guidelines that did not undermine health or safety. The changes opened long-dormant buildings to a wide range of new uses, boosting local businesses and tax rolls.

Use cutting-edge manufacturing processes to upgrade New York's aging infrastructure.

New York City and regional authorities spend billions every year on infrastructure. To strengthen New York manufacturers, public agencies should identify companies that can play roles in updating buildings and infrastructure to meet new standards for resiliency, safety, security, environmental impact, and Internet connectivity.

"Look at the transportation infrastructure," says Michael Simas, executive vice president of the Partnership for New York City. "You can 3D print a piece of

pipe, and that's an opportunity we can do locally. It's an endless task to take care of our city. If we can 3D print a part for an airplane, we can 3D print a part for a transit system. If we can do that in the Navy Yard, we can create lots of jobs. Think of all the infrastructure that can be in play—the MTA, the Port Authority. If we can use drones to paint the George Washington Bridge, that makes maintenance better and safer and could create new kinds of jobs."

New York and regional authorities should maintain a comprehensive database of production and maintenance projects, with detailed specifications and scopes of work. State, city, and regional officials should reach out to New York manufacturers—from 3D printing to engineering and design to metalworking—to determine what roles they can play in this ongoing work. These public entities should also sponsor regular "Rebuilding New York" events to detail the long-term process of updating and retrofitting the city, and identify ways that private property owners and facility managers can use New York manufacturers to maintain and improve their properties.

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