The Impact of Automation and Smart Technology on the Workforce and Economic Growth of the New Jersey Manufacturing Industry: The Food Manufacturing Sector as a Case Study

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The Manufacturing Automation Challenge

Automation linked with high-performance computing is revolutionizing manufacturing. Long a vehicle for cost reduction and quality improvement, automation is one of several elements of what is now termed *advanced manufacturing*, the ongoing adoption of new technology, flexible manufacturing equipment and processes, and high-performance teams to drive advancements in quality, cost, reliability and sustainability of manufactured goods (National Council for Advanced Manufacturing, 2019). The increasing integration of mechanical automation and (IT) technologies has ushered in the fourth industrial revolution, known as *Industry 4.0*, or *smart manufacturing* (SM). This new level of automation, a first wave in the digitalization of advanced manufacturing, is made possible by enhanced robotics, additive composite (3D) assembly, sensor-connected equipment, and cloud-enabled computing. SM will increase productivity rates and create more capable manufacturing environments. As Sniderman, Mahto, and Cotteleer (2016, p. 10) note, SM has applicability across the manufacturing value chain, from "accelerating innovation and design cycles" to "scaling aftermarket operations." Some anticipate that SM will create self-learning, nearly autonomous production systems,

linking supply chains to distribution networks, with in-line capability to design and custom produce new products. It also offers the potential to recruit a new generation of talent to the factory floor.

Grand View Research (2017) forecasts "significant growth" of the global SM market through 2025. End users are concentrated in the following industries: automotive, aerospace and defense, oil and gas, industrial equipment, food and agriculture, electronics, chemicals and materials, and health care. As Cooper, Harris, and Harrison (2017) indicate, "Most leading manufacturers…have already adopted some form of 'Industry 4.0' technologies, capabilities or approaches." Many are reaping returns on their investment. SM's impacts on manufacturing efficiency are evidenced by several recent, topical examples:

- Smart-system monitoring of equipment performance in Harley Davidson's York, Pennsylvania plant;
- Digital simulations of parts for power plants by GE; and
- Customized prosthetics through additive manufacturing at Walter Reed Army Medical Center.

The productivity value alone of SM, still in its infancy, is adding 30% operating efficiencies to retrofitted SM plants in the oil and gas industry (M. Parsons, personal communication, September 2018).

While there is general agreement that SM can benefit a company's bottom line, there is less certainty about the consequences for workers. The Bureau of Labor Statistics projects an overall decline (-4.3%) in U.S. production jobs by 2026, due in part to automation technologies (Potts, 2018). BioNJ (2018) cites technological disruption and other factors for the reduction in New Jersey-based biopharma research and development, and manufacturing jobs. However, a

2016 survey of U.S. manufacturers revealed that "37% believe that the adoption of advanced manufacturing technologies will result in their hiring additional employees" (45% no impact) (PwC & Manufacturing Institute, 2016, p. 2). As a case in point, after transitioning a traditional plant in North Carolina to a smart factory, Toyota increased its overall head count and the IT team more than doubled (Crawford, 2017). Automation can also boost job satisfaction, taking over monotonous and dangerous work, and freeing workers to redirect their time and effort toward problem solving and innovation.

While the total number of U.S. production jobs will likely fall, the "manufacturing sector is projected to offer 990,400 job openings on average every year over the next decade" due to incumbent worker retirements and skill mismatches (Potts, 2018). More than two thirds of manufacturers surveyed by the National Association of Manufacturers (Shapiro, 2018) cited "*the inability to attract skilled workers as their top challenge.*" It is especially difficult to find workers who can add value in SM environments. "Only 13% of manufacturers said they have encountered no difficulty in acquiring talent to exploit advanced manufacturing technology" (PwC & Manufacturing Institute, 2016, p. 4). In New Jersey, job openings for both traditional and advanced manufacturing positions exceed the supply of qualified applicants.

The SM Opportunity: The Upside of Digital

Employers identify the reputation of manufacturing as one of the major barriers to finding talent. According to Indeed.com, only 11% of employed, registered job seekers looked at job postings in "production" (PwC & Manufacturing Institute, 2016). This challenge presents a tremendous opportunity to recast manufacturing as a career of choice for the tech savvy. "SM can be the key to reinvigorating the manufacturing workforce, attracting and nurturing a younger talent pool that historically may not have considered…the manufacturing industry" (McKewen,

2015). Manufacturers can "position themselves as *makers* and present their case for improving the world in some way" (PwC & Manufacturing Institute, 2016). Pittsburgh, for example, draws skilled talent to the region by advertising opportunities to "tackle an industry's greatest challenges" and "achieve breakthroughs in the robotics industry" (Potts, 2018, p. 16). This positioning may be particularly appealing to millennials. When asked what they sought in their first job, over half indicated "their top priority was doing something that they found enjoyable or making a difference in society" (White, 2015).

A high-performance workforce, whether achieved with new hires or employee training, is indispensable to business success. It is clear that SM is changing job requirements and that existing skill sets are not well aligned to future needs. BioNJ (2018, p. 16) contends that retraining for biopharma manufacturing jobs will be "critical for the next decade" and highlights the demand for knowledge in advanced analytics, robotics, and "connected care." ManpowerGroup and UI LABS produced an extensive digital manufacturing roles taxonomy. They found that "all roles require broader understanding of the product life cycle and the digital connection" (Antonucci, Fornasiero, & Kowalski, 2017, p.11). Matthew Sullivan, President of TalentFleX Solutions, participated in a New Jersey Big Data Alliance Workforce Forum and advised that "manufacturing IoT (Internet of Things) environments are increasingly requiring plant managerial professionals to have increased skillsets in Data Analytics to understand real-time the challenges and opportunities that exist in their production environment…" (personal communication, November 12, 2018). A college degree is also increasingly necessary. In New Jersey, 45% of jobs in food manufacturing and processing require an associate degree or higher, a percentage expected to increase (New Jersey Food Industry Talent Network, 2018).

However, technology skills are not supplanting manufacturing know-how. Instead, they are being combined in "hybridized jobs" that blend skills from different domains. "There is a rise in the roles that have a definite hybrid/'tri-brid'/'omni' scope" (Antonucci, Fornasiero, & Kowalski, 2017, p. 11). Emsi analyzed hundreds of thousands of manufacturing job postings from 2017 and found that "manufacturing employers need workers with traditional production skills mixed with engineering-type skills" (Saleh, Sentz, & Metsker, 2018, p. 19). Burning Glass predicts that hybridized jobs will grow by almost 16% through 2026, nearly doubling the pace of growth for jobs overall (Sigelman, 2018). These jobs are less vulnerable to automation and often pay higher salaries. For instance, a production plant manager with data skills will earn a $33,000 premium above the median salary.

SM will affect roles across an entire operation, from design to the shop floor to the supply network, and everything in between. ManPowerGroup and UI LABS identified more than 60 conventional jobs that provide motivated workers a path to progress to new SM positions. With the equivalent of two years of education and training, fabricators, machinists, assemblers, packagers, and others (see the full list in Antonucci, Fornasiero, & Kowalski, 2017, p. 52) can move into roles such as:

- Collaborative Robotics Technician
- Manufacturing Cybersecurity Technician
- Product Life Cycle Quality Data Analyst
- Fleet/Asset Optimization Specialist
- Instrumentation Engineer

Employers will need to evaluate the abilities of incumbent workers and focus their limited training dollars on those who demonstrate an interest in learning new skills. In summary,

automation and digitalization of manufacturing workplaces are: 1) lowering the need for traditionally skilled workers; 2) increasing the need for workers with IT, electronics, and data science backgrounds; and 3) creating a major skills gap in manufacturing industries.

New Jersey Food Processing Industry Case Study

A case study of the New Jersey food processing industry will provide insight into the impacts of SM on New Jersey's advanced manufacturing workforce. The food processing industry was chosen as a representative case study for advanced manufacturing more generally because: 1) food and agriculture as a segment will show a rapid rise in adoption of SM, partly owing to applicability of SM to unique industry challenges such as food fraud prevention; 2) there are commonalities and linkages of food processing to other manufacturing sectors, especially pharmaceutical production; and 3) there is transferability of the hybrid position concept to industries as diverse as finance.

Through focus groups and employer surveys, the New Jersey Food Industry Talent Network (2018) distinguished the top four trends affecting food companies in New Jersey: robotics and programmable equipment, social responsibility, sustainability, and innovation. These trends were generally relevant across food industry subsectors and are particularly resonant for bakeries and tortilla manufacturers, which are predominant among New Jersey food manufacturing establishments (New Jersey Business and Industry Association, 2017). This subsector is likely to remain strong. The Talent Network identified bakers as one of five "up trending" jobs in the New Jersey food industry. Bread and baked goods, and baking mixes, ingredients, and flours are 2 of the top 20 categories that comprise "specialty food." The Specialty Food Association reports that "specialty food represents 14.8% of all food sales at

retail" and that nearly all of the 61 specialty food categories experienced sales growth between 2016 and 2017 (Tanner & Purcell, 2017).

Industrial, small-scale, and franchise bakeries are incorporating SM technologies. Bakeries, high-end restaurants, and retail stores are the largest end-user segment currently testing 3D food printing devices (McCue, 2018). The use of 3D printing in bakeries is likely to increase, as 3D Systems Corp. and CSM Bakery Solutions jointly entered the 3D printing market for food in August 2018, with an initial focus on baked goods (Gelski, 2018). These technologies can help companies to achieve social responsibility and sustainability goals, and drive innovation. They may also open the field to new workers while, paradoxically, simultaneously reducing the demand for experienced culinary artists.

Bakeries, especially franchised/smaller operations, often serve dozens or hundreds of customers, requiring them to produce a variety of products. Through the use of 3D printing, bakeries are able to customize the design and ingredients in their products. The food printing market "is strongly motivated by the increasing demand for customized food products with nutrient content tailored for individual dietary needs" (McCue, 2018). Dr. Christoph Verheyen, a researcher at the Technical University of Munich, anticipates that "medical and super foods will become the healthy alternatives in the bread and cereal market" (Eagle, 2018). Medical foods are especially formulated for the dietary management of a disease that has distinctive nutritional needs.

Medical foods, and a similar category called functional foods (foods that provide a distinct health benefit), blur the lines between food and pharmaceuticals. Major players in this space include Nestle, Unilever, General Mills, Kraft Foods, and Stoneyfield Farm. Nestle is a pioneer in this field. At its Product Technology Center in Bridgewater, New Jersey, Nestle

Health Science plans to work on "nutritional solutions in oncology, food allergies and gut health among others" (Deak, 2018). Pharmaceutical companies are entering this space, attracted by shorter product development cycles and their expertise in validating health claims through clinical trials. For instance, Otsuka Pharmaceutical established a functional food affiliate in 2017. New Jersey has an opportunity to accelerate the growth of this emerging field through establishing connections between the food and pharma industries, supporting investments in SM technologies such as 3D printing (a model is the 3D Systems Culinary Lab in California), and leveraging existing relationships. For example, in 2015, Rutgers University signed a Memorandum of Understanding with Tel-Hai College focused on functional foods. The schools collaborate on student projects and research.

In addition to furthering the development of innovative new products that improve human health, SM technologies can help companies achieve sustainability targets and bolster profit margins. The U.S. Department of Energy cites energy use as one of the biggest opportunities for cost reductions. Artificial intelligence is being incorporated in controls software to reduce over-baking, lowering energy consumption and enhancing product quality. PreciBake, a German software developer, established its North American operations in New York. The company "assigned 50 computer engineers to refine the application of sensors and software for bakery equipment" (Higgins, 2017). Its products are used on rack ovens in in-store bakeries to adjust cooking temperatures and in quality control applications in industrial bakeries.

To leverage SM technologies, employers need access to digital talent. Deborah Silver, Professor at Rutgers University, analyzed Burning Glass Technologies data on analytics and data science-related job postings in the New York-New Jersey region. She found that food manufacturers in this region, compared to their counterparts nationally, are top recruiters of data

talent (#2 nationally among food manufacturers). Major employers include Mars, Mondelez, IFF, and Campbell Soup. The data skills that are in high demand among advanced manufacturers include robotics, C++, simulation, and computer vision. Burning Glass acknowledges that C++ skills are under-credentialed (D. Silver, personal communication, January 14, 2019).

Employers in New Jersey are struggling to find skilled workers at all levels. Every one of the self-identified employer issues raised by food companies are talent related: poor succession planning, lack of qualified applicants, small applicant pool, lack of awareness of industry, and limited funding for training (New Jersey Food Industry Talent Network, 2018). Laura Morris, Director of Employee and Community Relations for Rastelli Foods Group in Swedesboro, New Jersey, shared:

> "As we make the decision to automate select processes, the challenge becomes finding those with technical experience for repair and calibration of machines that also desire to continue their education to keep up with growing technology. Downtime caused by machinery operation failure can have steep financial impact, so there is a growing need to prepare individuals in this area" (personal communication, January 10, 2019).

To address the skills gap in automated food manufacturing and processing equipment maintenance, Jerry McMillan, Chief Operation Officer at Rastelli, suggests that employers work with the equipment suppliers to produce relevant training curricula. He also emphasizes that most labor savings achieved through equipment automation will be passed on to workers with higher wages (personal communication, January 10, 2019).

Conclusions

Investment in SM and automation is accelerating across New Jersey manufacturing industries. Impacts to the workforce are complex, but recent national data and a study of the New

Jersey food industry point to four major effects: 1) loss and displacement of traditional unskilled production jobs; 2) a supply gap for more skilled, entry-level workers with IT skills and interests; 3) potential increase in salaries and career opportunities for upskilled current workers and new entrants into SM jobs; and 4) improvement in the quality of work in New Jersey manufacturing.

Recommendations and Resources

1. Develop Hybridized Training and Education Programs in Advanced Manufacturing

New Jersey educational institutions should sponsor degree programs that encompass both technical training and IT/computer science courses. Programs could be fielded jointly by four-year institutions and community colleges or technical training centers. These programs should be available at the associate degree level and higher. Non-traditional educational and training pathways are also encouraged. Examples:

- Rutgers offers a Professional Science Master's program that combines courses in science or engineering and business and policy.
- The Regional Additive Manufacturing Partnership of Maryland hosts workshops for teachers and administrations on careers in manufacturing and provides resources for introducing 3D printing and other technology into the classroom.

2. Prioritize and Incentivize Lifelong Learning

Employers can encourage lifelong learning through:

- Individual development plans (common in Europe) and career pathing for employees,
- Accepting credentialing or other skill accreditation instead of or in addition to degrees, and
- Creating a culture of learning — providing/rewarding continuous training.

Higher education institutions can facilitate lifelong learning. As an example:

- Through a "knowledge partnership," the Wharton School at the University of Pennsylvania offers its graduates the opportunity to return every seven years for free executive training.

3. Leverage Industry 4.0 Technologies for Workforce Training

Provide training opportunities that use and demonstrate the technologies of Industry 4.0, such as online simulations and virtual workspace learning. Examples:

- The virtual reality center at Rowan University offers the technological infrastructure to make digital training environments a reality.
- The Clemson University Center for Workforce Development created virtual reality simulations of factory floors for K-12 and college students. Students act as a safety auditor within the simulated environment, tagging safety violations.

4. Re-brand New Jersey Manufacturing

Conduct outreach programs, starting as early as middle school, that illustrate manufacturing as an important part of New Jersey industry, a rewarding career, and a way to contribute. Example:

- Gateway Regional High School (Woodbury Heights) implemented a career education and internship program that exposes students to numerous careers through career days, talks by industry experts, employer site visits, internships, and job shadowing.

5. Leverage Partners and Tap Existing Resources

Many educational institutions, industry associations, and community and government organizations offer training, consulting, research, networking, and mentoring resources. New

Jersey industry needs increased coordination of these diverse resources to advance manufacturing practices. Examples:

- Rutgers, Johnson & Johnson, and Honeywell are members of a nationwide network of Clean Energy Smart Manufacturing Industry Institute manufacturing centers that accelerate the adoption of SM (northern region, hosted at Rensselaer Polytechnic Institute).
- A proposal for a national training center for SM food and beverage applications is subject of a New Jersey Economic Development Authority grant and could begin operation in Cumberland County in 2019-2020.

6. Share Information about Future Trends with Employers, Workers, and Students

The insights from this report, and others like it, should be presented to employers, job seekers, community leaders, workforce development boards, and the like. Example:

- The San Diego Regional Economic Development Corporation sponsors an *Innovation Trends* symposia for students. The program provides information about key sectors, market trends, and workforce needs.

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