



Automation, employment and reshoring in the apparel industry

Long-term disruption or
a storm in a teacup?

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Automation, employment and reshoring in the apparel industry: Long-term disruption or a storm in a teacup?

Fernanda Bárbara de Mattos, Jeff Eisenbraun, David Kucera & Arianna Rossi

International Labour Organization

May 2020

Foreword

The ILO's Employment Policy Department has taken a key interest in how automation affects the quality and quantity of employment, Decent Work in short. Much of the concern about new automation technologies and jobs is based on a narrow emphasis on substitution effects at the task level, but technology affects jobs no less importantly through complementarity effects, market expansion effects, income effects and input-output production linkage effects with associated income-induced effects. These effects can play out in different directions at different levels of aggregation, that is, at the task, enterprise, industry and economy-wide levels. Relatively absent in these discussions is a sense of how automation is playing out at the shop-floor level. This has motivated the Department to undertake industry case studies focusing on the producers and potential users of new automation technologies and what their greater use might mean for the structure of global supply chains and the global division of labour in these industries. A key outcome in this regard is the report *Robotics and reshoring: Employment implications for developing countries* (2020). It was the Department's intention to follow up this research with interviews of key informants in industries of strategic importance for developing countries, as embodied in this study of the apparel and footwear industry in collaboration with Better Work.

Sukti Dasgupta

Branch Chief, Employment and Labour Market Policies, Employment Policy Department

Mito Tsukamoto

Branch Chief, Development and Investment, Employment Policy Department

The global garment industry has been a unique source of employment in developing countries, especially for young women and for migrant workers, and has traditionally been considered an entry point for industrialisation. This assumption is nowadays often called into question due to the dramatic shifts in business models and the rise of new technologies and innovations, which could foreseeably transform the industry and affect its potential for employment generation. In the Better Work programme, a partnership of the ILO and the IFC aiming to achieve safe and decent working conditions in the global garment industry, we believe that decent jobs in this sector can be transformational, especially for women workers and their families, and can play a central role in an emerging country's development strategy. The question of whether and how new technologies, and in particular automation and the use of robotics, may impact garment sector employment, is therefore central to our mission and to our ability to provide policy advice on this topic to industry stakeholders across different geographies. This research is a significant contribution in the understanding of how brands, retailers and global manufacturers in the garment industry perceive and plan their strategies when it comes to technology and automation, and it provides a complementary, in-depth and sobering analysis to existing projections and estimates of the potential of job losses in the sector. We are grateful to the ILO Employment Department for the fruitful collaboration in carrying out this project.

Dan Rees

Branch Chief, Better Work, Governance Department

1. Introduction

Discussions on technology, automation and its impacts on the world of work have made headlines across the globe. Especially in labour-intensive industries, there is a fear that emerging technologies will disrupt industries, dramatically decreasing the need for workers, and potentially causing a radical restructuring of global production away from developing and emerging economies, towards the high-income countries many lead brands hail from, in a process termed reshoring. Another possibility is near-shoring, whereby production takes place near end-markets, be it high-income or emerging and developing economies, where consumer markets have been growing. Several studies focus on technological feasibility, using job characteristics and occupational data to estimate potential impacts of emerging technologies.¹ Others have looked to the past to assess whether greater use of technology has been associated with shifts in employment. However, relatively little is known about what is actually happening at the factory floor.

The apparel and footwear industry is traditionally labour-intensive and often considered the springboard for industrialization in many developing countries. Therefore, understanding the implications of automation and technological change in this industry is particularly relevant to assess its continued potential as employment generator and engine of growth. In apparel and footwear specifically, existing research suggests strong presence of routine work and high risk of job displacement. For instance, Chang, Huynh and Rynhart (2016) concluded that between 64 and 88 per cent of textile, garment and footwear workers in Cambodia, Indonesia and Viet Nam are at high risk of displacement due to automation. This research highlights that their estimates relate to the risk these job *could* be automated, and not that they *will*, recognizing that factors other than technological feasibility are involved in automation decisions. We argue further that even these assessments of potential automation are overstated in light of economic considerations and practical issues faced at the shop floor.

This study investigates the potential opportunities and risks brought about by automation and employment in apparel and footwear manufacturing from the point of view of industry players. It summarizes the main findings from a series of in-depth interviews with 11 representatives from four leading brands in the apparel and footwear industry and a supply chain management company conducted between March 2018 and February 2019. These semi-structured interviews focused on the current and projected use of automation technologies by the firms and their suppliers; broader developments in the industry and impacts on global production patterns; obstacles and potential benefits of automation; and likely impacts on employment and skills demand at the production level. Although the scope of this case study is relatively limited due to the number of subjects interviewed, the heterogeneity in business models and prominence of

¹ See Section 2 for a brief literature review.

respondents among apparel brands and retailers suggest that this exploration is a significant contribution towards understanding the most recent trends and expectations in technological upgrading and automation in the short and medium term.

The next section introduces the motivation behind this study and research questions. Section 3 presents the main outcomes of the interviews in terms of expected benefits and obstacles to automation in apparel and footwear manufacturing, as well as current and prospective use of automation technologies in the industry. Against this background, section 4 examines discussions with respect to the apparel and footwear geography of production. Section 5 summarizes main findings and presents some concluding thoughts.

2. Background and motivation

New technologies are fundamentally transforming industries across the globe, including apparel and footwear. Autonomous and semi-autonomous machines can improve efficiency, consistency and productivity at the factory level. New machinery is also quickly transforming warehousing and distribution centers. Digital technologies can facilitate data gathering and monitoring throughout production processes and allow for seamless information flow between retailers, warehouses and factories. In addition, the internet plays an increasingly key role in determining which products customers want (e.g. through the rise of internet personalities, known as influencers) and how they shop. At the same time, traditional brands are competing with new players in the apparel space such as Amazon and Alibaba, which are already amongst market leaders (Dowsett and Fares, 2019; Danziger, 2020).

This transformative potential of new and emerging technologies is highlighted in academic research. Empirical studies looking to the past to assess economic and labour market impacts of automation technologies do not present a consensual view on the net employment impact of greater use of robots and other automation technologies.² But there is general agreement that workers with lower skills and education, often routine manual workers in assembly and related occupations, are more vulnerable than those of higher skills. Forward-looking assessments of potential job displacement impacts of the so-called 4th Industrial Revolution offer a wide range of estimates of potential job displacement, but consistently indicate that routine repetitive tasks are the most susceptible to automation in the near future. A widely cited study by Frey and

² Empirical research by Graetz and Michaels (2018) indicates that, in 17 developed countries, the use of robots is associated with a decline in the share of working hours of lower skilled workers relative to those of medium and high skilled labour between 1993 and 2007, despite no significant impact on total working hours. Acemoglu and Restrepo (2017) suggest adoption of industrial robots has been negatively correlated with employment, most often of routine manual workers in assembly and related occupations, and workers without college education. Moreover, the Asian Development Bank (2018) finds empirical evidence that, in 2005-15, robot adoption was associated with a decrease in routine employment and a rise in non-routine work – routine manual work, such as that of production workers suffered the most.

Osborne (2013/2017), based on the occupational makeup of employment, suggests that 47 per cent of US jobs are at high risk of automation. According to this research, the probability of automation by computer-controlled equipment in the next decade or so is 99 percent for hand sewers and 89 percent for sewing machine operators, important occupations in apparel and footwear manufacturing. Studies adopting a task-based approach that allows job characteristics to vary within occupations at the individual level, propose relatively small, though not trivial, impacts – 9 per cent of US jobs are at high risk according to research by Arntz, Gregory and Zierahn (2016; 2017), while Nadelkoska and Quintini (2018) suggest about 14 per cent of workers in 32 OECD countries are at high risk. It is important to note that these estimates relate to the risk these jobs *could* be automated, reflecting exclusively technological considerations, and not the probability that they *will* be automated, which also take into account economic and other concerns. Still, given the higher proportion of workers in occupations intensive in routine repetitive tasks, the share of jobs at high risk of potential automation is likely to be greater in developing and emerging countries than in high-income countries.³ Dao et al.'s (2017) analysis of 49 countries across income levels indicates that countries and sectors more specialized in routine-intensive activities have experienced greater declines in the labour share, which is, as noted by Autor and Salomons (2018), consistent with the possibility of labour displacement. The risk of job displacement is compounded by risks associated with automation-enabled reshoring of economic activity. Productivity-enhancing automation technologies offer an alternative to firms' traditional strategy of offshoring manufacturing activities to reduce production costs. Recent empirical studies have found a positive association between greater use of automation technologies in developed countries and reshoring.⁴

These debates are particularly critical in the context of the apparel and footwear global value chain for two main reasons. First, the industry has been marked by extensive offshoring of manufacturing to developing and emerging economies and large trade flows of final goods to high-income countries, suggesting it is exposed to the risk of reshoring. Second, apparel and footwear manufacturing is characterized by routine and repetitive work, yet automation remains limited. Is it reasonable to expect greater automation in apparel and footwear manufacturing in the near future? If so, is there likely to be a restructuring of global production away from developing and emerging countries?

In many developing and emerging countries, the manufacturing of apparel and footwear has been instrumental in economic and social development processes, providing an entry point into global markets and employment for large shares of the population. The industry flourished

³ This is exemplified by several applications of the Frey and Osborne (2013) methodology to developing and emerging countries yielding markedly higher shares of workers at high risk: about 55 per cent of jobs in Cambodia, Indonesia, Philippines, Thailand and Viet Nam, and over 70 per cent in Bangladesh, China, El Salvador, Guatemala and Nepal have been found to be at high risk of automation (Change, Huynh and Rynhart 2016; World Bank 2016).

⁴ See for instance Dachs, Kinkel and Jager (2017), Faber (2018), and Krenz, Prettner and Strulik (2018).

through the offshoring of production from lead firms in developed countries in search of abundant low-cost labour, as evidenced by export and employment data (table 1).

Table 1. Exports and formal employees in top 10 apparel and footwear exporters in 2017

	Exports in 2017, US\$ billion	Formal employees, around 2000 (1)	Formal employees, latest available year (2)
Bangladesh	30.1	1,037,310	2,827,468
Cambodia	8.0	203,612	660,327
China	205.6	3,284,000	7,239,994
Hong Kong, China	17.4	28,200	18,100
India	21.1	469,195	1,505,710
Indonesia	13.1	761,183	1,087,242
Turkey	15.9	164,212	560,112
Viet Nam	44.1	511,364	2,984,980
Total developing	355.4	6,459,076	16,223,606
United States of America	7.1	498,472	107,340
EU 28	179.3	2,279,365	1,291,153
Total developed	186.4	2,777,837	1,398,493

Note 1: Bangladesh, 1998.

Note 2: Bangladesh, 2011; China, 2017; Hong Kong, China, 2010; India, 2017; Indonesia, 2017; Turkey, 2017; U.S., 2017; Viet Nam, 2017; EU 28, 2017 except Latvia (2016). No data for footwear for Denmark and apparel for Finland. No data for Luxembourg and Malta; Data for Cambodia relates to export factories only and hail from the Ministry of Commerce of Cambodia and refer to December 2018 (cited in Schill, 2019).

Source: UNCTADStat (2019), refers to SITC Rev. 3 groups 84 (Articles of apparel & clothing accessories) and 85 (Footwear); UNIDO (2019), refers to ISIC Rev. 3 groups 18 (Wearing apparel; dressing and dyeing of fur) and 19 (Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear).

Eight of the top ten garment and footwear exporters in 2017 were developing or emerging countries, namely Bangladesh, Cambodia, China (including Hong Kong), India, Indonesia, Turkey and Viet Nam. Combined, these countries accounted for 57 per cent of global exports in 2017, equivalent to \$355 billion, up from 41 per cent in 2000. Employment in these countries also expanded significantly, for instance, the number of formal employees more than doubled in Bangladesh, China and India, and increased multiple times over in Turkey and Viet Nam between 2000 and 2017. That is, across developing and emerging garment manufacturers, the number of

workers in apparel and footwear consistently expanded since 2000, along with exports.⁵ In contrast, apparel and footwear employment nearly halved in the EU and more than halved in the US in the same period.⁶ At the same time, global consumption of apparel and footwear is highly concentrated in developed economies.⁷ In 2017, the US, the EU and Japan accounted for nearly 70 per cent of global imports of clothing and footwear.⁸ In this context, a key concern for developing and emerging countries relates to reshoring, if automation enables the relocation of labour-intensive manufacturing to high-income economies.

Automation technologies, proxied by robot usage in apparel and footwear manufacturing, remains limited. Only ten countries purchased at least ten robots for the textiles, apparel and footwear industries in a single year between 1993 and 2016, and the stock of robots in these industries is dwarfed by those of the automotive and electronics industries (figure 1). As the International Federation of Robotics (IFR) does not provide more detailed categories, textiles is grouped with apparel and footwear and thus the presence of robots in the industry is likely even lower than that reported.

⁵ With the exception of Hong Kong, China.

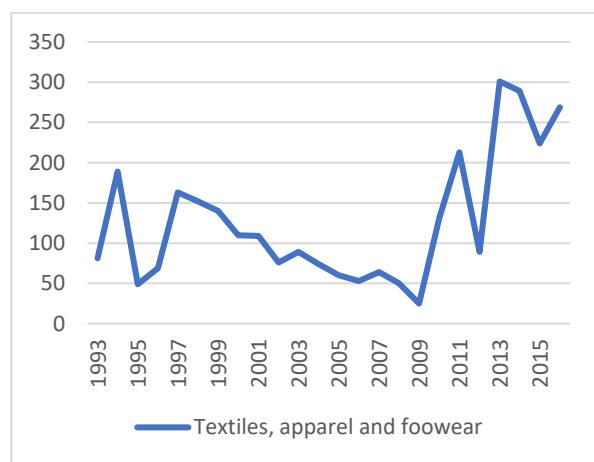
⁶ EU refers to EU 28.

⁷ In 2019, McKinsey & Company (2019) indicated that China would overtake the US as the largest fashion market in the world for the first time. McKinsey & Company: *The state of fashion 2019*.

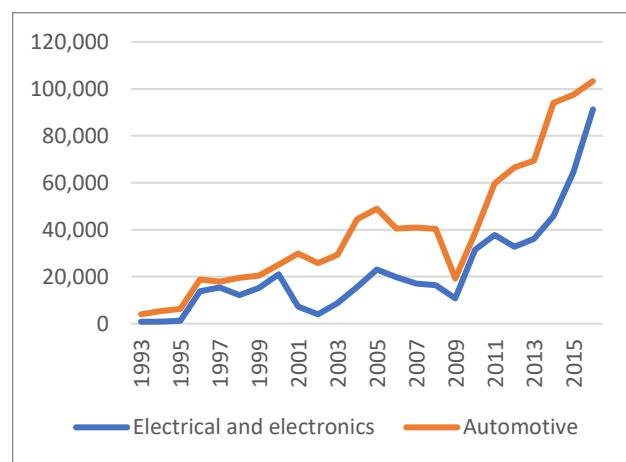
⁸ These are among the main markets for exports from emerging and developing countries. For instance, almost 80 per cent of apparel and footwear exports from Bangladesh, more 60 per cent of exports from Cambodia, India and Viet Nam, and nearly 50 per cent of exports from China (incl. Hong Kong and Macau) are for the US and EU markets.

Figure 1. Annual unit sales of industrial robots in textiles, apparel and footwear, electrical and electronics and the automotive industries 1993-2016

Panel A. Textiles, apparel and footwear industry



Panel B. Electrical and electronics and automotive industries

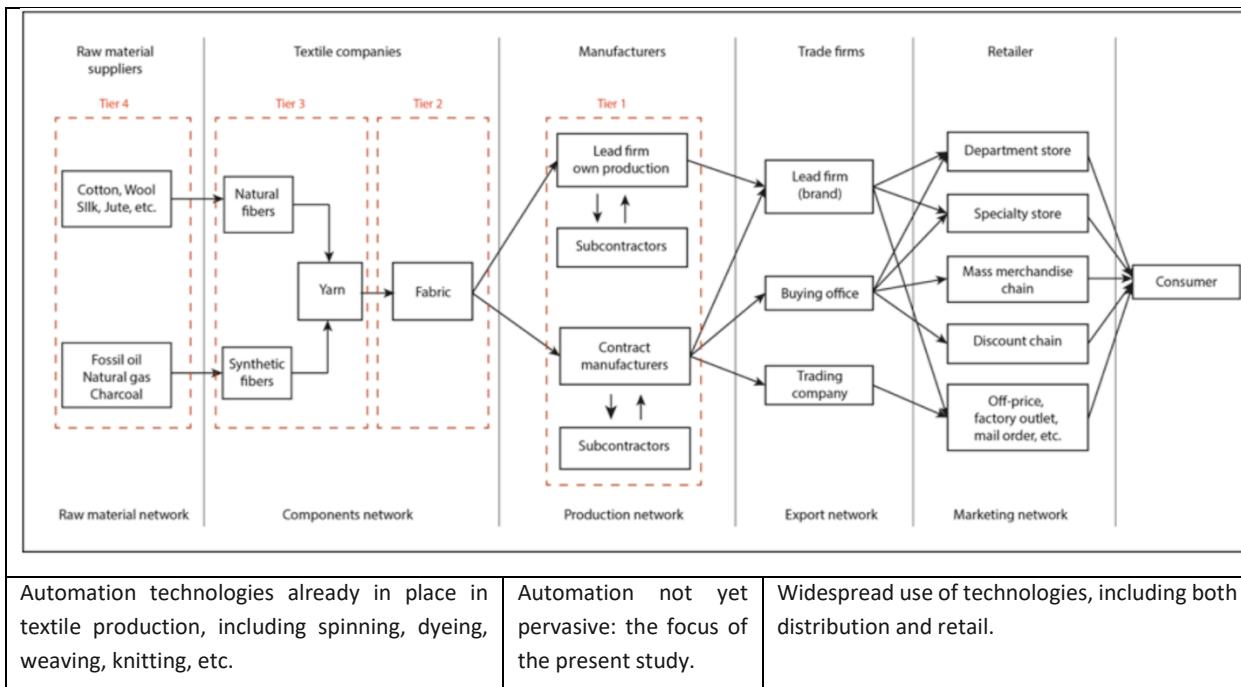


Note: Textiles, apparel and footwear refer to ISIC Rev 4. Groups 13-15, electrical and electronics refers to groups 26-27 and automotive to group 29.

Source: IFR (2017).

The various tiers of the apparel and footwear value chain differ in the current usage of automation technologies (figure 2). The early stages of the value chain, particularly textile manufacturing, are already highly automated, as are the trading, distribution and retail segments of the chain. This study focuses on apparel manufacturing, that is, the assembly of ready-made garments and footwear, currently heavily labour-intensive, that lies between the highly automated stages.

Figure 2. Textiles and clothing industries supply chain



Source: Obser (2015).

Our study aims to complement the literature briefly reviewed above by providing an insider's perspective based on interviews with large firms in the apparel and footwear industry. To this end, a series of eight semi-structured interviews was conducted with four leading brands in the apparel and footwear industry and a supply chain management company, between March 2018 and February 2019. The supply chain management company works with a network of more than 10,000 factory partners in over 50 countries across the world. The four leading brands are large companies from the US and Europe with annual revenues that range from \$5 to \$39 billion. Two are renowned athletic clothes, footwear and accessories brands, often making headlines about innovation. The other two are multi-brand corporations – one firm includes ten brands from premium fashion to sportswear while the other company owns eight brands and is a proponent of fast fashion. All of these firms have global presence, with hundreds of suppliers, and some have own factories. Although four companies cannot be considered representative of an entire sector, their experience can be seen as indicative of larger industry trends. The main findings from the interviews are summarized below.

3. Automation in apparel and footwear manufacturing

The interviews revealed several factors which may encourage and deter automation. Powerful supplier firms may be well positioned to invest in and benefit from automation through more

consistent quality, improved efficiency and environmental sustainability. In addition, automation might aid in satisfying consumer demand for customized goods. But several obstacles to automation were also identified. The first relates to remaining technical bottlenecks which prevent the automation of apparel and footwear assembly. There are also economic impediments, associated with high technology costs in an industry with tight margins and, sometimes, fleeting supplier-brand relationships. Another obstacle concerns the workforce and shifting skills needs. The remainder of this section explores these findings.

3.1 Drivers for automation in apparel and footwear manufacturing

Powerful suppliers and first tier global manufacturers may be well positioned to reap automation benefits

Suppliers' business models were identified as one of the key considerations in automation decisions. Large and powerful supplier firms might have the resources to invest in and the ability to reap the benefits from automation. In addition, brands, suppliers and technology companies have started to collaborate for the technological upgrading of apparel and footwear manufacturing. This is in line with research by Azmeh and Nadvi (2014), Merk (2014) and others, who argue that there has been a decline in power asymmetries in the global value chain, and that large Asian supplier firms have transformed into multinational firms in their own right, and can play a key role in reshaping the global apparel value chain.

When asked whether they have observed any association between the location of the factory and the adoption of automation, respondents consistently answered negatively. The degree of automation adoption is more closely related, they argued, to suppliers' business models. A respondent from one of the sports companies stressed that although they work with many suppliers, a significant amount of production is concentrated in a relative small number of large suppliers which own and operate factories across countries. In this context, the respondent argued, it is the supplier management strategy, rather than location of production, which determines whether and to what extent automation technologies are adopted. This resonates with research on the rising power of tier 1 garment manufacturers which argues that big supplier firms, especially from large developing and emerging countries, have become critical in the organization of production and trade (Azmeh and Nadvi, 2014; Merk, 2014).

“Due to our [supplier] groups usually operating in multiple countries, I don’t think it’s a geographical question. It’s [automation] really a question around the mindset of the different management groups. And, of course, there are differences. Some are more aggressive than others.”

Suppliers have not always seen the need for automation or digitization. A source from one of the fashion conglomerates provided the example of machines which automatically trim threads: although they have existed for a while, they are not commonly used because there is no perceived need for them. However, this might change in the future, as evidenced by the

collaboration between brands, suppliers and technology firms to develop and implement new technologies for apparel and footwear manufacturing.

The interviews revealed several approaches to brand-supplier collaboration. The supply chain management company offers financing support and capacity building to help their network of suppliers adapt to the changing needs of the market, and adopt new technologies. A sports brand has a department working with suppliers to explore options for lean manufacturing for footwear, though ultimately investment decisions are made by the factory partner. A respondent from a multi-brand conglomerate suggested that there will likely be partnerships between the brand and suppliers through direct joint investments in machinery or longer contractual arrangements to justify suppliers' investments.

The corporations interviewed are also partnering with technology developers. One brand partnered with a leading electronics company to experiment with automation in a footwear factory in Mexico; however, that operation was shut down in late 2018 citing commercial unviability. Another company partnered with a large incubator and accelerator of tech startups to solve technical bottlenecks in the industry. In contrast, the companies interviewed do not currently collaborate with other brands within the industry. One respondent suggested that, in future, the apparel and footwear industry might follow in the footsteps of the automotive sector where rival firms BMW and Mercedes-Benz recently signed a partnership agreement. As stated in a communiqué by Daimler, Mercedes-Benz parent company, the alliance allows more successful and efficient progress by sharing technological and financial challenges (Hafner, 2019).

Demand for customized goods is on the rise

An important point made in several conversations relates to the fact that basic products have remained unchanged, limiting incentives to improve production processes, including automation. One interviewee from the fast fashion conglomerate summarized: "a lot of technology has not changed because the fashion has not changed. A lot of products are very basic and will continue to utilize similar machines because there is no need for automation". This sentiment was echoed by other respondents. It was highlighted by a source from a sports brand that there are limitations associated with automating processes designed to be done manually. But new processes might be required for companies to meet a growing demand for customized products.

Multiple respondents asserted that automation can be a tool for customization. It was argued that rather than substitute workers in mass production, automated sewing could, in future, be used to produce small batches of customized goods that could be offered to customers at a premium. Another point made in the interviews was that automation could be used to efficiently produce small quantities of products in a way that labour-intensive processes would not be able to do. In this context, meeting demand for customized goods could propel automation in apparel and footwear manufacturing. Indeed some automated-customization initiatives have made headlines across the globe in recent years, such as Adidas' pop-up knit customization in Berlin in

2017 (Thomasson, 2017). The initiative allowed customers to design their own sweaters, which were custom-fit with the help of a laser body scan and machine-knit in store.

Discussions with multiple brands suggest that delivering custom products is a priority for their businesses. A respondent suggested that co-created, customized goods with customer inputs helps create customer loyalty. Another respondent pointed to research concluding that customers, particularly younger customers, are willing to pay more for personalized products. For instance, McKinsey & Company research in Brazil suggests consumers are demanding more, and willing to pay premiums for, personalized products (Francis and Hoefel, 2018).

Efficiency is increasingly important

Greater efficiency and consistent quality were identified as drivers of automation. This search for greater efficiency goes beyond the automation of production lines; it includes improving internal practices to minimize production costs and reducing lead times. At the same time, efficiency is also connected to the search for environmental sustainability.

"The end is to get the product in the hands of the customer as quickly as possible at a reasonable cost."

A respondent from a sports company argued that machines are projected for accuracy and precision, which could be advantageous relative to workers. In turn, the supply chain management company and one of the fashion conglomerates highlighted data-driven approaches aimed at reducing lags and bottlenecks. A respondent from the latter suggests efficiency gains may result from better internal practices, including improved management systems, forecasting and purchasing practices. In turn, the supply chain management company is encouraging suppliers to create digital replicas of labour-intensive processes, including capturing data on tablets instead of clipboards and using radiofrequency identification (RFID) technology to track production as it happens. According to them, in the future, supply chain competitiveness is likely to be defined by automation, digitization and connectivity, that is, the ability to gather and use data for fast, flexible and resource efficient production.

The interviews suggest that automation is perceived by brands as a means for the quick delivery of reasonably priced goods. The company whose model relies on fast fashion highlighted automation's potential to reduce lead times. Also speaking about lead times, one of the sports companies suggested that automation might be required for production closer to consumers, given labour costs in some parts of the world.

"I believe that the environmental aspect will be the biggest driver for new technologies and automation in our industry."

Environmental sustainability is another prominent factor propelling automation in apparel and footwear manufacturing. The environment was identified by a respondent as the biggest driver for future automation in apparel and footwear. Waste reduction and circular economy processes are a key

motivation for another firm, which is experimenting with various innovations in this area. Efforts to improve sustainability might also be a reflection of shifting consumer demand. The McKinsey New Age of the Consumer US Survey 2019 found that younger generations are willing to pay higher prices for products which have reduced environmental impacts (McKinsey & Company, 2019).

3.2 Obstacles to automation in apparel and footwear manufacturing

Respondents consistently remarked that automation in apparel and footwear manufacturing remains limited, which is corroborated by the data on robots in apparel and footwear presented in section 2. It was noted that there is currently more automation in textiles – from fiber to spinning, knitting, weaving, dyeing, printing and finishing – and ancillary operations. A respondent from one of the fashion corporations stated that the firm deploys automation in warehouses, for packaging and delivery preparation, and in the front end of the business, i.e. retail. A sports company is using automated delivery systems in a small number of plants, with robots transporting lots of 10 or 50 pieces between production lines. Impediments to greater automation in garment and footwear assembly include technological limitations, costs and concerns over the availability of skills.

"If you walked through a factory four and a half years ago, and you walk through the same factory today, it is not very different."

Technological impediments remain

A key conclusion from desk research that was substantiated in the interviews is that a fundamental obstacle to automation in the assembly of ready-made apparel and footwear is technical. In particular, there are difficulties linked to the flexibility required to handle fabrics and the wide range of constantly changing products. To date, automation in apparel manufacturing relates to specific processes and, most frequently, to worker-machine collaboration.

Sewing continues to be predominantly done by traditional methods – workers manipulating pieces of fabric through sewing machines – due to the high level of dexterity and flexibility required to work with pliable and stretchy fabrics, which come in many weights and grades. A respondent from one of the multi-brand conglomerates stated that sewing machines are far from allowing for full automation of any technical production.

"I would say that automation is at a very, very beginning stage in apparel (...) due to the nature of the fabric, which is very flimsy and not so rigid, it [automating] is very hard."

"The biggest disadvantage of automation today in our setup is that there is a borderline to how flexible it is."

These challenges are exacerbated by frequent changes in the range of products, coupled with the variety of sizes in which any given product is manufactured. A respondent from the supply chain management company stated that although some of the factories

they work with are experimenting with automated sewing, factory managers must rely on workers if they aim to maintain flexible operations due to the limited functionality of existing technologies. Limited flexibility was also cited as a major obstacle to automation by one of athletic brands interviewed.

According to a source from one of the sports companies, factories are increasingly using templates for pieces like pockets and waistbands, but workers are still needed to place fabric in frameworks that are then fed to machines for stitching. A respondent from another sportswear company argued that semi-automation mitigates issues related to dexterity and precision required to load machines, especially with malleable materials like fabric. At the same time, this source suggests, semi-automation unlocks potential productivity increases by allowing workers to simultaneously operate multiple machines. Respondents from various companies stated that some automation technology is seen in cutting and stitching for apparel and footwear, as well as in molding and injecting in footwear production.

Discussions around 3D printing also revealed technical impediments. 3D printing was cited as a good option for prototyping, sample development and product customization, but is currently associated with various limitations. It was noted that the technology is not yet suitable for high volume production and that it is not currently compatible with a wide range of materials. A source from a multi-brand conglomerate indicated that the company has not yet used 3D printing at scale in factories. Still, several respondents suggested that they expect greater use of 3D printing in future as the technology continues to evolve.

The perception of technological impediments shared among interviewees suggest that estimates focusing on the task composition of occupations alone overestimate the occupational disruption posed by automation. Studies cited earlier portend a vast displacement of apparel manufacturing workers based on the routine, repetitive, nature of sewing. Yet evidence from key informants interviewed suggest these assessments overstate such risk in light of practical issues faced at the shop floor. As noted among several interviewees, the caveat remains that it is difficult to anticipate technological developments beyond the near future.

Automation costs are high in an industry with thin margins

It was argued that large investment requirements inhibit automation adoption in garment and footwear manufacturing. Costs may be prohibitive due to thin margins and transactional relationships.

A respondent from the supply chain management company asserted that suppliers are not willing to invest in technologies with return on investment greater than six months, even if investments are of relatively small magnitude – such as \$5,000 sensor packages. This source

"The vast majority of buyers, are transactional(...) they always demand a lower price."

stressed that incentives for large investments are limited by lack of proof these drive efficiency, coupled with tight margins and the transactional character of many of the brand-supplier relationships. However, this respondent stressed, this is an industry of copycats, so the state of automation in the sector may change fast if one supplier experiences positive results from automation.

"You can't substitute just one sewing machine on the floor, you need to substitute all and that's a huge cost, so the incentive to upgrade needs to be big too."

Automation may be inhibited by high costs. A respondent from the supply chain management company asserted that some of the technologies being adopted now, such as RFID technology, have been around for more than a decade, but only recently prices have decreased enough to justify adoption in labour-intensive industries. In addition, as asserted by a respondent from one of the sports corporations, automating production

lines would require substituting multiple machines, with cost-benefit analyses that include not only acquisition costs, but everything from installation through to decommission. A source from a multi-brand fashion company predicted that large capital investments in an industry with low margins are likely to hinder widespread automation in the next five years. A respondent from this company reported that manufacturers in their supply chain are, instead, striving to achieve greater efficiency with the existing equipment through better management and processes. But even these process-based attempts at leaner manufacturing are restricted to a handful of larger supplier firms which have the resources to do so.

It was also noted that suppliers may have difficulties financing investments. A respondent from the supply chain management company stated that many smaller and medium enterprises in Asia do not have credit records which can be used to access financing. This source argued that the lack of credit records constrains the use of existing technologies, such as automated cutting, which are expensive to purchase, install, and fix.

Workers' skills are a concern

Availability of workers with appropriate skills affects a supplier's decision to invest in automation technologies. Respondents revealed deskilling and upskilling in apparel and footwear assembly may both occur. At the same time, new skills may be needed for the installation and maintenance of higher-tech machinery.

"You will meet challenges for automation that require a different workforce to help you on the software side and on the maintenance side of these automated lines."

On the one hand, technologies may decrease skills needs, such as for stitching of footwear uppers. As a respondent from a sports brand stated, training workers for complex stitching processes in footwear can take up to six months, whereas workers can be trained to use semi-automated machines in a couple of days. This might be particularly useful as brands continue to churn more and more products. On the other hand, as a respondent

from the other sports corporation remarked, workers operating new machines may need to upskill in order to operate multiple machines across several steps of the assembly process. According to this source, this contrasts to traditional assembly operations in footwear and luxury bags manufacturing, where each worker performed a single operation, using a single machine, before passing the piece to another single-operation worker.

In addition, as indicated by respondents from multiple brands, automation will require more skilled workers for machine programming and maintenance. It was noted that it might be relatively easy to purchase imported machinery, but it might be hard to find workers which can operate and fix these in lower income countries. It was mentioned that in other, more technology-intensive, industries such as pharmaceuticals, it is common for technology vendors to be placed near users to provide full services, and this is not yet the case for the apparel and footwear industry.

As a respondent from one of the fashion conglomerates summarized, about 20 per cent of the future skills needed in the industry should entail significant shifts from current skills sets, while 80 per cent of skills needed are expected to be similar to those of apparel and footwear workers today. This is line with previous research which suggests that there is likely to be greater need for re-skilling and up-skilling in the industry (ILO, 2019). A respondent from the supply chain management company suggested that, in the past, firms have typically regarded workers as easily substitutable and a shift in the views of management is required for firms to invest in workers' training. There are ongoing conversations with governments on the projected skills needs of more automated manufacturing in countries such as Ethiopia and Viet Nam.

3.3 Impact of automation technologies in apparel and footwear manufacturing employment

When and to what extent automation will spread is not yet clear, as illustrated by the following excerpt: "If you asked our supply chain teams they would say that all of our trims will be automated in factories within five years. I don't believe that. They're taking new innovations, seeing huge opportunities and building them into business plans. But we don't know yet how they work, how easy it is to import them into certain countries, if they'll scale, or if they can deliver the quality we need". Nevertheless, the companies interviewed and their suppliers are currently experimenting with many technologies. One company is exploring technologies on cutting and preparation, stitching and assembly of footwear in at least two facilities, while another company is experimenting with innovations for improving the circular aspect of production, reducing material waste and improving sustainability. In turn, the supply chain management company is experimenting with automatic sewing to produce t-shirts in some of the factories in their network.

The perspectives shared in the interviews suggest brands do not believe automation will lead to significant job loss in the foreseeable future. Rather than worker displacement, they perceive potential for greater machine-worker collaboration in apparel and footwear, as highlighted by respondents from two of the brands interviewed. Furthermore, as a respondent from a different company asserted, to the extent that technologies may contribute to lower product prices and greater demand, net impacts could be positive. One respondent suggested that the goal of automation is increasing output with the workforce currently in place. While in such a scenario there would be no job loss, automation would reduce the job creation potential of apparel and footwear manufacturing.

"There is a lot of opportunity to look at small, low-cost devices that assist the worker to do part of the job."

"I don't think it's about reducing the workforce, it's about increasing the output with the workforce that you have."

Automation could affect not only the number and skills profile of jobs, but also the working conditions and compensation associated with these jobs. One of the companies argued that automation may improve work quality by reducing occupational safety and health risks at the factory floor. However, the presence of robots could increase pressure on the pace of workers, as has been observed in robot-worker collaboration in warehousing (Madhavan, Righetti and Smart, 2018). Greater automation in apparel and footwear manufacturing could also reduce the number of workers or their working hours with potentially negative consequences on wages. These are critical concerns in apparel and footwear manufacturing, where poor working conditions and low pay have made headlines on multiple occasions (Blattman and Dercon, 2017).

4. Shifting geographies of the apparel and footwear global value chain

Debates about current and expected trends in automation in apparel and footwear manufacturing are closely linked to concerns around the geography of production. Optimizing shifting trade incentives, cutting transport costs, and reducing lead times are some of the main expected benefits from a geographical restructuring of production. On the other hand, the material supply chain and expanding consumer markets in developing and emerging countries suggest reshoring is likely to be limited.

Some of the firms interviewed have started to reduce reliance on China, motivated by increasing costs, labour shortages concerns over tariffs, as well as by the perception that the country no longer considers the apparel and footwear industry strategic. In addition, tariffs and trade agreements were acknowledged as key in sourcing decisions. Following the

"If you sea freight goods from Asia to the US, custom clearance and internal transportation, we're talking about six weeks of time at the end of the day."

extension of the African Growth and Opportunity Act, one company turned to Ethiopia with a view to export to the US market, while relying on Bangladesh and Viet Nam's duty-free access to European markets. A respondent from another company declared that the firm is building capacity in Latin America to take advantage of custom duties in accessing the US market. Moreover, bringing production closer to the consumers for greater speed to market is another trend identified throughout the interviews.

These trends, however, do not appear to be associated with reshoring, but instead with greater production capacity and sourcing from other low-income locations and, to a lesser extent, a movement of production to locations closer to end markets (i.e. near-shoring). The firms interviewed indicated greater sourcing from other Asian countries (such as Bangladesh, Viet Nam and Cambodia) as well as Sub-Saharan African countries (such as Ethiopia and Kenya) and parts of Latin America. Moreover, expanding middle classes in emerging and developing countries suggests that apparel and footwear manufacturing will likely remain in Asia and other traditionally low-cost locations. Indeed, interviewees recognized that Asia is not only a hub for apparel and footwear production, but also an important and growing consumer market.

"The component supply chain is still going to drive where production takes place."

"In apparel a lot of the tier two, tier three which costs billions to set up is heavily entrenched in Asia."

Another reason production may remain in low-cost locations, particularly Asia, relates to the importance of geographic proximity between assembly of clothing and footwear and the material supply chain. This is, as a respondent from the supply chain management firm underscored, part of the reason there is still so much garment manufacturing in China. A respondent from a sports firm stressed that establishing tier two and tier three suppliers in new locations requires heavy investments. As this respondent argued, moving garment and footwear production to high-income countries or neighboring regions for greater speed to market would require staging materials based on forecasts, which is risky in the absence of suppliers in other tiers of the supply chain. A caveat is that, as a source from a multi-brand conglomerate highlighted, the development of new materials could eventually reduce issues associated with raw materials.

"You see a lot of articles about Industry 4.0 and onshoring of production of t-shirts back to the US or Europe. In the big scale of things, as [other respondent] pointed out, it's in homeopathic quantities."

Some cases of reshoring have been documented in recent years. Consulting firm A.T. Kearney reported over 80 cases of apparel industry reshoring to the US in recent years, while the US-based Reshoring Initiative documented 75 cases for the textile and apparel industries from 2007 to 2015 (Anson, 2016; A.T. Kearney, 2014). However, there seems to be

consensus among the companies interviewed that reshoring has been limited to far. In addition, as a respondent remarked, proponents of reshoring and those who defend bringing

manufacturing back to developed countries expect jobs creation to ensue when, in fact, the examples seen thus far relate to automated facilities, with minimum, if any, direct impact on employment. The reshoring cases recorded by the Reshoring Initiative suggest that only 3,226 jobs were created in the US. Moreover, an initiative often highlighted as a successful example of automation-enable reshoring was recently dissolved. In 2016, Adidas made headlines with the inauguration of cutting-edge highly-automated footwear production facilities in Germany and the US, but in late 2019, it announced that these would be closing and that the technology developed for those factories would be transferred to suppliers in Asia (Adidas, 2019; Thomasson, 2019).

In the future, the relationship between reshoring and automation of apparel and footwear manufacturing will depend on the potential of new automation technologies and the extent to which these can offset the competitive advantages of developing and emerging countries, where labour is abundant and low-cost (Kucera, forthcoming; Kucera and Bárbara de Mattos, forthcoming). One respondent noted that it might be very hard to justify automation in the lowest labour-cost countries, such as Viet Nam and Indonesia, but easier to do so in Mexico and parts of Europe to allow production closer to market. It was suggested in some of the interviews that automation technologies could make near-shoring more attractive, to Mexico and other parts of Central America for the US market, Bangladesh and other parts of Asia for the rest of the continent, and Eastern for Western Europe. This echoes findings from a McKinsey & Company report which surveyed apparel sourcing executives and managers as well as industry participants and found that nearly 80 per cent believe that greater near-shoring is likely by 2025, depending critically on the use of new automation technologies in apparel production (McKinsey & Company, 2018).

Interview respondents also noted that although some production may be moving countries, many of the players remain the same. As previously noted, some very large suppliers are multinational companies in their own right, with production facilities strategically located across the globe. Examples provided in the interviews include a Sri Lankan supplier in Mexico, and Bangladeshi suppliers with plants in Ethiopia.

The interviews unveiled some scope for future reshoring of final assembly, especially of customized, higher end, products. Respondents suggested that apparel and footwear goods could use base models and parts pre-made in traditional lower-cost locations, availing from the latest available technologies for personalization in or near end markets. One respondent also indicated that on-shored production could be used for short-run of products to test customers' reactions. This could allow for fast delivery and respond to growing demand for custom goods, with limited impacts on the global division of labour.

5. Conclusion

Some studies suggests that new technologies will be increasingly able to automate work traditionally done by workers, particularly in routine, repetitive tasks which characterize many labour-intensive industries such as apparel and footwear manufacturing. For instance, it has been estimated that between 64 and 88 per cent of textiles, apparel and footwear workers in Cambodia, Indonesia and Viet Nam are at high risk of displacement by computer-controlled automation technologies (Chang, Huynh and Rynhart, 2016). In such a scenario, the low-cost labour advantage of developing and emerging exporters would be eroded, and arguably, with the exception of large developing countries such as China and India, the main risk of job loss would be automation in (or near) developed countries and associated reshoring (or near-shoring) of production. This would have significant implications for the viability of the industry as an engine for economic growth and employment in these countries. Reshoring (or near-shoring) would combine cost reductions associated with reduced need for workers with those related to closer proximity between production and consumption, including lower transport costs and inventory needs.

We argue that assessments on potential worker displacement based exclusively on the task composition of occupations overstate risk in light of practical issues faced at the shop floor – with the caveat that it is difficult to anticipate technological developments and their employment implications beyond the near future. In the interviews, statements on the topic of current and projected use of automation in their own supply chains and the industry at large suggest that significant technological bottlenecks remain. Firms highlighted technical bottlenecks related to dexterity and flexibility required to deal with malleable fabrics. At the same time, technical feasibility did not emerge as the single decisive factor in automation decisions. Limited incentives – connected to whether there is a perceived need for change in production processes, large investment requirements and concerns in terms of skills availability, among others – need addressing before automation at scale can be adopted. Respondents do not believe automation technologies will lead to sizeable job losses in the industry in the near future, and suggest a likely outcome is greater worker-machine collaboration. Nevertheless, increases in productivity due to automation could reduce the industry's job generation potential. Workforce implications in the medium to long-term are, therefore, unclear. Furthermore, employment impacts are likely to be uneven, depending on the structure of the industry and labour force in each country (ILO, 2019).

None of the respondents thought that automation technologies would result in significant reshoring of production, but many believe that as technology improves and prices decline, there is the potential for some reshoring. One plausible scenario is that brands maintain a dual sourcing strategy: continue importing basic low-priced products with large and stable demand, while also expanding re- or nearshored production that is increasingly automated to manufacture higher priced and customized products. A key reshoring deterrent relates to benefits associated with

the geographic proximity of apparel and footwear factories and the materials supply chain, which is concentrated in developing and emerging countries. In addition, demographic trends – including population growth and expanding middle classes – indicate that maintaining production close to consumer will require significant production capacity in developing and emerging countries in Asia and beyond.

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