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► The effects of automation in the apparel and footwear industries and their gender dimensions: Indonesia case study

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Abstract

This paper addresses the drivers of and limitations to automation and technological upgrading in the apparel and footwear industries and their effects on men's and women's employment, quality of work and patterns of gender segregation. We do so through case studies of two apparel and two footwear factories in Indonesia, one of the world's largest exporters in the industry, based on factory visits and interviews with employers, technology specialists, workers and worker representatives. These factories are all fairly large and modern and were selected with the expectation that they likely represent "best practice" in terms of technology adoption in supplier factories in an industry, which is generally a laggard in this regard, especially when compared to automobiles and electronics, two other industries organised through GSCs. Our paper sits at the intersection of two strands of literature, the first on automation and employment and the second on feminisation and defeminisation of employment in the face of technological upgrading and the linkages with gender segregation at the task and industry levels. Among our findings is that there is growing use of automation in fabric cutting and spreading and of semi-automation in footwear sewing, but that there is little automation in apparel sewing largely due to technical bottlenecks. While automation created labour displacement at the task level, it did not necessarily do so at the factory level, as affected workers shifted to different tasks. In terms of the gender division of labour, there is evidence that automation is integrating more men into production through the deskilling of sewing in footwear and in the operation of automatic and semi-automatic machines in both apparel and footwear production. While the reduction in the physical demands of certain shopfloor tasks has weakened the traditional rationale for the gender division of labour, we did not identify corresponding shifts on the shopfloor.

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¹ [Building partnerships on the Future of Work \(EMPLOYMENT\) \(ilo.org\)](https://www.ilo.org/publications/new-issues/building-partnerships-on-the-future-of-work-employment)

1. Introduction

The apparel and footwear industry has long provided a strategic entry point for developing countries endeavouring to break into global markets. In some respects, the attraction for developing countries is evident, for the financial and technological barriers to entry are low and the potential for job creation is high, given the labour-intensive nature of production and expanding global markets. Yet for these same reasons, the industry is also highly competitive and many of the jobs within it are of low quality and pay and with limited prospects, all the more so given the footloose nature of the industry. The industry is organized through global supply chains (GSCs) driven by lead firms (brands and retailers) concentrated in the global North and with supplier firms (factories) concentrated in the global South. A defining dynamic of GSCs is that bargaining for added value takes place not just between workers and employers within firms but also between firms having disparate market power along supply chains.

More than any other manufacturing industry, apparel and footwear production is not just labour-intensive but also female-intensive, i.e. women make up a disproportionate share of the workforce among diverse countries. This mix of factors motivated a sizeable literature analysing the reasons for women's overrepresentation in the industry, whether export competitiveness in the industry depends on women's low pay, and the extent to which women benefit from working in the industry versus the extent to which they are a "disposable" workforce, including in the face of technological upgrading (e.g., Joekees 1999; Kabeer and Mahmud 2004; Bair 2010; Berik 2017; Seguino and Braunstein 2018; Barrientos 2019).

Concerns about technological upgrading in the industry were spurred in recent years by studies suggesting that jobs in apparel and footwear production are at high risk of potential automation, based on a method developed by Frey and Osborne (Frey and Osborne 2017; Chang et al. 2016). Based on the extent of routine tasks within these jobs, these studies addressed the *technological* rather than *economic* feasibility of these jobs being automated in coming years. The following estimates of the risk of potential automation are particularly relevant: for sewing machine operators, 89 per cent; for hand sewers, 99 per cent; for shoe and leather workers, 52 per cent; and for shoe machine operators and tenders, 97 per cent.

Other studies argue that these estimates are overstated because they do not adequately account for the variety of more and less readily automatable tasks within jobs (Arntz et al. 2016; McKinsey 2017). In spite of their differences, a key common motivation of these studies is to derive economy-wide estimates of the risk of potential automation based on technological feasibility. Other recent studies address technological bottlenecks by looking at how firms developing automation and semi-automation machinery for the industry are endeavouring to overcome these bottlenecks, resulting from the pliability of fabrics combined with the wide range of products and product sizes (Altenburg et al. 2020; Kucera 2020). These studies unquestionably provide useful insights. At the same time, a more in-depth understanding of both technological and economic feasibility requires analysis at the level of supplier factories, where investment decisions are made.

Our paper addresses the drivers of and limitations to automation and technological upgrading in the apparel and footwear industry and its effects on the quality and quantity of women's and men's employment from a shopfloor perspective and how this is related to patterns of gender segregation. We do so through case studies of two apparel and two footwear factories in Indonesia, one of the world's largest exporters in the industry, based on factory visits and interviews with employers, technology specialists, workers and worker representatives. These factories are all fairly large and modern and were selected with the expectation that they likely represent "best practice" in terms of technology adoption in supplier factories in an industry that is generally a laggard in this regard, especially when compared to automobiles and electronics, two other industries organised through GSCs.

Our paper sits at the intersection of two strands of literature, the first on automation and employment and the second on feminisation and defeminisation of employment in the face of technological upgrading and the linkages with gender segregation at the task and industry levels. Empirical studies in this second strand of literature find that technological upgrading is often associated with the defeminisation of employment (e.g., Kucera and Tejani 2014; Tejani and Milberg 2016; Greenstein and Anderson 2017; Seguino and Braunstein 2018;

Tejani and Kucera 2021).² Yet these findings are commonly based on economy-wide or industry-level data, whereas the hiring and firing decisions underlying them take place within firms. Both strands of literature, then, stand to benefit from a more shopfloor perspective.

Patterns of gender segregation among industries result in large part from firms' past hiring decisions, and Seguino and Braunstein (2018) provide several possible explanations for such hiring decisions. These include (a) gender stereotypes about men and women's qualifications, (b) concerns about the negative effect on productivity of hiring women in jobs dominated by men, (c) using gender segregation among occupations as a divide and conquer strategy to weaken workers' bargaining power, and (d) gains to firms through paying men efficiency wages.

These explanations endeavour to account for why firms in male-intensive industries tend not to hire women and female-intensive industries tend not to hire men in the first place. Other explanations address why, in the context of defeminisation driven by technological upgrading, firms either do not retain women workers they previously hired or at least maintain the same proportions of women and men workers. Kucera and Tejani (2014) summarise these as follows: (1) the lesser importance of low-wage women's labour in more capital-intensive production, (2) gender norms designating men as primary and women as secondary earners, with men more likely to be hired for higher paying jobs, (3) the different skills requirements of the new jobs created in the face of technological upgrading, combined with the real or perceived skills differences of women and men, and (4) firms' unwillingness to invest in training for women due to their higher turnover.

There are also more specific hypotheses addressing why women are overrepresented in the apparel and footwear industry and particularly within sewing operations, which make up the largest share of production jobs in the industry. Still timely in this regard is a 1982 paper by Elson and Pearson, which speaks directly to the questions addressed by our paper and merits quoting at length:

The answers that companies give when asked why they employ women [...] show that there is a widespread belief that it is a "natural" differentiation, produced by innate capacities and personality traits of women and men [...] Where do women get their skills? [...] [S]ince industrial sewing of clothing closely resembles sewing with a domestic sewing machine, girls who have learnt such sewing at home already have the manual dexterity and capacity for spatial assessment required. [...] It is partly because this training, like so many other female activities which come under the heading of domestic labour, is socially invisible and privatized, that the skills it produces are attributable to nature, and the jobs that make use of it are classified as "unskilled" or "semi-skilled" (pp. 92-93).

These views are echoed by Barrientos in her work on gender and GSCs, who writes, "Gendered patterns of work in global value chains often relegate women to providing a cheap labour force using socially acquired skills that are insufficiently recognized or remunerated" (2019, p. 4). The views of Elson and Pearson and Barrientos provide a useful contrast to those of Salzinger (2003) and Caraway (2007), who argue that patterns of gender segregation result from a "trope of productive femininity," with a seeming disregard for whether this trope has a basis in reality. As Caraway writes, "whether women possess these traits is irrelevant: the crucial point is that employers believe that they do" (2007, p. 30). However, the underlying reality is not irrelevant to employers who are contending with a shortage of skilled sewers and are using automation as a means of addressing this; nor is it irrelevant to those who stand to lose jobs in the face of such automation.

The challenges faced by women workers in export-oriented development are usefully viewed in the context of "low-road" versus "high-road" strategies, as exemplified in the work of Joekes (1999) and Barrientos (2019). Joekes associates the high-road strategy with shifts towards new products and industries and an emphasis on continuous productivity increases. The low-road strategy in contrast is associated with a concentration on labour- and female-intensive products such as apparel and electronics, with an emphasis on increasing market shares

² There is a sense in which Indonesia is anomalous in the context, since it is only one of two among a sample of 14 export-oriented countries for which there is a *positive* long-run effect of labour productivity growth on female shares of manufacturing employment (Tejani and Kucera 2021). Yet this is a result for manufacturing as a whole, and the effect for the apparel and footwear industry is negative across the 14 countries.

through cost cutting. For Joeke (ibid.), neither high- nor low-road strategies hold promise for women workers. She provides several country examples of how the high-road is associated with the defeminisation of employment, as women are not hired in new industrial jobs. The low-road in turn is associated with driving down women's wages and further casualisation of their employment. In contrast, Barrientos (ibid.) argues that low- and high-road strategies are usually seen as a continuum that can vary within industries. The high road is associated with economic upgrading from which can follow social upgrading, particularly as regards better working conditions, though this involves "a constant process of bargaining and contestation" (ibid., p. 4). Barrientos points to Nike's Equitable Manufacturing initiative in Indonesia as an example of the high-road strategy, in which "economic upgrading became linked to social upgrading. This has led to improved conditions and rights for a largely female workforce" (ibid., p. 195). Barrientos emphasises the significance of Nike being part of the Better Work programme, a partnership between the International Labour Organization and the International Finance Corporation, and that factories in the programme across a number of countries benefited from both improvements in economic performance and reduced gender inequality by several measures, including gender pay gaps (ibid.; ILO/IFC 2016). Worth noting is that the two apparel factories in our study are also in the Better Work programme in Indonesia.

In better understanding the drivers of and limitations to automation and technological upgrading, our interviews with employers and workers in apparel and footwear factories in Indonesia provided a number of useful insights. Yet our findings are less clear with respect to the causes of gender segregation and its relationship with technological upgrading. This is partly because our visits and interviews took place at one point in time and the information we collected on change over time was often more anecdotal than systematic. This may also have resulted to some extent from the greater reticence of those interviewed on the sensitive topic of differences between women and men in the workplace. The site visits and interviews also took place amidst the tumult of the Covid-19 pandemic, which created its own limitations, especially as the authors contracted Covid-19 in the midst of the site visits. How these factories adapted to the Covid-19 crisis and resultant supply chain shocks is one of the questions addressed by our paper.

The remainder of our paper is structured as follows. Section 2 provides general country context, addressing the characteristics of the apparel and footwear industry, employment and working conditions, and the effects of the Covid-19 pandemic, as regards the industry as a whole in Indonesia. Section 3 describes the factory case study design. Sections 4 and 5 address findings for the apparel and footwear factories, respectively, including descriptions of the factories, the gender division of labour and working conditions, the effects of Covid-19, drivers of and limitations to automation and technological upgrading, as well as the impacts of automation, particularly on the quality of work and the gender division of labour. Section 6 provides a summary of main findings and concluding remarks.

2. Country context

General characteristics of the apparel and footwear industry

Indonesia was the world's 11th largest exporter of apparel and footwear globally in 2020. As seen in Table 1, its share of the global market in apparel and footwear has expanded to 2.2 per cent over the last decade. The country emerged as an important site in the triangular manufacturing trade, which took place in the region after the mid-1980s. In this arrangement, brands and retailers in the US and Europe continued to place orders with their traditional manufacturers in the East Asian first-tier newly-industrialised countries (NICs) who began to source production in low-wage countries (Gereffi and Memdovic 2003, p. 15). Low labour costs and unused Multi-Fiber Arrangement (MFA) quotas incentivised companies from South Korea, Taiwan (China) and Hong Kong (China) to set up manufacturing plants in Indonesia (Thee 2009, p. 564-565). The protection afforded to Indonesian firms by MFA quotas were essential to the development of the industry and by 1989, apparel and plywood were Indonesia's two major manufacturing export products (Thee 2009, p. 563-4).

During the 1990s, Indonesia became fully integrated into apparel GSCs and a major player in the global industry (Gereffi and Memedovic 2003, p. 28). However, there was a slowdown in apparel exports in the mid-1990s as Indonesia's competitiveness eroded due to the lack of investment, delays in procurement and intensifying competition from China and other Southeast Asian countries (Thee 2009, p. 572). After the Asian financial crisis of 1997, the Government of Indonesia introduced a new strategy focused on enhancing growth, productivity and value added within value chains including the textile and apparel industry (Ministry of Indonesia 2005, cited in Kadarusman and Nadvi, 2013, p. 1012). Although the MFA was an important driver of the apparel industry's expansion in Indonesia, competitiveness improved despite the phase-out of quotas and therefore export volumes were substantially higher in 2010 than in the 1990s (Kadarusman and Nadvi, 2003, p. 1013).

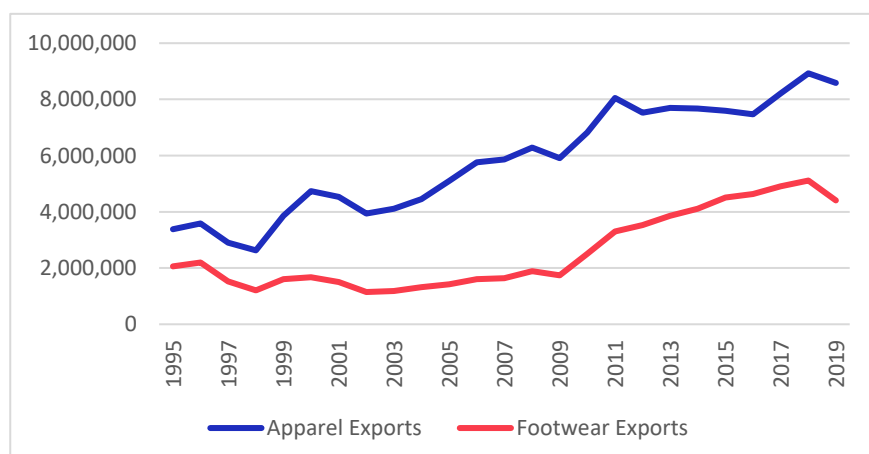
Table 1: Top global exporters of apparel and footwear

	Rank in 2020	Apparel and footwear exports in 2020 (million dollars)	% of global market	
			2020	2010
China	1	179,702	30.8	35.7
Viet Nam	2	58,528	10.0	3.4
Italy	3	33,013	5.7	6.4
Germany	4	32,305	5.5	4.7
Bangladesh	5	27,814	4.8	3.4
Netherlands	6	17,031	2.9	2.0
Turkey	7	16,425	2.8	2.8
France	8	15,629	2.7	2.6
India	9	14,888	2.6	2.8
Spain	10	14,847	2.5	2.2
Top 10		410,183	70.3	66.1
Indonesia	11	12,851	2.2	2.0
World		583,518		

Source: UNCTADstat (downloaded August 2021). Available online at: [UNCTADstat](https://unctadstat.unctad.org/)

Figure 1 presents apparel and footwear export values for the period 1995-2019 separately. On average for this period, footwear comprised around one-third of the total revenue of the two industries combined. In 2019, non-knit and non-crocheted apparel made up 54 per cent of apparel exports and knit and crocheted apparel 46 per cent; textile footwear made up 39 per cent of footwear exports, leather footwear 37 per cent, and rubber footwear 14 per cent (OEC, 2021).

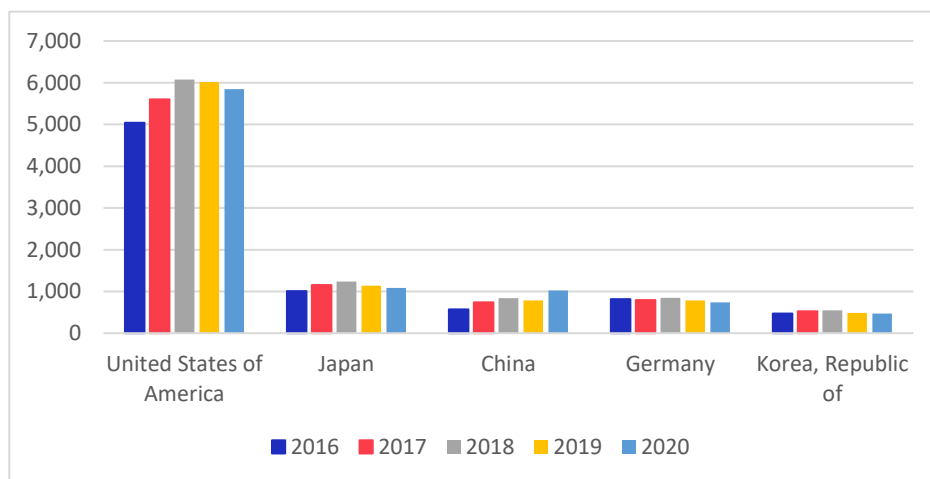
Figure 1: Apparel and footwear export values, 1995-2019 (thousands USD)



Source: Author's illustration using UNCTAD (2021)

The destination of Indonesia's exports is overwhelmingly the US as evident in Figure 2 and exports to Japan, the second-largest market, were about one sixth of US exports. Indonesia expanded its share of the US and Japanese apparel markets after the expiry of the MFA, but lost market share in the EU-15 (Gereffi and Frederick 2010, p. 11). However, the destination of footwear exports is more diversified as compared to apparel, with around 30 per cent going to Europe, 24 per cent to the US and the rest to Asia (OEC 2021).

Figure 2: Apparel and footwear exports, top five destinations in 2020, 2016-20 (million USD)

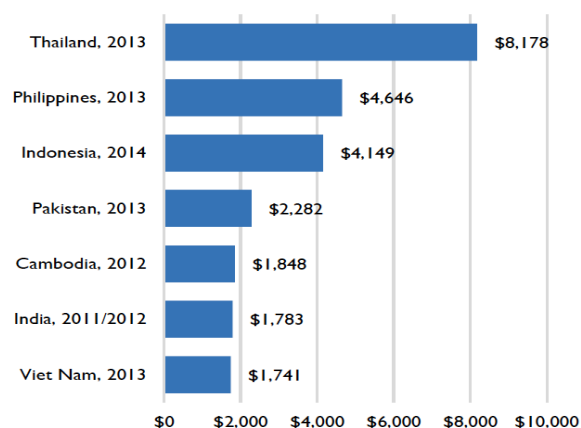


Source: Illustration using UNCTAD (2021)

Labour productivity (measured as gross value added per worker) in the apparel, textiles and footwear industry in Indonesia was relatively high in 2013, but lower than other countries in the region, such as Thailand and the Philippines, as seen in Figure 3. Large and medium scale firms³ in the industry that are able to exploit economies of scale have significantly higher labour productivity than smaller firms, though in 2015 their productivity was still one-third that of the manufacturing sector as a whole (Horne and Andrade 2017, p. 2). These firms employ about 260 workers per establishment on average with 45 per cent concentrated in the manufacture of textiles, 40 per cent in wearing apparel, and 16 per cent in footwear. Most workers (63 per cent) are clustered in small and medium enterprises (SMEs) in the apparel, textile and footwear industry (Horne and Andrade 2017, p. 2).

³ Large firms are classified as those employing 100 or more workers; medium size firms with between 20 to 99 workers, small firms with 5 to 19 workers and micro enterprises as those with 1 to 4 workers (Horne and Andrade 2017).

Figure 3: Labour productivity in apparel, textile and footwear manufacturing, current \$



Note: Labour productivity defined as gross value added in current prices per person employed, with official nominal exchange rates applied;
Source: Estimates based on official data from national accounts and national labour force surveys (various years); World Bank: World Development Indicators (2014).

Source: Reproduced from Horne and Andrade (2017), p. 2.

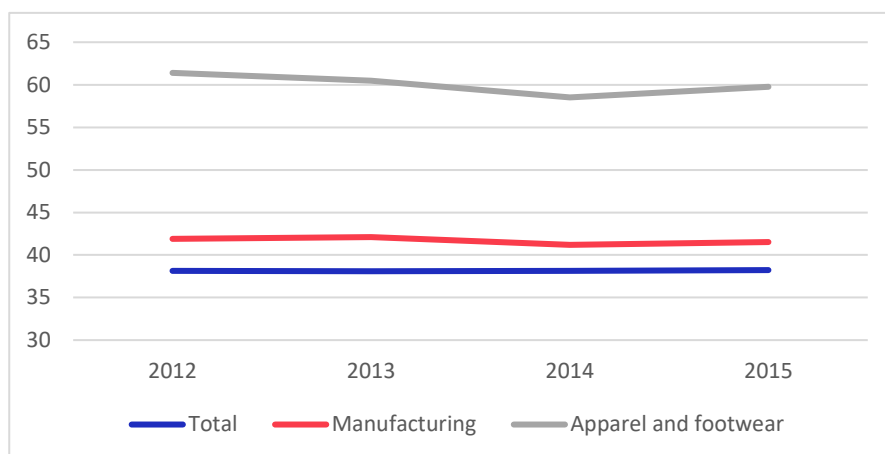
Labour, labour rights and work in the industry

After the fall of the Suharto regime and shift to democracy in the late 1990s, Indonesia ratified the ILO's "core" labour conventions and passed a new Trade Union Act in 2000 that guaranteed basic political rights for workers including freedom of association and the right to collective bargaining (Caraway 2004, p. 37). Workers were also able to defend against the flexibilisation of work to an extent in the second round of labour reforms carried out through the Manpower Act of 2003. The act put limits on contract labour and outsourcing, made firing workers more difficult, and provided for higher severance pay and other rights related to legal strikes, though it also gave important concessions to employers (Caraway 2004, p. 42). Caraway (2004) argues that international pressure and institutional design played a role in producing labour friendly outcomes and conserving protective parts of labour legislation through the process of neoliberalisation in Indonesia.

However, in general, the labour movement in Indonesia has been characterised as "organizationally fragmented and politically weak" even as the expansion in the number of unions has not resulted in significant coverage through collective bargaining agreements (Bartley and Engels-Zandén 2016, p. 237). Yet trade union density increased overall in recent years, from 7 per cent in 2001 to 13 per cent in 2019 (ILO 2023).

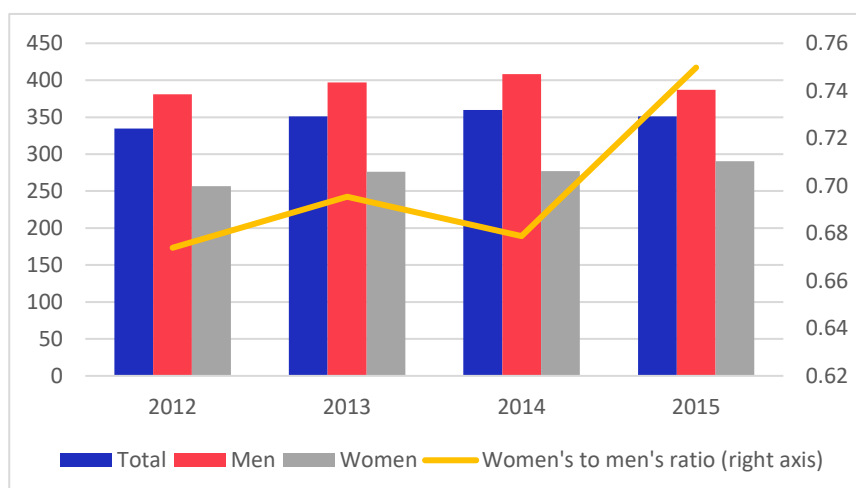
Women's labour force participation in Indonesia is significantly lower than men's and has been hovering between 45-55 per cent since 2000, compared to over 80 per cent for men (ILO 2021). Similarly, women's share of manufacturing employment has been relatively stable at 40 per cent of the total though many more women than men are employed in the apparel and footwear industry on average as seen in Figure 4. Between 2012 and 2015, approximately 3 million workers were employed in the apparel and footwear industry in Indonesia, which comprises roughly 18 per cent of total employment in manufacturing (ILO 2021). There is also a significant gender wage gap in manufacturing that narrowed slightly in 2015 to 0.74 as evident in Figure 5, though it was driven more by a decline in men's mean monthly earnings than a rise in women's. The wage gap in the apparel industry showed more progress and was down to 14 per cent in 2016, while, in footwear, women earned 17.4 per cent more than men (Horne and Andrade 2017, p. 7).

Figure 4: Women's share of employment, 2012-15 (per cent)



Source: Illustration using ILO (2021)

Figure 5: Mean monthly earnings of employees in manufacturing by sex, 2012-15 (2017 PPP \$)



Source: Illustration using ILO (2021)

Workers in the textiles, apparel and footwear sector in Indonesia tend to be more educated than their counterparts in other Asian countries: approximately 70 per cent of workers had secondary levels of education or higher as compared to 37 per cent in Vietnam and 5 per cent in Cambodia (Horne and Andrade 2017, p. 5). In fact, more women (67 per cent) had secondary education than men (64 per cent) in 2016 and workers in the leather and footwear sector had higher levels of education than those in apparel and textiles (Horne and Andrade 2017, p. 5). Although figures for the apparel and footwear are not available separately, 72 per cent of workers employed in the sector were wage and salaried employees in 2016, with a relatively lower rate of vulnerable employment as compared to manufacturing as whole (Horne and Andrade 2017, p. 6). However, there is a gender gap in this respect with fewer women in regular positions than men and thus a higher female casualization rate (Horne and Andrade 2017, p. 6). During the slowdown in the industry between 2012 and 2015, women lost employment in absolute terms while men gained slightly (Horne and Andrade 2017, p. 5).

Monthly minimum wages in Indonesia in the apparel industry are relatively high compared to a number of other Asian countries though lower than in China, Malaysia and the Philippines as seen in Figure 6. Nevertheless, minimum wages within the country are set at the provincial level, and there is a wide dispersion across regions that increased between 1997 and 2016 (Horne and Andrade 2017, p. 8). Important regions for textile, apparel and footwear production – West, East and Central Java – have some of the lowest provincial minimum wages in the

country though DKI Jakarta, which is also a key site for the sector, has the highest provincial minimum wage among them (Horne and Andrade 2017, p. 8). However, factories operating in West, East and Central Java apply the city or district minimum wage, which is higher than the provincial minimum wage. For example, the district minimum wage in Karawang in West Java is higher than the provincial minimum wage in DKI Jakarta.⁴ Minimum wage compliance, calculated as the share of wage and salaried employees earning more than the minimum wage on a monthly basis, increased between 2012 and 2015, but much more for men than women (Horne and Andrade 2017, p. 9). Better Work Indonesia's Annual Report for 2019 notes that the ILO has made proposals to "simplify and harmonise" the minimum wage system in the country and that "Policy debates around minimum wage issues remain contentious" (Better Work Indonesia 2019a, pp. 6, 14).

Long working hours are endemic in the industry with 60 per cent of workers in apparel and 51 per cent in footwear in Indonesia working excessive hours in 2016 (Horne and Andrade 2017, p. 9). However, men tended to work longer hours than women in both the apparel and footwear industries: 47 hours per week in both on average as compared to women's 39 and 43 hours per week in each industry respectively (Horne and Andrade 2017, p. 9).

Figure 6: Monthly minimum wages in apparel industry (\$), as of 1 January 2015



Note: All rates presented are effective as on 1 January 2015 and refer to the lowest skill grade for new entrants. For countries with decentralized minimum wage systems, figures reflect relevant rates in the main garment-producing locations.

Source: ILO compilation from official national sources.

Source: Reproduced from ILO (2015), p. 4

The effects of Covid-19

The massive demand contraction and supply disruption faced by the apparel industry as a result of Covid-19 has had dramatic effects on apparel workers (Tejani and Fukuda-Parr, 2020). Indonesia did not impose a general lockdown as opposed to countries such as Bangladesh; rather some social restrictions were imposed in the country on a provincial basis (ILO 2020). Still a survey of 216 Better Work (BW) factories in Indonesia in May 2020 found that 28 per cent of firms faced a reduction or hold on their orders, 18 per cent of them had orders cancelled altogether, while 24 per cent faced shortages in supplies and raw materials (ILO 2020). Around 70 per cent of BW factories closed for less than one month and firms reported losing about \$70 million in lost or delayed business.

Firms proceeded to furlough and lay off workers without any agreement with unions and 40 per cent of furloughs were unpaid or at reduced pay, which was often lower than half the regular wage (Clean Clothes Campaign 2020, p. 21). Just for the months of March to May 2020, Clean Clothes Campaign estimated that \$4 million were owed to workers in wage payments (Clean Clothes Campaign 2020, p. 22). There were also reports of mandatory overtime

⁴ Thanks to Olivia Krishanty of Better Work Indonesia for pointing this out to us.

work and an increased cost burden for workers who were required to purchase face masks and sanitisers and pay for their own Covid-19 tests if they became ill (Johnson 2021). The Indonesian government did offer cash aid to workers who were laid off if they completed online training programmes, but apparel workers were not among the priority beneficiaries. It was also hard for workers without smartphones and internet connections — often the poorest — to access the programme (BHRC n.d.).

However, the supply disruptions in China and the attempt by lead firms to diversify their supply chains geographically might mean that Covid-19 could benefit countries like Indonesia. Nevertheless, the second wave of Covid-19 in Indonesia in 2021 had devastating social and economic effects and this will need to be duly considered in any assessment on the impact of the pandemic on the apparel and footwear industry.

► 3. Factory Case study design

Factory case studies are based on semi-structured face-to-face interviews and factory visits undertaken by Indonesian researchers and the authors in mid-2022, based on fieldwork guidelines and questions developed by the authors. Four factories were studied, two producing apparel and two producing footwear. We name the four factories we studied based on their product categories as follows: Lingerie Factory, Sportswear Factory, Sandal Factory and Sports Shoe Factory.⁵ For each factory, this generally involved separate sets of interviews with one to three top managers, one to two technology specialists, one worker representative, two to three women production workers, and two to three men production workers, though in some cases top managers and technology specialists were interviewed together. The Sandal Factory was exceptional in not having a worker representative and at the Sports Shoe Factory, a compliance risk manager for the buyer was interviewed alongside top managers. To avoid disrupting the production process, workers were chosen by management. This and the small number of workers interviewed suggests that the views of the workers interviewed may not be representative of those in the entire factory. While this is a possible limitation, we nonetheless had the sense that the workers interviewed were generally forthcoming in their replies. Information on the job title/description, sex, age and tenure of interviewees are shown in Appendix Table 1.

The interviews were undertaken on the premise of anonymity in the reporting for factories and individuals. Interviews generally lasted for about an hour and were recorded and transcribed and, where necessary, translated into English for the authors. For top management and technology specialists, questions were asked in the categories of technological upgrading; technology and workers; and general comments on prospects. For worker representatives, the respective categories were (a) industrial relations and collective bargaining, (b) automation and technological upgrading, and (c) quality of work, training and career advancement. For workers, the respective categories were (1) the nature of work, (2) technology and worker experience, (3) current position and job quality, (4) home and work, and (5) looking ahead. (Fieldwork guidelines and the full set of questions are available from the authors on request.)

With regard to apparel, Indonesia has only a slightly lower share of knitted or crocheted than non-knit or crocheted apparel and clothing exports (OEC, 2021). We chose to focus on factories producing the latter in selecting the two apparel factories, since the production of knitted apparel is already widely automated (Nayak and Padhye, 2018; Altenberg et al., 2020). Moreover, the four factories we study represent a particular type of purposive sampling namely, what Etikan et al. (2016, p. 3) refer to as “extreme/deviant case sampling.” That is, the four factories are non-representative by design. They are all sizeable and modern factories with three of the four producing for large brands and retailers for markets in the US and Europe, and are thus more likely to represent the “best in practice” in terms of technology adoption. The Sandal Factory is exceptional in producing footwear largely for the Indonesian market, but is nonetheless a large firm and retailer in its own right. All of the factories

⁵ The interviews were completed for the Lingerie Factory on 5 July 2022, the Sportswear Factory on 11 August 2022, the Sandal Factory on 13 July 2022, and the Sports Shoe Factory on 14 July 2022.

belong to privately held firms, and thus we do not have ready access to the standard information and data available for publicly-held firms.

As noted above, the two apparel factories are in the Better Work (BW) programme, a partnership between the International Labour Organization (ILO) and the International Finance Corporation (IFC).⁶ This is highly relevant for interpreting our research findings, because firms in the BW programme have made a commitment to decent working conditions and to regular evaluations on multiple dimensions of compliance, including gender equality. Suggestive in this regard is that non-compliance with gender discrimination has declined in BW factories in Indonesia from 2011 to 2020, from about 12 to 10 per cent on average (ILO, 2022, p. 33).

► 4. Apparel factories

Description of factories and activities

The Lingerie Factory manufactures primarily bras but also lingerie and underwear for women, solely for export and predominantly for the US and European markets.⁷ It is a large factory, with just over 4,000 workers in 2022, and produces for such well-known brands and retailers as the PVH Corp. (owner of Calvin Klein and Tommy Hilfiger among others), Fruit of the Loom, H&M and C&A. The Lingerie Factory is one of three of an international group of factories owned by a Burmese entrepreneur, with the others located in Myanmar and Ethiopia, and several of the Lingerie Factory's top managers are Filipino expatriates. Taken together, these factors convey a sense of the factory's truly international character. The factory was moved from Jakarta to Central Java in 2009, where the regional minimum wage is about half that in Jakarta (for full-time workers) (Better Work Indonesia 2022).

The Sportswear Factory manufactures sportswear and outdoor apparel, solely for export and predominantly for the US market, and had just under 1,000 workers in 2022. Like the Lingerie Factory, the Sportswear Factory produces for the PVH Corp. as well as Columbia Sportswear among others. The factory was established by South Korean entrepreneurs in Tangerang, Banten, in the late-1980s and remains there to date, in spite of the higher regional minimum wage. The factory's parent company – still owned and managed by South Korean ex-patriates – more recently set up a second factory in Central Java (not the subject of this study) to benefit from the lower regional minimum wage, and there are ongoing discussions among top managers as to whether to further shift production to Central Java. Indeed, these large differences in regional minimum wages have been the subject of much policy discussion in Indonesia as well as a key factor in the location and re-location of apparel and footwear factories.

Shown in Table 2 are employment figures for the Lingerie and Sportswear Factories from 2018 to 2022, including breakdowns by sex and per cent shares of female employment. The tables shows that the number of total employees increased quite steadily in the Lingerie Factory over these years from 3,445 in 2018 to 4,084 in 2022, in spite of the Covid-19 crisis. Employment in the Sportswear factory declined from 1,016 in 2018 to a low of 715 in 2021 because of the Covid-19 crisis, but rebounded to 960 by 2022. For both factories, the female share of employment was consistently over 90 per cent over these years.

⁶ For further information, cf. [Better Work - Improving garment industry conditions](#)

⁷ For a useful step-by-step video of how bras are produced *manually*, see: [THE PRODUCTION PROCESS OF BRA - YouTube](#)

Table 2: Employment in the apparel factories in Indonesia

Lingerie Factory				
	Female	Male	Total	% Female
2018	3,195	250	3,445	92.7
2019	3,128	239	3,367	92.9
2020	3,455	242	3,697	93.5
2021	3,808	267	4,075	93.4
2022	3,811	273	4,084	93.3
Sportswear Factory				
	Female	Male	Total	% Female
2018	946	70	1,016	93.1
2019	912	66	978	93.3
2020	713	61	774	92.1
2021	657	58	715	91.9
2022	897	63	960	93.4

In spite of the considerable differences in products manufactured by the Lingerie and Sportswear Factories, production activities on the factory floor follow the familiar sequence of apparel cut-and-sew operations. That is, rolls of fabric are delivered for fabric spreading followed by fabric cutting and then sewing. These different operations are organised in both factories by departments with workers assigned to specific departments. Following trends in the apparel industry as a whole, automation has been implemented more fully in fabric spreading and cutting operations, as discussed below (Nayak and Padhye, 2018; Altenberg et al., 2020).

Gender division of labour and working conditions

While we do not have precise breakdowns on the number of women and men in these different operations, both the interviews and observation on the factory floor confirm that carrying fabric rolls to cutting operations is done overwhelmingly if not exclusively by men, fabric cutting predominantly by men, and sewing overwhelmingly by women. As sewing jobs are by far the most numerous in these factories, women make up by far the largest overall share of workers.

Workers are represented in the Lingerie Factory by a factory-level committee comprised of 12 worker and 12 employer representatives while workers in the Sportswear Factory are represented by a union with representatives in each of the factory's departments and that is affiliated with a union federation. Based on the interviews, there is a consensus among workers and employers that labour-management relations are generally positive, with, for example, no strikes reported during the tenure of either worker representative interviewed. Noteworthy in this regard is that worker representatives stated that they are involved in or consulted about the introduction of new technologies.

Both factories use contract workers, but the majority of workers have regular employment status and associated benefits. In the Lingerie Factory, contract workers typically attain regular employment status after one to three years, and around 70 per cent of workers in the Sportswear Factory have regular employment status. The standard full-time workweek is 40 hours, eight hours per day for five days per week. Overtime of one to two hours per day is also common during busy periods and is paid on an hourly basis with a premium over the average hourly wage. The default starting wage in both factories is the regional minimum wage for all operations within the factories, and interviewees do not report systematic pay differences between women and men. Tenure seems the most systematic determinant of wage increases, but wages can also increase depending on whether a worker is promoted to line supervisor, receives training for and operates new machines, as well as on overall performance. Performance incentives are also used for sewing teams in the Lingerie Factory, based on meeting production targets. In general, wage increases on top of the minimum wage are small, and thus the wage structure among workers is quite compressed. For workers with regular employment status, benefits include access to national health insurance (BPJS Kesehatan), 12 days of paid annual leave, and for women three months

of maternity leave and two days of menstrual leave per month. Both factories have on-site medical doctors. Though neither factory has childcare facilities, the Lingerie Factory does provide a lactation room.

Covid-19

Both the Lingerie and Sportswear Factory experienced complete lockdowns as well as temporary layoffs in 2020 because of the Covid-19 pandemic, with workers receiving partial wages during this period. In the Lingerie Factory, the female share of employment increased slightly during the Covid-19 crisis, in the face of increases in employment for both women and men from 2019 on. For the Sportswear Factory, in contrast, the female share of employment fell from 93.3 per cent in 2019 to 91.9 per cent in 2021 before rebounding to 93.4 per cent in 2022, illustrating that women experienced greater job loss than men during the crisis. In both factories, layoffs were done largely through job sharing, either through part-time work or full-time work on an alternating basis, with wages correspondingly reduced. The technology specialist at the Lingerie Factory argued for the importance of retaining current rather than hiring new workers during the pandemic, because it is “very difficult to find the same quality of operator.” Yet orders bounced back and were indeed higher in 2022 than just prior to the pandemic, with the Lingerie Factory adding 500 workers during this period and the Sportswear Factory returning to the pre-pandemic level of around 1,000 workers. The Sportswear Factory also benefited from one its key brands shifting a share of its production from Vietnam to Indonesia. According to interviews with top management, this shift began several years prior to the pandemic due to the brand wishing to diversify its suppliers, but received further impetus during the pandemic because of Vietnam’s stricter lockdown policies.

Drivers of and limitations to automation

The first process to be automated in the Lingerie Factory was fabric cutting in 2017, followed by semi-automation in strapping and hooking operations. According to top management, automated cutting (by blade rather than laser) has resulted in a doubling of output per worker while also resulting in more precise cutting and thus less waste. The Lingerie Factory has three automated cutting machines, with manual cutting still used for more slippery and delicate fabrics as well as shorter runs of fabric. Strapping and hooking are done entirely by new semi-automated machines in the factory. Comparing the new machines with the older manual machines, the number of workers per machine is reported by top management to have declined from eight workers to one worker for strapping operations and from three workers to one worker for hooking operations. It is worth emphasising that both the new strapping and hooking machines are not fully- but rather semi-automated, in that they require workers to continually feed fabric and components into the machines. This differs from automated cutting, where the operators play more of a monitoring role. Of all the automated or semi-automated operations in both factories, only the hooking operation represents sewing per se. The Lingerie Factory was also in the midst of introducing automated fabric spreading machines as of mid-2022.

Top management and the technology specialist emphasise that the reasons for introducing automation is not to reduce the number of workers but rather to increase productivity and cost-competitiveness – providing the example of Vietnam as a key competitor – while being able to increase output to meet the growing demand for orders with limited factory floorspace. Their perspective is substantiated by the increase in both orders and the number of workers in recent years, as noted above. The greater precision of automated machines is also stated to have resulted in marked improvements in waste reduction and, relatedly, product quality. In most general terms, the introduction of automation is stated by the technology specialist to be “definitely more profitable.” In particular, automated cutting is considered to be safer for workers than manual cutting, and both women and men workers stated that they prefer automated to manual cutting.

In addition to the general challenges to automated sewing created by the general pliability of fabrics, manual sewing – though using state-of-the-art sewing machines – is stated to be more suited to the short seam lengths in the sewing of bras. These challenges are overcome in the case of the semi-automated sewing of hook and eye fasteners in that these the closures are sewn onto semi-rigid patches of fabric. Still, the quest for further automated sewing continues, as stated by the technology specialist: “Actually, we are currently still looking for the suitable technology that can be used in the sewing process. If we find the right one, then we can do some trial to

study the machine before we implement them.” An additional impediment to further automation is the high cost of these new machines, including the high cost of replacement parts and maintenance.

As with the Lingerie Factory, the Sportswear Factory introduced automated fabric cutting machines in 2017. Top managers indicate that automated cutting machines reduce the number of workers per machine from three to two, while tripling the output per machine and increasing both precision and product quality. Yet manual cutting persists, both because certain apparel components are considered unsuitable for automated cutting and because of the high cost of the new machines. Automated fabric spreading machines are also in wide use in the Sportswear Factory, though there is no automated sewing in the factory. A key focus of the Sportswear Factory’s technological upgrading has been the introduction of automated hanger systems delivering fabric pieces to sewing lines. As of mid-2020, there were three hanger systems serving three of the 16 sewing lines of 40 to 50 sewing operators per line, which were introduced successively in 2015, 2017 and in 2018. There are still plans to introduce one new hanger system per year, but these were interrupted by the Covid-19 pandemic. The technology specialist expects to see more automation introduced in the next five to 10 years based on what he sees in other apparel factories as well as in technical exhibitions.

The drivers of automation largely overlap between the Lingerie Factory and Sportswear Factory– with top managers in both firms very mindful of Vietnam as a competitor – but there are additional elements for the Sportswear Factory worth emphasising. Top management in the Sportswear Factory state that their focus on productivity results from their efforts to comply with buyers’ corporate social responsibility (CSR) initiatives as well as with national and international labour law, which has cost implications. They point out, in this regard, that not all apparel firms in Indonesia pay the regional minimum wage, which presents a challenge to them because the apparel industry is “very sensitive to labour costs.” In this sense, the Sportswear Factory’s emphasis on productivity is the result of a conscious “high-road” business strategy, consistent with the spirit of the Better Work initiative. Significantly, though, this is not necessarily reflected in higher pay for workers, whose wages hover just above the regional minimum wage. The Sportswear Factory also emphasises that automation enables output increases in an old factory (over 30 years old) constrained by floorspace, given that the factory is surrounded by other factories and that the cost of nearby land is high. More specifically with respect to the automated hanger system, this collects data and monitors workflows along the sewing lines and thus helps identify production bottlenecks, while also setting the pace of production. Production targets are said by women workers to be about 10 per cent higher in the sewing lines with automated hanger systems.

As for the impediments to further automation, these are not primarily technical (leaving aside automated sewing) but rather financial, given the high cost of the machines. That is, the cost of an automatic cutting machine is about 150,000 USD while the cost of an automatic hanger system is about 70,000 USD. The factory’s plan is thus to introduce additional automatic cutting machines and hanger systems incrementally.

Automation impacts on employment, quality of work and the gender division of labour

In both apparel factories, the number of employees held steady or, for the Lingerie Factory, increased alongside the introduction of automation and associated output increases. In this sense, these technologies were labour-displacing at the task level, with fewer workers per machine, but not at the factory level. Moreover, the operators of these new machines were not new hires, but rather previously-hired workers for whom the factories provided in-house training. Workers, whose tasks were directly displaced by a new machine, were shifted to other tasks within the respective factory. One might argue that since there were fewer workers relative to machines and output, there is implicit labour displacement for the factory as whole, and that perhaps there would have been more employment in the absence of automation. Yet this seems a doubtful counterfactual in that these machines enabled the factories to maintain their cost-competitiveness in a highly competitive and dynamic context, while being able to fulfil larger orders in a timely manner within constrained factory floorspace. When pressed on these issues, neither women nor men workers in these factories expressed much concern about losing their jobs as a result of automation.

Quality of work, training and promotion

There is no clear-cut relationship between training for and operating new automated machines and earnings and promotion. Though perhaps overstating, the technology specialist in the Lingerie Factory put it baldly, stating that for workers operating the new machines, “the salary will stay the same.” A consistent picture that emerges from the interviews is that operating automated machines is just one among several factors affecting earnings and promotion in the context of a compressed wage structure within the factories. We do not have data on changes in profits or the wage bill to get a sense of how productivity gains might have translated into higher earnings for employers or workers. Yet while workers might not have systematically benefited from automation in terms of higher wages, those interviewed did express a preference for working on the new machines. For example, a woman operating an automated cutting machine in the Lingerie Factory stated that this was “not as complicated” as operating manual cutting machines. This is consistent with the views of the technology specialist in the factory, who stated that with automation, “the worker will have an easier job.” At the same time, working on automated machines typically required two-weeks of in-house training, provided by vendors, and in this sense represented skills upgrading. Top management and technology specialists indicate that there are no particular educational requirements for operating automated machines, with most workers in the factories having a high school or equivalent vocational education.

Effects on the gender division of labour

In this section, we address possible reasons for the marked gendered division of labour between different operations and corresponding departments in the factories with, as noted, fabric cutting done predominantly by men and sewing done overwhelmingly by women as the most striking examples. All of those interviewed in both factories, including women workers, repeatedly stated that women and men are treated equally, are considered equally for training and promotion, and are similarly receptive to training. To some extent, this may be a guarded response in that these are Better Work factories used to being regularly assessed on gender discrimination, and yet in our view there is evident sincerity in these statements.

At the same time, the reasons given for the gendered division of labour in the factories are not always consistent with each other. For sewing operations, for example, a women human resources manager in the Lingerie Factory stated that it is “just a coincidence that the sewing department has more women than men.” Yet top managers in the Lingerie and Sportswear Factories stated that women may be better suited than men for sewing in that they are “more patient” and “more sensitive and more careful.” Moreover, in the Lingerie Factory, semi-automated hooking operations, a form of sewing, is done largely by women. The reason given for this by top management is that women previously worked on the manual machines producing the hook and eye fasteners.

There is an important carry-over effect from the gender division of labour of manual to automated operations, even if the reasons for the gender division of labour in manual operations may no longer hold. This is because there is a tendency in these factories for workers to remain within departments defined by particular operations, creating path dependency in the gender division of labour in the face of automation. In the case of the Lingerie Factory, for instance, the technology specialist indicated that workers’ job descriptions refer to their particular departments. Furthermore, in the Lingerie Factory, the reason given by top management for automated cutting being done primarily by men is that, as with sewing, manual cutting was primarily done by men. Respondents in the Sportswear Factory provide more active reasons for fabric cutting being done primarily by men. In response to a question as to whether they prefer women or men to handle automated machines, top management replied that there was “no gender difference,” then went on to state that cutting machines are “kind of dangerous so it’s better [for] man workers to handle that.” The worker representative in the Sportswear Factory stated that men work in the operations that women “can’t do”, particularly fabric cutting, because “the machines are heavy [to operate]”.

The human resources manager in the Lingerie Factory indicated that about 30 percent of workers in automatic strapping operations are men, considerably higher than for sewing though lower than for cutting. That is, the share of men workers in automatic strapping is higher than average in the factory. For operating automatic hanger systems in the Sportswear Factory, only one of the supervisors of this system is reported by top management to be a woman, while the other supervisors are men.

Automation has loosened the gender division of labour in these apparel factories, or at least countered the reasons given for the gender division of labour for manual operations. The statements by women and men workers in the Lingerie Factory that automated cutting is easier and less complicated are also suggestive and contrast with some of the reasons given by top management and the worker representative in the Sportswear Factory for the predominance of men in cutting operations. Yet what is perhaps most striking is the path dependency in the gender division of labour in the face of automation, partly a result of the tendency for workers to remain within departments defined by specific operations. The relatively high share of men workers in these more automated tasks suggests that they are preferred for these tasks.

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► 5. Footwear factories

Description of factories and activities

The Sandal Factory we studied manufactures slippers and sandals for the Indonesian market. It is owned by a local Indonesian firm that produces for its own brand and serves the middle range of the market. The company's product range includes shoes, futsal⁸ shoes, footbeds, and insoles for men, women and children. Its products are sold in traditional and modern retail outlets supplied by a domestic distribution network but, since 2013, the company has also been selling its products through its own stores and franchises. Annual revenue is in the range of USD 40 million and manufacturing activities are spread across 10 factories in Indonesia. The Sandal Factory remains in the Tangerang province in Banten since its establishment in 1978 and it has 900 employees, most of whom are contract workers.

The Sports Shoe Factory produces sports shoes for the New Balance brand for exports mainly to the US and European markets as well as to Japan and China. It is part of a company established by South Korean entrepreneurs in 2011 in Taiwan (China) though the manufacturing headquarters are in China. The company owns six shoe manufacturing factories that produce for different brands: three in China, two in Vietnam, and one in Indonesia. The Sports Shoe Factory, which is located in Purwakarta, West Java, was producing for multiple sports brands such as Converse and Nike until 2017, when it switched to producing exclusively for New Balance. The factory has 5,200 employees, of which 3,500 workers are female and 1,700 are male. The bulk of workers (90 per cent) are production workers.

Although the factories produce different products, the production process for both is quite similar and consists of three main parts: producing the sole; cutting and stitching the upper; and attaching both to make the final product. The Sandal Factory uses an injection machine that injects materials directly into moulds to produce soles, while the Sports Shoe Factory makes soles from extruded rubber sheets using a hot-pressing machine. The company's logo is screen-printed on the soles manually though the Sports Shoe Factory also uses digital printing for this. The process of producing uppers starts with cutting large sheets of fabric, embossing them with the shape of different components, and then cutting these components using custom-made cutting die. These activities are carried out at individual stations by workers on manually operated machines in both factories,

⁸ Futsal is a football like game played on a hard court with teams of five players each.

although as we will see later, the Sports Shoe Factory has implemented some automation in the process. The cut components are then stitched together in the sewing department to produce the upper using manual and semi-automatic sewing machines. In the case of sports shoes, the back of the upper is moulded either manually or with a universal pressing machine to create a three-dimensional shape, called a stroble.

Soles and uppers are then delivered to the assembly department, which assembles them to create the final product. In assembly, the soles and uppers are put through an oven as part of a priming process (heat bonding) before they are attached to each other manually using glue or cement. The attached product is then put through a pressing machine to secure the bond. For slippers, the final footbed is finished by grinding extra fibres against a small spinning grinder, while sports shoes are additionally perforated and laced. Sports shoes and sandals are then packed in boxes, while slippers are packed in moulded plastic boxes. The entire process is called “cut to box” because it spans the range of activities from cutting to boxing.

Gender division of labour and working conditions

Both factories employ an overwhelmingly female labour force with cutting and sewing of components done largely by women though there is some variation across activities. “Heavy” work or tasks that require greater physical strength generally use male labour. In the sole department, the mixer used to prepare material for injection soles in the Sandal Factory and the extrusion machines in the Sports Shoe Factory are mostly operated by men. In cutting processes that involve handling of large rolls of fabric, the work was done exclusively by men. In the Sandal Factory, manual printing of the company’s logo that requires handling of odorous chemicals was done mostly by men under female supervision, and the Sports Shoe Factory also reported a mixed workforce on these lines. On the assembly line, the attaching of soles and uppers is done by mostly by men as is the grinding process for slippers and sandals. Packing has a mixed workforce as the final product can be placed in individual boxes by women, but shipping boxes are handled by men. Although we do not have a precise gender breakdown of workers for the Sandal Factory, these were provided by Sports Shoe Factory as below:

Table 3: Gender division of labour: Sports Shoe Factory

Position	Men		Women		Total
	Number	% of Total	Number	% of Total	
Operator (prod)	1451	31	3191	69	4642
Operator (non prod)	68	65	37	35	105
Team Leader	56	35	106	65	162
Supervisor	108	49	113	51	221
Department Head	46	46	53	54	99
Total	1729	33	3500	67	5229

As evident in Table 3, most production operators are women (69 per cent) while most non-production or white-collar workers are men (65 per cent). Men are overrepresented in leadership and supervisory positions given that they comprise only 33% of the workforce. On the other hand, although women have 67% of all jobs, they hold only 51% of supervisory and 54% of department head positions.

In the Sandal Factory, which produces for the domestic market, only 30 per cent of workers are permanent while the rest are contract workers. On the other hand, in the Sports Shoe Factory all workers become permanent after the first three months as mandated by the buyer. The regular full-time workweek is 40 hours, eight hours per day for five days per week but the Sandal Factory also requires a full day’s work on Saturdays during the high season. Generally, overtime in both firms is limited to around two hours per day as Indonesian law requires employers to provide meals for overtime of 4 hours per day and over, which is considered costly. Workers in both firms start by default with the regional monthly minimum wage though wage levels vary according to a worker’s position. Operating new machines or new technology is not directly awarded with higher pay. The Sports Shoe Factory’s

salary composition includes a base pay or minimum wage, a seniority component as well as bonuses for position and performance, which is evaluated monthly. Promotion is based on performance evaluation. There is a 10 per cent rise in salary from worker to team leader; 100 per cent from team leader to supervisor (though supervisors do not get overtime pay); and another rise of 30 per cent to department head who typically manages two to three production lines. Women's underrepresentation in these positions means they lose out relative to men. Higher remuneration for overtime could only be confirmed at the Sports Shoe Factory.

In the Sandal Factory, minimum wages are paid for 24 days of work a month and permanent workers are entitled to 12 days of paid leave a year. This means that contract workers' pay dips below the minimum wage for even a single absence a month. Due to the fluctuation of demand, the Sandal Factory is now implementing a rolling system in the lean season in which workers will work alternately for only 16 days a month (from 20 previously). This contributes to high turnover rates but is considered an unavoidable strategy. Management at the Sports Shoe Factory reported that absenteeism is a problem—about 1 per cent of workers are absent everyday—and put this down to 'worker ethic' though it could be driven by disparate causes. Permanent workers in both firms are entitled to paid leave and social insurance (BPJS) while the Sports Shoe Factory also provides a pension benefit, three months maternity leave, two days paternity leave, and has a health clinic on campus.

The Sandal Factory does not have any labour representation, while workers at the Sports Shoe Factory are represented by a union with around 4,000 members, 70 per cent of which are women though no woman has ever served as chairman. There is currently an agreement in place on wage rates though the union chairman did report that Covid-19 has made collective bargaining more difficult. Still the factory has agreed to the union's demand that the introduction of new technology will not lead to layoffs. There is also a provision that pregnant women will be prevented from standing and working with chemicals. A union coordinator is present in every building on campus and most complaints received involve harsh treatment by supervisors.

Covid-19

During the Covid-19 pandemic, both footwear firms faced a collapse in demand. The Sandal Factory, which was previously exporting to Malaysia and Singapore, did not resume export production after the pandemic. It shut down production for about one month, providing no compensation for contract workers, and then resumed work by halving the daily workforce and requiring workers to come in on alternate days. At the Sports Shoe Factory, New Balance cancelled all orders, except ones already in production, and did not transmit any new orders for three months. However, the Sports Shoe Factory continued to build inventory by producing classical or non-seasonal models during this time to prevent layoffs. A rolling scheme, with a no-work no-pay policy, was agreed in which employees only worked every alternate week with slightly reduced hours. This allowed them to retain all workers who earned half their monthly income during this period. Once demand rose and orders were received, both factories returned to regular production and work schedules though the Sandal Factory has implemented a permanent rolling work system during the lean season as described earlier.

Drivers of and limitations to automation

The levels of technology adoption in the two shoe factories we studied were quite dissimilar: the Sandal Factory bought new semi-automatic sewing machines in 2018 while the Sports Shoe Factory invested in semi-automatic sewing machines as well a digital printer, laser cutters, an automatic moving head cutting machine, and a NoSew machine (described below) in the last five years. The managers of the Sports Shoe Factory described two types of ongoing automation: productivity enhancing automation and product driven automation for models that require complex processes that cannot be done by hand. An important driver of productivity enhancing automation in the Sport Shoe Factory were increases in the statutory minimum wage and related price negotiations with the buyer. For example, the minimum wage in Purwakarta, where the Sports Shoe Factory is located, increased from about 260 USD in 2019 to about 290 USD in 2022 (Better Work Indonesia 2019b, 2022). Although the buyer complies with minimum wage regulations, there is no automatic increase in the freight on board (FOB) price when the minimum wage increases. Instead, as the Compliance Risk Manager informed us, the supplier's wage proposal is negotiated annually, and when the minimum wage rises, they negotiate on bonuses and/or the cost of meals and transport that are not mandated by the Government.

The Sports Shoe Factory has been purchasing semi-automatic sewing machines for some years and bought 300 of them in 2021. Management explained they were bought to enhance productivity and ensure quality, but also to reduce manpower because of the rising minimum wage. There is also a supply-side issue as Purwakarta has a younger workforce and it is difficult to find workers with advanced sewing skills. Semi-automatic sewing involves placing different components of the upper on a palette and sewing them automatically according to a pre-set programme. According to the technology specialist, the machine reduces human error and provides more consistency in products leading to lower rejection rates and waste. For instance, it eliminates errors in stitching overlapping parts of the upper, which can reduce its size if the overlap is too great. The technology has evolved over time to allow for edge and tip stitching, which has the longest cycle time in the production process and requires two people. Managers estimate that semi-automatic sewing has doubled speed and output as compared to manual operations because the machine can sew many pieces together at once. However, semi-automatic sewing does not work for very soft materials and tiny stitches, such as for children's shoes, which are better suited for manual processing.

Similarly, the purchase of an automatic traveling head cutting machine in which cutting die operate automatically was driven by the company's desire to enhance productivity and create capacity for other components that require manual cutting. Unlike manual machines, the automatic head can cut through six layers of fabric at once, and it is able to operate two types of cutting die at the same time, which increases speed and output. The machine is used to centralise the cutting of materials for use in the stroble and lining that don't need to be inventoried. The machine has high capacity and takes time to set up, which makes it better suited for these high-volume tasks. It cannot cut leather and cannot be used for parts that require greater accuracy, which are done through the manual process. Similarly, the company has invested in a perforation machine to perforate the foam layers in sports shoes as the process is cumbersome when done manually, causes needles to break and requires significant set up and clean up. Automation of this type, which improves the accuracy of delicate tasks, was described by management as "supporting the worker".

On the other hand, the company also purchased machines driven by the requirements of new products. In 2020, a laser cutter was purchased to cut fabric into desired shapes for seasonal and small-batch models followed by another one in 2021. Laser cutting involves programming fine laser beams on fabric to cut very delicate materials and patterns can be changed easily. It precludes the purchase of cutting die, which at approximately USD \$100 each are expensive to purchase for small-batch models and environmentally unfriendly. Moreover, the return on investment is quite long at about four years. The company also invested in a digital printing machine to print fabric with colourful and complex designs, which are difficult to achieve manually. Moreover, frequent design changes mean that partially used ink cartridges need to be changed, which becomes costly, and the manual printing process is therefore still maintained as a backup option.

The Sports Shoe Factory also invested in a 'NoSew' machine (also called a hot and cold press machine) for specialised products that require welding shoes without sewing them. However, the machine was lying idle for three years as New Balance (NB) dropped orders for the product. Since two new NB models require this process again, the company has invested in another NoSew machine, but a return on investment has not yet been achieved. Management explained that NB does not always give them a minimum number of orders when they upgrade their technology, which highlights that investment in new technology occurs mostly at the risk of the supplier. The following quote from the technology specialist at the Sports Shoe Factory sums up the considerations for suppliers well:

...And for investment, we need RoI [return on investment], and for RoI we need capacity. However, during this uncertain time, the demand will be small, but the variation will be high. Even right now, we have so many styles but for every style the quantity probably only 800, which is really small. And automation cannot keep up with that much of variation. I think what we need to do with the pandemic and automation is that we have to cut the cost down to the lowest because the minimum wage will keep rising every year. So what we can do is to do automation in order to reduce waste, reduce defect, and reduce the working hour.

The Sandal Factory is a study in the bottlenecks of applying new technology. It bought semi-automatic sewing machines in 2018 for models that require more detail and an automatic cutting machine to cut label tags that are

sewn into products. Managers at the Sandal Factory pointed to the importance of demand, budgets and flexibility in automating in the following way:

There are three factors, the first one is based on the demand, is there need for the new technology? The second one is we have to make sure that the machine will increase our productivity by studying them beforehand. When the productivity is high, then we will consider the budget. ...so, before we buy a new machine, other consideration will be also the sustainability of the machine. How long can we use the machine and is the machine flexible enough to follow the dynamic of the models? So all the machines that we have are the machines that are flexible.

The manager of the Sandal Factory pointed out that they do not use laser cutting, unlike other firms in the industry, because their products are still compatible with the older technology and they have no urgency to upgrade. The fact that the Sandal Factory produces for its own brand, and that demand for their current products persists, no doubt influences their decision. The need for flexibility and adaptability in production due to the variety in footwear patterns and models limited technology adoption in both firms. Manual processes still provide the most flexibility and the decision to automate depends on balancing and weighing the risks of financial investment and demand with productivity gains.

Automation impacts on employment, quality of work and the gender division of labour

The Sports Shoe Factory has automated to a much greater extent than the Sandal Factory though the company has an agreement with the union not to consequently retrench workers. According to the manager in the Sports Shoe Factory, automation has reduced working hours, work processes and the reworking and repair of faulty products. Semi-automatic stitching has seen the biggest decline in working hours, which has obvious gender implications. The technology lead explained that semi-automation was essential in Purwakarta to maintain quality due to a younger labour force with less experience in sewing as mentioned earlier. Semi-automatic sewing as well as automatic and laser cutting are labour saving and can potentially displace labour but since retrenchment due to upgrading is not permitted, workers are simply redeployed to other tasks on the shopfloor, which is a viable strategy as long as demand is high. There is thus labour displacement at the task level.

Management at the Sports Shoe Factory informed us that when the workforce needs to be reduced, they hire fewer replacements when workers quit as they are not allowed to retrench. Given the high turnover rates in the industry, we assume that this is not hard to do even when all workers have permanent status. Seen from another perspective, some of the work currently done by laser, such as digital printing, would not be possible to do manually, or would be quite labour-intensive, so in that sense automation has allowed the company to expand its product range and cater to different and new types of demand.

As we do not have time-series data from either of the shoe factories, we are unable to confirm if the workforce shrank or expanded. Moreover, in the Sandal Factory the manager mentioned that a rise in productivity would lead to a reduction in the number of workers, but, so far, a complete shift to semi-automatic technology is not viewed as desirable. According to the manager, this is because (a) the machines are costly and risky to invest in, (b) productivity can dip due to the manual placement of materials and (c) the machines tend to break down. Although management in the Sandal Sports Shoe Factory did not state this explicitly, the low cost of labour relative to semi-automatic sewing machines remains an important consideration.

Quality of work, training and promotion

In both firms, operating computerised or automated machinery does not lead to a higher wage. The manager of the Sandal Factory stated that for completely new machines with unfamiliar programs, workers with higher skills may be required. But both factories reported that the skill profiles of workers after automation were only slightly different and indeed lower in some cases. According to the Sandal Factory's manager, the work process is often simplified with automation and machines can be operated by anyone. For instance, he reported that semi-automatic sewing no longer relies on a worker's advanced sewing skills, such as accurately manoeuvring and

following the pattern. Rather, the worker must now learn to place fabric on the palette efficiently. This was confirmed by the technology lead at the Sports Shoe Factory who said that workers, "...only need to be trained to understand which button to push, which model to select, and how to put the material into the machine". We might understand this as a process of deskilling, which is also true of digital printing, which requires less training than manual printing, as the technology lead pointed out. However, when the Sports Shoe Factory hires mechanics they are now required to be computer and program literate.

In terms of the quality and work process, a semi-automatic sewer at the Sandal Factory reported: "The work has become much easier with the machine. Previously, in half an hour we would only get 50 pairs. However, this can be up to 200 pairs now". There was a similar response from the semi-automatic sewer in the Sports Shoe Factory who mentioned the ease of the machine doing the sewing. However, she complained of her hands being sore, the need to have the correct hand speed and the needle breaking and possibly injuring her eyes. Another semi-automatic stitcher from the same factory also talked about the challenge of meeting targets which required "moving our hands even faster" and being more "aggressive".

Managers at both factories emphasised the need for multi-skilled and adaptable workers who could operate more than one machine and be flexibly reallocated to different processes based on changes in demand and models. The Sandal Factory provides training on new machines for 30 minutes for up to two days to get workers adjusted. The Sports Shoe Factory outlined three types of training: (1) for new workers who learn how to do different tasks, particularly sewing, on backup machines, (2) multi-skilling training for workers who demonstrate skills but can currently work only on one machine and (3) special technology training to work with new machines. All training is on-the-job at both factories though several workers interviewed expressed the desire for more upskilling.

Effects on the gender division of labour

As discussed previously, the gender division of labour in both factories was pronounced and a gendered scheme was visible on tasks across the shopfloor. Management in both companies emphasised that workers were not treated differently based on gender, but on probing, some rationale was provided for gender segregation on the shopfloor. For example, the manager in the Sandal Factory noted that women's "psychological traits" made them more attentive to detail, so they were preferred for sewing. The Sports Shoe Factory presented it as a supply side issue: sewing is female-dominated because more women apply for sewing jobs than men. The Sandal Factory cited men's greater physical strength as essential for cutting large rolls of fabric and for printing. Similarly, in the Sports Shoe Factory, the manager stated that men were preferred to work the rolling and extruding machine as the rubber is quite heavy. The technology specialist at the Sports Shoe Factory explained that men were preferred for moulding work on the universal pressing machines, because they are taller and for attaching, because it is heavy and "requires a lot of energy". However, women do some of the attaching for baby shoes. Even the chairperson of the labour union implied that the gender segregation of work was just how things were: "When it comes to the gender, there is no differences between men and women, it all depends on the task they are doing... However, in sewing, for example, most of the workers are women and in assembly, there are mostly men. Actually, there is no preference, but that's just how it is now."

Automation has changed the gender division of labour at the margins in the Sports Shoe Factory. As a result of the deskilling of sewing tasks due to semi-automatic sewing, we observed more men in the sewing lines on the shopfloor. Management confirmed that more men applied for stitching and component cutting jobs and were evidently hired, though women still outnumbered them. At the Sports Shoe Factory, the laser-cutting machine and automatic head-cutting machine were operated by men with engineering diplomas, while the digital printing machine was run by a woman.

► 6. Concluding Remarks

In this paper, we examined automation in the apparel and footwear industry, which has lagged behind others such as electronics and automotives in terms of technology adoption, using Indonesia as a case study. Our interest in this exercise was not only to understand why garments have been a laggard in this respect but also to investigate the impacts of technologies that were adopted on employment, workers and the quality of work. This is especially relevant in the context of the dramatic predictions about employment losses associated with the implementation of automated technologies in apparel and footwear GSCs. We have a particular concern in this regard for the gendered impacts of technological upgrading on which there is already considerable literature, which has documented the pronounced gender segregation of production both within and across manufacturing industries. The literature has argued that there is a preference for female labour in labour-intensive tasks because the gender wage gap keeps labour costs low in industries that compete on unit costs and because of gender stereotypes about women's inherent suitability to particular tasks, which are often based on socially acquired skills. When technological upgrading has taken place, a corresponding defeminisation of labour has been noted in several quantitative studies that suggest that contributing factors are the persistence of gender stereotypes, lack of on-the-job training and gender segregation in education and vocational training.

This paper seeks to supplement these findings with a shopfloor perspective on the drivers of and limitations to automation in the apparel and footwear industry in Indonesia, which is highly integrated into GSCs. In general, the study confirmed that technology adoption in the industry has been incremental rather than rapid. When firms adopted new technologies, it was often to raise productivity to maintain cost competitiveness, especially in relation to Vietnam for the two apparel firms. Productivity increases through automation were considered vital to help firms in complying with labour regulations and CSR commitments. Rising labour costs emerged as an important driver of technological change in that sense as FOB prices, in the Sports Shoe Factory for instance, did not necessarily rise with statutory increases in the minimum wage. Firm location was also driven by considerations about minimum wages and the apparel firms under study either moved to or set up new operations in Central Java for its lower minimum wage. In general, these factors highlight the centrality of labour costs in total unit costs in labour-intensive industries such as apparel and footwear. Automation was also needed to meet product and quality requirements—another dimension of staying competitive—and to reduce waste, rework and rejection rates. In addition, the Lingerie Factory cited limited factory floorspace and the high cost of land as incentivising automation. Supply-side considerations, such as the lack of an advanced sewing skill pool in Purwakarta, were also important in the adoption of semi-automatic sewing in the Sports Shoe Factory.

Significant bottlenecks to automation on the technical and financial side remain. On the technical side, as noted by previous studies, automated machines cannot handle certain materials and tasks. For instance, while three of our four firms invested in automatic cutting machines, manual cutting was still used for slippery fabrics and short fabric runs in lingerie manufacturing as well as for leather and other components that need precision cutting in sports shoe production. Soft and delicate materials, short seam lengths and tiny stitches also pose challenges in the automation of sewing. In fact, in both apparel firms sewing is predominately done in the conventional way — with the sole exception of hooking operations in the Lingerie Factory — while the Sports Shoe Factory has introduced a significant amount of semi-automated sewing. In footwear, the need for flexibility in production to fulfil small-batch orders with constantly changing designs and models emerged as an important limitation to automation, as machines are not sufficiently adaptable in this respect. The relatively high cost of new machines is an additional constraining factor (e.g., 150K USD for a cutting machine) with relatively long periods to earn a positive return on investment (e.g., four years for laser cutting). Implicit here is the relatively lower cost of labour that disincentives automation. In addition, suppliers pay for technological investment, which can be risky if orders are not forthcoming, as evident in the case of the NoSew machine in the Sportshoe Factory that was lying idle for three years.

The issue of demand emerges as a critical one in this context. As the structuralist literature has noted, if demand expands more than productivity growth, productivity increases may not translate into reductions in the workforce (Ocampo, Rada and Taylor 2009). Technological investments in these factories were made in expansionary environments and the apparel and footwear industry in Indonesia has been growing over time (Figure 1).

Although it recently dropped out of the world's top 10 apparel and footwear exporters, Indonesia expanded its share of global trade in the industry between 2010 and 2020 though not as massively as Vietnam (Table 1). In the factories, there was automation created labour displacement at the task level, but not necessarily at the factory level. For example, as speed and output doubled with semi-automatic sewing in sports shoe production, displaced workers were redeployed to different tasks, which was also the case when automated cutting, strapping and hooking in the apparel factories led to a decline in required number of workers. The workforce in the apparel factories stayed the same or increased during the period of automation, despite the temporary collapse of demand during Covid-19, while the Sports Shoe Factory had an agreement with the union not to retrench workers due to automation. At the same time, the retention of workers cannot be termed a "high road" strategy because productivity increases have not translated into rising wages for workers, other than statutory increases in the minimum wage, and the wage structure remains highly compressed. All workers start with the minimum wage and additional training and operation of automated machines does not systematically lead to higher remuneration or promotion.

Nevertheless, a number of workers stated that working on automated machines had made tasks easier and less complicated, but work intensity also rose due to automation in some cases. Workers in the Sports Shoe Factory described speeding up hand movements to meet challenging targets on semi-automatic sewing machines. Meeting targets was a particular challenge when machines broke down with workers needing to put in overtime to complete them. Workers on semi-automatic sewing machines complained of occupational safety and health issues, specifically of sore hands and needles breaking and possibly injuring the eyes. In the Sportswear Factory, the fact that production targets were set at 10 per cent higher in sewing lines using automated hanger systems is also suggestive in this regard. There is also evidence of deskilling in semi-automatic sewing as the level of skill required to operate these machines is relatively lower than manual sewing.

Across the apparel and footwear factories, justification of the existing gender division of labour on the shopfloor was strikingly similar and seems to have changed little since some of the early studies discussed in the introduction. Although there was a repeated insistence that workers were not treated differentially based on gender, further discussion revealed gendered ideas about why men and women were better suited for different tasks. Stereotypes about women being more patient, careful and attentive to detail, it was argued, made them more suitable for sewing. Tasks that were hazardous, heavy or that required physical strength were considered better suitable for men. A notable difference in the gender division of labour between apparel and footwear was that men did the cutting in the former while women cut small components in footwear production even though large rolls of fabric were handled by men.

Automation can break down the rationale for such a gender division of labour by simplifying certain tasks and reducing the physical strength required for others. To that extent, we identified some changes in the factories we studied. In the Lingerie Factory, relatively more men were employed in automatic strapping than on average, and more men than women operated the automatic hanger system in the Sportswear Factory. Deskilling because of semi-automatic sewing has resulted in more men applying for sewing jobs in the Sports Shoe Factory and men are visible on sewing lines as well. Based on the above, we can conclude that some defeminisation in automated tasks is setting in though the pace is gradual, and the general workforce remains feminised on balance. There is also some evidence of job polarisation emerging in the future. The laser cutting and automatic head cutting machines in footwear are operated by men with engineering degrees and all mechanics now hired in the Sports Shoe Factory will need to be computer and programming literate. This may skew hiring towards men due to gender segregation in education and vocational training. However, there is also some path dependency in the gender division of labour when tasks shift from manual to automatic. Examples include hooking operations, which remained feminised and cutting operations, which stayed masculinised upon automation in the Lingerie Factory.

In conclusion, and contrary to some predictions, there is little automation in apparel sewing due to technical and financial reasons though semi-automation in footwear sewing is gaining pace. Our study documented the adoption of automated or semi-automated technologies in other tasks in the apparel and footwear industry, such as cutting, hooking, strapping and printing. Although automation is delivering productivity gains in these areas, low wages remain an important cornerstone of firm strategies to maintain competitiveness and we did not find that automation promoted a sharing of gains through "high-road" practices, which we would argue is partly

related to price pressures from buyers. Nevertheless, two out of the four factories in this study are in the Better Work (BW) programme, where working conditions and labour standards are subject to regular monitoring and audits. To that extent, our study may not be capturing the extent of precariousness in the industry and additional adverse impacts of technological change. For example, the Sandal Factory, which is not a BW firm, has a higher proportion of contract workers and no worker representation. In terms of the gender division of labour, there is some evidence that automation is integrating more men into production through the deskilling of sewing in footwear and in the operation of automatic and semi-automatic machines in both industries. At the same time, reduction in the physical requirements of shopfloor tasks makes it possible for the traditional rationale for gender division of labour to break down, though we did not identify such shifts on the shopfloor. The persistence of gender norms and stereotypes in that sense is striking.

Appendix Table 1: Interviewee profiles

Lingerie Factory				
Category	Job title/description	Sex	Age	Years of tenure
Top management	General Manager	Male	50	18
	Compliance Manager	Male	41	5
	HR Manager	Female	45	9
Technical specialist	IT specialist	Male	31	4
Worker representative	Staff industrial engineering	Male	35	6
Women workers	Automatic cutting operator	Female	25	6
	Sewing operator	Female	25	2
	Sewing operator	Female	26	2
Men workers	Preparation operator	Male	27	5
	Cutting supervisor	Male	35	8

Sportswear Factory				
Category	Job title/description	Sex	Age	Years of tenure
Top management	President Director	Male	45	10
Technical specialist	Industrial engineer	Male	38	5
Worker representative	Union leader	Male	41	22
Women workers	Sewing operator	Female	50	29
	Sewing operator	Female	40	11
	Sewing operator	Female	49	24
Men workers	Hanger line operator	Male	32	1
	Sewing operator	Male	54	30

Sandal Factory				
Category	Job title/description	Sex	Age	Years of tenure
Top management	Vice Manager	Male	58	15
	Human resources staff	Male	38	8
	Sewing department Manager	Female	NA	4
Technical specialist	Technician	Male	51	30
	IT Manager	Female	40	NA
Women workers	Automatic cutting operator	Female	33	4
	Emboss cutting operator	Female	30	8
	Computerized sewing operator	Female	24	4
Men workers	Head of production assembly	Male	40	5
	Head of production sole	Male	54	10
	Team leader cutting	Male	35	4

Sports Shoe Factory				
Category	Job title/description	Sex	Age	Years of tenure
Top management	Human Resource, General Affairs and IT Manager	Male	56	11
	Assistant Director, Lean and QMS Department	Female	NA	10
	Compliance Risk Manager for Buyer	Male	49	10
Worker representative	Chairman of the National Labour Union	Male	30	11
Women workers	Computer stitching operator	Female	29	10
	Computer stitching operator	Female	39	9
Men workers	Computer stitching operator	Male	30	4
	Laser cutting operator	Male	21	1
	Automatic cutting operator	Male	22	1

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