Technology Upgradation of the RMG Industries in Bangladesh

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Motivation

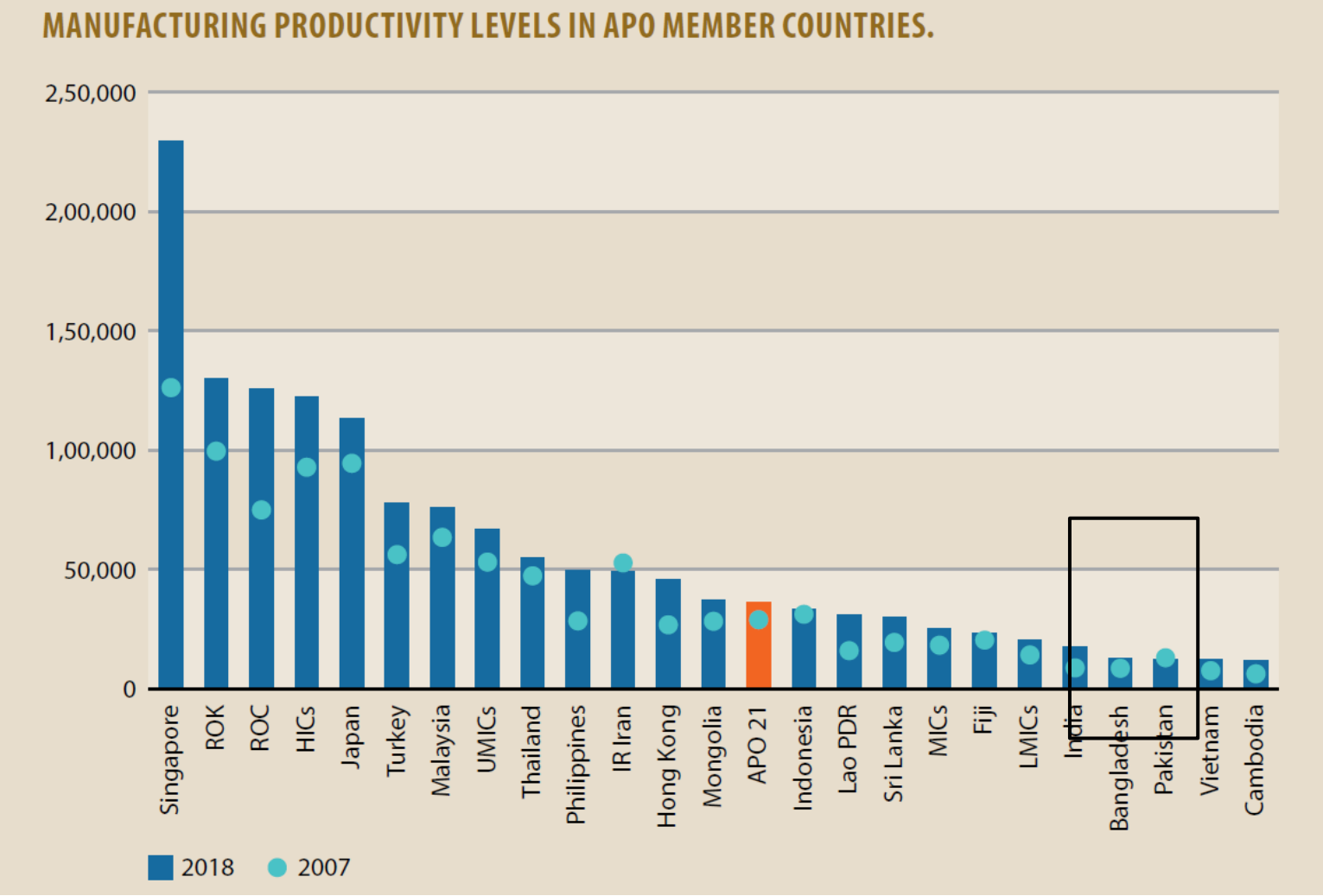
Factor accumulation dependent growth, not productivity

- Growth is due to factor accumulation ➔ the contribution of productivity in the production process has been very low in Bangladesh
- The risk of growth relying solely on factor accumulation is that at one stage the diminishing marginal return of factors set in, which ultimately leads to a stagnation of growth.
- For sustaining growth, the country should consider improving the productivity of the overall production in order to maintain high growth and also avoid the 'middle-income trap' in the future.

How to increase productivity (TFP)?

- How to increase the overall productivity, particularly of the manufacturing sector in developing countries, has been an issue of intense academic debate [man, machine, management]
- Skilling up the labor force has been the mainstay of this discourse.
- As we know, the government of Bangladesh has undertaken many interventions funded by development partners (e.g., SEIP, ASSET, etc.) as well as crafted policies for skill development (e.g., National Skill Development Policy 2020). ➔ Success of these projects have been questioned!
- However, as we know there is a complementarity between skills and technology adoption of the firms.
- There will always be a low level of demand for the skilled workforce if the firms lack the technological capabilities necessary for moving upward along the quality ladder of products.
- On the other hand, technological change cannot happen in void ➔ it requires the necessary human capital
- So far, our understanding of the state of technology in the manufacturing sector and the barriers to technology upgrading in Bangladesh is very poor.

Low manufacturing productivity



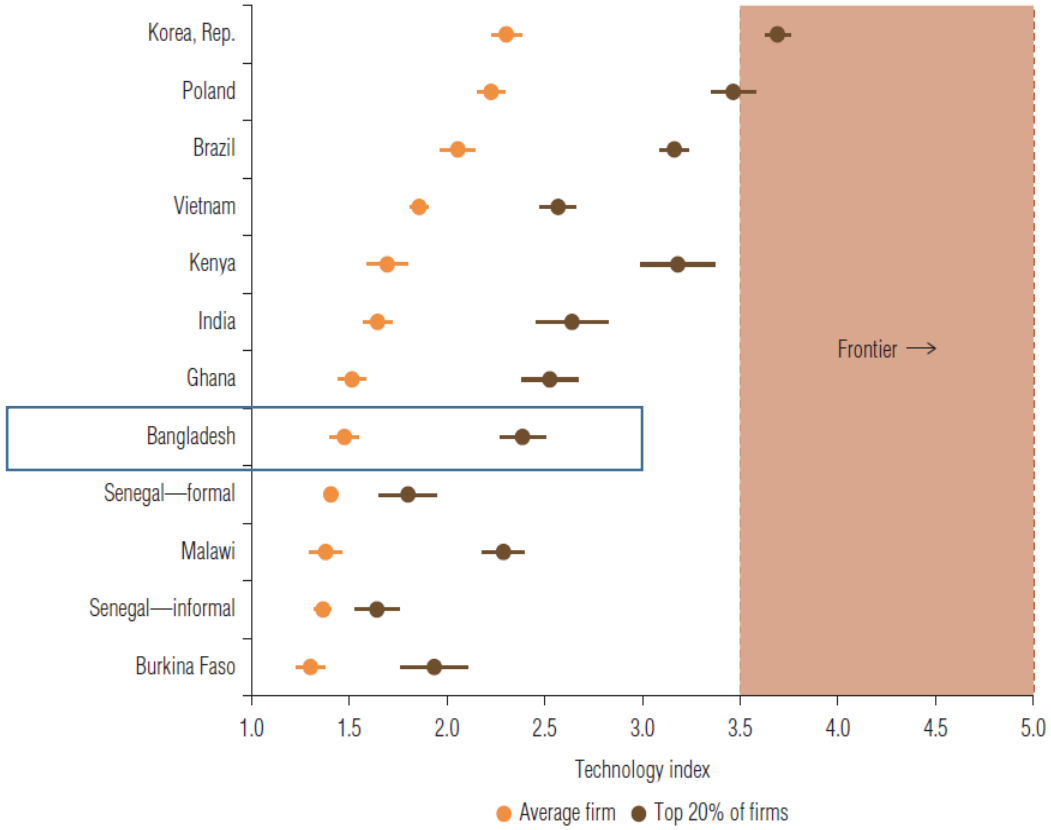
Source: Asian Productivity Organization (APO) Outlook 2022

Labor productivity in manufacturing = manufacturing output/ number of manufacturing workers

Low ranking in labor productivity in Asian countries!

Poor technological sophistication in manufacturing

FIGURE 0.2 Estimated Technology Sophistication by Country—Manufacturing



Source: Original figure based on Firm-level Adoption of Technology (FAT) survey data.

- In the technological sophistication index of the firms, Bangladesh lags behind Vietnam and India.
- Large industries, measured by the top 25%, are also well behind the technology frontier indicated by the shaded area in the figure.

Source: World Bank, 2022.

Specific Objectives of the study

- To what extent the technology has been upgraded in the RMG sector in Bangladesh?

- What are its impacts on labor demand and female workforce?

Conceptual note on firm upgrading

➔Task based production function (Autor and Handel, 2009; Acemoglu and Restrepo (2019); Verhoogen, 2021):

- Final output is a collection of series of tasks
- Technology (K/L) varies at the task level
- New technology can destroy or create new tasks
- New technology can change the K/L at the task level

- $Y_{ijst} = F_{ijst}\ (\vec{M}_{ijst}, \lambda_{ijst})$; [task level prod. fn: firm i, product j, task s, year t]
- $\vec{M}_{ijst} = verctor\ of\ physical\ inputs\ (machines, labor, raw\ materials)$
- $\lambda_{ijst} = firm\ capabilities$ [Sutton (2007, 2012)]

Firm upgrading: productivity of $\vec{M}_{ijst}\uparrow$ and $\lambda_{ijst}\uparrow$ [may not vary with s]

In study: firm➔ product➔ processes➔ sub-processes

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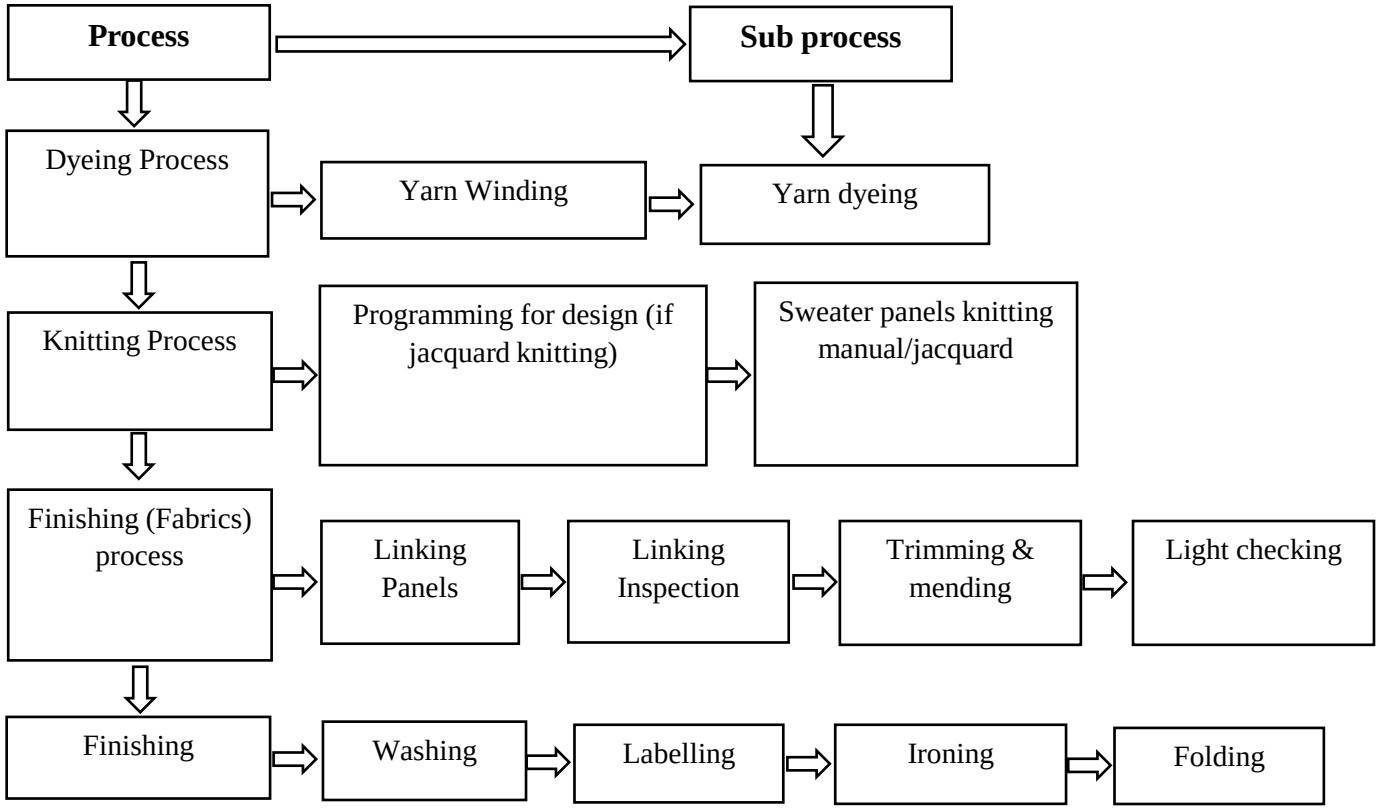
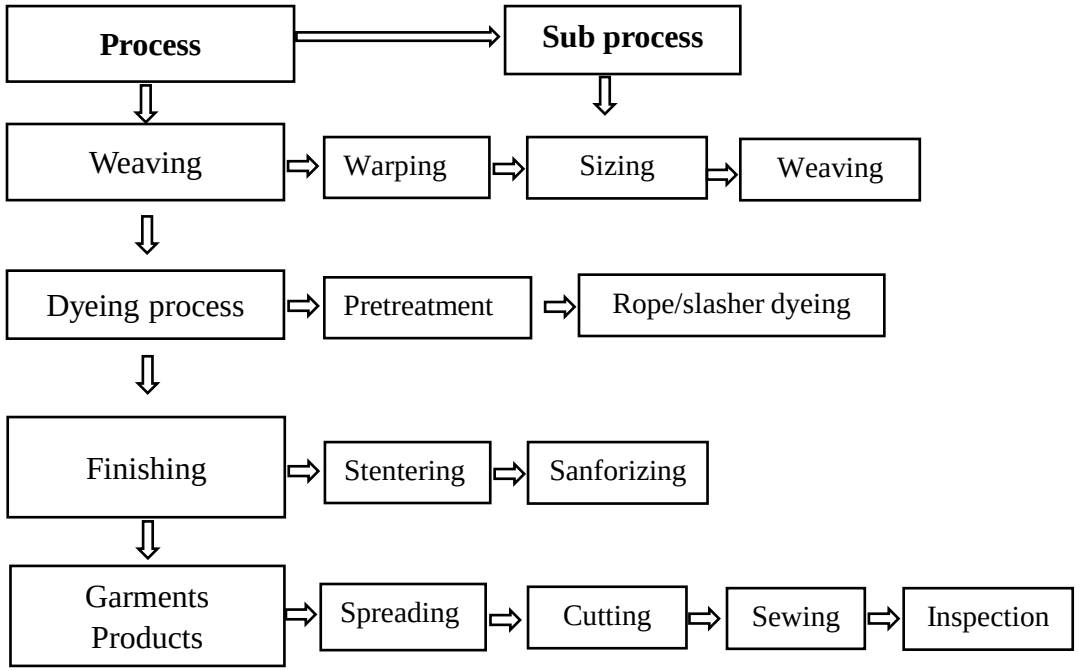
- **A few examples: Processes and sub-processes**

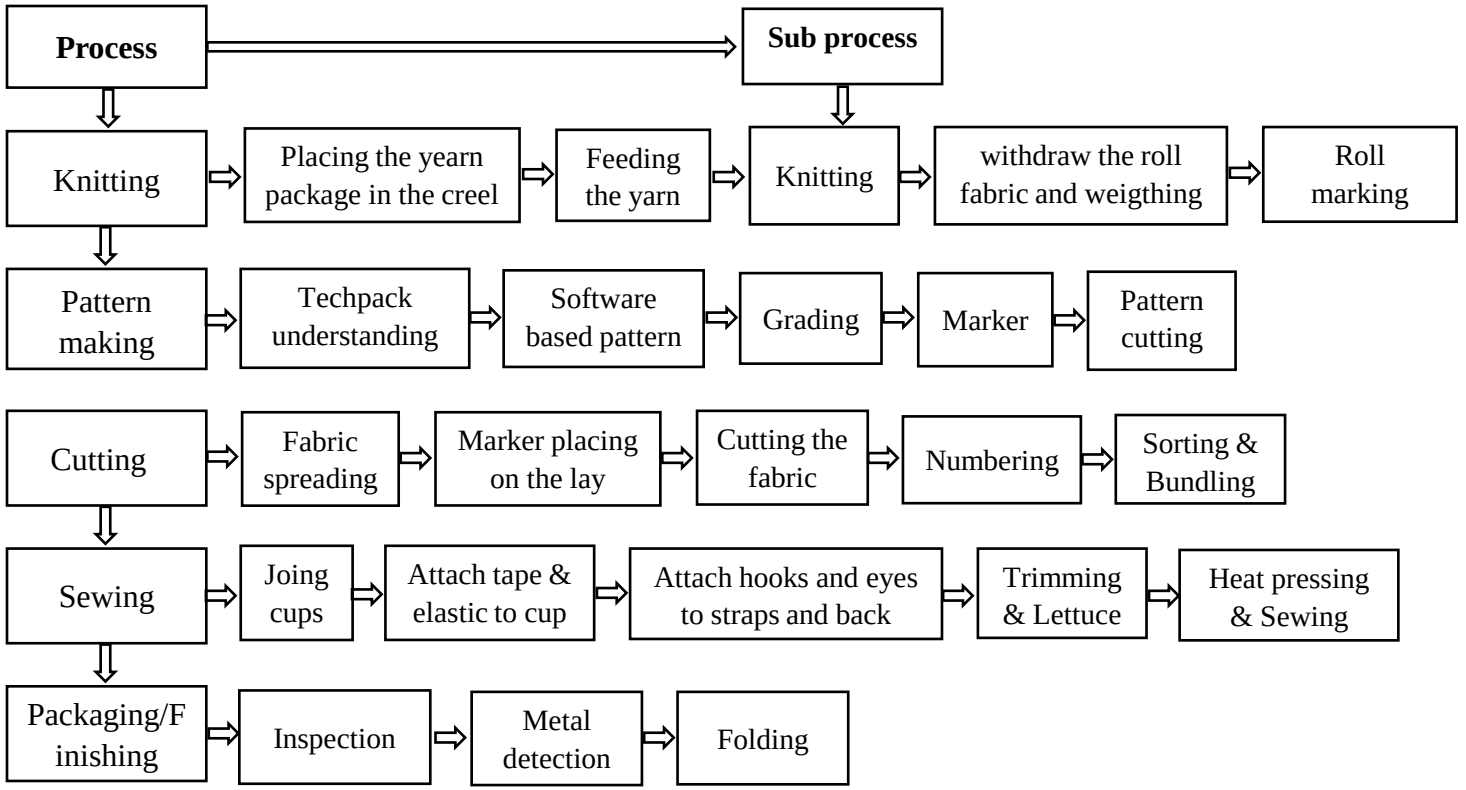
Sweater



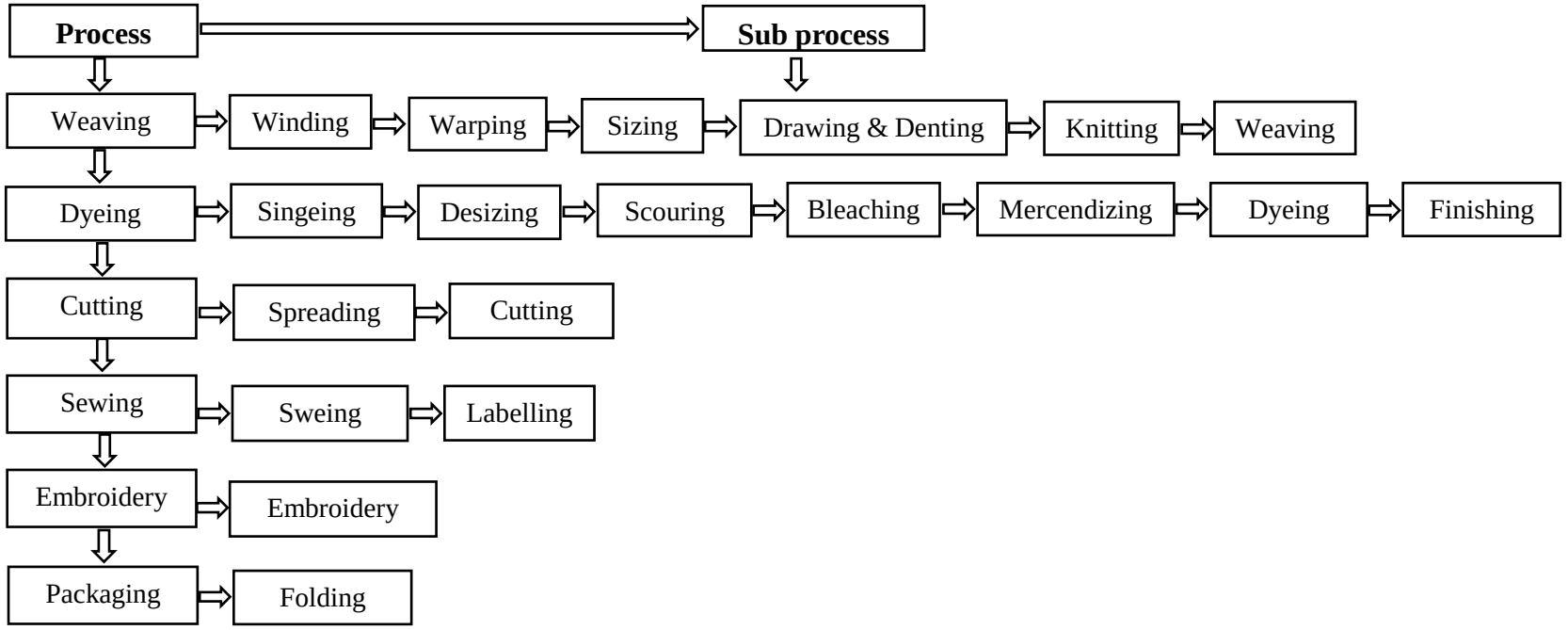
Woven trouser



Knit Lingerie



Home textile (bed sheet)



Data

➔ 8 products, 43 firms, 36 processes, and 136 sub-processes

Products (firms)

1. Knit-lingerie (5)
2. Denim Trouser (4)
3. Sweater (7)
4. T-shirt (8)
5. Jacket (5)
6. Woven Trouser (5)
7. Woven Shirt (7)
8. Home Textile (2)

Total (43)

Time

- 2023
- 2014 (based on recollection)

➔ Right after Rana Plaza

Characteristics of RMG firms

Factory type	Age	Composite	Part of conglomerate	Have multiple factories	Major expansion in last 10 years	New factories in last 10 years
Knit-lingerie (5)	18	3	3	5	5	5
Denim Trouser (4)	18	4	1	2	4	1
Sweater (7)	20	7	7	3	5	5
T-shirt (8)	20	7	7	6	7	4
Jacket (5)	17	4	3	4	2	2
Woven Trouser (5)	16	3	4	3	5	1
Woven Shirt (7)	17	7	4	4	7	4
Home Textile (2)	18	2	2	2	2	1
Total (43)	**18**	**37**	**31**	**29**	**37**	**23**

- Old factories dominate the sample
- Most of them are composite factories
- Most of them are part of large conglomerate
- More than half have multiple factories
- Almost all of them went through expansion or established new factories in last 10 years

Characteristics….

Factory type	Male Employment		Female Employment		Female %	
	2023	**2014**	**2023**	**2014**	**2023**	**2014**
Knit-lingerie (5)	1247	652	2570	1626	67.34	71.39
Denim Trouser (4)	1264	712	2813	1711	68.99	70.61
Sweater (7)	1661	1256	1799	1566	52.00	55.49
T-shirt (8)	1780	1183	1257	873	41.39	42.48
Jacket (5)	2381	466	1536	797	39.22	63.13
Woven Trouser (5)	609	432	846	551	58.14	56.08
Woven Shirt (7)	1551	689	2033	910	56.73	56.90
Home Textile (2)	3109	2618	2078	1552	40.06	37.22
Total (43)	**1609**	**905**	**1792**	**1143**	**52.69**	**55.81**

- Average size of RMG firm (employment) in 2023: 3400
- The average size increased by about 66% in about a decade
- The share of female in total labor force decreased from 56% in 2014 to 53% in 2023
- The change in female workers varies across type of products:
  - increased in home textile and woven
  - large decrease is for jacket

Characteristics: products and export

Factory type	Nos. of different products produced		Nos. of buyers exported to		Total export volume (million USD)	
	2023	2014	2023	2014	2023	2014
Knit-lingerie (5)	7	4	10	8	108	66
Denim Trouser (4)	4	4	10	5	74	42
Sweater (7)	5	4	25	16	48	27
T-shirt (8)	12	10	18	15	41	21
Jacket (5)	9	7	17	5	39	9
Woven Trouser (5)	14	10	7	5	42	37
Woven Shirt (7)	5	5	19	11	75	43
Home Textile (2)	20	12	35	21	523	351
Total (43)	**9**	**7**	**17**	**11**	**81**	**49**

- Product diversification is low: higher for home textile and knit lingerie
- Number of buyers has increased
- Export per firm also increased substantially (65%)

Indicators of firm capabilities: Technical Professionals

Factory type	Textile Engineer-BSc				Textile Engineer-Diploma			
	Male		Female		Male		Female	
	2023	2014	2023	2014	2023	2014	2023	2014
Knit-lingerie (5)	14.0	5.8	0.0	0.0	4.2	0.0	0.0	0.0
Denim Trouser (4)	4.8	1.8	1.8	0.0	3.5	6.5	0.0	0.0
Sweater (7)	15.9	6.0	0.0	0.0	3.6	2.4	0.0	0.0
T-shirt (8)	12.3	4.4	0.1	0.3	25.9	8.6	0.1	0.1
Jacket (5)	27.4	5.0	3.0	0.2	6.4	0.2	0.0	0.0
Woven Trouser (5)	3.2	4.6	0.0	0.0	1.2	1.0	0.0	0.0
Woven Shirt (7)	10.6	1.7	0.7	0.0	21.7	3.6	1.4	0.0
Home Textile (2)	96.0	86.5	0.0	0.0	54.5	50.5	0.0	2.0
Total (43)	**16.7**	**8.0**	**0.7**	**0.1**	**13.2**	**5.7**	**0.3**	**0.1**

- Number of both BSc and Diploma textile engineers has increased
- Hardly any female textile engineers!

Technical Professionals…..

Factory type	Industrial Engineer-BSc				Industrial Engineer-Diploma			
	Male		Female		Male		Female	
	2023	2014	2023	2014	2023	2014	2023	2014
Knit-lingerie (5)	15.6	7.2	1.8	1.8	0.0	0.0	0.0	0.0
Denim Trouser (4)	4.0	1.3	0.0	0.0	0.3	0.3	0.0	0.0
Sweater (7)	14.7	4.7	0.0	0.0	15.9	2.1	0.0	0.0
T-shirt (8)	5.6	2.1	0.3	0.0	7.1	4.4	0.0	0.0
Jacket (5)	9.6	5.0	0.0	0.0	0.0	0.0	0.0	0.0
Woven Trouser (5)	3.6	3.2	0.0	0.0	0.4	0.8	0.0	0.0
Woven Shirt (7)	9.6	0.1	5.9	0.0	0.7	0.0	0.0	0.0
Home Textile (2)	5.5	9.0	0.0	0.0	0.0	0.0	0.0	0.0
Total (43)	**9.0**	**3.5**	**1.2**	**0.2**	**4.1**	**1.3**	**0.0**	**0.0**

- Number of BSC Industrial engineers increased
- Diploma IE is new
- Some presence of female IE in recent years

Non-Technical professionals

Factory type	Non-technical Professional			
	Male		Female	
	2023	2014	2023	2014
Knit-lingerie (5)	44.4	19.2	4.4	2.8
Denim Trouser (4)	8.8	7.5	4.5	2.0
Sweater (7)	13.3	17.4	0.0	0.1
T-shirt (8)	98.4	39.0	2.1	1.3
Jacket (5)	4.4	5.8	0.8	0.4
Woven Trouser (5)	5.8	4.8	1.4	0.8
Woven Shirt (7)	45.1	10.7	13.0	2.1
Home Textile (2)	33.0	41.5	2.0	0.0
Total (43)	**36.5**	**17.9**	**3.8**	**1.3**

Core professional group
With no professional technical education

Non-technical professionals also doubled in the last one decade

Firm capabilities: mode of exports

Factory type	Nos. of buying houses		Share of exports through buying houses		Nos. of liaison offices/importers		Share of export through liaison offices/importers		Direct export: nos. of buyers		Direct export: share of export directly to buyers	
	2023	**2014**	**2023**	**2014**	**2023**	**2014**	**2023**	**2014**	**2023**	**2014**	**2023**	**2014**
Knit-lingerie (5)	1	3	12	30	1	0	8	2	7	4	80	68
Denim Trouser (4)	7	4	41	40	2	1	18	13	3	1	41	48
Sweater (7)	12	7	45	54	3	3	10	14	12	8	45	31
T-shirt (8)	9	7	35	61	3	1	10	13	7	4	55	27
Jacket (5)	7	1	40	27	4	1	10	27	11	1	50	46
Woven Trouser (5)	6	3	39	56	2	0	3	2	3	2	58	42
Woven Shirt (7)	5	5	59	70	1	1	8	6	7	1	33	24
Home Textile (2)	7	6	20	80	4	0	30	0	7	4	50	20
Total (43)	**7**	**5**	**38**	**51**	**2**	**1**	**10**	**11**	**7**	**4**	**52**	**38**

- Has the reliance on buying houses decreased over time? Yes [from 51% to 38%]
- Direct exports: Similar increase [from 38% to 52%]
- Share of liaison office remains same

Firm capabilities: use of software

Factory type	Nos. of firms using atleast 3 softwares	Average time since started using softwares (yrs)
Knit-lingerie (5)	3	10
Denim Trouser (4)	3	12
Sweater (7)	3	12
T-shirt (8)	2	8
Jacket (5)	2	9
Woven Trouser (5)	2	5
Woven Shirt (7)	2	12
Home Textile (2)	0	0
Total (43)	**17**	**10**

Names of the software

1. Enterprise Resource Planning (ERP) software
2. Arahne CAD/CAM software for pattern-making
3. Pattern software by BOLK
4. Warpalizer
5. Weavepoint
6. LaserGRBL
7. lLightBurn
8. Thumbnail Viewers

Use of software has increased over the last 10 years of so.

Firm capabilities: R&D

Factory type	Total R&D		Sample producing facility		Design studio		Testing lab	
	Yes	Avg. years since start	Yes	Avg. years since start	Yes	Avg. years since start	Yes	Avg. years since start
Knit-lingerie (5)	4	9	5	11	2	10	4	12
Denim Trouser (4)	3	15	4	14	1	17	3	8
Sweater (7)	5	8	6	20	5	16	3	11
T-shirt (8)	3	12	6	17	3	20	7	16
Jacket (5)	1	7	3	10	3	4	2	8
Woven Trouser (5)	2	8	4	11	3	6	2	12
Woven Shirt (7)	1	14	3	17	2	13	2	10
Home Textile (2)	2	17	2	17	2	17	2	17
Total (43)	**21**	**11**	**33**	**15**	**21**	**12**	**25**	**12**

- R&D, sampling, design studio, and testing lab: 11-12 years
- Investment in overall R&D is high in some products: home textile, lingerie, sweater
  low: woven shirt, woven trouser

Firm capabilities: Compliance and certification

Factory type	Technical certification		Social certification		Environmental certification		Social and environmental certification	
	Avg. no. of certificates	Years since certification	Avg. no. of certificates	Years since certification	Avg. no. of certificates	Years since certification	Avg. no. of certificates	Years since certification
Knit-lingerie (5)	2	6	2	7	5	8	2	9
Denim Trouser (4)	2	5	2	7	4	4	2	6
Sweater (7)	1	10	1	8	5	8	1	6
T-shirt (8)	1	8	2	8	4	11	1	9
Jacket (5)	1	4	1	6	5	4	2	8
Woven Trouser (5)	1	4	2	6	5	6	1	4
Woven Shirt (7)	1	13	1	8	3	6	1	8
Home Textile (2)	3	3	3	5	6	10	2	11
Total (43)	**1**	**7**	**1**	**7**	**4**	**7**	**1**	**8**

Technical	**Social**	**Environmental**	**Social and environmental**
CT-PAT	Better Work Bangladesh	LEED Certification	WRAP Certification
Global security verification	Amfori	Higg Index	Sedex
ISO 45001	Social & Labor Convergence	Eco Factory	Supplier to zero
ISO 9001		OEKO-TEX	
		Cradle to cradle	
		Fair trade international	
		Global organic textile standard	
		Organic 100 contend standard	
		Better Cotton Initiative	

Labor saving technology: Technological upgrading (K/L) [K = no. of machines]

Factory type	L/Machine		L(MO)/Machine		L(S)/Machine		L(H)/Machine		OW/Machine	
	2023	2014	2023	2014	2023	2014	2023	2014	2023	2014
Knit-lingerie (5)	1.26	1.36	1.06	1.07	0.05	0.06	0.12	0.21	0.02	0.03
Denim Trouser (4)	1.34	1.41	0.92	1.00	0.04	0.05	0.30	0.27	0.08	0.09
Sweater (7)	0.85	1.00	0.74	0.88	0.03	0.04	0.05	0.05	0.03	0.03
T-shirt (8)	1.39	1.53	0.97	1.00	0.05	0.07	0.25	0.32	0.11	0.14
Jacket (5)	1.11	1.09	0.97	0.97	0.04	0.04	0.09	0.07	0.00	0.01
Woven Trouser (5)	1.23	1.25	0.81	0.85	0.05	0.06	0.28	0.26	0.09	0.09
Woven Shirt (7)	1.20	1.29	0.83	0.92	0.05	0.04	0.21	0.25	0.12	0.08
Home Textile (2)	2.77	3.51	1.58	1.95	0.20	0.26	0.87	1.20	0.12	0.09
Total (43)	**1.21**	**1.31**	**0.91**	**0.98**	**0.05**	**0.05**	**0.18**	**0.21**	**0.06**	**0.06**

K = number of machines
L = total workers; MO = machine operators; S = supervisors; H = helpers; OW = other workers

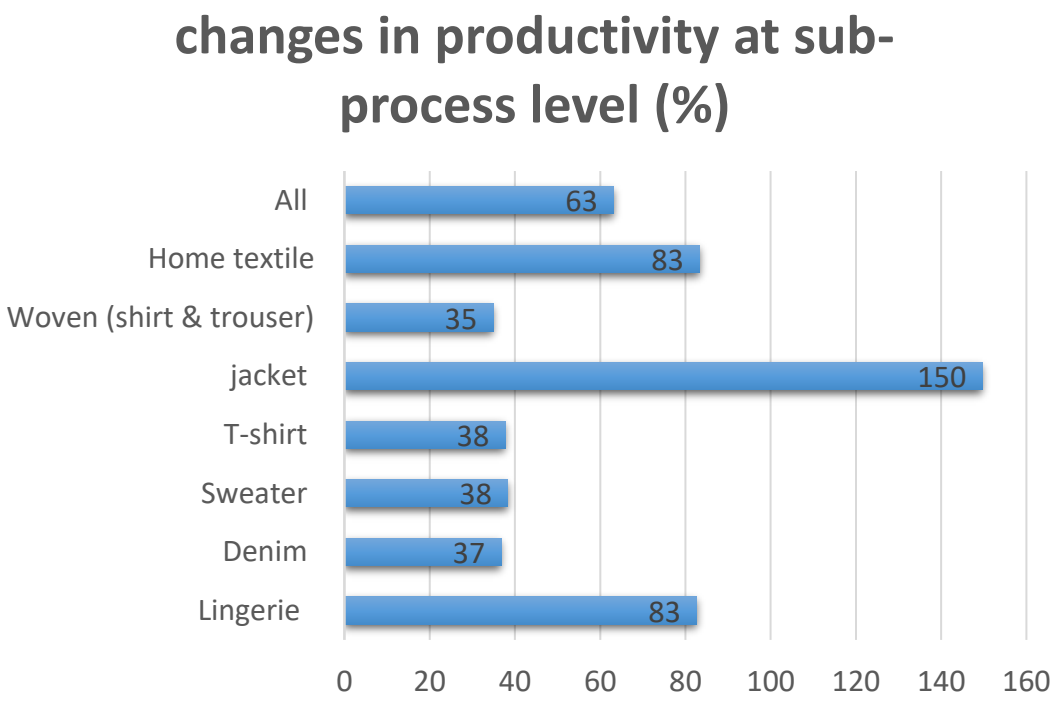
For each machine, the number of factory workers has decreased over time (1.31➔ 1.21)
➔ Machine operators, helpers decreased (machine specific)
➔ supervisors, other workers did not change
Lingerie, knit, home textile: larger decline

Technological upgrading (K/L)
[K = value of machines, million BDT]

Factory type	L/K	
	2023	**2014**
Knit-lingerie (5)	2.50	9.28
Denim Trouser (4)	17.28	18.29
Sweater (7)	1.01	2.27
T-shirt (8)	1.25	2.94
Jacket (5)	5.13	6.64
Woven Trouser (5)	13.34	16.69
Woven Shirt (7)	6.15	16.14
Home Textile (2)	0.79	1.03
Total (43)	**2.15**	**4.13**

- Larger decrease in K/L in terms of value
- For each million dollar of machine value, the total number of workers decreased from 4.13 to 2.15

Time saving technology: Change in productivity of sub-processes (2014-2023)



Example: Jacket

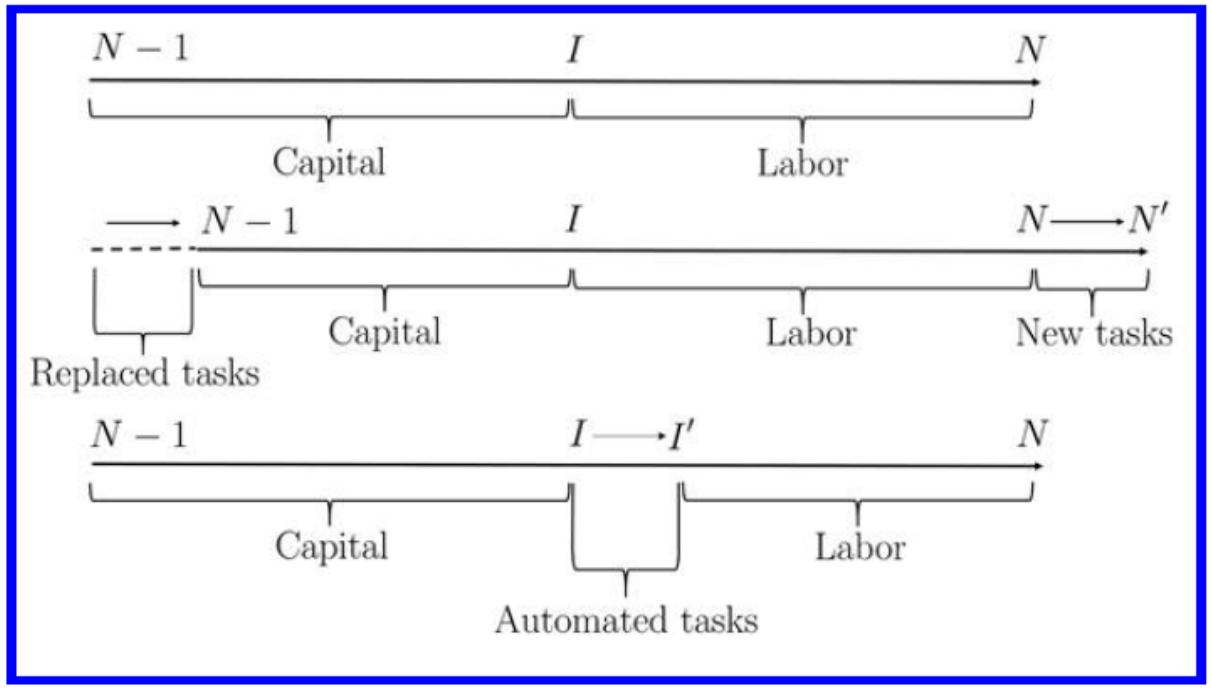
Sub-process	Productivity measure	2023	2014
Pattern making	style/hour	8	2
Spreading	style/hour	155	114
Cutting	piece/hour	12760	4150
Sewing	piece/hour	251339	220488
Inspection/metal detection	piece/hour	1633	893
Ironing	piece/hour	1924	897
Packaging	piece/hour	65	60
Knitting	kg/day	2500	1000
Embroidery	piece/day	8000	1500

Average of 136 sub-processes of 8 products!

Impact of higher K/L?

- Is technology labor displacing or/and labor reinstating?

Figure 1
The Allocation of Capital and Labor to the Production of Tasks and the Impact of Automation and the Creation of New Tasks



New technology (automation) not only displaces labor, it can also create new jobs!

Source: Acemoglu and Restrepo (2019)

Table: Effect of capital intensity of sub-processes on labor displacement (creation)

Independent variable	Dependent variable				
	Total workers	Proportion of machine operators	Proportion of supervisors	Proportion of helpers	Proportion of other workers
	(1)	(2)	(3)	(4)	(5)
Capital-Labor ratio	-2.651** (1.049)	-0.004** (0.002)	0.0003 (0.0008)	0.002 (0.001)	0.002** (0.001)
Capital, million BDT	-	0.0001** (0.00004)	-0.00003** (0.00001)	-0.00005* (0.00003)	-0.00004** (0.001)
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes
Process FE	Yes	Yes	Yes	Yes	Yes
Nos. of obs.	771	771	771	771	771
R-squared	0.196	0.5206	0.3244	0.4511	0.4660

$$Workers_{ijpst} = \alpha_0 + \alpha_1 (K/L)_{ijpst} + K_{ijpst} + FEs + u_{ijpst}$$

- Displacement of machine operators and helpers
- Creation in other workers

Is technology female labor displacing (gender biased technological change)?

Independent variable	Dependent variable				
	Proportion of female workers	Proportion of female machine operators	Proportion of female supervisors	Proportion of female helpers	Proportion of female other workers
	(1)	(2)	(3)	(4)	(5)
Capital-Labor ratio	-0.004	-0.006**	-0.0004	-0.008**	0.005***
	(0.003)	(0.003)	(0.0004)	(0.004)	(0.002)
Capital, million BDT	0.0001*	0.0001*	0.00002	0.0001	-0.0001**
	(0.0001)	(0.0001)	(0.00001)	(0.0001)	(0.00002)
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes
Process FE	Yes	Yes	Yes	Yes	Yes
Nos. of obs.	771	765	638	539	238
R-squared	0.4164	0.4077	0.2054	0.3534	0.6396

- Share of females in machine operators reduced due to higher K/L
- Share of females in helpers reduced due to higher K/L
- But, share of other workers in total other workers increased due to higher K/L

Conclusion: what have we learned?

- Technological progress should be understood at the process and sub-process level.
- A major expansion of the capacity occurred in the last 10 years or so (intensive and extensive margins)
- There are evidences on greater firm capabilities in recent years (no. of technical professionals, R&D, direct exports, use of software, certifications)
- Number of labor per machine has decreased. More pronounced for machine operators and helpers ➔ the industry has become more capital intensive
- Sub-process wise productivity has increased (output per hour or day). This is higher for jacket, home textile and lingerie
- Regression results show that higher capital intensity has both displaced and reinstated workers (displacement> reinstating)
- There are some evidence for gender biased technological change in some occupations (machine operators and helpers)