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Is technological change really skill biased? Evidence from the introduction of ICTs on the textile sector (1980-2000)

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Abstract: This paper investigates the effects of the introduction of information and communication technologies (ICTs) on the skills of a workforce. Using micro-data collected from workers in the textile sector, we analyse whether the introduction of ICTs has modified workers' tasks, so that higher skills and longer training periods than before are necessary. Our survey has shown that ICTs *i*) have replaced unskilled labour in some cases and skilled labour in others; *ii*) have changed workers' tasks in some cases but not in others; and finally, *iii*) have brought about an increase in skills for only a small number of occupations. This empirical evidence does not confirm the hypothesis that technological change, and in particular change introduced by ICTs, is necessarily skill biased.

Keywords: Technological change, skill bias, textile industry

J.E.L. code: O33; L670

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1. Introduction

This paper studies the effects of technological change on the labour market. The most common hypothesis in the literature on this topic is that the technological change embodied in information and communication technologies (ICT) is not «neutral» with respect to workers' skills, but that there is complementarity between technology and skills[1], i.e. the technological change is skill biased [for surveys, see Sanders-ter Weel 2000; Acemoglu 2002].

The theoretical models used in literature, with exogenous or endogenous technology, tend *to assume* directly that ICTs are skill biased, as in Caselli [1999], or that physical capital is a closer substitute for unskilled labour than for skilled labour, as in Funk and Vogel [2004], and as a consequence of this, in the long-run, the technological change results skill biased.

Historically, the idea that technological progress deskilles the labour force was prevalent for a long time [at least starting from Dobb 1928]. The birth of the tayloristic firm, in which skilled artisans are substituted by workers who are required to perform only the most repetitive tasks, and where technical competence is transferred to the machinery, is the paradigmatic example of the deskilling process [Braverman 1974]. The long-run analysis shows that there are some technologies which tend to favour unskilled labour (unskill-biased), some which favour skilled labour and others which are neutral, i.e. the technology does not modify the firm's demand for labour [Goldin-Katz 1996]. Then, the relative growth in demand for skilled labour and the inequality of wages might be the result of technological progress which affects the demand for different kinds of jobs at different speeds, rather than generalized skill biased technological change [Hamermesh 1993: 352; Acemoglu 2002: 13].

[1] We use the word «skill» to indicate a high level of education, capability or training on the job. The concept of technology-skill complementarity is also relative: it indicates that highly skilled workers are more complementary or suited to new technologies than unskilled workers, i.e. that the productivity of the former is greater than that of the latter in using new technologies.

Despite this, empirical analysis tends to consider the SBTC hypothesis as simply confirmed by the positive correlation between the use of technology and changes in labour composition in favour of more highly skilled or educated workers - or the positive correlation between technology and the wages of skilled workers [for a survey, see Link and Siegel 2003]. Most studies, after having identified a positive correlation between technology and skills, refer to a *causal mechanism* according to which new technologies introduced in the production phases have to be used by workers with high skills.

To our knowledge, not many studies have analysed the interaction processes between new technologies and workers «in the field», or studied at a micro level -for production industries and workers' skills- how new technologies affect the tasks performed by workers and the skills needed to achieve them[2]. Autor, Levy and Murname [2001] wrote explicitly that "while the empirical relationship between computer investment and use of educated labor is firmly established, […] the conceptual link explaining specifically *how* computer technology complements skilled labor or substitutes for unskilled labor is not well developed". This lack of knowledge is more problematic in view of recent empirical results [Dunne e Troske 2004] contrasting the conventional skill bias hypothesis.

Our aim is to analyse whether the introduction of ICT in a specific sector, in this case the textile industry, has really caused changes in tasks, that create a demand for workers with higher skills and longer training period than before. The analysis, designed independently by the work of Autor, Levy and Murname [2001], is carried out by comparing qualitative micro-data about occupations, tasks and skills, collected before (1980) and after (2000) the diffusion of ICT in the textile industry.

[2] This opinion is shared by Hamermesh [1993: 352] and Acemoglu [2002: 13-14].

The paper is organized as follows: Section 2 presents the technique used for the analysis and describes the data used; Section 3 introduces the results of the analysis. Section 4 describes our conclusions.

2. Technique used for analysis

This essay uses a classification technique based on qualitative data collected by direct research «in the field».

The unit of analysis is the type of occupation of each worker in a firm. A worker's «occupation» is her «trade», or a set of tasks and duties to be carried out. Closely related to the concept of an occupation is that of *skills*, i.e. the ability to carry out the tasks and duties involved in a particular occupation in a competent manner [ILO 1990]. Skills are characterized by *level* and *specialisation*. Skill level makes it possible to identify an occupation by the amount of formal education generally necessary for competent performance of the tasks involved. Skill specialization defines the occupation by the knowledge that is required of the sector, the tools and machinery used and the kind of goods produced. In this sense it is possible to classify occupations according to the range of skills they require. Unskilled occupations are those which require shorter training periods and which do not require high levels of education or particular skills[3].

We have used the International Standard Classification of Occupations ISCO-88 by the ILO [1990] to identify occupations in the textile industry. Each occupation has been listed according to its specific position in the textile production cycle.

The occupations have been analysed at a distance of twenty years (1980-2000), before and after the introduction of ICTs in the textile industry. The information about occupations

[3] For a survey on skills measurement, see Borghans, Green and Mayhew [2001]; Elias and McKnight [2001].

in the early eighties has been taken from a book by Ganugi and Romagnoli [1982] (hereinafter "GR"), who created detailed files based on a survey for each occupation and production phase[4]. The information about current occupations has been taken from a survey carried out in 2000[5] [Ciriec and Provincia di Prato 2000], through interviews with textile industry experts[6].

We have created a file for each occupation from these sources, which describes: *i*) the tasks and duties performed by each worker; *ii*) the ICT machinery and its technological characteristics, identified according to the U.S. Bureau of Census classification [USBC 1988; 1993][7]; *iii*) the skills necessary to carry out the tasks and the average minimum training period necessary for a new employee to achieve maximum expected productivity considering the technology; *iv*) changes in the workers' tasks, only for occupations that existed in both 1980

[4] GR analyzed textile industry occupations in the Prato area at the end of the Seventies. Each occupation was described in detail, identifying the tasks performed by workers (including the movements that she made), the specific phase of the textile cycle to which each occupation belonged and the technology used. Specifically, the information collected by GR for each occupation was: i) the tasks and the duties performed by the worker; ii) the tools and machinery used; iii) the incoming semifinished products and the outgoing products; iv) the changes in tasks between 1970 and 1980.

[5] This survey was carried out in Prato, a Tuscan town, known as a paradigm of a Marshallian industrial district [Becattini 1997]. In 1981, there were 8,326 textile firms in the area with a total of 41,656 employees, equivalent to 88.5% of workers in the manufacturing sector. In 2001 the firms had decreased to 4,976, and the employees to 32,218, equivalent to 71% of workers in the manufacturing sector [ISTAT Censimento dell'Industria e dei Servizi 1981; 2001].

[6] The survey was organized in several phases. First, we had several meetings with local textile industry experts to investigate the relationship between occupations, skills, technological innovation and the textile production cycle. The information collected during these meetings allowed us to select 28 entrepreneurs and managers of textile firms from all phases of the cycle, with in-depth knowledge of the textile industry and its organizational and occupational structure. We then carried out in-depth interviews with these people. These interviews, which lasted about four hours each, took place on company premises, to enable us to see how the machinery works and witness the tasks and the duties of workers.

[7] The classification includes 17 different technologies in the areas of: design and engineering (3 technologies), fabrication/machining and assembly (5), automated material handling (2), automated sensor-based inspection and/or testing (2), and communication and control (5). In particular the technologies are: 1) computer-aided design (CAD) or computer-aided engineering; 2) CAD output used to control manufacturing machines; 3) digital representation of CAD output used in procurement; 4) flexible manufacturing cells or systems; 5) numerically controlled or computer numerically controlled machines; 6) machines using lasers; 7) pick and place robots; 8) other robots; 9) automatic storage and retrieval systems; 10) automatic guided vehicle systems; 11) Automated sensor-based inspection or testing performed on incoming or in-process materials; 12) Automated sensor-based inspection or testing performed on final product; 13) local area network (LAN) for technological data; 14) LAN for factory use; 15) intercompany computer network linking plant to subcontractors, suppliers, or customers; 16) programmable controllers; 17) computers used for control on factory floor.

and 2000. Regarding occupations that existed in 1980 but not in 2000, we have analysed the tasks performed and the probable reasons for the «disappearance» of that occupation.

We analysed 123 occupations: 87 existing in 2000 (of which 24 did not exist in 1980) and 36 occupations that disappeared between 1980 and 2000[8]. We adopted precise definitions for the new technology and to classify workers' tasks and skills before and after the introduction of new technologies. Following a large portion of the existing literature [e.g. Doms, Dunne and Troske 1997; Caselli 1999; Dunne and Troske 2004], we defined technological change as the introduction of ICT machinery as classified by USBC[9] in any phase of textile production.

We classified occupations as «affected by technological change» or «not affected by technological change», according to whether or not ICT machinery needed to be used to carry out the tasks required[10]. For instance, a circular knitting machine operator is affected by technological change, as she uses a computerized circular knitting machine, which belongs to category 4 of the USBC classification.

We then classified the effects of technological change on our unit of analysis. The disappearance of an occupation because the tasks are performed by a computer based machine: the new technology completely replaces an occupation and renders workers who performed the tasks supernumerary. The creation of new occupations is another possible effect of technological change. The introduction of a new technology can alter the production cycle, introducing tasks that were not previously necessary; for instance, the introduction of

[8] The files are available on request from the authors.

[9] It is useful to note that in our analysis technological change is exogenous. Our aim is to observe whether new technology has been introduced in the various phases of the textile cycle in the last twenty years, rather than to identify the reasons for the existence of technological change.

[10] We did not consider «use intensity», and so we did not measure how much the machinery has to be used by a worker in performing his tasks. To classify an occupation among those affected by technological change we considered the simple indication of usage of one of the 17 technologies listed by the USCB [1988; 1993].

new a machine makes it necessary to employ workers who are able to use, program and service it.

Besides these «drastic» effects, the introduction of a new technology can have lesser effects, changing only the tasks or skills involved in an occupation.

The changing of tasks is a complex matter because the effects can vary from slight to drastic. Following a methodical comparison between the occupations described by GR and those described in our survey, (only for occupations existing in both surveys), we adopted a dichotomous scheme (substantially changed tasks; substantially unchanged tasks). For instance, the tasks of a heddle preparer/drawer-in have been changed substantially by the introduction of a computerized draw-in machine (technology that belongs to category 4 of the USBC classification). While this task was completely manual in the eighties, it is now completely computerized, and the worker has to start up, work and control the machine. In contrast, the tasks of cotton loom operators have been facilitated and accelerated by the introduction of the computerized cotton loom (a machine belonging to category 4 of the USBC classification), but they have not undergone radical change: the operators still have to furnish the loom with spools and bobbins, start up the machine, see that weaving is proceeding correctly and change the set up of the loom.

Technological change may also have no effect on tasks. This idea differs from that of Caselli [1999:79], who defines incremental technological change as change that does not alter a worker's tasks, and assumes that ICT technological change is not incremental. Our analysis has revealed some occupations in which tasks have not been modified despite the use of ICT machinery. For instance, the carboniser's tasks consist of setting the timer and temperature of the furnace in which cellulosic matter is removed from the rags: it isn't important if now the furnace is controlled by a microchip.

We have also analysed the effects of technological change on worker's skills. The information about skills was gained from interviews in which our aim was to investigate: i) the minimum level of formal education necessary to perform the tasks that constitute an occupation; ii) the minimum time necessary for a worker to become competent in performing her tasks. The collection of this information allows us to estimate the complexity of skills, according to formal education and on-the-job training[11]. We have used a dichotomous scheme (substantially changed skills; substantially unchanged skills) to classify the occupations that survived between the two analyses and check whether formal education and on-the-job training time have changed between 1980 and 2000.

Our question is: does the introduction of ICTs in an occupation require more skilled workers or longer on-the-job training than before? The survey has enabled us to identify «in real terms» whether changes in skills were due to the introduction of new technologies or not.

3. Technological change, occupations, tasks and skills in the textile industry

Figure 1 shows the main results of our analysis, while the table in the annex refers (to the following) for each occupation: i) the percentage of employees per occupation from the 2000 survey; ii) the technologies used; iii) whether tasks changed between 1980-2000; iv) information about changes in skills between 1980-2000; v) the specific phase of the textile production cycle to which each occupation belongs.

As we can see from Figure 1, the classification of occupations, created by intersection of new/disappeared/survived occupations with technological change (the analytic results are reported in column 3 of the table in the annex), identifies 6 groups of occupations:

[11] Our analysis is based on evaluations of «needs» and «mean times» rather than real data. This allows us to eliminate the problem of a general rise in the educational level of the population.

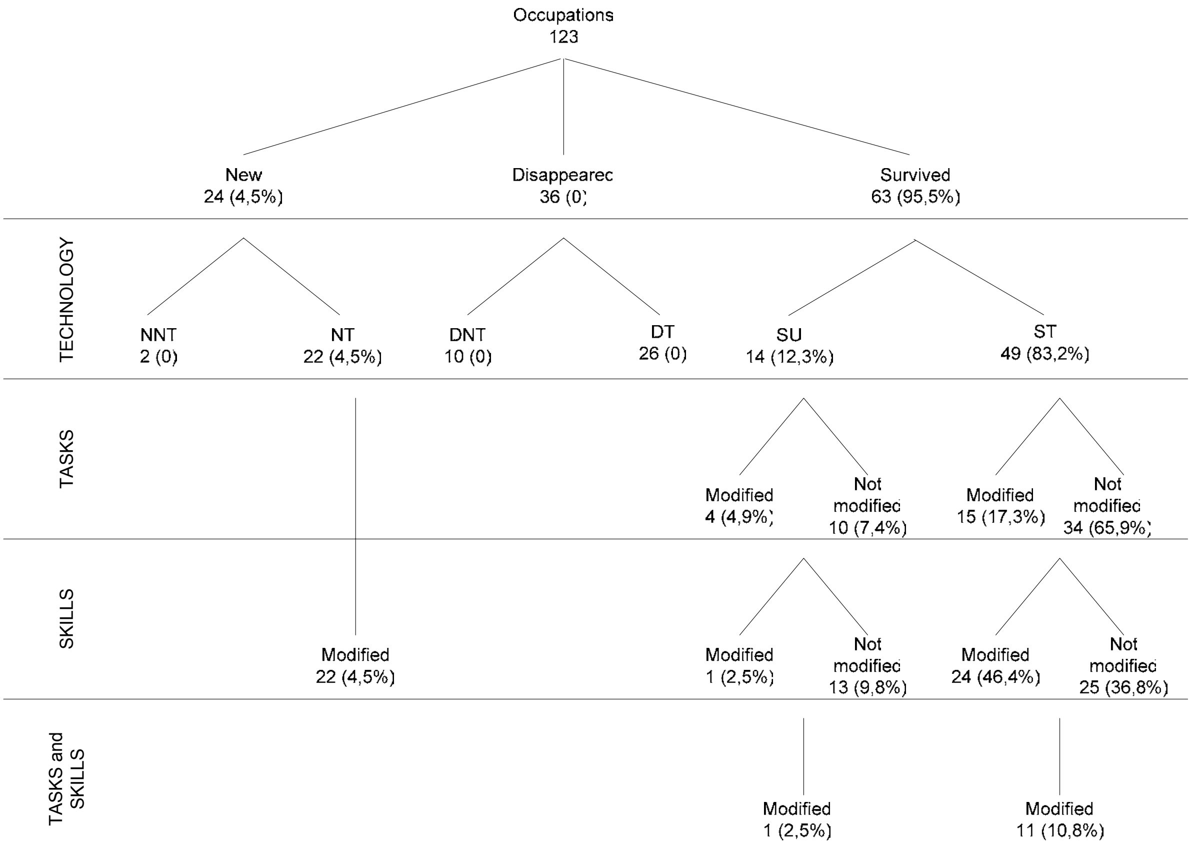
1. *Surviving occupations not affected by technological change (S).* These occupations existed in both 1980 and 2000 and were not affected by technological change. Many of these occupations are characterised by artisan/handicraft or manual work. For example the rag grader, who examines and classifies rags by type, quality, colour and length, and removes impurities now as she did in 1980.
2. *New occupations affected by technological change (NT).* These are occupations identified in 2000 but not in 1980. Their origin is directly related to technological change and is often due to the introduction of new products or new processes. For instance, the role of jet-dyeing machine operator was born with the introduction of a new yarn dye machine, the computerized steam jet dyer, for dying polyester and synthetic fibres.
3. *New occupations not affected by technological change (NNT).* These are occupations identified in 2000 but not in 1980. Their origin is directly related not to technological change, but to changes in the market or labour organization. For instance, the role of collection manager has been created due to the fashion industry, which demands a large number of collections during the year. Although a collection manager uses a computer and the internet, the role did not originate because of new technologies.
4. *Occupations that have disappeared due to technological change (DT).* These occupations were identified in 1980 but not in 2000, and their disappearance is due to the introduction of new technologies. ICTs have brought about: i) the unification of many tasks in one occupation, because of the reduction of processing times or the higher quality of products, which reduces the time needed for checking phases; ii) complete automation of some production phases. An example of the unification of tasks is provided by a self-acting spool tender, who in 1980 had to position spools in the spinning machine, replace used spools, add sliver laps and remove empty spools. Recently, the introduction of the

self-acting spinning machine has made it possible to automate the replacement and removal phases, so that the other tasks of the self-acting spool tender are carried out by a self-acting spinning machine operator and the former occupation has disappeared. An example of the automation of some production phases, on the other hand, is provided by the bale breaker. In 1980, she had to open the staple bales manually, but when the preparation phase became a closed cycle, her tasks ceased to exist because the new machines are linked by a computer network and a pneumatic system.

5. *Occupations that have disappeared for reasons other than technological change (DNT).* These occupations were identified in 1980 but not in 2000. Their disappearance is not directly due to the introduction of new technologies, but rather to the need to reduce operating costs and to incorporate several tasks in one occupation. For instance, a defect evaluator examined the nature and quantity of defects such as unevenness of colour or tears in bolts of fabric, evaluated the time needed for repairs and gave instructions to the mender. The need to reduce costs and the possibility of incorporating several tasks in only one occupation have led to the disappearance of the occupation of defect evaluator and the incorporation of her tasks in those of the weaving quality inspector and the mender.
6. *Surviving occupations affected by technological change (ST).* These are occupations identified both in 1980 and 2000, that have been affected by technological change in that period. The tasks of some occupations have changed, while those of others have not. An example of the former type of occupation is a basket loader, while the carboniser is an example of the latter. As a consequence of the introduction of electronic conveyor-belts, the basket loader no longer loads baskets by hand but has to operate a machine.

In Figure 1, we have calculated some indicators to order to measure the impact of technology on the textile industry. The first is the sum of surviving occupations divided by the total number of occupations identified. It shows that only 14 occupations, equivalent to 11.4% of the total, have not been affected by technological change. Their weight in terms of numbers of employees is equivalent to 12.3%, as we can see from the numbers in brackets in Figure 1. This means that 87.7% of the employees have an occupation in which ICTs are used.

Figure 1. Groups of occupations in the textile industry (1980-2000)



Legend: SU = occupations that have survived unchanged; NT = new occupations affected by technological change; NNT = new occupations not affected by technological change; DT = occupations that have disappeared due to technological change; DNT = occupations that have disappeared for reasons other than technological change; ST = surviving occupations affected by technological change.
Note: the absolute values indicate the number of occupations for each group; the values in brackets indicate the relative percentage of total employees surveyed in 2000.
Source: Survey of textile firms in the Province of Prato. 72 firms were interviewed; they employed 14.7% of total textile sector workers in the Province in 2000.

The second indicator is the turnover (replacement) rate of occupations, which is calculated as the sum of the new (NNT+NT: 24) and disappeared occupations (DNT+DT: 36), divided by the total number of occupations identified. This rate is 48.8%, meaning that about half of the occupations disappeared or were born in the period between 1980 and 2000. For 80% of the occupations, this turnover was due to the introduction of new technologies.

The birth of all NT occupations is due to the introduction of technologies classified as «flexible manufacturing cells or systems» (technology 4) into the textile production cycle. These new occupations are concentrated in the phases of knitting, dyeing, ennobling and special textile production (nonwoven fabrics), and represent 4.5% of the total occupations. The birth of the other 2 new occupations -coating machine preparation assistant and collection manager- (which employ a low number of people) is due to market changes, which demand a large number of collections every year. Let us now consider the occupations that have disappeared: the demise of 26 of the 36 disappeared occupations is due to technological change, which acted in a complex way and in some cases meant replacing relatively high skills with machinery, such as bobbin inserters and knitting machine operators. These occupations are clear examples of unskill-biased technological change. In other cases the introduction of a new technology, in particular closed cycle machinery, has led to the demise of some low skilled occupations that mainly dealt with machinery loading, such as bale breaker, picker tender, carding machine feeder, fibre drawer, etc. The disappearance of the other 10 occupations, on the other hand, is not directly due to technological change, but rather to the need to introduce organizational changes and reduce costs. This necessity for change increased the skills of individual workers, as many tasks were incorporated into one occupation– such as the first grader, whose tasks are now performed by a rag grader, or the defect evaluator, whose tasks are performed by a weaving quality inspector. In these cases, technology had no direct influence on the labour saving process[12].

As we have seen, technological change has not only affected the turnover of occupations. In order to measure the impact of technology on changes in tasks and skills we calculated two indicators, based on the numbers presented in Figure 1.

Regarding tasks, the indicator is calculated as the sum of new occupations and occupations whose tasks have been changed by ICT (22+15 = 37), divided by the total number of surviving occupations affected by technological change (NT+ST: 71), which includes new occupations (22) and pre-existing occupations affected by technological change (49). This indicator shows the share of occupations whose tasks have been modified by technological change: for 52.1% of the total occupations the introduction of new technologies has substantially modified related tasks, while for 47.9% of the total occupations the tasks remained substantially unchanged. These results do not confirm the hypothesis used in literature, for instance by Caselli [1999:79], that ICT always changes workers' tasks. The data regarding textile industry workers shows that only 21.8% of the total employees perform tasks that have been modified by technological change in the last twenty years.

In order to measure the impact of technological change on workers' skills, we have calculated the number of occupations affected by technological change in which the skills have been changed by ICT (22+24 = 46), divided by the total number of occupations affected by technological change (71). This demonstrates that the workers' skills have been modified in 64.8% of the total occupations affected by technological change. These skills are also higher than the ones required for the same occupations in the early eighties. Therefore, as we can see from the number in brackets in Figure 1, 50.9% of the total textile workers are

[12] There may be an indirect effect, which is very difficult to identify: if technology improves the quality of intermediate goods, this may indirectly cause the disappearance of quality control occupations.

performing tasks which require higher skills than before, following the introduction of new technologies. However, for 35.2% of the total occupations affected by technological change (36.8% of total textile sector employees), the workers' skills have not been modified. The phenomenon of skill-biased technological change has worked in the textile industry, but it cannot be said that the introduction of new technologies necessarily requires higher skills in order to carry out new tasks and duties. These results do not confirm the hypothesis that all ICTs are biased in favour of skilled workers.

The analysis of the production phases is interesting because it highlights the different impact of technological change on different production phases, with inhomogeneous changes in the tasks and skills required of workers. This means that the technological impact varies for different production phases within the same industry, and so the results of empirical analyses using aggregate sectorial data may depend on sectorial composition. For instance, the SBTC evidence for a certain sector may be due to the prevalence of firms characterised by a production phase in which technology is biased in favour of skilled workers, rather than the result of general SBTC.

4. Conclusions

This paper allows us to show in detail the effects of technological change on textile sector occupations, and in particular on the tasks and skills required to workers by firm. The data derives from a comparison between current occupations and occupations that existed in the early eighties, surveyed by Ganugi and Romagnoli [1982].

The comparison reveals a sector that is strongly affected by technological change, mainly in the form of the introduction of flexible manufacturing cells or systems and automatic storage and retrieval systems. We have shown that technological change has brought about the demise of many occupations, the birth of others, and a change in the tasks of the occupations that have survived. Currently, less than 13% of the total number of textile industry workers (at least in the area analysed) are employed in occupations that have not been affected by technological change over the last twenty years.

Our results suggest that technological change has mainly been concerned with labour saving, thus incorporating many tasks in one occupation and causing occupations related to labour intensive production phases to disappear. We have seen that physical capital has replaced low skilled occupations in most cases, and that in some cases high skilled occupations have been replaced by new machinery. The overall result is a reduction of the workforce in the textile industry.

Two further major results concern tasks and skills. Firstly, technological change has altered tasks in about half of the occupations affected by technological change, corresponding to about 22% of total employees. On the other hand, it has not modified the tasks of the remaining occupations, corresponding to 65.9% of total employees. Secondly, technological change has created a need for higher skills in 65% of occupations affected by technological change, corresponding to about 51% of total employees, while it has not modified the skills of the remaining 35% of occupations affected, corresponding to about 37% of total employees. These findings mean that the introduction of ICT in textile industry has not always modified tasks and increased the level of skills in all cases: we have shown that the introduction of new technologies has modified workers' tasks and consequently the skills needed to perform those tasks in only 15% of total occupations, corresponding to 10.8% of total employees.

Our analysis of the textile industry does not confirm the hypothesis that technological change, and ICT in particular, has directly increased the demand for skilled workers. We have also found plenty of evidence in our analysis to falsify the generalised hypothesis of technological asymmetry, which states that technology is more likely to replace unskilled workers. There is probably a macro trend towards SBTC in the textile industry as in other industries, but in this case it seems to be a result of the different speeds at which technology spreads: some of it biased in favour of skilled labour, some neutral and some biased in favour of unskilled labour.

Our empirical evidence allows us to confirm that the ICT revolution has introduced technology that is not always biased in favour of skilled work. These results prompt a complex question: why do many studies record generalized SBTC at a macro level if the effects of technology are so differentiated at a micro level? Our analysis casts doubt on the validity of models that assume that technology is always skill biased, and those that hypothesise an asymmetry in the degree of substitutability between physical capital and different types of occupation, and asymmetry in training costs for different groups of workers. Our results suggest that we should build models which take into account the co-existence of a heterogeneous set of technologies with different impacts on workers, i.e. some biased in favour and others against skilled labour, as the hypothesis of generalized SBTC lacks solid grounds.

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Annex

Occupations in the textile industry in Prato (1980-2000)

Occupation	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1st grader	-	DNT				RMP
Airo ageing machine operator	0.7	NT	2		yes	E
Bale-breaker	-	DT				PRE
Basket loader	0.3	ST	2;8	yes	yes	D
Basket washing machine operator	0.9	NT	2		yes	E
Beamer	-	SU		no	no	WA
Beater operator	-	DT				PRE
Blending machine operator	1.3	ST	2;8	yes	yes	PRE
Bobbin inserter (in loom)	-	DT				WE
Border sewer	0.2	SU		no	no	F
Buttonhole machine operator	-	SU		no	no	F
Calenderer	1.5	ST	2	no	no	E
Carboniser	1.4	ST	2	no	no	RMP
Carder	2	ST	2;8	no	yes	C
Carding machine feeder	-	DT				C
Centrifugal extractor operator	-	ST	2	no	no	D
Chenille-machine operator	0.2	NT	2		yes	S
Circular knitting machine operator	1.1	ST	2	yes	yes	K
Circular or straight knitting machine programmer	0.1	ST	2	no	yes	PRO
Cloth cutting machine operator	-	NT	2		yes	K
Cloth roller	3.7	ST	2	no	no	E
Cloth weigher	-	DNT				WE
Coating machine operator	1.9	ST	2	yes	yes	SF
Coating machine preparation assistant (paper)	-	DNT				SF
Coating machine preparation assistant (resin)	-	NNT	2			SF
Collar cutter	-	DNT				F
Collar feller	-	DNT				F
Collar knitter	0.2	SU		no	no	F
Collar strip preparer	-	DNT				F
Collection manager	-	NNT	14			WO
Comb inserter (in loom)	-	DT				WE
Comber tender	3.5	ST	2	yes	no	PRE
Combing card tender	-	DT				PRE
Combing machine can emptier	-	DT				PRE
Combing machine can replacer	-	DT				PRE
Combing machine monitor	-	DT				PRE
Cotton loom operator	-	ST	2	no	no	K
Cotton loom programmer	0.4	ST	2	no	yes	PRO
Crochet machine operator	-	NT	2		yes	K
Cutting and sewing machine operator	0.9	SU		yes	no	F
Decating machine operator	1.6	ST	2	no	yes	E
Defect evaluator	-	DNT				WE
Defect remover	-	SU		no	no	WE
Designer (on paper)	-	DT				WE
Drum operator	0.2	NT	2		yes	SF
Dryer	-	ST	2;8	no	yes	RMP
Drying and finishing machine operator	5.7	ST	2	no	no	E
Drying machine operator	-	ST	2;11	yes	no	D
Dye chemist	-	ST	2	yes	yes	D
Dye fixer	-	DT				D
Dye weigher	0.2	ST	2	no	no	D
Dyer	12	ST	2	no	yes	D
Embossing machine operator	-	NT	2		yes	SF
Fibre coupling tender	-	DT				C
Fibre drawer	-	DT				C
Fibre oiler	-	DT				C
Final inspector	1.3	SU		yes	no	F
Finisher	-	DNT				F
Flow dyeing machine operator	-	NT	2		yes	D
Fringing-machine operator	-	NT	2		yes	K
Fuller	5.1	ST	1;2	no	no	E
Furnace tender	1.7	SU		no	no	E
Garnetter	-	ST	2	no	no	RMP
Glazer	-	DT				C
Hand-Knotter	-	DT				WA
Ironer/Ironing press operator	0.3	ST	2	no	no	F
Jet dyeing machine operator	-	NT	2		yes	D

Jigger dyeing machine operator	-	NT	2		yes	D
KD machine operator	-	ST	2	no	yes	E
Knitted-cloth technician*	2.5	ST	13;14	yes	no	PRO
Knitting machine operator - over 10000 picks per hour	5	ST	2	no	yes	WE
Knitting machine operator - up to 10000 picks per hour	-	DT				WE
Knitting machine operator - up to 5000 picks per hour	-	DT				WE
Knotting machine tender	-	ST	2	no	yes	WA
Lining remover	-	SU		no	no	RMP
Machine cleaning and maintenance	0.1	SU		no	no	C
Master Dyer	-	NT	2		yes	D
Mender	2.5	SU		yes	yes	WE
Mercerizer machine operator	-	NT	2		yes	D
Napper operator	-	NT	2		yes	E
Napping machine tender	-	NT	2		yes	SF
Opener	-	ST	2	no	no	RMP
OV machine operator	-	SU		no	no	F
Picker tender	-	DT				PRE
Plaid and blanket machine operator	-	NT	2		yes	K
Potting machine operator	0.3	ST	2;8	no	no	E
Pre-ironing press operator	-	ST	2	no	no	F
Pressing machine operator	-	DT				D
Printer	-	NT	2		yes	SF
Quilting-machine operator	-	NT	2		yes	K
Rag grader	0.2	SU		yes	no	RMP
Rag washer	0.3	ST	2	no	yes	RMP
Reeling-machine operator	0.1	ST	2	no	no	WA
Ring spinning frame operator	0.5	ST	2	yes	no	S
Sample preparer	2.9	ST	13;14	yes	yes	WO
Sanforizing machine operator	-	NT	2		yes	E
Scouring-machine operator	0.1	ST	2	no	no	E
Selfacting spinning machine operator	0.4	ST	2	yes	yes	S
Selfacting spinning machine spool tender	-	DT				S
Sewing machine operator (joining pieces)	-	DNT				E
Sizer	-	ST	2	no	no	WA
Skein loader	-	DNT				D
Spinning-machine technician	6.5	ST	2	no	yes	S
Spool monitor	-	DT				C
Spool replacer	-	DT				WE
Steamer tender	1.9	ST	2	no	no	E
Straight knitting machine operator	0.7	ST	2	yes	yes	K
Teaseller	5.1	ST	2	no	yes	E
Tester of washed textiles	-	DT				PRE
Trimmer machine operator	2.7	ST	2	no	no	E
Turbang tumble dryer operator	-	NT	2		yes	E
Twister tender	2.9	ST	2	no	no	WA
Warehouse manager	-	ST	6;14	yes	yes	WO
Warper spool replacer	-	DT				WA
Warper tender	1.5	ST	2	yes	yes	WA
Washing machine operator	-	DT				PRE
Waxing machine operator	-	NT	2		yes	SF
Weaving machine heddle preparer (drawer in)	0.7	ST	2	yes	yes	WA
Weaving quality inspector	5.2	SU		no	no	WE
Weaving supervisor*	2.5	NT	2		yes	WE
Winder	1.4	ST	2	no	no	WA
Wringer machine operator	3	ST	2	no	no	E
Yarn quality technician*	2.6	ST	13	no	yes	S

Legend: (1) percentage of employees per occupation divided by total number of employees;
(2) SU = surviving occupations; NT = new occupations affected by technological change; NNT = new occupations not affected by technological change; DT = occupations that have disappeared because of technological change; DNT = occupations that have disappeared for reasons other than technological change; ST = surviving occupations affected by technological change;
(3) kind of technology used (see note 7);
(4) yes indicates that the tasks changed between 1980 and 2000;
(5) yes indicates the upgrading of skills (or the birth of new skills) between 1980 and 2000;
(6) phase of the textile cycle: RMP = raw material processing; PRE = preparation; C = carding; S = spinning; WA = warping; PRO = programming; WE = weaving; WO = wool; K = knitting; F = finishing; D = dyeing; E = ennobling; SF = special fabrics
Note: *for these occupations the number of employees has been collected as a group, without separate details for each one; in the table the number of employees for each occupation has been obtained dividing the total by three.