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RESEARCH ARTICLE

Deciphering long-term labor skill development in Italy, 1871–2011

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Abstract
While the effects of technological change on deskilling and upskilling of the contemporary labor force have been intensely debated among economists and sociologists, historians have been more or less silent. Here, we historicize this debate by applying a set of HISCO-based measures to a recently homogenized set of aggregated census data for men in Italy from 1871 to 2011, coded in HISCO, to study the effects of waves of technological changes. With the transition from agriculture, via industry to services, we identify the main subprocesses and study occupational diversity and specialization, class formation, and skill development. The first industrial revolution saw modest growth in lower-skilled work in Italy, and a decline in unskilled work; the second, growth in lower- and higher-skilled work, and a decline in medium and unskilled work; the third, growth in lower- and higher-skilled work.

Keywords: Technology; labour; censuses; HISCO; economic development

Introduction*

When machines replace workers, do they replace those with lower, middle, or higher skills? Does technological change lead to upskilling or deskilling, or both, that is, polarization? Underscoring the need for comparative research, we look at the historical record over a long period. We use a standard demographic source – the censuses in the form of the new Unified Italian Historical Census Dataset (UIHC). This dataset homogenizes census results. It connects Italian occupational designators to the Historical International Standard Classification of Occupations (HISCO), and thus to HISCO-based measures of economic sector and specialization, and to HISCLASS, a social class scheme that contains measures of skill. Thus,

* The present work was set up and discussed jointly. M.H.D. van Leeuwen wrote paragraphs 5.1, 5.2, 5.3, 5.4, 5.6, and 5.7; F. Maccelli wrote paragraphs 2, 3, 4, and 5.5. Paragraphs 1, 5.8, and 6 were written together.

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we derive a view of skill development over the long run. We limit ourselves to the male labor force for now, since occupations of women in census data have been less well, and less consistently, registered.[1]

This study contributes to the following streams of research. First, it demonstrates the uses of a simple methodological toolbox to derive measures of economic specialization and skills from census data with occupations coded in HISCO. Second, it advances the literature on the relationship between technological change and workers through a study of skill variations over 150 years. It historicizes the current skill debate by seeking out simple methods to analyze historical materials, faithfully explaining potential pitfalls and gray zones, and also pointing out fruitful areas for future research through four key questions. We begin by sketching the timing and magnitude of the structural transformations in the Italian case: How did the sectoral development of the economy take shape (empirical results in section "Sectoral developments")? Was there a discernible specialization of labor in the long run, and was it accompanied by an increased division of labor (sections "Economic specialization and increasing occupational diversity" and "Specialized occupations")? Then, we come to the core of this article: How did the skill distribution of the labor force develop over time (section "Using HISCLASS to display skill development")? Finally, what conclusions can we draw on the relationship between technology and skill change (section "Conclusion and Discussion")?

Before we can come to the core of the article, we introduce the debate around our questions in section "Long-term economic development", followed by a succinct sketch of the Italian economic development using the framework of industrial revolutions in section "Skill distribution during Italian economic development". In section "The Italian Census", we present the Italian census data, and we analyze the HISCO-based measures and procedures for our census data.

Long-term economic development

Classical economists and sociologists rooted their analyses in the study of changing occupational specialization. When Smith (1776) asked himself what caused the wealth of Great Britain, he proposed rising productivity due to the division of labor. He discussed the growth of repetitive and tedious jobs and their deskilling effects on workers. Saint-Simon (1821), Ricardo (1821), and Babbage (1835) suggested that specialization was convenient for employers, allowing better exploitation. Ure (1835) stressed the tendency toward deskilling, with continuous substitution by machines. Durkheim (1893) believed that a continuous division of labor increased

[1]An in-depth discussion of this phenomenon is beyond the scope of the present article (Horrell and Humphries 1995; Goldin 2021). We wish to avoid the problem highlighted by Humphries and Sarasùa (2012) – namely, that important aspects of female labor force participation as derived from census data are in part statistically manufactured by an uncritical reliance on this source. In the Italian case, the literature has focused both on the underregistration of women working in agriculture and on the excessive number of female textile workers in the censuses, for example, of liberal Italy (Zamagni 1987). A new estimation procedure is currently being produced using micro-data and alternative sources (Mancini 2018). We will therefore explore the skill variations of women in a separate article, allowing us to explain data and methodology (Emigh et al. 2016: 102).

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the skillset of workers. Classical economists were aware that the society they lived in had undergone a *sectoral change* (Clark 1940: 176; Fisher 1939; Fourastié 1949). The transition of the labor force from agriculture to manufacture and then to services was the most important feature of economic modernization theories in the 1960s (Chenery and Taylor 1968; Kuznets 1966; Rostow 1960), with flows of capital and labor from less to more productive sectors of the economy, which increases productivity, demand, investment, and per capita income.

The *relationship between technological change and labor skills* is a puzzle (Caselli 1999). Ricardo (1821) recognized machinery's displacing effect on human labor, but also believed that, in the long run, the introduction of machinery would be beneficial. Marx (1867), by contrast, argued that task subdivision was the prelude to mechanization and deskilling. The Marxian tradition strongly influenced historical research. Mantoux (1906) believed the first industrial revolution worsened material conditions of workers. Thompson (1963) and Braverman (1974) extended that analysis to cover the twentieth century, as did Rosenberg (1972), Bhaduri (1973), Marglin (1974), Roemer (1981), Hounshell (1985), and Noble (1995). Lazonick (1979) explained that many new machine-driven occupations required substantial new skills, as in the case of the mule spinner. Gordon et al. (1982), Nelson (1987), and Chin et al. (2006) found a mixed pattern: nineteenth-century technologies eliminated certain skilled jobs, but some new jobs required new skills. Gray (2013) shows that the electrification of the US manufacturing sector polarized workers' skills between 1880 and 1940.

In economic theory, the coevolution of new technology and skills was captured by the Skill Biased Technical Change approach (Goldin and Katz 1998, 2008; Griliches 1969; Nelson and Phelps 1966; Welch 1970), which states that technological change bolstered the value of education because firms needed more skilled employees. Bessen (2011) found that technical change was task-biased and automation increased weavers' skills during the first industrial revolution. Autor et al. (2003) developed a new framework (Routine Based Technological Change, RBTC). It suggests that technology impacted skills only for routine-based work, having no effect on the skills of those in non-routine occupations, at either end at the skill distribution (Acemoglu and Autor 2011; Acemoglu and Restrepo 2019; Autor 2019; Autor and Dorn 2013; Gray 2013; Weisdorf and de Pleijt 2017).

Haslberger (2021) demonstrated that routine-based technological change did not per se lead to polarization during the period 1995–2013. In OECD countries, technological change can be both routine-based and skill-based, and the result might differ per country. The discovery of such variation questions the notion of a general development over time and space and makes it all the more interesting to document historical variation.

This literature is related to the general questions posed in the introduction We investigate, for Italy, the dynamics of *sectoral economic change* (section "Sectoral developments"), capture the process of *specialization* indicated by Smith (sections "Economic specialization and increasing occupational diversity", "Specialized occupations", and "New occupations in industry"), and try to understand whether a division of labor had deleterious effects on workers. The connected *technological change-labor-skills nexus* is the most controversial puzzle (sections "Using HISCLASS to display skill development" and "Skilling or deskilling? Historical

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roots of workers' skills in Italy"). Here we look at takeaways from the literature, in particular, the following (which we will answer in section "Skilling or deskilling? Historical roots of workers' skills in Italy" and in the *conclusions*): (1) Was there a general rise in workers' skills (Bessen 2011; Goldin and Katz 1998, 2008)?; (2) Has there been polarization of skills, characterized by simultaneous growth of higher-skilled and lower-skilled occupations (Autor 2019; Gray 2013)?; and (3) Was there a general trend toward deskilling (Braverman 1974; Hobsbawm 1964)?

Italy thus serves as a laboratory for historicizing the debates on the effects of different stages of industrial revolutions.

Skill distribution during Italian economic development

We interpret changes in skill distribution in light of what we know about the development of technological change. Economic growth occurring can be identified by rising rates of change in labor productivity, and total factor productivity during the phases of the various industrial revolutions (see Table 1).

Labor productivity (LP) is often used to assess the effects of new technologies on labor and is defined as GDP per unit of labor input.[2] Figure 1 shows that in Italy it began to grow after unification in 1861, but "Giolitti's era"[3] marks Italy's industrial takeoff, at an annual rate of 1.5 percent (1891–1911). The period of major economic development between 1951 and 1973 saw impressive growth at 5.8 percent, spanning industry, agriculture, and services. During the third industrial revolution (1993–2010), labor productivity grew modestly by 1.0 percent.

Total factor productivity, defined as the proportion of output not explained by capital and labor input to production (Solow 1957), illustrates varying dynamics for Italy (Figure 1). The period 1891–1911 shows a lower rate of change (0.4 percent) than that during the Italian economic "Golden Age" from 1951 to 1973 (3.3 percent). The last period (1993–2010 and beyond), characterized by the introduction of ITC technologies shows a low rate of total factor productivity (0.3 percent) in Italy, as well as in many other advanced countries (Gordon 2016).

At the time of the country's unification in 1861, Italy's economy was characterized by a preponderance of agricultural employment. The mix of the first and second industrial revolutions (Giannetti 1998) during the late nineteenth century saw rapid but localized mechanization of the cotton industry and heavy machinery manufacturing. Steam-driven mechanization arrived rather slowly in Italy (Bardini 1997; Scagnetti 1923), and mechanization began to gather pace only at the beginning of the twentieth century, fueled by cheaply available hydroelectricity from the Alps. By 1911, the northwest of the country was at the core of the change, with three-quarters of all workers in the Italian textile sector working in Piedmont and Lombardy (Giannetti and Vasta 2005: 43). Mechanization in the sector stood at 1.51 horsepower per employee in cotton spinning, in stark contrast to the traditional silk sector where mechanization stood at 0.07 hp/worker (Federico 2006: 30).[4] At

[2]All labor productivity growth rates are annual.

[3]Prime Minister Giovanni Giolitti was the leading political figure of this period (see also Fenoaltea 2011).

[4]The cotton-production process represented the first and most important example of mechanization. In contrast, silk represented the traditional production process and was not subject to mechanization.

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Table 1. Economic development and industrial revolutions from a global perspective

Industrial revolutions	*Phase*	*Timing*	*Name*	*Lead countries*	*Driving innovations*
First	I	1750–1820	Industrial revolution	United Kingdom	Seam engine and mechanization of textiles
	II	1820–1870	Age of steam power and railways	United Kingdom; Continental Europe; USA	Steam power (iron and coke); iron and coal mines; railways
Second	I	1870–1950	Age of electricity, steel, and mechanical tools	USA and Germany	Electric power cheap steel; steam engine for ships; copper and cables
	II	1950–1970	Age of petroleum, cars, and mass production	USA and Europe	Assembly line; internal combustion engine; oil industry; plastic materials; household electrical equipment
Third	I	1970–2000	Age of Information and Communication (ICT)	USA, then Europe and Asia	ICT revolution; microelectronics; computer and software; digital telecommunications; biotechnology and new materials
	II	2001–present	Age of the Internet of Things (IoT)	Global	Internet of Things, machine-to-machine interactions; cloud computing; additive manufacturing; 3D printing; AI

Source: Based on Perez (2010) and Freeman and Louçã (2001).

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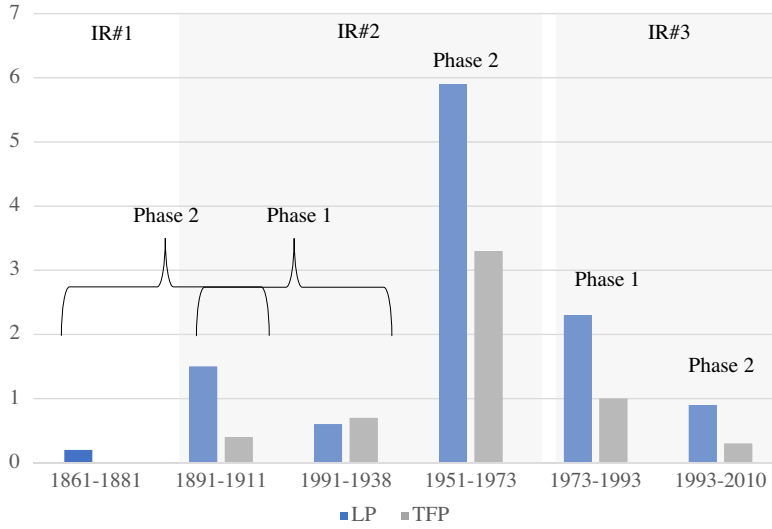


Figure 1. Industrial revolutions in Italy, 1861–2010: % change of labor productivity (LP) and total factor productivity (LFP).
Source: Broadberry et al. 2013.

that time, the percent of Italian per capital national product from manufacturing was already at 23.9 percent (1910), at par with other European countries in the past, as Belgium in 1850 (24 percent), ahead of Norway in 1890 (22.5 percent) and less than Germany in 1870 (29.7 percent) (Crafts 1984: 446). Waterpower also served other sectors, such as steel and chemicals (Du Boff 1967; Giannetti 1998). Thanks to this natural resource, Italian industrialization simultaneously showed characteristics of the first and second phases of the second industrial revolution. In 1899, Agnelli founded the FIAT automobile firm in Turin, and steel plants were built in Piombino, Elba, and Genoa. After World War II, the second phase of the second industrial revolution saw mass production fueled by the oil industry and the large-scale adoption of automobiles. The widespread application of the internal combustion engine not only in personal transport but also for tractors and airplanes redefined infrastructure – new networks of highways, ports, and airports – coupled with universal use of electricity and the extension of worldwide telecommunications (Giannetti 2021).

The ICT revolution was characterized by the automation of production: businesses became grouped around complex chains of production of components and subcomponents (Dosi 1988). This led to the increasing integration of Italian firms into international value chains and the openness of global markets in the 1990s and the early 2000s. This phase was marked by a strong concentration of leaders in the value chains in certain regions, and a fall in the average size of firms. After the early 1980s, Italy's traditional locally based system of production – industrial districts – became diffused and characterized by low capital and R&D–intensive sectors (Amatori et al. 2014; Becattini et al. 2009).

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Table 2. Italian population censuses, 1871–2011

Year	Date	Male workforce (thousands)	Current male population (thousands)	Resident male population (thousands)	No. of occupational categories
1871	31 December	9,236	13,472	14,316	352
1881	31 December	9,425	14,293	15,134	371
1901	10 February	11,017	16,155	16,990	297
1911	10 June	11,253	17,021	18,608	312
1921	1 December	13,456	19,089	18,814	190
1931	21 April	13,457	20,133	20,161	339
1936	21 April	11,956	21,123	20,826	364
1951	4 November	14,680	22,961	23,259	360
1961	15 October	15,098	24,186	24,784	295
1971	24 October	13,748	26,145	26,476	247
1981	25 October	13,585	27,326	27,506	247
1991	20 October	12,836	27,542	27,558	539
2001	21 October	13,454	27,617	27,587	539
2011	9 October	13,474	29,229	28,746	386

Source: MAIC–ISTAT, Italian Population Censuses, 1861–2011.

The Italian Census

Population censuses represent a crucial source for studying the long-term occupational structure of Italy (Fenoaltea 2015, 2016), and they have been used by many scholars, including Ciccarelli and Missiaia (2013), Broadberry et al. (2013), Giordano and Zollino (2015), Malanima et al. (2016), Giordano et al. (2017) and Felice et al. (2021).

Table 2 lists the censuses used to create the Unified Italian Historical Census Dataset (UIHC) between 1871 and 2011. Like other studies, we exclude the first Italian census held in 1861 due to its weak occupational data (see Giordano and Zollino 2015, 2021; Vitali 1968, 1970).[5] The censuses aimed to count the total population while distinguishing between employed and unemployed men and women. We focus here on working males above 10 years old in the population census; these were asked if they worked, and their occupations were registered by category, the number and nature of which varied between censuses. Italian censuses reported different minimum ages of employees: 9 years old in 1881, 9 years and 40 days in 1901, rising to 10 in 1911, and 14 in 1981.

[5]The issues Giordano and Zollino highlight concerning the proportion in industrial employment in southern Italy are likely to affect subsequent censuses too.

The questions about occupations covered what work they did and whether they were owners or managers, or craftsmen or workers. The Italian census classified those working in more than one job according to their main occupation as determined by the relative amount of time spent on it or by the relative income share. The censuses did not take account of multiple occupations, despite their prevalence in the rural context before World War II.

The Italian historiography based on census data highlights certain critical issues (Fenoaltea 2015, 2016; Fuà and Scuppa 1988; Vitali 1968, 1970; Zamagni 1987, 2016; Chilosi and Ciccarelli 2022). Censuses were held at different times of the year and thus influenced by the seasonal migration of unskilled and semiskilled workers that was common until the 1960s.[6] Another problem is that work done in the family home was dealt with inconsistently in the early censuses and eventually excluded. This has a significant effect on data concerning women's work (Mancini 2018).

Migration wave might have affected differently the working-age population. While we cannot directly address selective migration with our data, we can point to the following.[7] Between 1869 – the first year for which estimates are available – and 2005, about 28 million Italians migrated, mostly beyond Europe. The emigration rate increased from 5 percent in 1876 to nearly 25 percent in 1913 (Gomellini and Ó Gráda 2013: 5). World War I interrupted these flows, and they were also halted during the fascist period. After World War II, Italian emigration flows were mainly oriented toward Europe: the share of transatlantic emigration dropped to 10 percent of the total. Return emigration was also very high. The Golden Age (1951–1971) saw strong internal migration, notably from south to north (Gallo 2012). Some characteristics of emigration are clear for the first period (1875–1914) and between 1945 and 1975: men were more likely to leave than women; most were between 15 and 29 years old, followed by those aged 30 to 40. As stated by Gomellini and Ó Gráda (2013: 387), emigrants were mainly unskilled workers especially from southern Italy with a low degree of literacy (Sori 1979: 205; 2009). Betran and Pons (2004) argue that unskilled emigrants accounted for 80–90 percent of the total until 1914. In the whole period, the share of the category "*condizioni non professionali*" (not in the workforce) was negligible until the mid-1900s, rising to about 5 percent of the total on the eve of World War I (Federico et al. 2021: 17–18). Therefore, migration flows affected the employment structure between Unification and World War I by reducing the percent of unskilled workers.

Censuses use a small number of predefined occupational categories rather than a greater variety of self-reported job titles. We have developed a procedure to work around this as best we can. Censuses also hold certain advantages as they distinguish between rural and urban workers and between employers and employees in their positions as owners, clerks, artisans, and workers. That means we can distinguish between factory owners or managers and their workers, and identify small artisan business owners.

Changes to the institutions collecting the censuses led to differences not only in how data were collected but also in how they were processed. The Italian National Statistical Institute (ISTAT) was created only in 1926. Previous censuses were managed by the Ministero dell'Agricoltura, Industria e Commercio (MAIC), and other institutions such as the Ufficio centrale di statistica, Direzione generale di

[6]For example, the censuses of 1871, 1881, and 1901 were held in winter, the 1911 one in summer.

[7]We thank the referees for this valuable point, as well as for other valuable comments.

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statistica, or the Ufficio temporaneo di censimento. One of the most controversial censuses was that of 1921. Economic crisis and political instability – the "Red Biennium" – inspired workers to declare themselves simply "workers" without any specification of industry or particular function (ISTAT 1927), reducing the number of occupational titles listed in the original Italian professional scheme. Italian censuses did not use a dictionary of jobs, nor a detailed handbook of classifications.[8] Italian censuses ignored machinery and tools used by the workforce, unlike German censuses, which included statistics also on machinery and horsepower (Timmer et al. 2016; Veenstra and de Jong 2016).

HISCO-based measures and procedures

Coding into HISCO

The Historical International Standard Classification of Occupations (HISCO) is a comparative and historical occupational classification system (van Leeuwen et al. 2002). It is based on the 1968 version of the ISCO classification developed by the International Labour Organization (ILO). HISCO provides a systematic basis for comparing occupational data from different countries. It distinguishes 1,675 different occupational categories by means of a five-digit classification, of which the first digit refers to one of the seven "major groups," the next two digits refer to 76 "minor groups," and the last 3 to 298 "unit groups." The major groups are: Professional, technical, and related workers (group 0/1); Administrative and managerial workers (2); Clerical and related workers (3); Sales workers (4); Service workers (5); Agricultural, animal husbandry and forestry workers, fishermen and hunters (6); and Production and related workers, transport equipment operators and laborers (7/8/9). HISCO, for that matter, already includes in its structure the division into Agriculture (6), Industry (7,8,9), and Services.

Codes 7-xx.xx, for example, refer to the secondary sector of the economy, with codes 7-4x.xx identifying chemical processors and related workers. They are included in the code 7-45.xx for petroleum-refining workers. They are then broken down into various more specific occupational categories: petroleum-refining worker, specialization unknown (7-45.00), desulphurization treater (7-45.20), pumpman (7-45.30), controlman (7-45.50), blender (7-45.60), paraffin plant operator (7-45.70), and other (7-45.90). HISCO has auxiliary variables to code information often found in historical records that could not be accommodated in the ISCO framework, notably status, relation, and product.

From HISCO, it is easy to derive the HISCO-based social class scheme HISCLASS (van Leeuwen et al. 2011, 2016; van Leeuwen 2020). One of the defining criteria in HISCLASS is skill level, and coding all occupations in our dataset in HISCO thus allows us to study skill development over time. Other Italian scholars have used HISCO and HISCLASS to build and explore socioeconomic questions (Breschi et al. 2006, 2014; Federico et al. 2021; Fornasin and Marzona 2007).

[8]Nor did the censuses capture those carrying out illegal or stigmatized work – for example, beggars and thieves, although female sex workers were included until the 1936 census.

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For coding the original Italian census classifications into the HISCO classification, we first divided the censuses into two groups using a direct assignment method for the first group, from 1871 to 1936, to code every Italian occupational census group directly to a five-digit HISCO occupational title. For example, we connected the group of "*Fabbri (fabbri ferrai),*" which is included in all censuses, to the HISCO code 8-31.10, namely "Blacksmith, General," and the "*Giardinieri*" category from the 1911 census to the code 6-27.40 for "Gardener." Similarly, the "*Farmacisti*" profession, present in 1931, was tied to "Pharmacist" (0-67.10). More specifically, we used a control method divided into different phases. First, for each census, we assigned one HISCO code to each Italian job title. Second, we compared the similar linking HISCO codes for the original Italian titles across censuses. Third, we reversed the operation and checked the HISCO codes for occupation titles referred to by Italian titles. Fourth, we formalized the differences by selecting the appropriate HISCO code.[9] For the second group of censuses, from 1951 to 2011, we used an indirect assignment method. First, we standardized the occupational titles by mapping the 1951, 1961, 1981, 1991, 2001, and 2011 census data onto the 1971 occupational classification; then, we codified the 1971 jobs to the ISCO68 and HISCO.[10] An extended version is provided in Appendix I.

The procedure we opted for brought with it problems concerning vague occupational titles. On the one hand, the census classification of categories within economic sectors was very useful for allocating job titles correctly. For example, "laborers" is a vague occupational title, but we could place it, for example, in the textile sector if the laborers referred to were listed there in the census. However, in some cases, a census category was broader than a HISCO five-digit code. This was not problematic if the two alternatives were in the same economic sector, or if the two had the same skill level. If there were two different options, we consulted various sources, such as workers' manuals. We used the HISCO code we believed most likely to be correct, or, if two HISCO codes seemed equally likely, the one which applied to the greater number of persons. We then ran a sensitivity test for each doubtful case based on the alternative option. If the results of the main and alternative options were similar, it did not matter which one we chose; if they differed significantly, then at least we knew where, when, and to what degree, and that our results were sensitive to our particular allocation.[11]

We believe that HISCO and HISCLASS have certain strengths: they introduce order and uniformity, codifying occupations into different skill groups; the HISCO scheme was based on ISCO68, the most important standard classification for twentieth-century occupational data and the one most used by scholars across the

[9]We also use some other sources, such as dictionaries and workers' manuals (see, e.g., Belluomini 1885 and Pinchetti 1892), to be more precise in the codification.

[10]We use the conversion table (*tabelle di ragguaglio*) of the Italian censuses. These tables make the occupational classifications of a given census comparable with that of the previous one. We have chosen the 1971 census as the benchmark because it is close in time to the ISCO68 classification and, consequently, connection with HISCO. Also, we used the 1948 survey, *Rilevazione lessicale dei termini attribuiti all'esercizio di un'arte, mestiere o professione*, which collected 30,000 titles using various definitions and included their local and dialect names.

[11]Sensitivity test in included in Appendix II.

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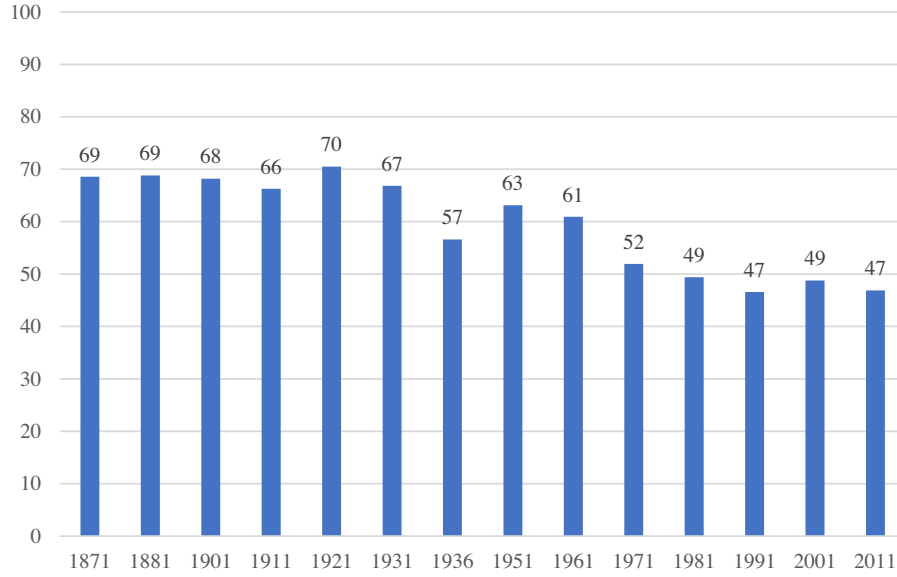


Figure 2. Male workforce as a percentage of the male population, Italy, 1871–2011 (%).
Source: Our calculations are based on the UIHC.

globe; HISCLASS allows a measure of skills.[12] In the following sections, we first present a macro survey of the labor force participation rates, and go on to discuss the sectoral development and, most importantly, the skill distribution of the male labor force.

Labor force participation

Figure 2 shows the male labor force participation rate over time.[13] Between 1871 and 2011, the size of the working population increased, though its proportion relative to the total working population decreased (Daniele and Malanima 2009). In 1871, 69 percent of males were in the workforce, a figure that declined notably after 1981 due to aging (Caltabiano and Rosina 2018: 26). It is also linked to the growth of education from the 1960s onward and the introduction of new technologies in the

[12]A very small number of HISCO codes were directly assigned to a skill level in HISCLASS (van Leeuwen and Maas 2011: Table 4.2, p. 50). This goes for *militari* (5-82.20), *conduttori di case di tolleranza e prostitute* (5.70-70), *accenditori di fanali e lumi, servizio delle valli, dei fiumi, canali e porti* (*custodi d'argini e navalestri*) (9.81-35), *facchini e imballatori* (9.71-45), *tirafili, guardafili, ecc.* (30.80-40), *giornalieri, braccianti e lavoranti senza speciale qualificazione* (6.21-05), *terraiuoli e marraiuoli* (6.21-05), *brentatori* (9-71.05), *acquaioli* (9-71.05), and *manovali edili* (9-51.20).

[13]We adjusted the census data series by eliminating men without occupation. These included *attendenti alle cure domestiche* (house husbands), *scolari* (students), *pensionati* (retirees), and *proprietari e benestanti* (rentiers), or *persone in cerca di prima occupazione* (those seeking first employment). For the period 1871–1931, the male labor force participation rate is calculated based on the total current male population; for the period since 1936, data are calculated based on the total resident male population, according to the ISTAT classifications. Male current and resident population include all males regardless of age.

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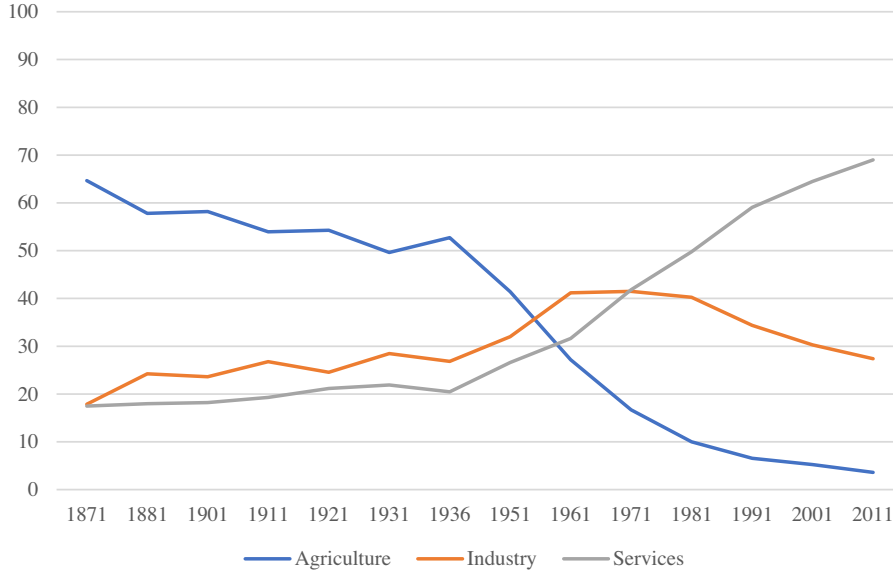


Figure 3. Distribution of the Italian male workforce by economic sector, 1871–2011 (%).
Source: Our calculations are based on the UIHC.

late 1970s and early 1980s. The lowest proportions of younger generations in the workforce appeared in the 1991 and 2011 censuses (47 percent, also as a product of joint effect of aging population) and a widespread retirement system, especially since the 1980s.

Sectoral developments

From HISCO's major groups it is easy to analyze the three macroeconomic sectors, and the results are displayed in Figure 3. We included agriculture-only occupations in HISCO major group 6 ("Agricultural, animal husbandry and forestry workers, fishermen and hunters"). "Industry" includes all production workers in HISCO major groups 7, 8, and 9. "Services" includes HISCO major groups 0/1, 2, 3, 4, and 5.[14]

One of our four questions relates to *how the sectoral development of the economy has affected the labor force*. Figure 3 confirms a clear structural shift in economic activity across the three sectors, a trajectory broadly in line with that of many other countries. In 1871, more than half the male labor force was employed in agriculture, 18 percent in industry, and 17 percent in the services sector. During the period 1901–1936 the impact of industrialization was limited, while the services sector expanded continuously. In the 1950s, agriculture still employed 41 percent of the total male labor force, industry 32 percent, and services 27 percent. In fact, Italy remained a predominantly agricultural country right up to World War II, and it was not until 1951

[14]Following ISCO68, HISCO places miners in the secondary production sectors (minor group 7-1 Miners, Quarrymen, Well Drillers and Related Workers).

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to 1971 that the proportion of workers employed in agriculture shrank sharply, in contrast to that for industry and services. From 1971 onward, the industrial workforce began to be supplanted as the ICT revolution took hold and services became the main employment sector. By the end of our period, the picture had been reversed: the services sector now accounting for 69 percent of the labor force, with 28 percent working in industry and barely 3 percent employed in agriculture.

Economic specialization and increasing occupational diversity

The division of labor is one of the salient features of the modern age, as discussed before. Over time, certain jobs once done by one person have developed into specialized tasks now requiring a multitude with potentially different skills. There are several ways we can try to answer the questions of *specialization of labor* and *increasing division of labor* (question two in our introduction), and we look at one way in the current section on the number of occupational categories in use. In section "Specialized occupations" we look at specialized versus general occupations, and in section "New occupations in industry" we look at new occupations in industry).

Using HISCO, with its fixed number of categories, *we can identify economic specialization by examining the number of categories in use at any given time*. The basic five-digit codes in HISCO have, in fact, been developed so that all known historical occupations can be accommodated, both new and old. The increase in occupational diversity is reflected in the number of codes in use. However, we should exercise caution if the number of possible categories changes, and in the Italian case there are indeed important variations in the number of census categories over the years. For a fair comparison, we thus selected two groups of censuses, each with approximately the same number of occupational categories. The first includes the censuses of 1881, 1936, and 2011 with approximately 370 categories, while the second includes those of 1901, 1911, and 1961 with approximately 300. Table 3 lists the HISCO categories in use for them, both in absolute numbers and as fractions of the total male labor force in our dataset. We observe increasing occupational diversity between 1911 and 1961, as well as between 1881 and 2011. We interpret this as indirect evidence of occupational specialization, and we go on to discuss this in section "Specialized occupations".

Specialized occupations

There is also another way to study *occupational specialization*. HISCO is set up so that the more general, or less specialized, tasks are commonly mentioned before the more specialized ones. For example, the group of Blacksmiths, Toolmakers or Machine-Tool Operators 8-3 incorporates seven specialized subgroups, including 8-31 "Blacksmiths, Hammersmiths and Forging-Press Operators," and a general group for occupational titles that belong in one of the seven subgroups but with uncertainty over which subgroup. The general group is number 8-30 and is called "Blacksmiths, Toolmakers and Machine-Tool Operators, Specialization Unknown," with the five-digit code 8-30.00 for "Blacksmith, Toolmaker or Machine-Tool Operator." In addition, each of the seven subgroups includes a category for occupational titles that belong somewhere in the relevant subgroup, but we do not know quite where. For example, the

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Table 3. Number of occupational categories for men in the census, and the number of HISCO five-digit codes they cover, Italy, 1881–2011

Year	No. of census categories	No. of HISCO categories	Ratio
1901	297	192	0.6
1911	312	182	0.6
1961	295	240	0.8
1881	371	216	0.6
1936	364	272	0.7
2011	386	301	0.8

Source: Our calculations are based on the UIHC.

aforementioned subgroup 8-31 has a number of well-defined occupations such as 8-31.20, "Hammersmith," or 8-31.40 – namely, "Forging-Press Operator," with a general code ending in –.10 (8-31.10), which is titled "Blacksmith, General."[15]

Following the above procedure, we look at the more specialized codes that correspond to Italy's industrial revolutions. In the first industrial revolution, distinguishing between different fibers in the textile sector and varying production techniques reveals an increase in mechanization. For example, in the 1871 census we see only a few, general, codes such as Weaver (7-54.00) and Spinner (7-52.20), with a few occupational categories capturing a degree of specialization, such as "Fiber Comber" (7-51.45), "Fiber Carder" (7-51.35), and jobs done by hand such as "Loom Threader" (7-54.20) or, again, "Fiber Carder" (7-51.35). The 1901 and 1911 censuses contain a high degree of differentiation among fibers, referring to silk, cotton, wool, linen, hemp, jute, and artificial fibers. The appearance of Machine Loom Threaders (7-54.25) indicates more specialized labor. Chemical and metal production was revolutionized, too. In 1911, for example, we see more specialized jobs appearing such as "Miller-Grinder" (7-41.30), "Mixing- and Blending Machine Operators" (7-41.40), and "Gas Compressor Operator" (9-69.25). After World War II jobs such as "Miller-Grinder" (7-41.30), "Synthetic Fiber-Maker" (7-49.25), "Tire Maker or Vulcanizer" (9-02.00), "Petroleum-Refining Workers" (7-45.00), and "Plastic Injection Molding Machine Operator" (9-01.50) appeared. An important new figure was the "Power-Generating Machinery Operator" (9-61.00), who appeared early in the twentieth century, later specializing between the world wars as "Steam Power Plant Operator" (9-61.20), "Water Treatment Plant Operator" (9-69.50), "Refrigeration System Operator" (9-69.70), and "Pumping-Station Operator" (9-69.40). In the metal processes sector, jobs such as "Electroplater" (7-28.30),

[15]Non-specialized HISCO codes are those ending in 00, 05, or 10, with the following exceptions: 0-62.10, 0-66.10, 0-72.10, 0-73.10, 0-74.10, 0-77.10, 0-83.10, 1-21.10, 1-22.10,1-23.10, 1-24.10, 1-29.10, 2-01.10, 2-02.10, 2-22.10, 4-32.00, 5-83.00, 6-41.00, 6-22.10, 6-24.00, 6-24.10, 6-25.10, 6-26.10, 7-57.10. Furthermore, the following HISCO codes not ending on 00, 05, or 10 are general: 1-30.20, 1-30.30, 4-10.25, 4-51.25, 5-10.20, 6-11.15, 6-21.20, 8-12.08, 9-37.15 (van Leeuwen and Maas 2011). In addition, there are also four very general occupational categories for production work – namely 9-99.00 "Worker, no further information", 9-99.10 "Laborer", 9-99.20 "Day-Laborer", and 9-99.30 "Factory Worker", that are counted as non-specialized.

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Table 4. Number of occupational categories for men in the census, and the number of non-specialized and specialized occupations in HISCO five-digit codes they cover, Italy, 1881–2011

Year	No. of census categories	Of which general	Of which specialized	Ratio
1901	297	120	177	1.48
1911	312	137	175	1.28
1961	295	130	165	1.27
1881	371	107	264	2.47
1936	364	134	230	1.72
2011	386	163	223	1.37

Source: Our calculations are based on the UIHC.

Table 5. Number of male workers in the census, and the number of non-specialized and specialized male workers (in HISCO five-digit codes) they cover, Italy, 1881–2011

Year	Total no. of male workers	Of which general	Of which specialized	Ratio
1901	11,017,002	8,590,294	2,426,708	0.28
1911	11,253,433	9,199,469	2,053,964	0.22
1961	15,098,314	11,374,025	3,724,289	0.33
1881	9,424,688	7,104,527	2,320,161	0.33
1936	12,141,304	9,686,912	2,454,392	0.25
2011	13,474,165	6,667,779	6,806,386	1.02

Source: Our calculations are based on the UIHC.

"Hardener" (7-26.30), and "Metalworking Machine Setter" (8-33.05) appeared, marking the post-World War II modernization phase.

The appearance of the general category "Machinery Fitter and Assembler" (8-41.00, 8-41.10) and ones for "Aircraft" (8-41.20), "Turbine" (8-41.30), and "Industrial" or "Agriculture" (8-41.55) reflect the specialization that occurred during the second industrial revolution.

The third industrial revolution can be linked to the creation of new specialized occupations. In the 1991 census we see highly specialized workers such as "Mechanical Engineering Technician" (0-35.10), "Metallurgical Technician" (0-37.00), "Civil Engineering Technician" (0-33.10), "Optometrist" (0-75.20), and "Systems Analyst" (0-83.10), and we observe also new low-skilled jobs such as "Electronic Computer Operator" (3-42.20), "Personnel Clerk" (3-93.30), "Correspondence Clerk" (3-93.20), "Coding Clerk" (3-99.30), "Business Service Salesmen" (4-42.20), "Estate Agent" (4-41.30), and "Hotel Receptionist" (3-94.20).

Table 4 displays the number of specialized and non-specialized (general) occupational categories for male workers in Italy. They indicate an overall decrease in the ratio of specialized to general occupational categories in the census. It is

difficult to distill finer change over time from the table, and in any case, it relates to the number of categories and not to the labor force they cover.

If we move away from the number of categories in use in the census and consider the number of men they cover (Table 5), we observe an overall relative increase in the number of men in specialized occupational groups over time. More detailed changes over time are difficult to decipher, save a modest decline from 1881 to early in the twentieth century, and a large increase in more recent decades.

New occupations in industry

Industrialization is reflected in the labor force in two ways. The first relates to the emergence of new types of work, such as that performed by telegraphers, machinery mechanics, or crane operators. The second is reflected not by entirely new occupational activities and titles but by, usually, a gradual introduction of mechanical contrivances into existing activities, for which the diversification of existing occupational codes is an example. Weaving, for instance, can be done either by hand or machine, and HISCO has different codes for a variety of weaving activities. The codes range from industrial ones such as Beam Warper, Loom Threader (Machine), Cloth Weaver (Machine, except Jacquard Loom), Lace Weaver (Machine), Carpet Weaver (Machine), and Net Maker (Machine), to manual ones, or to weavers and others about whose use or otherwise of machines we have no data. The first type can be defined as industrial, and the second and third types as non-industrial.

Van Leeuwen and Maas (2011) developed a procedure to identify industrial occupations based on HISCO.[16] They selected those occupational titles for which the HISCO description of the tasks and duties involved clearly indicated the use of mechanical power. This procedure results in a lower bound of the extent of industrial occupation, as some job titles of industrial work will have been non-specific. The procedure we followed is thus able to document the rise of mass production as captured by the rise of new specialized industrial, occupations.

Table 6 thus documents the minimum number of titles of occupations held by men working in industry as a percentage of all HISCO titles. As before, we selected censuses with approximately the same number of categories, which showed a huge increase in the percentage of codes indicating industrialized occupations. An initial growth in industrial occupations, and therefore an increase in them toward

[16]Industrial HISCO codes are: 0-12.20, 0-12.40, 0-12.50, 0-12.60, 0-12.70, 0-12.80, 0-22.30, 0-22.35, 0-22.40, 0-22.50, 0-27.20, 0-27.30, 0-27.40, 0-31.20, 0-31.30, 0-38.20, 0-84.20, 1-31.80, 1-59.35, 1-62.40, 1-74.39, 1-79.20, 3-21.40, 3-21.50, 3-22.20, 3-22.90, 3-31.70, 3-99.50, 5-60.20, 5-60.30, 5-60.60, 5-91.20, 5-99.70, 6-23.50, 6-25.20, 7-11.20, 7-11.25, 7-11.30, 7-11.40, 7-12.30, 7-12.40, 7-13.20, 7-13.30, 7-13.40, 7-13.50, 7-13.60, 7-13.70, 7-13.80, 7-13.90, 7-32.20, 7-32.30, 7-32.40, 7-32.50, 7-32.60, 7-33.20, 7-33.30, 7-33.40, 7-51.25, 7-51.30, 7-51.40, 7-51.45, 7-51.50, 7-51.55, 7-52.30, 7-52.40, 7-52.50, 7-53.30, 7-53.50, 7-53.90, 7-54.15, 7-54.25, 7-54.40, 7-54.50, 7-54.60, 7-54.65, 7-55.20, 7-55.30, 7-55.40, 7-59.25, 7-59.35, 7-59.45, 7-61.35, 7-72.30, 7-72.60, 7-74.30, 7-74.40, 7-75.20, 7-79.30, 7-82.30, 7-83.20, 7-95.50, 7-95.70, 7-96.30, 8-02.20, 8-03.50, 8-12.05, 8-12.08, 8-12.10, 8-12.20, 8-12.40, 8-12.50, 8-12.60, 8-12.70, 8-12.80, 8-12.90, 8-20.50, 8-31.30, 8-31.40, 8-35.20, 8-35.30, 8-39.70, 8-39.80, 8-74.65, 8-74.70, 8-91.28, 8-91.36, 8-91.40, 8-91.68, 8-91.72, 8-99.70, 9-10.30, 9-10.40, 9-10.50, 9-10.60, 9-10.70, 9-10.80, 9-21.30, 9-21.35, 9-21.40, 9-23.20, 9-23.30, 9-24.40, 9-26.30, 9-26.50, 9-39.60, 9-43.30, 9-49.70, 9-53.40, 9-57.60, 9-59.60, 9-71.30, 9-71.35, 9-71.55, 9-71.60, 9-71.70, 9-74.20, 9-74.25, 9-74.30, 9-74.40, 9-74.45, 9-74.50, 9-74.55, 9-74.60, 9-74.70, 9-74.75, 9-74.90, 9-99.30.

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Table 6. Number of occupational categories in the census, and the number of total and industrial occupational five-digit codes, Italy, 1881–2011

Year	No. of census categories	No. of HISCO codes	Of which industrial (%)
1901	297	192	0.52
1911	312	182	1.10
1961	295	240	6.25
1881	371	216	2.78
1936	364	272	4.04
2011	386	301	5.98

Source: Our calculations are based on the UIHC.

specialization, can be seen with the industrial takeoff of the early twentieth century: occupational codes for industrial workers rose from 0.52 percent (1901) of the total to 1.10 percent (1911). The table indicates a clear peak during the economic "Golden Age" (1951–1971). The Marshall Plan was used in Italy to introduce mass-production technologies from the US (Fauri 2010) and led to a major shift in labor from agriculture to industry. The heavy and more advanced industries, like metal-making, engineering, and chemicals, were the best-performing industrial sectors, supported by the role of state-owned enterprises (Colli and Vasta 2010). This shift resulted in more people being employed in industry, where in the 1961 census 6.25 percent of HISCO employment codes were industrial. These workers were concentrated in heavy industries, such as chemicals, rubber, and automobiles. This growth process stops in the closing period: in the 2011 census, the number of industrial categories out of the total HISCO drops slightly (5.98 percent). In this period, the greatest specialization of industrial workers is concentrated in small and medium-sized enterprises in the light sectors, and also those in food products and metallurgy (Amatori et al. 2014; Federico 2006).

Using HISCLASS to display skill development

To show *skill development* we use the Historical International Social Class Scheme (HISCLASS). To generate HISCLASS, each of the 1,675 categories in HISCO was matched to one of the 10,000 categories found in the Dictionary of Occupational Titles (DOT). The numeric information (e.g., on skill level) in DOT was used to score each HISCO category on each of the HISCLASS dimensions.[17] HISCLASS includes 12

[17]Rural and urban workers end up in different social classes. As censuses generally distinguish between the two types of worker, no further action was needed for our Italian dataset.

If the census records contained information on hierarchical distinctions within one HISCO code, such as relating to masters and journeymen, we generally gave it the same HISCO code but coded it differently with an auxiliary variable called "Status" in HISCO. Using status, some occupational titles are used to correctly place them in the appropriate social class within HISCLASS (see van Leeuwen and Maas 2011: 180). In the Italian case this refinement applied mostly to occupations from 1871 to 1931. For example, in the 1871 census we see different types of agricultural worker with the same HISCO code, but a different status code:

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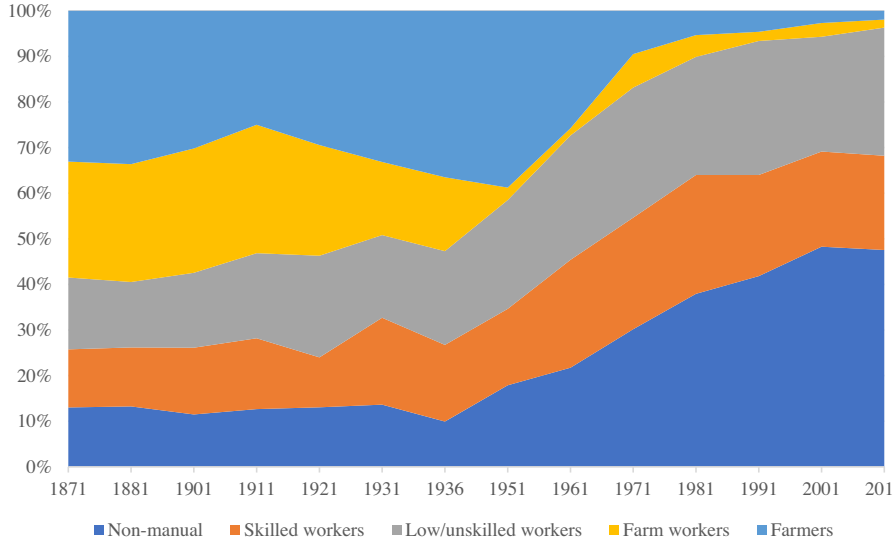


Figure 4. Distribution of male workers according to skill level and economic sector, Italy, 1871–2011.
Source: Our calculations are based on the UIHC.

social class categories.[18] These social classes can be grouped into the four main categories of skill: the first – higher skilled – includes 1 and 2; the second – medium skilled – includes 3, 4, 6, 7, and 8; the third – lower skilled – includes 5, 9, and 10; the fourth – unskilled – includes 11 and 12. The unskilled level corresponds to individuals with primary education and whose work involves low levels of preparation – that is, "short demonstration only or anything beyond a short demonstration up to and including 30 days" (van Leeuwen and Maas 2011: 51). Low-skilled workers have the more extensive reading and numeracy skills attained by those who have completed both primary education and some systematic occupational training lasting more than thirty days and up to one year. Medium-skilled labor requires secondary education or extensive occupational training of between one and ten years. Highly skilled workers are the best educated and trained and are seen as able to apply "principles of logical or scientific thinking," in general having undergone tertiary general or vocational education. Their specific vocational preparation lasts more than 10 years.[19]

"*Agricoltori Affittuaiuoli, Pigionanti e Logaiuoli*" (12. Lease-holder) as well as "*Proprietari e Possidenti*" (11. Owner, proprietor) and "*Capitalisti e benestanti*" (11. Owner, proprietor).

[18](1) higher managers, (2) higher professionals, (3) lower managers, (4) lower professionals, and clerical and sales personnel, (5) lower clerical and sales personnel, (6) foreman, (7) medium-skilled workers, (8) farmers and fisherman, (9) lower-skilled workers, (10) lower-skilled farm workers, (11) unskilled workers, and (12) unskilled farm workers.

[19]Having a clear definition and operationalization provides clarity, but it also raises issues of applicability in the early years of the study when few individuals had attended secondary education and quite a few may have had no formal schooling at all. On-the-job training or apprenticeship might have functioned as a substitute for formal education. The degree to which this happened should be further researched. If the skill content of the same occupational title changed much over time, that might produce a negative bias in the detected trend in upskilling over time. It is also true, however, that the introduction of new machinery in an

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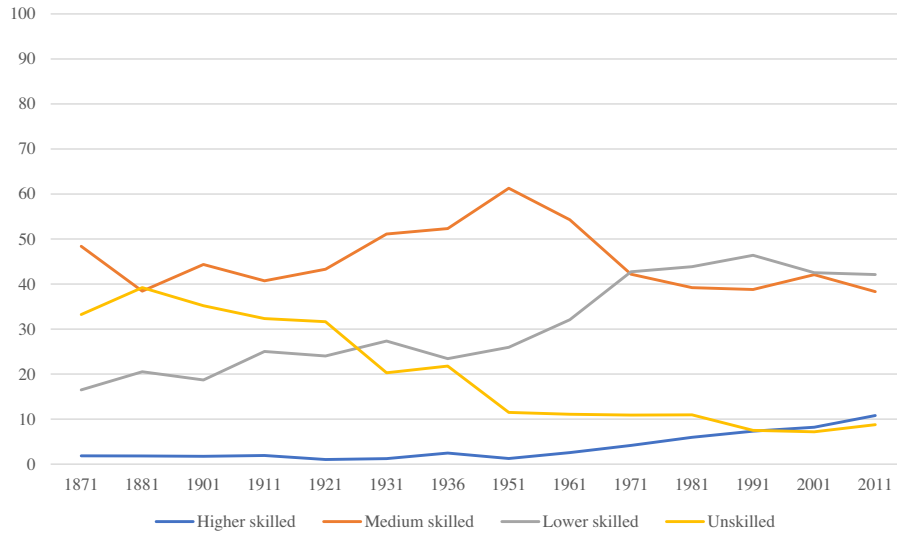


Figure 5. Italian male labor force according to four skill levels, 1871–2011 (%).
Source: Our calculations are based on the UIHC.

Following van Leeuwen et al. (2016), we amalgamated the 12 HISCLASS categories into 5 classes: non-manual workers (HISCLASS 1 to 5),[20] skilled workers (6 and 7), low and unskilled workers (9 and 11), and farmworkers (10 and 12). Figure 4 shows clearly the decline of the rural classes of farmers and farmworkers compared to skilled workers and non-manual workers. We have thus been able to confirm the changes in sectoral employment and skill level by examining the social class structure over time.

Skilling or deskilling? Historical roots of workers' skills in Italy

The review of the literature, sources, and HISCO-based routines, alongside fundamental insights into shifts between economic sectors, has enabled us to test three main hypotheses. First, was there a general rise in workers' skills, expressed by the rise of more specialized and more sophisticated jobs (Bessen 2011; Goldin and Katz 1998, 2008)?[21] Second, has there been polarization of skills, characterized by simultaneous growth of higher-skilled and lower-skilled occupations (Gray 2013; Autor 2019)? Third, was there a general trend toward deskilling (Braverman 1974; Hobsbawm 1964)?

occupation could be reflected in the occupational title, leading to a new category with a higher skill level in the DOT. We thank one of the anonymous referees for raising this point.

[20]Following the HISCLASS, we can define non-manual "as all work that does not involve any significant relationship with Things or that is classified by the DOT characteristics Physical Demands as 'sedentary occupation'. [...] Non-manual aptitudes are verbal, numerical, spatial, and clerical perception" (Van Leeuwen and Maas 2011: 48).

[21]We can see this process in the decline of general HISCO codes (.00, .05, and .10), as observed in Table 5.

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To test the above hypotheses on changes in the skill distribution of the labor force, we begin by plotting the skill levels underlying HISCLASS (Figure 5). In broad strokes, we observe that the period 1881–1951 as a whole witnessed a growth in medium-skilled work and a large decline in unskilled work (also compensated by the growth in lower-skilled work). Overall, there was no clear polarization into higher-skilled work. The period 1951–1971 did witness the expansion in both lower- and higher-skilled work. Afterward, at least until 2011, when our data end, we see a growth in higher-skilled work.

Now we will look more in detail at skill developments, placing our results in the wider literature. During the first phase of the second industrial revolution (1893–1914), steam power was introduced in certain sectors in the North. This can be proxied using the 1911 industrial census measurement "horsepower" per worker. The figure in Appendix III shows a high value for paper and paper products, and for manufacture of basic metals and chemicals. On the eve of World War I, labor-intensive industries (for food and tobacco, textiles, clothing and leather, wood and furniture, and paper) absorbed more than three-quarters of manufacturing employees. Among the capital-intensive sectors, glass manufacturing, steelmaking, and transportation had grown. However, despite these achievements, many aspects of backwardness persisted within Italian industry: according to some estimates, in 1911 the total value of steel production was almost equal to that of processed silk (Amatori et al. 2014: 637–638).

This first phase of the second industrial revolution (1893–1914) can be only imperfectly observed due to the absence of a census for 1891. As far as we can tell from Figure 5, there does not appear to have been a major upskilling, with neither higher- nor medium-skilled work growing much, while lower-skilled work increased and unskilled work decreased. That suggests difficulties in extending mechanization to sectors other than those relating to textiles, metal-working, and chemicals in the last two decades of the nineteenth century and the first few decades of the twentieth century (Giannetti 1998). We observe the persistence of traditional medium-skilled work done by artisans in traditional sectors.

The outbreak of World War I coincided with the end of the first wave of globalization. During this period, protectionist and autarkic measures produced contrary effects. The domestic market for capital-intensive and scale-intensive industries was stagnant. No real enlargement of industrial mass production was feasible: firms adapted their market strategies to existing demand, sapping the changing dynamics of workers' skills.[22] Medium-skilled jobs were also concentrated in agriculture, in traditional craft jobs, and among those offering personal services such as hairdressers and barbers (Felice 2019; Romei 2002). The period 1914–1951 shows a relatively flat trend for higher-skilled workers, a continuous decline in unskilled work but with an uptick in lower-skilled work toward the end of that period, and a notable increase in the share of medium-skilled work.

The "Golden Age" period (1951–1971) came during the second phase of the second industrial revolution. The Italian economy experienced extremely high GDP and manufacturing output growth rates on the back of modernization in industries.

[22]According to some authors, especially Salvati (1992), although the Italian fascist regime increased the number of service clerks, they were traditional clerks or public administrators who functioned differently from those in the American case described by Goldin and Katz (2008).

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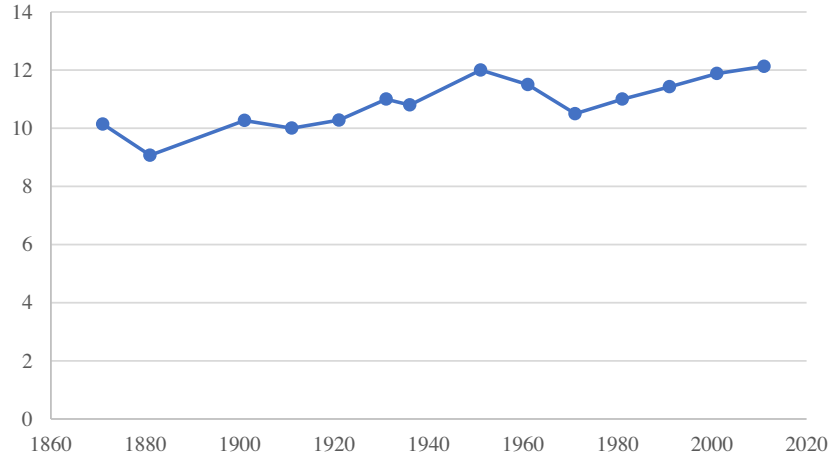


Figure 6. Average skill level (in years) of the Italian male labor force 1871–2011. *Note*: See Footnote 23 for details.
Source: our calculations using the IUHC and the DOT (1971) conversion table.

Workers operating the new machines were required to work more quickly with equipment that as far as possible was made "fool-proof." A large percentage of workers moved into capital- and scale-intensive industries, mainly automotive, chemical, rubber, heavy engineering, steel, and shipbuilding. The share of manufacturing workers in the total increased from less than 40 percent in the fascist period to about 60 percent in 1971 (Amatori et al. 2014: 639–640).

The proportion of lower-skilled workers increased rapidly, while that of the medium skilled sharply declined. Mass production provoked a large-scale collapse in the number of unskilled and medium-skilled workers, mainly in agriculture, with a simultaneous increase in the number of lower-skilled workers, mainly in the industrial sector where there was also a modest increase in the number of higher-skilled workers. It is likely that this increase was the result of the expansion of big business and of initial increases in the number of lower-level clerks in industry. The growing size of large industrial plants necessitated a greater number of lower-skilled workers with standardized skills as well as more office and administration personnel. The period 1951–1971 witnessed both lower- and higher-skilled work growing.

After 1971, at least three processes were in motion. The first was the decrease in the proportion of lower-skilled workers in manufacturing, as a result of the decline of the large-scale business plants concentrated in specific sectors, such as steelmaking and the automotive industry (Amatori et al. 2014). The second was an impressive growth in the number of highly trained workers and the standardization of less specialized jobs in the services sector, such as those of office clerks, cashiers, or call center operators. The third process is the rise of service occupations, which led to a decrease in the diversification of job titles; the reduction in census categories for office clerks can be viewed as a consequence of the standardization of skills.

The introduction of ICT during this first phase of the third industrial revolution saw a peak in the proportion of lower-skilled workers in 1991 and a decrease in that of the medium skilled after 2001, while the proportion of unskilled workers remained stable.

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The number of higher-skilled jobs increased in line with the more complex organization required by new production technologies and the corresponding increase in new clerical jobs in services. The ICT revolution might have contributed to this form of skill polarization, although its clarity is obscured by the limited timeframe of the data. The fastest growing number of jobs were not only for technically qualified personnel but also for clerical and sales workers and clerks in social and medical jobs. Figure 5 suggests a complex picture of the effects of waves of technological change on the distribution of the male labor force over different skill levels.

Now, we direct our attention to the effect on the *average* skill level, see Figure 6.[23] While we think this is a promising research direction, some limitations at present should be noted. First, we are tied to the census years. Second, we are tied to the 1971 equivalence table of the DOT, both with regard to its accuracy in that year, and in keeping the equivalence constant over time.[24] Figure 6 indicates that the average skill level of the Italian labor force has increased over the whole time period. This was especially so between the census of 1921–1951 and 1971–2011. There were, however, also brief periods of stability, and even temporary decline (between the census of 1871–1881, 1931–1936, and 1951–1971). In the next section of this article, we will place these pieces of the puzzle next to others and sketch the most likely evolution of the economic transformations in general and the skill development in particular in Italy.

Conclusion and discussion

Italy is an interesting case for investigating the effects of technological change on workers' skills. It represents a late-comer country that experienced different phases of such change during the period under study, transitioning from geographically limited growth during the first decade of the 1900s to considerable and wide-ranging economic development during the "Golden Age" (1951–1971), and subsequently to a contradictory phase characterized by ICT. There were also practical reasons for us to study Italy. The development of the Italian economy has been reflected for over 150 years through census data. We harmonized Italian census data from 1871 to 2011 to create a new dataset (the Unified Italian Historical Census Dataset or UIHC), coding into HISCO more than 4,800 occupational titles recorded in the censuses. We then used the HISCO family of measures to historicize the relationship between the industrial revolutions and the evolution of labor skills.

[23]For this we use the skill scores for each 6-digit HISCO code derived from the DOT when creating HISCLASS. To do this we need to make several assumptions that make this exercise experimental, and we offer the results of this experiment as a starting point for further research. The US Department of Labor (1971) offered a conversion table for the two elements of skill – GED and SVP – to time in years. For SVP, we took the middle of the year range, with the highest, open-ended category set at 10 years. For GED the conversion is as follows: GED 1 = grade 1-3, equals 2 years of education; GED 2 = grade 4-6, equals 5 yrs; GED 3 = grades 7-8, equals 7,5 yrs; GED 4 = grades 9-12, equals 10,5 yrs; GED 5 = college 1-2, equals 13,5 yrs; GED 6 = college 3-4, equals 15, 5 yrs.

[24]The latter may not be realistic in some cases as occupations evolved. This may be a problem if we try to go beyond the four broad skill groups of HISCLASS, even if it is true that new occupations (generally with higher skill levels) are given new HISCO codes (with a higher skill level). Tackling this issue is beyond the scope of this article as it would involve looking at various incarnations of the DOT over time.

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Table 7. Summary of changes in male labor force during the three industrial revolutions, Italy, 1871–2011

	First IR (1871–1911)	Second IR (1911–1971)	Third IR (1971–)	Overall
Male LFP	65% (1901)	61% (1961)	48% (1991)	Decrease influenced by aging population
Main sector	Primary	Secondary	Tertiary	Primary to Tertiary
Major economic specialization	Textile	Chemical, Mechanical	Services	Industry to Service
Occupational. diversity: no. of HISCO codes (year of census)	216 (1881)	269 (1951)	301 (2011)	Increase
Ratio specialized/ general occupations	0.33 (1881)	0.25 (1951)	1.02 (2011)	Increase
Growth of industrial occupations	Yes	Yes	No	IR 1 and 2
Growth of service occupations	No	No	Yes	IR 3
Main social group	Farmers and farmworkers	Lower/unskilled	Non-manual	From workers in Agriculture to those in Services
Skill development	Growth of medium- (save 1st decade) and lower-skilled and decline of unskilled work	Growth of lower skilled, and decline of unskilled work; also, of higher-skilled work growth	Growth of higher-skilled work	With glissando's overall rise of skill level, complex evolution of skill distribution, with a general decrease of medium skilled and rise of lower and higher skilled

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By way of conclusion, Table 7 collates the partial empirical answers discussed earlier to answer the four main questions: (1) How did the sectoral development of the economy take shape? (2) Was there a discernible specialization of labor in the long run, and was it accompanied by an increased division of labor? (3) How did the skill distribution of the labor force develop over time? (4) What conclusions can we draw on the relationship between technology and skill change?

In terms of *sectoral development* (section "Sectoral developments"), looking at the data on the number of male workers reveals that the main sector of the economy in Italy at Unification was the primary one, and it declined over the entire period. Figure 3 shows that the growth in the secondary sector began after 1910 and continued to grow until the services sector took off during the second part of the second industrial revolution in Italy, after World War II. The increase in the number of industrial occupations over the entire second industrial revolution in Italy, as well as the growth in service occupations in the third, supports this observation. This process is in line with the theories and empirical observations produced in the 1960s (Chenery and Taylor 1968; Kuznets 1966; Rostow 1960).

The data also show the occupational diversity characteristic of an overall process of *division of labor* and *economic specialization*, as suggested by classical economists (Smith 1776; Ricardo 1821) and confirmed by the growing number of HISCO codes for male workers (section "Economic specialization and increasing occupational diversity", Tables 3 and 4) and by the increase in the ratio of specialized to general occupations among male workers (section "Specialized occupations", Table 5), also in the industrial sector (section "New occupations in industry", Table 6) and also in line with other studies (Gordon et al. 1982; Nelson 1987; Chin et al. 2006).

As to the *evolution of the distribution of skills* (section "Using HISCLASS to display skill development") from a historical perspective, Italy experienced an overall increase in the number both of lower- and higher-skilled male workers. By contrast, the proportion of unskilled workers fell, and that of medium-skilled workers first increased before declining (Figure 5). With some fluctuation, the overall average skill level of male workers increased over time (Figure 6).

On the *relationship between technology and skill changes* (section "Skilling or deskilling? Historical roots of workers' skills in Italy") we see in general terms, that the introduction of new technology in Italy led to medium-skilled workers being substituted first by lower-skilled workers and then also by higher-skilled workers (Figure 5). We thus observe, in the long run, a process of polarization already highlighted by Gray (2013) and Autor (2019). Additionally, we interpret the changes in different phases of the various industrial revolutions (Table 1 and Figure 1) to capture the various effects of different technological changes in Italy (Figure 5). Unlike the situation in other countries (Bessen 2011; de Pleijt et al. 2020; Weisdorf and de Pleijt 2017), we observe a moderate process of deskilling during the second part of the first industrial revolution in Italy (1881–1911). This was due to difficulties in extending mechanization and the persistence of traditional medium-skilled work done by artisans in traditional sectors (Giannetti 1998; Fenoaltea 2016). It was followed by a rise in the number of medium-skilled workers during the fascist period when there was more work both for traditional clerks and for agricultural workers (1921–1936). This decline and rise can be seen in the trend of average skill level. The second phase of the second industrial revolution (1950–1970) was the

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major period of deskilling. As stressed by the Marxist tradition (Braverman 1974; Hobsbawm 1964), it was characterized by mass production technologies which required less skilled workers, as shown in Figure 6. The results suggest that the rise of these technologies benefitted workers with general (lower) skills and hurt those who possessed medium skills, as in the US case (Gray 2013). The third industrial revolution was characterized by a rise in the proportion of lower- and higher-skilled workers, in line with the findings of other scholars (Autor 2019; Autor and Dorn 2013). For this last period, Italy experienced a mixed pattern: on the one hand, polarization occurred, as stressed by Haslberger (2021); on the other hand, it was a period of long-term increase in average skill levels. In general, these waves seem to have prompted deskilling during the twentieth century, markedly so in the "Golden Age" (1951–1971). This latter period saw the growing importance of higher-skilled workers, which continued until 2011.

Our first attempt to historicize the *relationship between technological change and skill development* in the male labor force using census data and the family of HISCO-based measures will not be the last. Our approach has two main flaws. To begin studying only men not only leaves out women, it also limits our understanding of the structural transformation of the male labor force itself, since after 1950 it coincided with the rise of dual-earner households and the decline of the male breadwinner model (Goldin 2021; Mancini 2018).[25] The other important limitation is that we were obliged to attribute a constant skill level to each HISCO code. Obviously, more work is needed to test the effects of our assumption, and, where needed, relax it.[26] But HISCO is more flexible than it might seem at first sight. We captured skill changes in new and perhaps more specialized names of occupations. If the tasks and duties of an occupation changed substantially over time, the occupation would be given a different HISCO category. We can only hope that future work will ascertain whether that is a major issue.

Given that historical sources containing occupational information have become increasingly available in digital form and that we now have measures and routines as a comparative framework for analysis, we look forward to seeing studies on other countries. Only by such comparisons will we be able to distinguish commonalities from national idiosyncrasies and understand the historical variety in the relationship between technological change and work (Schneider and Vipond 2023; Staccioli and Virgillito 2021).

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ssh.2025.11

[25]For example, domestic textile labor – done predominantly by women under the putting-out system – disappeared with the introduction of factories and the appearance of heavy industry. As Olivetti and Petrongolo (2016) argued, the marked rise in female participation is a postwar phenomenon pushed by the growth of the services sector. Were we to study male and female participation rates together, we might see the period from the 1880s to the 1950s as one of the rise of the male breadwinner model, followed by a period of stabilization and then a new phase of dual-earner households.

[26]See note 18.

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