RUHR
ECONOMIC PAPERS

Ronald Bachmann
Gayane Stepanyan

It's a Woman's World? Occupational Structure and the Rise of Female Employment in Germany

RWI #889

Imprint

Ruhr Economic Papers

Published by

RWI – Leibniz-Institut für Wirtschaftsforschung
Hohenzollernstr. 1-3, 45128 Essen, Germany

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, e-mail: W.Leininger@tu-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Ronald Bachmann, Prof. Dr. Manuel Frondel, Prof. Dr. Torsten Schmidt, Prof. Dr. Ansgar Wübker
RWI, Phone: +49 (0) 201/81 49-213, e-mail: presse@rwi-essen.de

Editorial Office

Sabine Weiler
RWI, Phone: +49 (0) 201/81 49-213, e-mail: sabine.weiler@rwi-essen.de

Ruhr Economic Papers #889

Responsible Editor: Ruhr Bachmann

ISSN 1864-4872 (online) – ISBN 978-3-96973-028-7

Ruhr Economic Papers #889

Ronald Bachmann and Gayane Stepanyan

It's a Woman's World? Occupational Structure and the Rise of Female Employment in Germany

RWI

Bibliografische Informationen
der Deutschen Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at **http://dnb.dnb.de**

RWI is funded by the Federal Government and the federal state of North Rhine-Westphalia.

http://dx.doi.org/10.4419/969730287
ISSN 1864-4872 (online)
ISBN 978-3-96973-028-7

Ronald Bachmann[1] and Gayane Stepanyan[2]

It's a Woman's World? Occupational Structure and the Rise of Female Employment in Germany

Abstract

We analyse whether the rise in female labour force participation in Germany over the last decades can be explained by technological progress increasing the demand for non-routine social and cognitive skills, traditionally attributed to women. We do so by examining which task groups and occupations drive the increase in the female share and how this is related to women's wages. Our findings show that the share of women indeed rises most strongly in non-routine occupations requiring strong social and cognitive skills. While the female share in high-paid occupations increases over time, the share of women in the upper parts of the overall wage distribution rises much less which implies significant within-occupation gender wage gaps.

JEL-Code: J21, J31, O33

Keywords: Female labour market participation; occupations; tasks; technological progress

December 2020

1 Ronald Bachmann, RWI, DICE/Heinrich-Heine-Universität Düsseldorf, IZA; 2 Gayane Stepanyan, Heinrich-Heine-Universität Düsseldorf – *We are grateful to Bernd Beber, Friederike Hertweck and Bernhard Schmidpeter, and participants at a seminar at RWI for comments and suggestions. Janin Marquardt, Johanna Muffert and Dominik Paluch provided excellent research assistance. –* *All correspondence to: Ronald Bachmann, RWI – Leibniz Institute for Economic Research, Hohenzollernstraße 1¬ 3, 45128 Essen, Germany. E-mail: bachmann@rwi-essen.de*

1. Introduction

The position of women in the labour market has been the subject of intense debate and scrutiny for a number of decades, especially in the context of the gender wage gap, but also with respect to a relatively low female labour market participation. While the gender wage gap has substantially fallen over time in many industrialised countries, it is still sizeable (Blau and Kahn, 2007); and although the labour market participation of women has increased strongly in many industrialised countries during the last decades, there is evidence that women tend to mainly find jobs with bad working conditions and in atypical employment (Bachmann et al., 2020). Therefore, gender equality in the labour market is still far from being realized.

Technological progress, however, could change this picture. For example, there is evidence for the labour market for highly-skilled workers in the US that the probability for a man to work in non-routine cognitive and highly-paid job has decreased in recent decades. On the other hand, the probability for a woman to work in such occupations has increased more than the supply of women per se on the labour market (Cortes et al., 2018). This development can be explained by a greater demand for social skills, where women have a comparative advantage (Borghans et al., 2006). The greater demand for social skills can in turn be explained by a team model where social skills reduce the coordination costs when workers trade tasks to work more efficiently together (Deming, 2017). Furthermore, there is evidence of an increasing complementarity between cognitive and social skills (Weinberger, 2014). Against the background of technological change, social skills are therefore a prerequisite for sustainable employment, with women benefiting relative to men.

In this paper, we therefore analyse which type of occupations have been the main drivers of the increase in the labour market participation of women in Germany since the mid-1980s. We do so by examining which task groups and occupations drive the increase in the female share and how this is related to women's wages. Furthermore, using a shift-share analysis, we investigate whether the increase in the female share is due to the growth of occupations which had a high female employment share in the mid-1980s, or whether the overall female share grows because it increases across all occupations in a similar way.

The German case is particularly interesting because the increase in female labour market participation is among the highest amongst industrialised countries. For example, from 1980s to the 2010s, the share of women who are nonemployed fell by

nearly a quarter, while the corresponding share of men remained virtually unchanged. Furthermore, the German economy features fast technological progress, e.g. in terms of robot adoption (Suedekum et al., 2017) and a strong polarization of employment, at least for men (Bachmann et al., 2019).

In order to answer the question of which occupations explain the increase in female employment, we use data from the Socio-Economic Panel (SOEP) for the time period 1984-2017. For most of our analyses, we categorize jobs in two ways: first, we use a task-based categorization into non-routine-cognitive, non-routine manual and routine jobs; second, we use the percentiles of the wage distribution to divide occupations into high-wage and low-wage occupations.

Our results show that the growth of the female share was indeed strongest in non-routine, high-paying occupations which require a high degree of cognitive and social skills. However, wages at the individual level do not fully reflect that women more often work in high-paying occupations, which implies significant gender wage gaps within occupations. Furthermore, when taking into account the employment weight of occupations in a shift-share analysis, it turns out that the overall increase in the female employment share is entirely due to a within effect, i..e an increase in the female employment share in all occupations, rather than a disproportionated increase of occupations with a high female employment share.

The paper is structured as follows. First the existing literature is briefly summarized in Section 2. Section 3 contains the methodology and results for the task-based and the wage-based approach. Section 4 contains the shift-share analysis on the occupational drivers of the female employment share, as well as a more detailed analysis of the link between task groups and wages in this context. Section 5 features evidence on which specific occupation groups feature the highest growth rate in the female employment share. Section 6 summarizes the main results and Section 7 concludes.

2. Literature

There is a large literature on gender gaps in the labour market. As for the gender wage gap, it has been found that it has substantially fallen over time in many industrialised countries, but it is still sizeable (Blau and Kahn, 2017). For the German labour market in particular, clear differences for the entire life cycle between men and women in labour market participation and employment can be observed up to the year 2000

(Fitzenberger et al. 2004). In addition, even if educational level, work experience and choice of sector are taken into account, there is a difference in hourly wages of 13 per cent between all employed women and men aged 15 to 65 (Anger and Schmidt 2010). However, it has also been shown for the US that structural change, and in particular the rise of the service economy, has led to a narrowing of the gender wage gap (Ngai and Petrongolo, 2017).

There is also a large gap in participation rates between women and men, which is increasing over the life cycle. This gap, and its increase over the life cycle, can be explained by various factors (see Olivetti and Petrongolo, 2016, for an overview). One important factor is the presence of children, as having children is related to mothers' return to the labour market after they gave birth (Schönberg and Ludsteck, 2014), differences in the childcare system (Baker and Milligan, 2008) and the reconciliation of work and family life in general (Gregory and Connolly, 2008; Felfe 2012).

With respect to the polarisation between low- and high-wage/skill jobs, there is now ample evidence that the share of medium-wage and medium-skill jobs has significantly declined in most industrial countries (e.g. Goos et al., 2009 for Europe; Autor et al., 2003 for the US; Bachmann et al., 2019, for Germany). This development can be explained by a model of job tasks – as in e.g. Autor et al. (2003) – that defines jobs as routine work if the tasks in the job are a clearly definable and limited set of cognitive and manual activities that can be performed by following explicit rules. These can be more easily replaced by computing technology. Therefore, computer capital acts as a substitute for routine jobs and as a complement for non-routine (cognitive) jobs, which can explain a large part of the decreased demand for routine work.

Looking at worker flows, it has been shown that the decline in routine jobs is mainly related to the decrease in the transition of unemployed and non-participants in the labour market into routine jobs (Cortes et al. 2018). Furthermore, routine workers have been found to display higher churning flows through unemployment, i.e. a higher transition rate from employment to unemployment, but also a higher transition rate in the reverse direction (Bachmann et al., 2019).

The automation literature is in some ways a continuation of the job polarisation literature, but it is more concerned with the possible effects of technological change on the labour market. Frey and Osborne (2017) argue that the traditional definition of routine jobs as being the only jobs that can be automated is no longer valid with regard

to recent technological innovations. Big data makes it possible to program even very complex tasks. In addition, an improvement in the robots' ability to perform manual tasks can be seen, so that according to the authors not only the traditional routine jobs are highly likely to be automated, but about 47% of all jobs (Frey and Osborne 2017). The authors also expect that workers will need to invest more in creative and social skills to remain employed.

Acemoglu and Restrepo (2017) also expect that robots and computer-based technologies will lead to automation of workplaces. They study the effect of industrial robots on local labour markets in the US between 1990 and 2007 and estimate that one robot more per thousand workers reduces the ratio of employment to population by about 0.18 to 0.34 percentage points and that of wages by 0.25 to 0.5% (Acemoglu and Restrepo 2017). However, they also explain that due to the low number of robots used in the industries to date, the effect has remained relatively small and could only have a greater impact in the future. In addition, some model specifications of the authors suggest that robots, unlike other computer capital, have a generally negative effect on labour demand and that this effect is not heterogeneous for different skill levels of workers. In addition, the authors estimate that the effects of robots have a stronger impact on men than on women. However, at least for Germany, job creation in other sectors has been shown to even lead to positive net effects from robot technology (Südekum et al., 2017).

Given the speed of technological innovation, one may wonder why not even more jobs have been automated in the last decades. Taking this question as a starting point, Autor (2015) argues that the literature often overestimates the substitutability of machines for workers and underestimates the complementarity between human work and machines, so that automation scenarios are generally overestimated. Although mainly routine jobs of medium qualification are automated, this does not apply to all medium qualification jobs. Accordingly, some medium-skilled occupations are characterised by a bundle of automatable and non-automatable tasks and tasks that cannot be unbundled easily. Examples are occupations in the health sector, some craft and repair occupations but also typical white-collar occupations in which coordination and decision-making tasks are involved. Human labour is therefore likely to have a comparative advantage in carrying out these bundles, with relatively high levels of worker competence being a prerequisiste (Autor 2015). This can be viewed as an important reason why the combination of specific skills, especially cognitive and

social skills, has been found to be important for labour-market success (Weinberger, 2014).

This view of automation is also held by other authors. For example, Arntz et al. (2017) replicate the automation scenarios of Frey and Osborne (2017) with German data and then reassess taking into account the whole spectrum of tasks in the professions. As a result, the risk of occupations being automated is re-estimated and revised from 39% to 9% (Arntz et al. 2017). Furthermore, they note that workers specialize in non-automatable niches of their occupations. The fact that the requirements and tasks in occupations change due to technological change is implicit in this strand of the literature.

However, there is also measurable evidence for the job polarization hypothesis and task changes in occupations. Black and Spitz-Oener (2010) show that the requirements for skills and competences within occupations have changed, so that interactive and analytical skills have become more important and routine tasks have decreased. The authors also note that the requirements for women have changed more than for men. The decrease in routine and the increase in non-routine interactive and analytical tasks may also explain part of the decrease in the gender pay gap (Black and Spitz-Oener 2010).

3. The evolution of female employment according to task categories

To answer the research question which occupations and tasks have most strongly contributed to the rise in female employment, we use data from the German Socio-Economic Panel (SOEP) for the years 1984 to 2017 (Bohmann and Giesselmann, 2018). The SOEP is a representative annual panel survey of private households/ persons in Germany. In order to avoid structural breaks, we focus on persons working in West Germany. In order to identify occupations, we use the ISCO88 classification (International Standard Classification of Occupations) of the ILO (International Labour Organization).

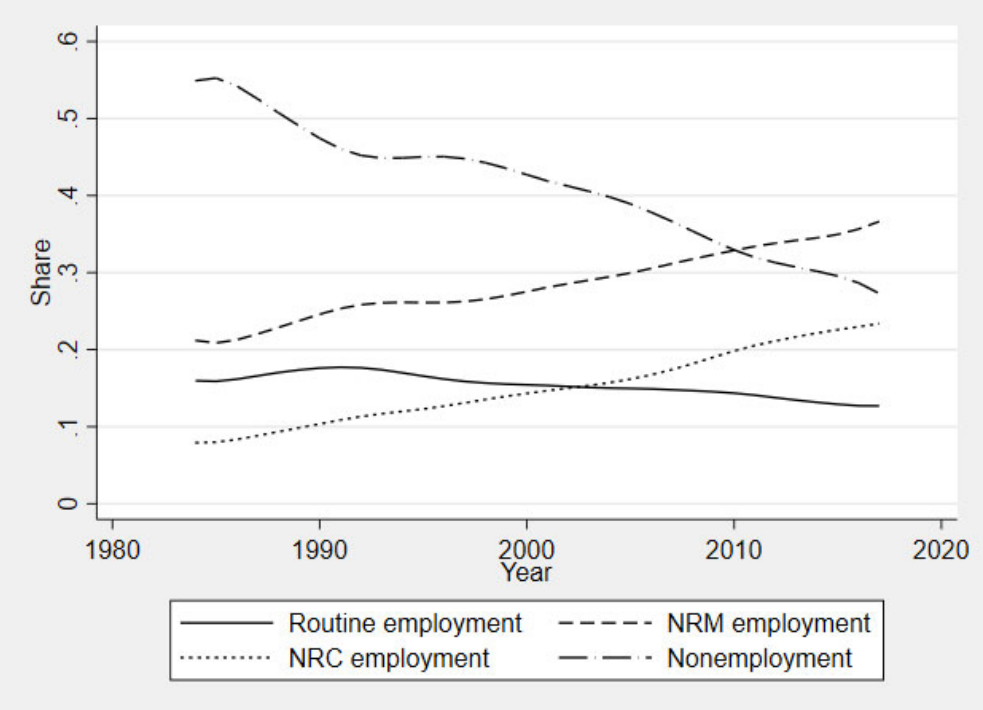
In order to categorize jobs, we use two procedures: first, a task categorization, and second, a categorization according to the hourly wage. In the task categorization, we use the one from Cortes (2016), applied to Germany in Bachmann et al. (2019). The occupations are divided into the categories “Routine”, “Non-routine Cognitive” (NRC), and “Non-Routine Manual” (NRM). Routine occupations are occupations that are easily programmable and follow a specific and limited set of rules. They include

both routine cognitive and routine manual occupations as in Autor et al. (2003). Non-routine cognitive occupations are those that are intellectually demanding, i.e. that require creativity and problem-solving skills. This includes both analytical and interactive professions. The non-routine manual occupations are all occupations in the service sector that are not primarily characterized by cognitively demanding tasks and manual occupations that are not very well programmable. Table A.1 in the appendix shows how the occupations are assigned to each task category.

Figures 1 and 2 show the development of the employment shares of the different categories for women and for men who are of working age (20-64) over the time period under investigation. For women, it becomes transparent that the shares of nonemployment and of non-routine occupations have changed most: while more than half of all women of working age were not employed in 1984, this share falls below 30% by 2017. Furthermore, the share of NRC employment in female employment increases strongly, as does the share of NRM employment, although from a higher initial level. Finally, we observe a small decrease in the share of routine employment in female employment.

Figure 1

Distribution of women across task categories and nonemployment, 1984-2017

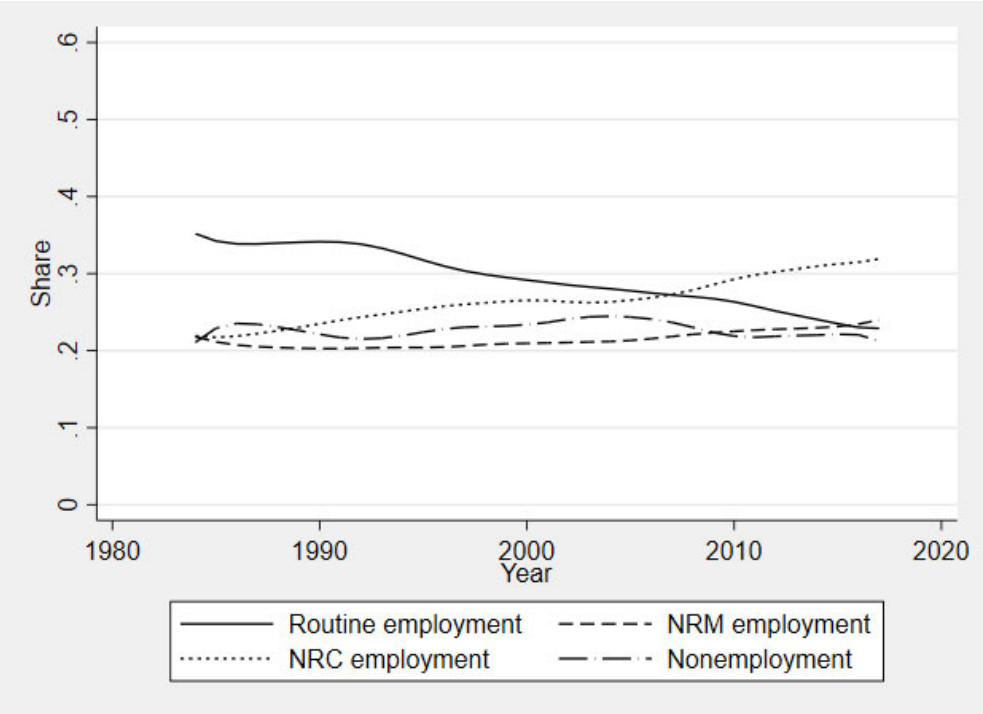


Source: SOEP, own calculation.

This stands in contrast to the evolution of male employment (Figure 2). Two employment shares change most. First, the share of routine employment in male employment declines strongly over time, from more than 35% to less than 25%. Second, the share of NRC employment increases strongly, from slightly above 20% to more than 30%. The share of NRM employment is relatively constant, as is the share of nonemployment amongst men.

Figure 2

Distribution of men across task categories and nonemployment, 1984-2017



Source: SOEP, own calculation.

In order to focus more strongly on the relative position of women and men in the labour market, we now compute the share of women and men in the respective employment and nonemployment categories. For ease of exposition, we do so for the time periods 1985-1989 and 2013-2017. It becomes apparent that the share of women in nonemployment drops by 11.5 percentage points (pp), with a corresponding increase for men (Table 1). This reduction is matched by a disproportionate increase (13.7 pp) of NRC employment, and a smaller increase of the female share in NRM employment (8.5 pp). The share of both men and women in routine employment hardly changes because routine employment of women stays low and even slightly declines as seen in Figure 1.

The increase in the proportion of women in cognitive occupations is thus stronger than the increase in female employment for the labour market as a whole and, accordingly, also stronger than the increase for routine and manual jobs. The development for cognitive jobs corresponds in content to the results of Cortes et. al., who found a disproportionate increase in women in cognitive jobs. However, Cortes et al. (2018) restrict their analysis to women with a university degree only, whereas here all women are considered, so that the results are not entirely comparable.

Table 1
Employment share of task categories and nonemployment separately for women and men, selected time periods

		1985-1989	2013-2017	Difference
Women	Routine employment	0.332	0.356	0.024
	NRM employment	0.518	0.603	0.085
	NRC employment	0.285	0.422	0.137
	Nonemployment	0.690	0.575	-0.115
Men	Routine employment	0.668	0.644	-0.024
	NRM employment	0.482	0.397	-0.085
	NRC employment	0.715	0.578	-0.137
	Nonemployment	0.310	0.425	0.115

Source: SOEP, own calculation.

4. The evolution of female employment by wage categories

In addition to the task-oriented categorisation of occupations, we differentiate occupations according to the level of the average wage in the occupation, because occupations with good pay can generally be seen as desirable and scarce positions that individuals strive for. This categorisation is useful for identifying whether female employment has increased mainly in low-wage occupations or more in the high-wage sector.

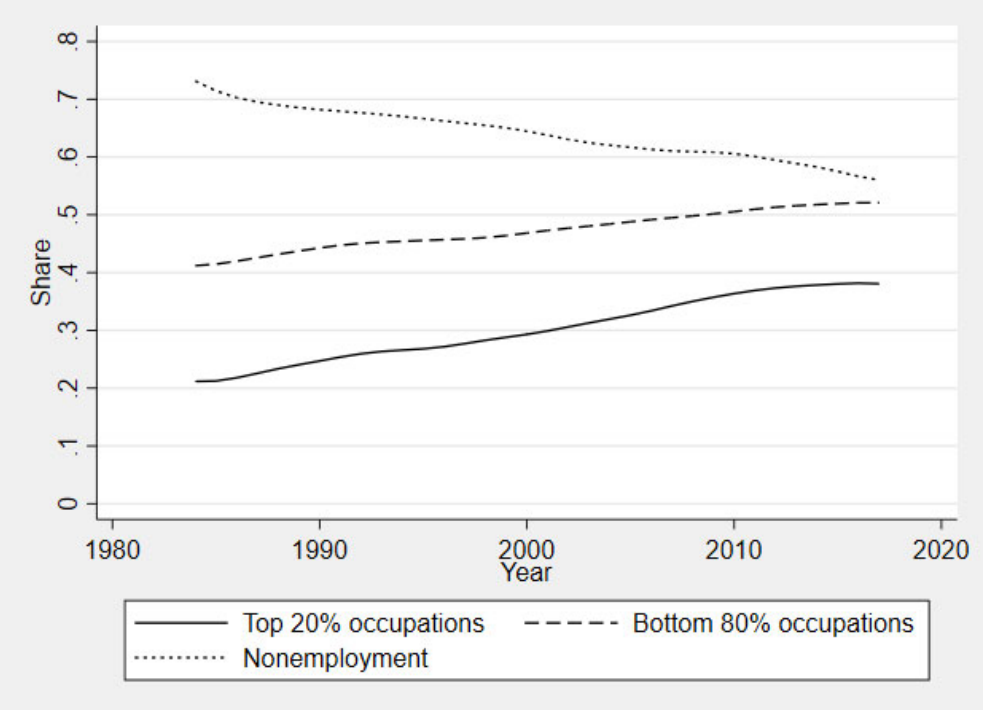
For the wage-oriented categorization, we classify occupations into two categories: high-wage occupations are defined as occupations where the average wage is in the top 20% of the wage ranking of occupations; low- and medium-wage occupations are those occupations in the bottom 80% of the wage ranking of occupations. In calculating the wage distribution, we take into account all workers who are in full-time, part-time or marginal employment and, in order to ensure comparability between the different job types, hourly wages are used. We compute hourly wages using he information on the gross monthly wage and on working time. In addition to a variable

for the weekly, contractual working time, SOEP also contains a variable for the actual working time, i.e. the actual working time exceeding or falling short of the contractual working time. Since there are relatively many missings, the hourly wage is calculated using the maximum of the two working time variables in order to include as many observations as possible. Although this has the effect that the hourly wage of a person may be slightly underestimated, as the actual working time is probably rather overestimated, it should not have a strong effect on the results.

From the hourly wage variable, we compute two wage classifications used in the analysis. First, we compute the average wage of all occupations for the ISCO 2-digit and 3-digit classification. From this, we can classify the occupations into high-wage (top 20%) and medium- / low-wage occupations (bottom 80%). Second, we compute the wage distribution of the worker-level wages, and assign each individual his or her percentile in the wage distribution. Again, we use this to assign individuals to the high-wage segment of the wage distribution (top 20%) or the middle / bottom of the wage distribution (bottom 80%).

Figure 3

Share of women in the top and bottom of the occupation-level wage distribution and nonemployment



Source: SOEP, own calculation. – Notes: ISCO 2-digit

We use these two wage classifications in order to assess whether the development with respect to wages at the occupational level and at the individual level is comparable, i.e. whether an increase of the share of women in the top 20% of occupations is associated with a corresponding increase of the share of women in the top 20% of the individual wage distribution. It is conceivable that the share of women in well-paid occupations increases, but that women are paid less than men in these occupations and therefore do not move up into the top 20% of the individual-level wage distribution.

In the following, the development of women's employment is described using the occupational wage categorisation. Overall, the reduction in the nonemployment share is matched by a strong increase in the female employment share in the bottom 80% of the occupational wage distribution, rising from just above 40% to over 50% (Figure 3). The increase in the female employment share in the top 20% of the occupational wage distribution was even stronger. This share nearly doubled during the time period under consideration. These developments imply that increasing labour market participation of women resulted in more women working in higher-paying occupations relative to lower-paying occupations.

Table 2

Distribution of men and women across the occupation-level wage distribution and nonemployment

		1985-1989	2013-2017	Difference
Women	Top 20%	0.208	0.368	0.160
	Bottom 80%	0.416	0.514	0.097
	Nonemployment	0.690	0.575	-0.115
Men	Top 20%	0.792	0.632	-0.160
	Bottom 80%	0.584	0.486	-0.097
	Nonemployment	0.310	0.425	0.115

Source: SOEP, own calculation. – Notes: ISCO 2-digit

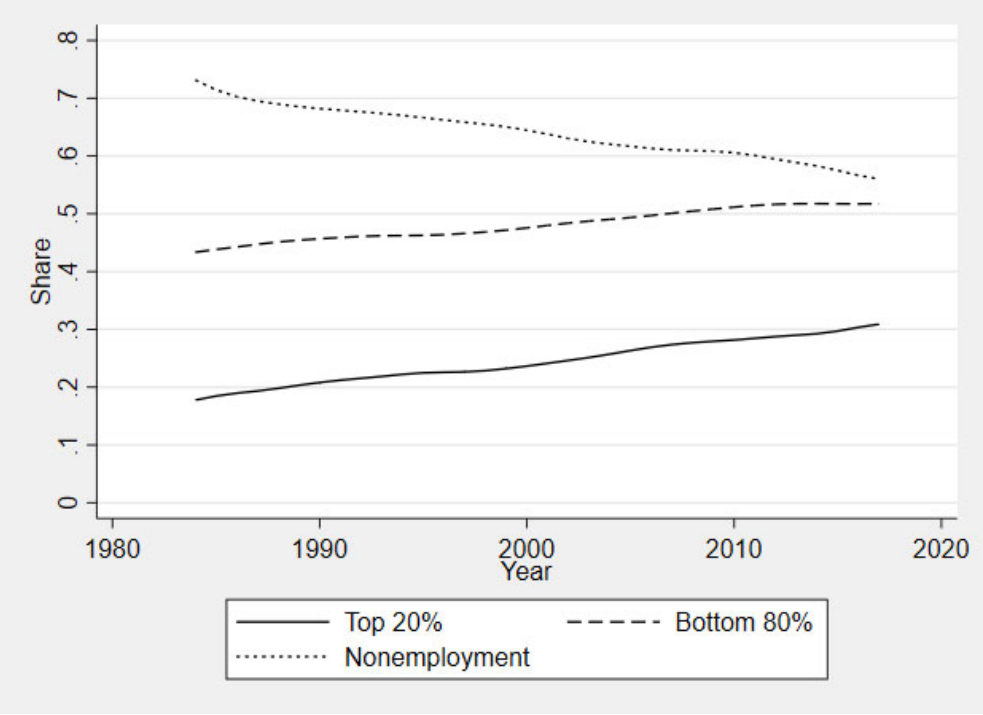
Again focusing on the distribution between men and women in specific wage categories for selected time periods reveals a similar picture (Table 2): Comparing the time period 1985-89 to 2013-2017, one can see that the share of women in the top 20% of the occupational wage distribution increased by 16 pp and therefore nearly doubled. However, the female share in this category still only reaches 36.8%, i.e. men are still much more strongly represented in high-paying occupations. In the bottom 80%, there

is an increase of nearly 10 pp, leading to a roughly equal split of employment shares between women and men within this category.

Given that the share of women in high-paying occupations increased strongly, the question arises whether this was accompanied by a corresponding increase in the share of women actually receiving high wages. Figure 4 shows that this is only the case to a limited extent. We can see that the share of women in the top 20% of the wage distribution in total female employment increased over time, but it did so at roughly the same rate as the share of women in the bottom 80% of the individual-level wage distribution. A depiction at the 3-digit ISCO level yields a very similar impression (Figure A.1 in the appendix).

Figure 4

Share of women in the top and bottom of the individual-level wage distribution and nonemployment



Source: SOEP, own calculation. – Notes: ISCO 2-digit

Looking at the distribution between men and women in specific categories for selected time periods confirms this result (Table 3): The share of women in the top 20% of the individual-level wage distribution strongly increased (by 10 pp), but still only makes up less than 30% in the time period 2013-2017. Correspondingly, the share of men in the Top 20% occupations dropped by 10%, to 70% in 2013-2017. By contrast, the share of women in the bottom 80% of the individual-level wage

distribution increased by 7 pp from 45% to nearly 52%, which means that there is roughly equal share of women and men in the bottom 80% of occupations.

Taken together, these results imply that women managed to increase their employment strongly, and that this resulted in a disproportionate increase of women working in high-paying occupations. In other words, the share of women in high-paying occupations increased more strongly than the share of women in lower-paying occupations. However, this increase did not fully translate into an equivalent increase in the female share in the top 20% of the individual-level wage distribution, which implies significant gender wage gaps within occupations.

Table 3

Distribution of men and women across individual-level wage categories and nonemployment

		1985-1989	2013-2017	Difference
Women	Top 20%	0.195	0.296	0.102
	Bottom 80%	0.448	0.517	0.069
	Nonemployment	0.690	0.575	-0.115
Men	Top 20%	0.805	0.704	-0.102
	Bottom 80%	0.552	0.483	-0.069
	Nonemployment	0.310	0.425	0.115

Source: SOEP, own calculation. – Notes: ISCO 2-digit

5. Dissecting the growth of women's employment

Up to now, we have seen that the proportion of women has increased in non-routine cognitive and high-paying occupations. However, it is not yet clear whether this development is due to an increase in the proportion of women within occupations (within-variation) or whether jobs in which women are increasingly to be found account for a larger proportion of cognitive occupations (between-variation). To answer this question, we decompose the total observed difference in the female share over time into two components. The first is due to changes in the share of occupations in total employment, holding the female share within occupations constant, and the second is due to changes in the female share within occupations, holding the share of occupations in total employment constant. The decomposition reads as follows:

$$\Delta FemaleShare = \sum_i \Delta OccShare_i * \overline{FemaleShare_i} + \sum_i \overline{OccShare_i} \Delta FemaleShare_i$$

where ΔFemaleShare represents the difference in the overall female share between two time periods, i denotes the ocupation, and $OccShare_i$ the share of this occupation in total employment. The bars denote the mean over both time periods. Table 4 shows the results of the decomposition. The results clearly show that the increase in women is entirely due to within-variation. If the proportion of women per occupation had remained constant in all occupations (between), the proportion of women for task-oriented categorisation would not have increased at all, on the contrary: it would even have increased.

Table 4

Decomposition of increase in female share in cognitive jobs and jobs in the top 20 of the occupational wage distribution

	Total change	**Within effect**	**Between effect**
Top 20% occupations, ISCO 2-digit	0.824	0.915	-0.091
Top 20% occupations, ISCO 3-digit	0.753	0.832	-0.079
Cognitive occupations, ISCO 2-digit	1.198	3.370	-2.173

Source: SOEP, own calculation.

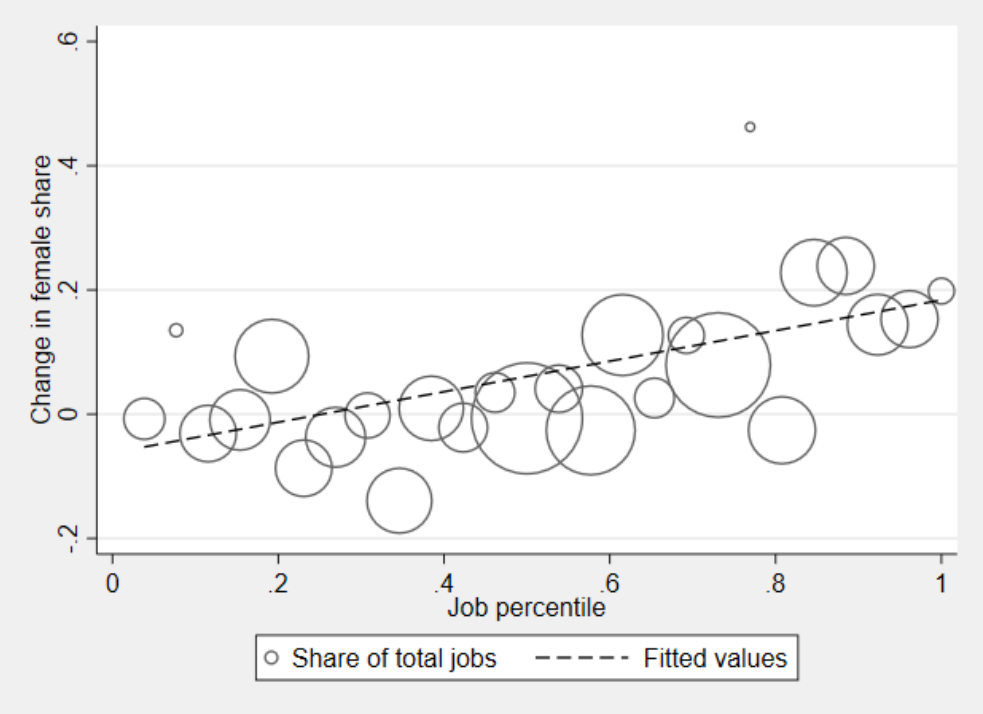
We now examine in more detail how the changes in the female share by occupationare are related to wages. First, we provide descriptive evidence on how the change in the proportion of women in an occupation is linked to the initial position of the respective occupation in the wage distribution, both graphically and within a regression framework. Second, the occupations in which the proportion of women has increased are identified in order to find out whether they display the characteristics predicted by the recent literature on the importance of social, interactive and cognitive skills (Deming, 2017; Cortes et al., 2018).

In order to depict the link between the female occupational share and wages, we calculate the 5-year average from 1985 to 1989 and 2014 to 2017 of the female employment share in occupations. We use these two averages to compute the growth of the female share in occupations, indicating by how much the proportion of women has increased or decreased. We then relate this variable to the percentile ranking of the corresponding occupation in the time period 1985-1989 to see if there is a positive relationship between a well-paid occupation and the increase in the proportion of women in the job. The results of this exercise using the 2-digit ISCO classification are depicted in Figure 5, where the size of the circles in the graph reflects the proportion of the respective job in the total number of jobs. As one can see, the correlation

between the growth in the female share in an occupation and the wage ranking of the respective occupation is clearly positive. This confirms the results from the very broad categorization in Section 4 that the increased participation of women in the labour market occurred disproportionately in high-paying occupations. Particularly in the uppermost areas of the percentile rankings, the share of the majority of occupations has risen by between 10 and 20 pp. At the 3-digit ISCO level, the development is similar (see Figure A2 in the appendix).

Figure 5

Correlation between the growth in the female share in an occupation and the wage ranking of the respective occupation



Source: SOEP, own calculation. – Notes: ISCO 2-digit

We now investigate this relationship using a regression framework. The results are displayed in Table 5. The dependent variable is the same as in Figures 5 and A.2, i.e. the growth of the female occupational share between 1985-89 and 2013-2019, and the explanatory variables are either the percentile of the wage distribution of the respective occupation or dummy variables for NRM and NRC occupations.

The wage percentile of the occupation is significant at the 1%-level, both for the 2- and 3-digit ISCO classification (columns 1 and 3). The NRC dummy is also significant at the 1% level (columns 2 and 4). The results show that an NRC occupation is associated with an increase of the difference in the proportion of women by about

0.16, i.e. 16 pp at the 1-digit level, and 21 pp at the 3-digit level. The NRM dummy is also positive, but much smaller in size, and only significant at the 10% level in the 3-digit ISCO classification (column 4).

Table 5

Regression of the change of the share of women on task groups and percentile of occupation in wage distribution separately

	(1)	(2)	(3)	(4)
Percentile	0.246***		0.381***	
	(0.071)		(0.064)	
Manual		0.037		0.084*
		(0.053)		(0.048)
Cognitive		0.160***		0.211***
		(0.053)		(0.047)
Constant	-0.062	-0.003	-0.153***	-0.055*
	(0.042)	(0.038)	(0.037)	(0.033)
R^2	0.331	0.310	0.253	0.163
N	26	26	106	106

Source: SOEP, own calculation. – Notes: Models 1 and 2: ISCO 2-digit; models 2 and 4: ISCO 3-digit. Standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1 .

Table 6 shows the regression output when both categorizations, wage percentiles and task dummies, are combined. Although the NRC dummy and percentiles both represent similar jobs and therefore probably explain in part the same variation in the difference in the proportion of women, the two corresponding coefficients differ strongly.

Table 6

Regression of growth rate of share of women on task groups and percentile of occupation in wage distribution jointly

	(1)	(2)
Percentiles	0.213**	0.379***
	(0.102)	(0.090)
Manual	0.075	0.097**
	(0.053)	(0.045)
Cognitive	0.090	0.053
	(0.060)	(0.058)
Constant	-0.102	-0.200***
	(0.060)	(0.046)
R^2	0.423	0.287
N	26	106

Source: SOEP, own calculation. – Notes: Model 1: ISCO 2-digit; model 2: ISCO 3-digit. Standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1 .

In particular, the cognitive dummy loses its significance at all levels if the job percentile is included in the model, which suggests that both variables explain the same part of the variation in the dependent variable. Interestingly, the coefficients of the job percentile hardly change, suggesting that the difference or increase in the number of women in a job is better explained by the location in the wage distribution of the job than by the task categorization.

6. Which specific occupations drive the growth in female employment?

In order to better understand the changes in female employment described above, we now look at the specific occupations in which a particularly strong increase in the proportion of women can be recorded. Table 7 lists the ten occupational groups at the 2-digit level in which the increase in the proportion of women has been particularly strong. Overall, six of the occupational groups in the top ten are cognitive occupational groups. The strongest increase can be observed for legislators and senior officials. The strong increase in this occupation is mainly due to sub-group 114, senior officials of interest groups (3-digit ISCO level, not reported). These include political parties, workers and trade associations. This increase is not very surprising as women are increasingly striving for the upper echelons of the public sector, and it is precisely here that institutional change has been called for and pushed forward. However, the sharp increase should be viewed with caution. First, the number of cases for occupational group 11 is relatively small and, second, the increase starts from a very low baseline.

The increase of 20 percentage points in the group of life scientists and medical doctors is relatively evenly spread amongst the professions in this 2-digit group. While the increase in the number of female teachers (groups 23 and 33) and personal service and security workers (group 51) as typical female occupations is not surprising, the increase in the groups of corporate managers; physical, mathematical and engineering science professionals; extractive and construction occupations is less typical. In the case of female managers, the main occupations are personnel managers and advertising and public relations managers (3-digit ISCO level, not reported).

In the building professions, it is mainly female building cleaners who have become more numerous. The increase in the group of personal service occupations and security staff can partly be explained by traditional women's occupations such as hairdressers, beauticians and related occupations, but also by an increase in policewomen and, to a

lesser extent, prison guards. This development could mean that women choose more traditionally male professions. Alternatively, it can be interpreted to mean that public efforts to recruit more women can be successful. Again however, the results at the 3-digit level should be interpreted with some care given the low number of observations in the SOEP.

Table 7

Top 10 occupations with strongest increase of share of women from 1985 to 2015

Increase of share of women	Occupation ISCO code	Occupation title
0.462	11	Legislators and senior officials
0.239	23	Teaching professionals
0.228	24	Other professionals
0.198	22	Life science and health professionals
0.153	12	Corporate managers
0.144	21	Physical, mathematical and engineering science professionals
0.135	92	Agricultural, fishery and related labourers
0.127	71	Extraction and building trades workers
0.127	33	Teaching associate professionals
0.093	51	Personal and protective services workers

Source: SOEP, own calculation. – Notes: ISCO 2-digit

The main explanation for the changes outlined here seems to be that the occupations that drive the results require cognitive and social skills and are therefore less easily automated. The importance of cognitive and social skills are due to a high degree of interactivity (especially teachers, psychologists, personnel or advertising and public relations managers, doctors and policewomen) and the need for cognitive and management skills (especially legal professions, archives and museum scientists, heads of interest groups, architects and bioscientists). In terms of interactivity, it is also significant that mostly those office workers who have contact with clients have seen an increase in the proportion of women. Assuming that these professions tend to be less automated, it can be concluded that women are more likely to work in professions where less disruptive technological shocks occur. Another important finding is that more than half of the top ten occupational groups typically require a university degree.

7. Conclusion

Analysing the increase of female employment in Germany over the last decades, it becomes apparent that female employment has strongly grown in high-paying and NRC occupations and that this growth is stronger than for men. This fact and the general increase in female employment leads to a larger proportion of women in these jobs, so that the proportion of women has increased from 21% to 37% in the top 20% of the occupational wage distribution, from 20% to 30% for the top 20% occupations of the individual-level wage distribution and from 28% to 42% for the cognitive occupations.

It is noteworthy that the proportion of women in the top 20% of occupations with the highest hourly wage has risen more strongly than the proportion of women in the top 20% of the overall wage distribution. Women therefore are more often found in high-paying occupations, but are still paid less than men, so that not all women who are in a top 20% of occupations also move up into the top 20% of the overall wage distribution.

The disproportionate increase in female employment in cognitive and well-paid occupations is thus at least partly the result of changing demands due to technological change, with social skills playing an important role. At the same time, while women are more strongly represented in well-paid occupations at the end of the observation period, their individual wages have not increased to the extent that one may have expected, i.e. even when in high-paying occupations, they are often paid less than men. One potential explanation for this is that women tend to have a higher demand for temporal flexibility in order to balance their job and household production (Goldin, 2014; Cortés and Pan, 2019; Petrongolo and Ronchi, 2020).

In addition to these features, the quantitative analysis has shown that the increase in female employment in high-paying and NRC professions can be fully explained by within-variation, i.e. a growing proportion of women in all types of high-paying and NRC occupations, not a disproportionate growth of occupations with a high share of women at the beginning of the observation period. In addition to the increase in cognitive occupations, non-routine manual occupations have also seen a strong increase, which among women mainly include simple occupations in the service sector. Furthermore, both task and wage categorisation can explain significant changes in the proportion of women in occupations. However, when including both the wage percentile of an occupation and task dummies, the wage percentile assumes most of

the significance, implying that job tasks per se are not the main driver of the increase in the female share in an occupation.

Both the developments of the task categories in the labour market and the change for men and women separately follow the logic of the job polarisation literature. The decline in the demand for highly qualified workers after the year 2000 discussed in the literature (e.g. Beaudry et al. 2016) cannot be identified from the task categorisation used in the data. Rather, manual and cognitive jobs continue to increase, while routine jobs decrease, as described in the job polarization literature. In addition, evidence was also found in other papers that job polarization in Germany took place a decade after the US (Dustmann et al. 2009).

It is not possible to say clearly whether the lack of a decline in demand for highly qualified labour is a delay in the German labour market or whether it is a development which differs from the US experience. The results of the qualitative description of the occupational groups in which a particularly strong increase in female employment has taken place and the job polarisation and automation literature make the following development of female employment appear plausible: Women increasingly practice cognitively demanding and interactive occupations or non-routine manual jobs in the service sector. These sectors are relatively unlikely to become automated, mainly due to the requirements for interactivity, cognitive or social skills. This development is accompanied by a slight decline in routine work, which is also in line with the sharp drop in routine tasks within jobs observed especially among women (Black and Spitz-Oener, 2010).

We also showed that the decline in routine work is much more strongly pronounced for male workers than for female workers. There are three plausible explanations for this feature. First, the share of men in this occupational category is larger than that of women, such that men are more affected by automation and job polarisation. Second, a stronger negative effect of technological change on men has been described in the literature, e.g. of robots (Acemoglu and Restrepo 2017). Third, women may perform more interactive activities within routine jobs, so that, according to Autor's argument regarding the bundling of tasks, women are less exposed to automation within routine jobs (Autor 2015).

Looking more closely at the growing occupations, and linking this to the relatively low proportion of women in the top 20% of the individual-level wage distribution, it can be concluded that while women are generally more strongly represented in the

well-paid and cognitive occupations, they are not in the highest-paid jobs, as these are typically found on the productivity front, where highly-skilled workers benefit from strong wage increases complementary to the new technological capital employed, as predicted by economic models of job polarisation and automation (Autor and Dorn, 2013).

It is also of interest whether women are increasingly working in cognitive or manual non-routine occupations because the requirements and tasks in these professions have changed due to technological change in a way that gives them a competitive advantage over men or because women prefer professions in which cognitive, social or interactive skills are required. Cortes et al (2018) and Deming (2017) find evidence for the first explanation. However, the experimental literature also shows that women have stronger preferences for occupations with such requirements (Azmat and Petrongolo 2014). The results are not contradictory, however, but rather complementary, so that both probably explain part of the increase in these occupations. The automation literature, which considers a large proportion of occupations to be at risk of becoming automated, also stresses the importance of creative and social skills for remaining employed (Frey and Osborne, 2017).

Our results are thus in line with the results described by Cortes et al. (2018) as the "end of men". It therefore remains to be seen whether the progress women have made towards labour market equality during the last decades will continue in the future, and whether this will eventually extend to an improvement of women's wages at the individual level, too. The increased demand for social skills as described by many authors, and resulting wage changes, should in any case be investigated in more detail in future research.

References

Acemoglu, D., Restrepo, P., 2017. Robots and jobs. Evidence from US Labor markets. National Bureau of Economic Research, Working Paper No. 23285. DOI 10.3386/w23285.

Anger, C., Schmidt, J., 2010. Gender Pay Gap. Gesamtwirtschaftliche Evidenz und regionale Unterschiede. IW-Trends-Vierteljahresschrift zur empirischen Wirtschaftsforschung 37 (4), 3-16.

Arntz, M., Gregory, T., Zierahn, U., 2017. Revisiting the risk of automation. Economics Letters 159: 157-160. DOI: 10.1016/j.econlet.2017.07.001.

Autor, D.H., Levy, F., Murnane, R.J., 2003. The skill content of recent technological change. An empirical exploration. The Quarterly Journal of Economics 118 (4): 1279-1333. DOI: 10.1162/003355303322552801.

Autor, D.H., 2015. Why Are There Still So Many Jobs? The History and Future of Workplace Automation. Journal of Economic Perspectives 29 (3): 3-30. DOI: 10.1257/jep.29.3.3.

Autor, D.H., Dorn, D., 2013. The growth of low-skill service jobs and the polarization of the US labor market. American Economic Review 103 (5): 1553-1597. DOI: 10.1257/aer.103.5.1553.

Azmat, G., Petrongolo, B., 2014. Gender and the labor market. What have we learned from field and lab experiments? Labour Economics 30: 32-40.

Bachmann, R., Cim M., Green C., 2019. Long-run patterns of labour market polarisation: Evidence from German micro data. British Journal of Industrial Relations 57 (2): 350-376.

Bachmann, R., Felder R., Tamm M., 2020. Labour market participation and atypical employment over the life cycle – A cohort analysis for Germany. Evidence-based HRM 8 (2): 192-213.

Baker, M., Milligan, K., 2008. How does job-protected maternity leave affect mothers' employment?. Journal of Labor Economics 26 (4): 655-691.

Beaudry, P., Green, D.A., Sand, B.M., 2016. The great reversal in the demand for skill and cognitive tasks. Journal of Labor Economics, 34 (S1): S199-S247.

Black, S.E., Spitz-Oener, A., 2010. Explaining women's success. Technological change and the skill content of women's work. Review of Economics and Statistics 92 (1): 187-194. DOI: 10.1162/rest.2009.11761.

Blau, F., Kahn L.M., 2017. The gender wage gap: Extent, trends and explanations. Journal of Economic Literature 55 (3): 789-865.

Bohmann, S., Giesselmann, M., 2018. Eine kurze Einführung in das Soziooekonomische Panel (SOEP) - Teil 1. Was sind Paneldaten? SOEP Survey Papers No. 489.

Borghans, L., ter Weel, B., Weinberg, B.A., 2006. People People: Social Capital and the Labor-Market Outcomes of Underrepresented Groups, NBER Working Paper No. 11985.

Cortes, G.M., 2016. Where Have the Middle-Wage Workers Gone? A Study of Polarization Using Panel Data. Journal of Labor Economics 34 (1): 63-105.

Cortes, G.M., Jaimovich, N. , Siu H., 2018. The "end of men" and rise of women in the high-skilled labor market. National Bureau of Economic Research Working Paper No. 24274. Updated version (November 2020): The Growing Importance of Social Tasks in High-Paying Occupations: Implications for Sorting.

Cortés, P., Pan, J., 2019. When time binds: substitutes for household production, returns to working long hours, and the skilled gender wage gap. Journal of Labor Economics 37 (2): 351-398.

Deming, D. J., 2017. The Growing Importance of Social Skills in the Labor Market. The Quarterly Journal of Economics 132 (4): 1593-1640. DOI: 10.1093/qje/qjx022.
Dustmann, C., Ludsteck, J., Schönberg, U., 2009. Revisiting the German Wage Structure. The Quarterly Journal of Economics 124 (2): 843-881. DOI: 10.1162/qjec.2009.124.2.843.
Felfe, C., 2012. The Willingness to Pay for Job Amenities: Evidence from Mothers' Return to Work, Industrial and Labor Relations Review 65(2): 427-454.
Fitzenberger, B., Schnabel, R., Wunderlich, G., 2004. The gender gap in labor market participation and employment. A cohort analysis for West Germany. Journal of Population Economics 17 (1): 83-116. DOI: 10.1007/s00148-003-0141-6.
Frey, C.B., Osborne, M.A.: The future of employment. How susceptible are jobs to computerisation? Technological Forecasting and Social Change 114 (2017): 254-280.
Goldin, C., 2014. A grand gender convergence: Its last chapter. American Economic Review 104(4): 1091-119.
Goos, M., Manning, A., Salomons, A., 2009. Job Polarization in Europe. American Economic Review 99 (2): 58-63. DOI: 10.1257/aer.99.2.58.
Gregory, M., Connolly S., 2008. Feature: The Price of Reconciliation: Part-Time Work, Families and Women's Satisfaction. The Economic Journal 118 (526): F1-F7.
Ngai, L. R., and B. Petrongolo, 2017. Gender Gaps and the Rise of the Service Economy. American Economic Journal: Macroeconomics 9 (4): 1-44.
Olivetti, C., Petrongolo, B. 2016. The evolution of gender gaps in industrialized countries." Annual review of Economics 8: 405-434.
Olivetti, C., Petrongolo, B., 2017. The economic consequences of family policies: lessons from a century of legislation in high-income countries. Journal of Economic Perspectives 31(1): 205-30.
Petrongolo, B., and Ronchi, M. (2020). Gender gaps and the structure of local labour markets. Labour Economics 64: 101819.
Schönberg, U., Ludsteck J., 2014. Expansions in maternity leave coverage and mothers' labor market outcomes after childbirth. Journal of Labor Economics 32 (3): 469-505.
Spitz-Oener, A., 2016. Technical Change, Job Tasks, and Rising Educational Demands. Looking outside the Wage Structure. Journal of Labor Economics 24 (2): 235-270. DOI: 10.1086/499972.
Suedekum, J., Dauth, W. , Findeisen, S., Woessner N., 2017. German Robots – The Impact of Industrial Robots on Workers. CEPR Discussion Paper No.12306.
Weinberger, C., 2014. The increasing complementarity between cognitive and social skills. The Review of Economics and Statistics 96 (5): 849-861.

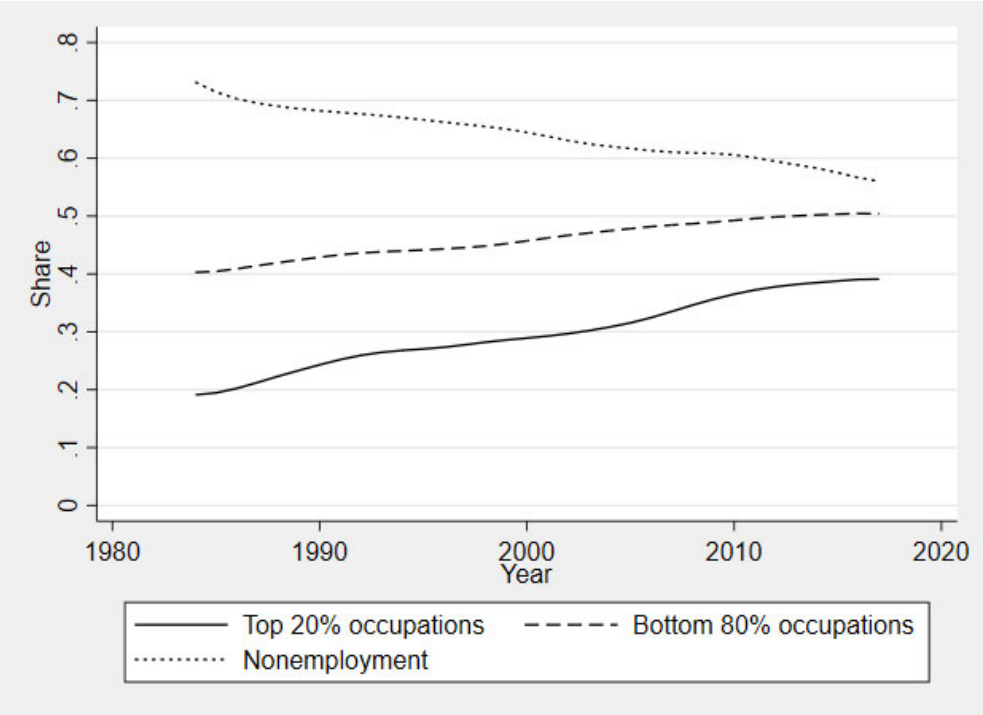
Appendix

Table A.1

Mapping of ISCO groups to task categories

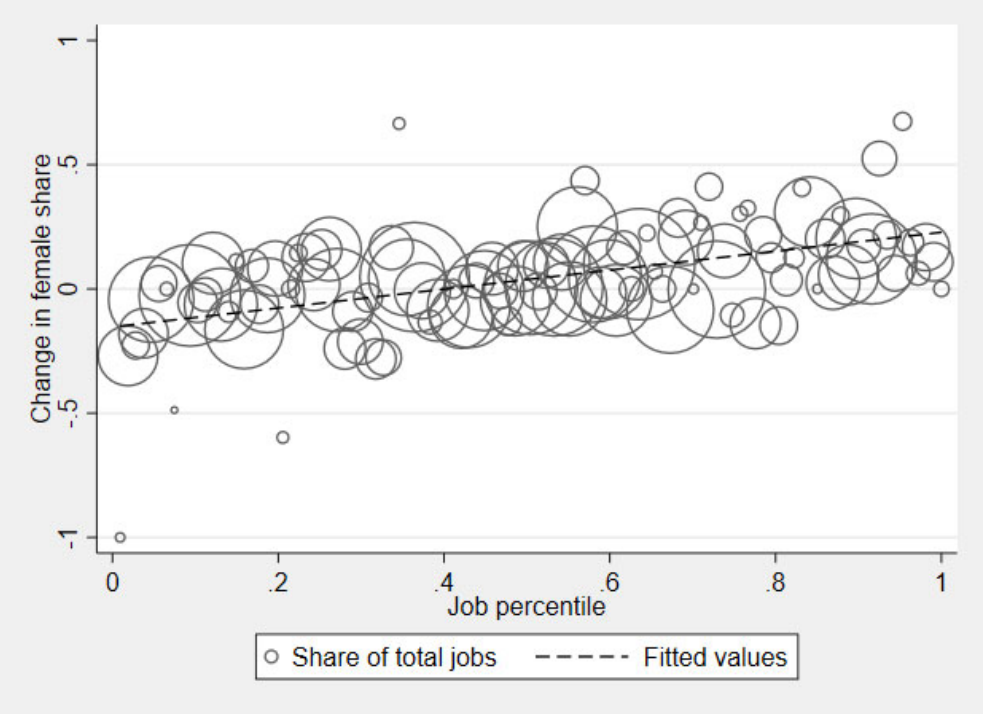
ISCO	Description	Task category
11	Members of legislative bodies and senior officials	NRC
12	Managing directors and divisional managers in large companies	NRC
13	Small business managers	NRC
21	Physicist, mathematician and engineers	NRC
22	Teaching professionals	NRC
23	University teachers	NRC
24	Other researchers and related professions	NRC
31	Technical experts	Cognitive
32	Life science and health professionals	Cognitive
33	Teaching associate professionals	NRM
34	Other skilled workers (medium qualification level)	NRM
41	Office clerks	Routine
42	Customer service clerks	Routine
51	Personal and protective service workers	NRM
52	Models, sales persons and demonstrators	NRM
61	Skilled agricultural and fishery workers	Routine
71	Extraction and building trades workers	Routine
72	Metal, machinery, and related trades workers	Routine
73	Precision, handicraft, craft printing and related trades workers	Routine
74	Other craft and related trades workers	Routine
81	Stationary plant and related operators	Routine
82	Machine operators and assemblers	Routine
83	Drivers and mobile plant operators	NRM
91	Sales and services elementary occupations	NRM
92	Agricultural, fishery and related labourers	NRM
93	Labourers in mining, construction manufacturing and transport	NRM

Figure A.1. Share of women in the top and bottom of the individual-level wage distribution and nonemployment



Notes: ISCO 3-digit

Figure A.2. Correlation between the growth in the female share in an occupation and the wage ranking of the respective occupation



Notes: ISCO 3-digit