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ScienceDirect
Research in Social Stratification and Mobility 25 (2007) 13–37
Research in Social Stratification and Mobility
http://elsevier.com/locate/rssm

Are female workers less productive than male workers?

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Received 1 August 2005; received in revised form 17 April 2006; accepted 31 May 2006

Abstract

This paper addresses whether there are productivity differences between men and women among blue-collar workers. We compare the wages under piece- and time-rate contracts of men and women working in the same occupation in the same establishment in three countries: the U.S., Norway, and Sweden. The findings are summarized in four points. First, the gender wage gap is smaller under piece- than under time-rate work. According to the interpretation put forth here, two-thirds of the gap at the occupation–establishment level is due to productivity differences, while one-third is not "accounted for," but could be due to discrimination or experience or other factors. Productivity differences between sexes in typically male-dominated blue-collar industries are however very small, of 1–3%: Sweden 1%, U.S. 2%, and Norway 3%. Second, in age groups where women on average have extensive family obligations, the wage gap is larger than in other age groups. Third, under time-rate work, the wage gap is more or less independent of supposed occupation-based productivity differences between men and women, while under piece-rate work, the wage gap mirrors quite closely assumed productivity differences, with women receiving a wage premium in female-advantageous settings and a penalty in male-advantageous settings. Fourth, in contrast to Sweden, in Norway and the U.S. women sort more often into piece-rate work than men.

Keywords: Piece- and time-rate contracts; Matched employer–employee data; Wage gap; Productivity; Sex and Productivity

1. Introduction

There is no question there is a gender wage gap: women on average earn 10–25% less than men in most industrialized nations. There are however endless questions concerning its causes. One prominent explanation holds that the gap reflects discrimination against women. Implicit then is the contention that men and women on average are equally productive. Under a legitimate system they should hence receive the same wages. Another and historically prominent explanation holds that women are less productive than men, so that even when they do the same work for the same employer, they produce less. It is thus legitimate that they also earn less, at least from an economic point of view.

It is exceptionally difficult to adjudicate between these two opposing claims. No adjudication exists and none is in sight, simply because the central variable on which both explanations rest – productivity – is difficult to observe and measure. Where productivity in principle is unambiguous, it is rare that researchers have access to records thereof. More often, what constitutes productivity is ambiguous, as in many types of service and professional work, and how to measure it at the individual level is clear neither to employers nor to social scientists.

However, in some work settings one has better access to reasonable measures of productivity than in others. Where piece-rate work is performed, wages earned should on average match productivity, so that variation in

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doi:10.1016/j.rssm.2006.05.002

wages, for the same work for the same employer, in principle should reflect variations in productivity. As Goldin (1990, p. 114) observed: "There is no clearer case of an individual who is paid her marginal product at every instant in time."[1] Under piece-rate work one is paid in proportion to what one produces, while under time-rate work wages are independent of output.

It is moreover the case, and for the present purpose important, that it is harder to discriminate on the basis of gender in terms of wages paid under piece- than under time-rate work, because under the former one gets paid for what is produced while under the latter one gets paid for being available for producing. This is forcefully expressed in the 1957 Equal Pay legislation in the European Union. Paragraph 3 of Article 119 provides (Ellis, 1998, p. 64): "Equal pay without discrimination based on sex means ... that pay for the same work at piece rates shall be calculated on the same basis of the same unit of measurement."[2]

These two considerations, that wages under piece-rate work reflect productivity and that it is more difficult to discriminate on the basis of gender under piece-rate work, lead to the following three observations. Each of them may provide some progress toward solving the two opposing claims regarding the extent to which the wage gap reflects productivity differences or discrimination.

First, to the extent that the gender wage gap reflects productivity differences, not wage discrimination, one should expect to find the same gap under piece- as under time-rate work. In both cases, the gap reflects productivity differences.

Second, to the extent there is wage discrimination between men and women, but no differences in productivity, one should expect a wage gap under time-rate but none under piece-rate work.[3]

Third, to the extent that there is both wage discrimination and differences in productivity, one should expect a smaller wage gap under piece- than under time-rate work. The gap under the former will reflect productivity differences, while the gap under the latter will reflect the same productivity differences plus a discrimination component. The difference in the gaps under piece- and time-rate work gives an estimate of the discrimination component of the wage gap.[4]

Such, then, is the overall situation. But there are important variations within it. In his extensive study of piece-rate work, effort, and wages, Max Weber remarked: "On the work suitability of the genders there are hardly any exact investigations." This is followed by the statement that on the one hand, "It is beyond doubt that within the linen textile factory men are at an advantage on the wide machine (for bed clothing and the like)," while on the other hand, "At the handkerchief machine it appears to me that females decidedly are best suited." In other kinds of work he finds that men and women contribute equally: "On the machines for the narrow linen it seems that male and female work compete, to the extent that able female workers show at least the same output as the able men" (Weber [1908]1924, p. 163, our translation).[5]

With Weber's remarks in hand, one would expect that women are at an advantage in some kinds of work, work that could be termed "female advantageous." In those lines one should observe that women earn more than men, at least under piece-rate work. In other kinds of work, for example, those involving heavy lifting, men should be at an advantage, and it could be termed "male

[1] This point was observed and extensively developed already by Max Weber. In his study of piece-rate work and productivity he used wages earned under piece rates as indicators of productivity and reported many statistics similar to those we report below (Weber, 1908[1924], esp. pp. 167, 177). Several others have made the same point (e.g., Foster & Rosenzweig, 1993, p. 771; Phelps Brown, 1977, p. 158; Rhoads, 1993, p. 141; Shearer, 1996, p. 276).

[2] There may obviously be discrimination with respect to who gets to do piece- versus time-rate work, and among those who do piece-rate work, who gets to do which piece-rate jobs.

[3] The lesser amount of discrimination between men and women under piece-rate work has been observed by historians of work. Scranton (1989, p. 401), writing on the Philadelphia textile industry around 1920, observes: "The generality of piece rates made gender shifts valueless unless dual male–female schedules for the same work were implanted. Of this there is no evidence in Philadelphia textiles, though sex segregation of jobs was widespread." This was not a universal practice, at least not in other national contexts. For France, Downs (1995, p. 59) reports a female piece rate set at 55% of the male rate for the same work at Renault in 1916 with similar numbers for the rest of industry. She also reports a move in Britain during World War I to equalize piece-rate schedules between men and women, but with no similar move to equalize time-rate wages for the same work (Downs, 1995, pp. 115, 300). Biernacki (1995, p. 426, no. 174) reports arguments for equal piece rates between men and women in Britain already in 1891: "British workers articulated the right of women workers to equal pay with men on the ground that the finished products were indistinguishable: 'When a manufacturer sells a piece he does not tell the merchant that it has been woven by a woman'." The same sentiment appeared in France during World War I, expressed as (Downs, 1995, p. 114): "...; each piece produced should be paid according to what it is worth and not according to who made it." For similar U.S. practices in the 1930s, see Milkman (1987, p. 21).

[4] This point was observed by Goldin (1990, p. 105) who also made some computations along these lines based on the U.S. wage data from 1890, as did Weber (1908[1924]). See also Gunderson (1975) for Canada and Chen and Edin (1994, chap. 3) for Sweden.

[5] Here, as below, translations from German, Norwegian, and Swedish were done by Trond Petersen.

advantageous." Here one should expect that men earn more than women and that the wage gap is larger than elsewhere.

From these analyses also arise a question about sorting of men and women into payment schemes. If there is discrimination against women under time rates, then in order to escape it women may more often than men choose to work under piece rates. But this will affect the wage gap, as will be explained in the next section. Specifically, a wage gap under piece rates need no longer reflect productivity differences but may be contaminated by the effects of differential sorting of men and women.

Against this background our investigation focuses on four processes. *First*, we investigate the gender wage gap under piece- and time-rate work, respectively, comparing men and women working in the same occupation in the same establishment, which we refer to as the occupation–establishment or job level. This will shed light on the extent to which the gap reflects productivity differences versus discrimination. It is important here to note that productivity differences between employees most meaningfully can be assessed at the occupation–establishment level. The reason is simply that in most employment settings productivity gets jointly determined by the person and the job (e.g., Granovetter, 1981). This makes comparison of productivity of employees in different jobs difficult, but allows within-job comparison. Across jobs one cannot easily disentangle the individual contribution from that of varying technologies, market conditions, etc. It is similar to sports competitions: one can easily determine who is the better runner, swimmer, or jumper, but comparisons across sports are less meaningful.

Second, we investigate whether the gaps vary according to life-cycle stage, as one should expect that having children impacts productivity, as elaborated in the next section.

Third, we investigate how the wage gaps vary according to whether men versus women are believed to be at an advantage in terms of productivity for the type of work in question. This will provide additional information on the extent to which the gap reflects productivity differences versus discrimination.

Fourth, we investigate the extent to which women tend to sort into piece-rate work more often than men, which may contaminate any inference about productivity differences under piece rates.

Our focus is on blue-collar work. This may help illuminate matters maximally. Not only is this the setting where piece-rate work is and has been most prevalent, it is also in blue-collar work that women stereotypically have been seen to suffer their greatest productivity disadvantages, rather than in, for example, clerical, caring, and teaching work (e.g., Williams, 1995, chap. 7). At the same time, there are sufficient variations within blue-collar work to identify settings where women at least stereotypically are at a productivity advantage. If a big overall productivity gap is found in work where women are negatively stereotyped, then the stereotypes were accurate. If not, however, it has implications for how one should view women's relative productivity not only in stereotyped but also in work that is not so. There is then all reason to expect that women in occupations where they are not negatively stereotyped are equally or even more productive than men. And it is this kind of work that has grown most in importance over the last 50 years: much work in modern industries and occupations demands less in terms of classically masculine traits. Frederick W. Taylor saw it coming: "The Gorilla types, are no more needed." (cited from Milkman, 1987, p. 17).

The research will use unique individual-level data on wages, occupation, payment system (piece versus time rate), and sex, from several thousand establishments and more than 1 million employees, from the U.S. in the period 1974–1978, from Sweden in 1990, and from Norway in 1990. The U.S. and Scandinavia are the vanguards when it comes to gender equality: the U.S. in legal regulation of the workplace, Norway and especially Sweden in family policies aimed at making it easier to combine family and career. Intrinsic interest attach to these cases simply because they might foreshadow the direction other rich nations eventually might move in the gender equality sphere. The choice of countries was determined by data availability. Focusing on three rather than only one country is relevant in so far as this can demonstrate that the processes extend across cultural contexts.

Research evidence, scant as it is, suggests a substantial sex differential in productivity, potentially justifying a major gender wage gap. Phelps Brown (1977, p. 158) writes that "in many employments there are objective reasons for the work of women being of lower net value than that of men," drawing partially on Sanborn's (1964) comparison of wages under piece-rate systems. With data and computations similar to the present study, he reports a productivity gap of 10–13% in the U.S. footwear and furniture industries in the 1950s (see also Gunderson, 1975; Rhoads, 1993, p. 141). The present study, which is more comprehensive, somewhat more recent, giving data from the 1970s in the U.S. and 1990 in Norway and Sweden and covering three countries, supersedes these findings. Another line of

research using plant-level data on value added finds that women are about 15% less productive than men (e.g., Hellerstein, Neumark, & Troske, 1999). The significance and meaning of that research will be discussed at length and compared to the present study in the conclusions.

While the analyses address an important question, there are clearly significant measurement and other problems in the data we present. These should not impede precise analysis, only caution against undue inflation of its precision. Because the problem is important but difficult to analyze, we shall be explicit about the central shortcomings of the results. We believe the consistency of patterns across countries, together with the quality and extensiveness of the data, lend considerable credence to our findings, providing the to-date and possibly for-some-time-to-come most comprehensive analysis of the phenomenon. But we do not decisively settle it. For that we need entirely new types of data, namely individual productivity records, data unlikely to be made available on a large scale and likely to be restricted to a few specialized jobs, as among the auto glass installers in Lazear (2000), or the output of 185 production workers in a machine shop in Burawoy (1979, chap. 9), or the number of calls handled in a call center in Fernandez, Castillo, and Moore (2000). Such studies have yet to cover a large number of employees, a broad array of occupations, or several countries.

2. Productivity differences

We now elaborate on what has been written and what is known about the four questions outlined in Section 1, with each subsection below providing the conceptual background for one of the four empirical Sections 5–8, each addressing one question. Much of this scholarship is historical.

2.1. Question 1: overall productivity differences

The *first* question addresses whether women overall, with no attention to variations between occupations and industries, are less productive than men. In some scholarly writing, and in some popular opinion, women are generally held to be less productive than men. If not always entirely explicit, the contention is there, at least as an important undercurrent (e.g., Phelps Brown, 1977, p. 158; Rhoads, 1993, pp. 12–14, 141–42). It is however probably fair to say that to the extent there currently is a central explanation and also implicit justification for the gender wage gap, it is that men and women do different kinds of work, are employed in different firms, and so on but not that they differ greatly in innate productive capabilities.[6]

Historically, however, this was not the central justification. Rather, women were plainly viewed to be less productive than men in most situations. This might have been due to lack of physical strength, lack of initiative, family responsibilities, more sick days, etc., and jobs were correspondingly divided into those suitable for each sex, such as light work for women and heavy for men. If such is the case, lower wages are on average legitimate. In 1893, Clara Zetkin, the leader of German socialist women, stressed "women's categorical difference from men: they were physically different," leading her to deny that "total equality between men and women ever be possible because of biological difference" (from Schmitt, 1995, p. 137).[7] We shall first address whether there is evidence that women overall are less productive than men, without any distinction with respect to the kind of work done or to family responsibilities.

2.2. Question 2: productivity gap by life-cycle stage

The *second* question relates to one particular alleged cause of women's lower productivity: the impact of family responsibilities. In periods where women have extensive family obligations, such as caring for small children, they may on average be less productive than men in the same age groups (e.g., Becker, 1985). This relates to an older historical phenomenon and discussion, which may help illuminate the issue. Before and at the turn of the 20th century, and especially up through the 1920s and 1930s, many organizations practiced a so-called marriage bar under which married women were not hired and women upon marriage or childbirth often were fired.[8]

[6] See, for example, Goldin (1990, p. 69), Petersen and Morgan (1995), and Reskin and Roos (1990, pp. 36–37, 49–52). Some occupational sorting can obviously occur due to underlying productivity differences. This may explain why some women are in low-paying occupations.

[7] In early 2005 in the U.S. such claims came to the fore in entirely unexpected ways as an explanation for the lack of women in the upper echelons of mathematics and the sciences. A speech by Lawrence H. Summers, then President of Harvard University, unleashed a vigorous debate in academia and newspapers as well as initiatives to increase the presence of women in such fields. The claim, widely found offensive, was that the lack of women in these positions in part is due to "differential aptitude at the high end, . . ." (Summers, 2005, p. 1). See Angier and Chang (2005) for an initial reaction to Summers' remarks and Pinker (2002, chap. 18) for the type of studies that he may have relied on.

[8] For the U.S., see Goldin (1991), for Norway see Hagemann (1994), and for Sweden see Hobson (1993).

The arguments supporting the bar were many. One common line was that women's proper role was in the home, that women were morally superior and that work would morally corrupt them (see Davies, 1982, chap. 5). Another justification was in terms of the family wage, where male breadwinners had to earn more in order to support a family. With high unemployment as was the case especially in the 1930s, married women had someone else to support them and should give up their work so that unemployed men or unmarried women could take their place. This was the moral economy of the working class, where work should be spread around to as many families as possible (Greenwald, 1989).

For the present purpose it is however the third argument that is of interest. Many employers argued that women upon marriage became less productive. This was a running concern in Weber's (1908[1924]) study, including a fascination with the relationship between preparation for wedding, marital status, sexual activity, and work effort and labor productivity. He writes (p. 168): "It seems ... [that] ... older, unmarried female workers, ... are still useful on the bobbin winder, and then, since immune against erotica, are quite especially useful. ..."[9] He also notes (p. 174) that male labor productivity depends strongly on marital status, higher among married than single men, opposite of the presumed relationship among women, as also found in Burawoy (1979, chap. 9).[10] In Norway, the marriage bar for telegraphists was justified in part by the claim that the employer "had the right to the full work of the employee without the reduction stemming from the work a married women would have to do in the home" (Hagemann, 1994, p. 256). As Strom (1992, p. 391) reports for the U.S., "Employers who were opposed to hiring women gave a variety of explanations, many of which focused on the transference of the married women's allegiance from job and employer to home and husband." The sociologist Mary Schauffler, in her 1927 study of three clerical occupations, reported about married women that "Employers say they are too independent in their attitude, they are apt frequently to be absent and late, ..." (cited from Strom, 1992, p. 392).

Goldin (1991, pp. 525, 527) claims that the marriage bar was closely related to concerns about productivity, stating as evidence that (p. 527) "The bars, interestingly, were rarely found among factory operatives for whom piece-rate payment often was used (47% of all female operatives in the 1890s were on incentive pay) and for whom, therefore, the relationship between earnings and productivity was strictly maintained." She continues, "The marriage bar was most often found among firms and sectors having internal promotion and regular salary advances, and among local school boards having fixed salary scales. The sectoral distribution creates a prima facie case that the marriage bar emerged when the relationship between pay and productivity was severed."

These concerns about family responsibilities and their impact on productivity were important historically for many institutional barriers to women's employment. But they appear also in contemporary employment. Hanson and Pratt (1995, p. 157) report on employer attitudes in their study of Worcester in Massachusetts: "Many employers use familial ideology to frame women workers; their stereotypes about women are tied to assumptions about the way that family arrangements will affect their productivity as employees."

To assess indirectly the impact of family obligations we address, in our second question, whether relative productivity varies with life-cycle stage. Specifically, we investigate whether the gap is larger in periods when family obligations peak.

2.3. *Question 3: male- versus female-advantageous occupations*

The *third* question we address concerns the claim that one should expect women to be at a productivity advantage in some lines of work, while men to be at an advantage in other lines. Stereotypes have been around for a long time (Kessler-Harris, 1982; Reskin & Hartmann, 1986, pp. 41–42; Williams, 1995, chap. 7). Not all but some of these are probably accurate statistical generalizations. For example, in the U.S. automobile industry, one finds the statement from 1943: "On certain kinds of operations – the very ones requiring high manipulative skill – women were found to be a whole lot quicker and more efficient than men." Or from the electrical industry in 1942: "..., so the job requires feminine patience and deft fingers," and further, "Westinghouse finds that women can handle these minute parts, ..." (all citations from Milkman, 1987, p. 59). The War

[9] Later Weber continues (p. 174): "... the in no way irrelevant sexual life of the worker in relationship to the work effort has altogether not been researched," lamenting the lack of research on coital frequency by the medical profession.

[10] Weber (1908[1924], p. 174) further remarked that for some women it is not obvious that marriage will have a detrimental effect on productivity because it may lead to a more well-ordered life style. And for male workers he identified some offsetting effects of marriage, including a finding that married men seem to suffer more from stomach and intestinal diseases, which he attributed (p. 173, no. 3) to the "culinary disqualifications of the working-class wives."

Labor Board concluded, "If men were to be substituted for women on the so-called women's jobs, there would probably be a very real loss in efficiency and productivity since it is recognized that men are not as well adapted as women for light, repetitive work requiring finger dexterity." (cited from Milkman, 1987, p. 81). Such stereotypes, considered as accurate statistical facts, appear also in a number of court decisions. In a European sex discrimination case, the court wrote that "... demand on the muscles, may in fact tend to favor male workers, since it may be assumed that in general they are physically stronger than women workers, ..." (from Ellis, 1998, p. 158).

Similar sentiments are found both in Norway and Sweden. One forceful governmental report from Sweden states (Kock, 1938, pp. 368, 383, 385, 388): "For some types of work women are clearly more suited than men," stipulating that this holds where good color view, ability to judge appearances well, and finger dexterity are needed. In fact, "In a number of areas women's superiority in the work done is so high, that one could not do without them." In other kinds of work it is equally clear that men are more productive, such as in some parts of manufacturing where physical strength is needed and in meat cutting "where women cannot manage the cutting knife as well as men." The identical stereotype was found in meatpacking in the U.S., where "handling the knife" was not considered women's work (Abbott & Breckinridge, 1911, p. 639).[11]

There are also interesting instances of attempts to gender-type certain kinds of work using arguments about presumed productivity advantages but where various parties disagreed on which sex constituted the superior class of workers. For example, in the printing industry, with the introduction of the Linotype typesetting machine in 1885–1905, the U.S. employers argued that "The machine is specially suitable for female use," also claiming this was in part so because the work was intellectual (cited from Baron, 1992, p. 78). Unions on the other hand sought to gender-type the work as masculine, stressing that it required strength and endurance, was dirty, and that women lacked the mental abilities needed (Baron, 1992, p. 80). A report by the U.S. Bureau of Labor Statistics from 1906 sides with the union in this matter: "The high average speed maintained by Linotype operators is the foremost factor in preventing the displacement of men by women in this line of work" (cited from Baron, 1992, p. 82).

These views are not just historical antics. They show up in contemporary employment relationships as well. Hanson and Pratt (1995, p. 210) write: "... women are valued for their stability and loyalty but employers also mentioned women's capacity to doing boring, repetitive work and their superior manual dexterity." Here too employers refer to women's "nimble fingers" (p. 210), but many refer to their physical weakness as well, stating that "Women can't do heavy work." Or from Scandinavia in 2003, the Finnish Equality Ombudsperson in a complaint letter to its counterpart in Norway accused Norwegian fish factories of refusing to hire Finnish men as filet cutters, while routinely hiring Finnish women for the same jobs, claiming that refusal to hire was because of their sex. The Norwegian daily *Aftenposten* (Nilsen, 2003) called several employers in the industry. One response was: "This is so simply because Finnish women produce more than the men. This is not the case only for Finnish women, but also for Norwegian. The women have smaller hands and are faster. We don't want Norwegian men either."[12]

To sum up our third question, we investigate settings where men versus women are thought to be more productive, in male- versus female-advantageous occupations, assessing whether the wage gaps match presumed productivity differences. Here there has been much writing but as Weber noted "hardly any exact investigations."[13]

[11] Downs (1995, pp. 110, 213) reports identical considerations in various French and English industries during World War I, where women are praised for their extraordinary productivity at some tasks, stressing their biological advantages in the form of "nimble little fingers," ability to endure monotonous work, work requiring eye acuity, and so forth.

[12] In one contemporary context marked innate productivity differences between men and women does lead to complete sex segregation. In sports the rule is separate teams, competitions, and requirements for men and women, with some sports done only by men others only by women, with men outperforming women in most sports. As Epstein (1992, p. 293) writes: "That a given physical task in general imposes a heavier toll on women than men is a statistical truth, which is not overridden by the common exceptions of powerful women and frail men that we all encounter in everyday life." One could of course imagine sports developed specifically to take advantage of female physique where men on average would be at a disadvantage.

[13] Productivity differences have been extensively discussed in contemporary firefighting. Few women have held firefighter jobs and still few do. In firefighter tests the 20% fittest women perform about as well as the 20% least fit men, so that in New York the top female applicant came in "at number 4652 of 21,000 and the next appeared after a drop of about two thousand names" (Olson, 1997, pp. 181–82). Physical strength is exceptionally important in this setting and there is no question that men on average are better fit for the occupation, not to deny that sexism has existed and probably still exists in such work. But this is an unusual type of work and it would be an error to invest much energy discussing relative productivities in that setting. Similar differences are found in some jobs in the military (Epstein, 1992, p. 277; Gutmann, 2000).

Table 1
Relative wages between women and men for time- and incentive-rate workers, according to productivity differences and discrimination regime

Discrimination	Productivity differences by sex		
	No	Men more productive	Women more productive
No	No wage gap	Wage gap in favor of men, same under time and piece rates	Wage gap in favor of women, same under time and piece rates
Yes	Wage gap in favor of men under time rates, no wage gap under piece rates	Wage gap in favor of men, larger under time than piece rates	Wage gap in favor of women under piece rates, direction of wage gap under time rates is not decidable

Notes: For description of the issues see Section 1. There are two discrimination regimes, no discrimination and discrimination against women, ignoring possible discrimination against men. The wage gap refers to the average female wage as percent of the average male wage, at the occupation–establishment level under piece and time rates, respectively.

A summary of the central ideas outlined here with respect to Questions 1–3 regarding the wage gap is given in Table 1, where the two dimensions or independent variables are discrimination regime and productivity differences, while the dependent variable is the wage gap under time- and piece-rate work, respectively.

2.4. Question 4: sorting into payment schemes

The *fourth* question we address is whether men and women tend to sort into one payment scheme rather than another.

A sizeable economics literature has addressed not only how piece-rate systems may induce workers to expend more effort but also how they may serve to sort low- and high-productivity workers into time- and piece-rate jobs (Lazear, 1986, 2000). The idea is that only for workers above a certain productivity level will it pay to work on piece rates because only those workers will tend to produce above the minimum output required in order to make any piece-rate earnings. Output below the minimum receives a low guaranteed wage, which is all that low-productivity workers typically will be able to get.

Such sorting may result in unexpected effects. One scenario occurs when men and women on average are equally productive, so that if all men and women worked under the same payment system (e.g., piece rates), then their observed average productivity would be identical and if there is no discrimination so would wages be. But if there is some wage discrimination under time and none under piece rates, then various perverse effects may emerge. What could happen is that a higher proportion among females than males would choose to work on piece rates, due to its lack of penalty for being female. But then, from an initial position of identical productivity distributions by sex, a remarkable result would ensue: women would under both piece and time rates on average be less productive than men. The precise mechanism is this. Suppose that the 30% most productive females choose piece rates while only the 20% most productive males would do so. On piece rates, then, one excludes in terms of productivity the lower 70th percentile among females and the lower 80th percentile among males, thus getting a female group that on average is less productive. Conversely, among time-rate workers we would find the lower 70th percentile among females and the lower 80th percentile among males. So females would also on time rates on average be less productive because they do not include the workers found between the 70th and 80th percentiles in terms of productivity.

These effects are perverse but are the logical outcomes of entirely understandable processes. Employers may assume women to be less productive than men and hence offer lower wages to women under time rates, while under piece rates both sexes receive wages commensurate with their productivity. After men and women have self-selected themselves into the two schemes the women on average become less productive than the men under both systems. This confirms the employer's assumptions and prejudices, making them a self-fulfilling prophecy. It becomes so not due to any underlying productivity differences between men and women, but rather is forced upon women by the discriminatory behavior of employers under time rates making relatively more women self-select into piece-rate systems. This in turn justifies the employer's initial behavior, to pay women less than men under time rates. The wage gaps observed under the two systems are not representative of underlying productivities as these would be observed in the absence of discrimination. Without discrimination and thus self-selection, men and women would on average be equally productive under each of the two payment systems.

If this scenario is correct one should observe two things. First, there should be a wage gap under both time and piece rates, perhaps larger under the former, because

the latter does not have the discriminatory component. Second, proportionally more women than men should be on piece rates.[14]

Against this scenario one may object that workers rarely have as much choice between payment systems as is here presumed. In most cases, workers must accept a given type of job and the payment system that goes with it.

In summary of our *fourth* question, we assess the extent of sorting by sex into payment schemes.

3. Data

We use extensive and unique data sets from three countries: the U.S., Norway, and Sweden, covering the periods 1974–1978 (U.S.), 1984 and 1990 (Norway), and 1970–1990 (Sweden). For Norway and Sweden we emphasize the most recent year 1990. We describe the U.S. data in most detail. The corresponding Norwegian and Swedish data are similar, but contain more information.

The U.S. data come from eight Industry Wage Surveys conducted by the U.S. Bureau of Labor Statistics in the period 1974–1978, corresponding to industry codes at three and more digits as defined in the *Standard Industrial Classification Manual* (U.S. Executive Office of the President, 1987). All are in the manufacturing sector.[15] The populations for the surveys and the sampling frames are described in various U.S. Department of Labor publications (e.g., 1977a, p. 40).[16] The selection of industries was to a large extent determined by availability from the Bureau of Labor Statistics. We have information on 298,997 individuals working in 356 occupations, 2669 establishments, and 29,474 occupation–establishment units (see Petersen & Morgan, 1995, Table 1).

In each industry, the Bureau of Labor Statistics drew a sample of several hundred establishments, often covering 80–90% of the establishments and production workers in the industry. Establishments with fewer than 20 employees are underselected. For each establishment, information was obtained from establishment records, both on establishment characteristics and on a large number of the production workers in the establishment. Within each industry, a selection of occupations was surveyed, providing a wide representation of production occupations in the industry. The individual-level data, on tapes purchased from the Bureau of Labor Statistics, provide information on each individual in the relevant occupation and establishment, as well as on characteristics of the establishment in which the individual worked.

For each employee surveyed, information was obtained on sex, occupation (an industry-specific code), method of wage payment (piece or time rate), and hourly wages. No information was collected on race, age, experience, or education. The occupational classification is unusually detailed, corresponding in many cases to nine digits in the *Dictionary of Occupational Titles* (see U.S. Department of Labor, 1977b). In other cases, the titles are specific to the Bureau Labor Statistics data, based on industry-specific codes, but are usually as detailed as nine-digit DOT titles.[17] Within such detailed occupations, there is probably little variation in educational credentials.

Wage data are given in hourly units, excluding premium pay for overtime and work on weekends, holidays, and late shifts. Thus, we do not conflate pay earned in regular hours with pay from overtime and irregular hours, making the wage data less prone to bias than virtually any other study. Men work more overtime hours than women, due either to preference for or better access to overtime hours, and overtime hours are usually paid at a higher rate. Nonproduction bonuses, such as year-end bonuses, are excluded (e.g., U.S. Department of Labor, 1977a, p. 40).

For Sweden we have access to the database on wages collected by the Central Confederation of Employers

[14] Results from experimental economics also suggest that there are sex differences among undergraduates at U.S. colleges in both performance under and preferences for working under various payment schemes (Gneezy, Niederle, & Rustichini, 2003; Niederle & Vesterlund, 2007). Women perform relatively worse under and steer away form competitive reward systems. In the experiments this occurred under tournament systems, where the reward of each individual depends on how other individuals perform. Under piece-rate systems, where each worker is judged relative to a fixed reward schedule but not relative to how others do, women perform well and prefer these to the competitive tournament systems.

[15] The industries are: nonferrous foundries, textile dyeing and finishing, cotton and manmade fiber textiles, wool textiles, men's and boys' shirts, miscellaneous plastics, wood household furniture, and fabricated structural steel. The results in Table 2, combining all eight industries, are also available separately for each industry from Trond Petersen upon request.

[16] For a full listing of the publications see the note to Table 1 in Petersen and Morgan (1995).

[17] The occupational codes are reported on "job lists" and are intended to reflect jobs in the establishments surveyed. We are therefore able to report within-job wage differences. A job is commonly defined (e.g., Treiman & Hartmann, 1981, p. 24) as a specific position, with particular duties and responsibilities, in a specific setting, such as grinder in a given establishment. To get a sense of the level of detail, see Petersen (1991) for a listing of the occupations in the nonferrous foundries industry.

(SAF). These data contain information for all blue-collar workers in every industry in the private sector within the SAF domain. For 1990 the data cover 643,349 individuals working in 1849 occupations, 23,544 establishments, and 87,640 occupation–establishment units, which is about 36% of employees in the Swedish private sector and a much higher percentage in the manufacturing industries. Member firms have been providing information to the database from 1970 to 1990, yielding a panel of individuals and establishments for a 21-year period. The data come from establishment records, have been used as inputs in annual wage negotiations, and are monitored by SAF and the labor unions. They are of very high quality. See the more detailed description in Meyersson Milgrom, Petersen, and Snartland (2001).

For each employee surveyed, information was obtained on sex, method of wage payment (piece or time rate), age, hours worked, part- or full-time employment, union status and if unionized the name of the union, and a detailed description of job content. The occupational codes are industry specific. The data cover practically the entire occupational spectrum for blue-collar workers.

The wage data are reported in an unusually detailed manner. For each individual, the wages and hours worked are reported separately for those earned during regular and those earned during overtime hours. Wages are given in hourly units. The computations of the wage gap are done for wages earned in regular hours. Furthermore, for employees who alternate between time- and piece-rate jobs, the wages are specified separately for the two wage forms.

The Norwegian data parallel the Swedish, collected by the Norwegian Confederation of Employers. For the blue-collar workers analyzed here, we have information on 165,249 individuals working in 317 occupations, 6200 establishments, and 24,502 occupation–establishment units (see Petersen & Snartland, 2004; Petersen, Snartland, Becken, & Olsen, 1997), covering a substantial proportion of workers in the manufacturing sector.

In the analyses, we restrict the number of observations used in several ways. The main restriction is that the occupation–establishment units for which we compute the wage gap must be sex integrated for the given wage form, so that men and women work side-by-side either under piece or under time rates in the same occupation and same establishment unit. This reduces the number of individuals on which the analysis is based. The notes to the tables list the number of observations used for occupations, establishments, occupation–establishment units, and for employees paid in each of the wage forms.

3.1. Caveats

Four clarifications and qualifiers are needed. First, crucial to our analysis is the assumption that variation in piece-rate wages reflects variation in productivity. It is fairly obvious that this is so at the occupation–establishment or job level at which our analysis is conducted. There can be some but unlikely systematic deviations here. It is important to understand that effort and skill on the one hand and the actual output on the other at times can be less than perfectly correlated, as when an employee operates defective machinery or gets inferior input materials, in which case high effort nevertheless can result in low output. But actual output (or productivity) and actual pay are without exception correlated under piece-rate systems. There is strong agreement on this in the literature (Foster & Rosenzweig, 1993; Goldin, 1990, p. 114; Phelps Brown, 1977, p. 158; Rhoads, 1993, p. 141; Sanborn, 1964; Shearer, 1996). However, the relationship between productivity and pay under piece rates can at times be more complex than usually assumed. Variation in wages will not always perfectly reflect variation in productivity. The reason is simply that piece-rate systems are not always perfectly colinear with productivity, mostly because they contain a guaranteed wage in addition to a piece-rate component. Depending on the relationship between the guaranteed wage and the piece-rate schedule, wages typically either reflect productivity perfectly or understate it somewhat, so that a 10% increase in productivity will result in less than a 10% increase in wages. In the discussion of our results we shall abstract from this complication, proceeding as if we had wage data that perfectly matched variations in productivity. Despite this imprecision, piece-rate wages probably provide the best measure of productivity that can be assembled on a large scale and perhaps our best hope for gaining an advantage on the problem.

Second, we study wages at the occupation–establishment or job level, where men and women do the same work for the same employer, the level at which productivity differences most meaningfully can be assessed. At that level, wage differences between men and women tend to be small (for the U.S., Petersen and Morgan, 1995; for Norway, Petersen et al., 1997; for Sweden, Meyersson Milgrom et al., 2001). We thus compare variations around a small baseline. But that wage gap pertains mostly to time-rate workers, since the majority of workers are paid on time rates. One should expect considerable wage compression and a small wage gap under time rates, in part due to equal pay laws. But under piece rates – where wages by law are exempted from being

equal by sex and instead legislated to be commensurate with productivity – there is however no logical or other reason that the wage gap should be small. The tie between productivity and wages should in itself induce considerable wage dispersion and hence the possibility of larger wage gaps. The small gap under time rates may even make our analysis more forceful. If we find evidence of productivity differences under piece rates, it is unlikely that these primarily reflect a practice where women are paid less than men, due to the small gap under time rates, but more likely reflect actual productivity differences. Or if about the same small wage gap is found under time and piece rates, then that documents trivial or no productivity differences between the sexes, and that whatever gap is found under time rates may also correctly reflect a small or no productivity difference.

Third, it might be objected that under piece-rate systems there may be social pressures among workers to produce the same amount of output, thus resulting in same productivity, less wage dispersion, and also in a lower or no gender wage gap. But this is not necessarily the case. In Norway, as reported in Petersen and Snartland (2004, Tables 2 and 8), there is more dispersion in wages under piece- than under time-rate jobs. Specifically, among the subset of workers who switch between piece- and time-rate jobs, the standard deviation and the coefficient of variation of wages are 100 and 50% higher under piece than under time rates. Similar computations were made for the Swedish data, showing again more wage dispersion under piece- than time-rate work, though not as pronounced as in Norway.

Fourth, it may be the case that the sex differential in productivity depends on the payment form itself, as shown in the laboratory experiments in Gneezy et al. (2003). If so, productivity differences under piece rates may be different from those under time rates. Results about the differences under piece-rate systems will still be correct, but will not extend to differences under time rates. Our attempt to estimate the discrimination component in the wage gap under time rates will then fail.

4. Methods

For our first research question, we computed first the average female wage as a percentage of the average male wage at the occupation–establishment level, separately for time- and piece-rate workers. This was done for men and women being paid on the same wage form working in the same occupation and establishment, the level where productivity most meaningfully can be assessed. Then an average of this gap was taken across the sex-integrated occupation–establishment units for the given wage form. See Appendix A for technical details. A relative wage of 100% corresponds to wage parity, while numbers below 100 correspond to a wage gap against women, thus the further below 100% the larger the gap; the closer to 100% the smaller the gap.

For our second question, we compute the same wage gaps, but now separately by life-cycle stage, first using graphs for 5-year moving averages and next for each of five age groups defined by 10-year intervals.

For our third question, we turn to a separate analysis of the wage gap for a selection of occupations that we judge to be female versus male advantageous in terms of the productivity of the sexes, doing the same computations as above.

Finally, we study whether women sort more often into piece-rate work than men. We present measures of sex segregation on payment schemes.

5. Results 1: overall productivity differences

Table 2 gives an initial view of our central message, reporting in columns 1 and 2 the gender wage gap for piece- and time-rate workers, respectively. The

Table 2
Gender wage gap at the occupation–establishment level among workers on piece- vs. time-rate contracts, in the U.S., Norway, and Sweden

	Piece rate 1	Time rate 2	Productivity differential 3	Discrimination component 4
U.S.	98.28	97.55	−1.72	−0.73
Norway	96.98	96.16	−3.02	−0.82
Sweden	98.97	98.48	−1.03	−0.49

Notes: The gender wage gap is first computed for each occupation–establishment unit that employs workers of both sexes and offers the same payment scheme to both sexes (piece or time rate). Then an average of this gap is computed across all relevant occupation–establishment units. Column 3 is computed as the number in column 1 minus 100. It gives the estimated productivity gap between men and women. Column 4 is computed as column 2 minus column 1. It gives the estimated discrimination component of the wage gap between men and women. The number of cases, in terms of occupations (N_o), establishments (N_e), occupation–establishment units (N_{oe}), number of women (N_f), and number of men (N_m), are as follows: for the U.S., under piece rates—$N_o = 136$, $N_e = 486$, $N_{oe} = 1161$, $N_f = 19{,}000$, $N_m = 13{,}400$, and under time rates—$N_o = 239$, $N_e = 1231$, $N_{oe} = 3101$, $N_f = 35{,}361$, $N_m = 29{,}205$; for Norway, under piece rates—$N_o = 95$, $N_e = 256$, $N_{oe} = 414$, $N_f = 4235$, $N_m = 8231$, and under time rates—$N_o = 200$, $N_e = 2266$, $N_{oe} = 3394$, $N_f = 22{,}656$, $N_m = 55{,}606$; for Sweden, under piece rates—$N_o = 500$, $N_e = 2300$, $N_{oe} = 5653$, $N_f = 62{,}174$, $N_m = 112{,}709$, and under time rates—$N_o = 772$, $N_e = 6797$, $N_{oe} = 13{,}114$, $N_f = 107{,}597$, $N_m = 130{,}179$. Note that in each country the database itself is larger (see Section 3). The numbers above refer to units that are sex integrated for the given payment system, disregarding all totally sex-segregated units.

third column gives the wage penalty for being female under piece rates, computed as the wage gap in column 1 minus 100. This gives the estimate of the productivity differential. The fourth column gives the difference in the wage gaps between time- and piece-rate workers, computed as column 2 minus column 1. This is the estimate of the discrimination component, which to repeat, also could be due to experience and other factors not accounted for here. Note that all computations are based on occupation–establishment units that are sex integrated for each of the payment forms. In the first column, included are only occupation–establishment units where both men and women work under piece-rate systems, while the second column includes only units where both sexes work under time-rate systems. See the note to the table for the numbers of observations on which the analysis is based.

It is striking that in all three countries the gender wage gap is smaller under piece- than time-rate systems. In the U.S., Norway, and Sweden, women earn 1.72, 3.02, and 1.03% less than men under piece rates. Under time-rate work, in contrast, the wage gaps are 2.45, 3.94, and 1.52%. These gaps are larger than under piece-rate work, with 0.73, 0.82, and 0.49%.[18]

Given the interpretation forwarded here, one may, from column 1 or 3, infer that women in the three countries on average are 1.72, 3.02, and 1.03% less productive than men in typically male blue-collar occupations. This productivity gap shows up as a legitimate wage gap of 1–3% among piece-rate workers.

One should keep in mind that there is no necessary reason why the gap under piece rates should be smaller than under time rates. It could in fact be larger, in which case men may be discriminated against under time rates.

One can further conclude, for the interpretation put forth here, that within-job wage discrimination against women in these three countries is close to absent, amounting to as little as one half to a full percentage point (see column 4). Among time-rate workers then, for the wage gap at the occupation–establishment level about two-thirds would be legitimate, due to productivity differences, while about one-third would be due to within-job wage discrimination. As always, the residual wage gap could be due to other factors, such as age and experience, which may play a larger role in wage setting under time- than under piece-rate systems.

In summary, in all three countries there is evidence that women are slightly less productive than men, with about 1–3%, not a large productivity difference, certainly not one that can justify large gender wage gaps. There is also evidence that there could be some minimal residual within-job wage discrimination, of about 0.5–1%.[19]

Crucial to these analyses is that the wage gap is computed without controls for education and experience. These no doubt matter for productivity. But the pay received under piece rates is pay for productivity, with no separate bonus or differential for experience or education. The latter have an impact only insofar as they influence productivity. The employer's as well as our concern is whether there is a productivity differential, leading to a wage differential, but not the exact source of the differential, be it experience, education, work effort, or even machinery advantageous to one sex. For the piece-rate wages in the present analysis the correct gap is thus the uncorrected gap. Time-rate wages often contain elements of payoffs for education and experience. Within narrowly defined occupations, there is likely little variation in education but clearly some in experience. But for the present purpose, where comparisons to piece-rate wages are made, it is the uncorrected and rather small time-rate gap that must be in focus.

As mentioned in Section 3 on data, the scope for, as well as the actual wage variation at the occupation–establishment level, is higher under piece than time rates. It is thus perhaps surprising to find that the wage gap is somewhat smaller under piece than time rates, confirming first that there is roughly equal productivity by sex and second the assumption that it is harder to discriminate on the basis of sex under piece rates.

6. Results 2: productivity gap by life-cycle stage

It might be worthwhile to speculate further on the finding that women appear to be about 1–3% less productive than men. One plausible reason for this may be that women on average have larger responsibilities in the family sphere than men. We have no information on family obligations in these data. But on average, these are likely to be higher in say the age groups 31–40 and 41–50 than among those 30 years and younger or those 51 years and older. Most women will have had their first child by age 31 and a substantial proportion of women

[18] For analyses more generally of the gender wage gap at the occupation–establishment level see Petersen and Morgan (1995) for the U.S., Petersen et al. (1997) for Norway, and Meyersson Milgrom et al. (2001) for Sweden.

[19] One could also perform statistical significance test of the differences. But given the large number of observations, as these are population data, the tests would all turn out significant at conventional levels.

will have children in their late teens or even grown up by the time they are 51 years old, thus resulting, on average, in the highest child-rearing burdens between ages 31 and 50, though clearly with considerable individual variation. Assuming that innate productivity differences between men and women are on average very low, after having taken into account family obligations, the following argument can be made. The wage gap under piece-rate contracts should be larger among those 31–50 years old, the years where on average the largest toll is taken on women from family responsibilities. This is a particularly strong test if we find that the gap is smaller among those 51 and older than among those 31–50 years, because the older cohorts may work in industries, occupations, or work-settings less favorable to women, as they started their careers at a time when sex discrimination was commonplace.[20]

We computed the wage gap separately for groups of employees working in same occupation–establishment unit, and under same payment form, but now separately for several age groups. This was done only for occupation–establishment units that are sex integrated within both the given age group and the given payment system, where men and women say 31–35 years old work side-by-side on piece rates. To ensure a sufficient number of men and women working in the same occupation and establishment under the same payment system, we used 5-year intervals for age. We then report 5-year moving averages, with age intervals defined first for ages 18–22, then for ages 19–23, and so on in 1-year increments up until age groups 65–69 and 66–70, yielding altogether 49 different age groups defined by 5-year intervals. We made the computations for Norway and Sweden, but not the U.S. where we have no information on age.

Fig. 1 reports the resulting 5-year moving averages for the wage gaps. It is clear, in both Norway and Sweden, that the gaps are smaller among the younger age groups, for both payment forms, and then are bigger among those 31–50 years old, and finally for Norway with a clear decrease in the gap as age increases beyond 50 and the same for time-rate workers in Sweden. With some minor exceptions, the piece-rate gap is always smaller than the time-rate gap, in both countries and for all age groups.

We also computed the same type of wage gaps at the occupation–establishment level under time- and piece-rate work separately for each of five age groups defined by 10-year intervals, a less satisfactory and more arbitrary way of doing the computations, yielding 5 rather than the 49 age groups in Fig. 1. Table 3 gives the results.

Table 3
Gender wage gap at the occupation–establishment-level within age cohorts, by wage form (Norway and Sweden)

Age	Norway		Sweden	
	Piece rate	Time rate	Piece rate	Time rate
21–30	97.05	97.69	98.49	98.04
31–40	97.42	95.86	97.95	96.95
41–50	96.31	95.08	98.00	96.71
51–60	97.12	96.06	98.47	96.92
61–70	96.93	95.77	98.18	97.35

Notes: The wage gaps reported represent the unweighted mean of the wage gaps within every occupation–establishment unit which is sex integrated, that is which employs at least one woman and one man within an age cohort, for the given wage form, piece- or time-rate system. The total number of observations for each country and payment system above is lower than the number of observations reported in the note to Table 2. Included above are only observations that are sex integrated not only for the given payment system but also within the given age group. In Norway, the number of women and men under piece rates are $N_f = 3294$ and $N_m = 5167$, while in Table 2 they were $N_f = 4235$ and $N_m = 8231$. Under time rates we have $N_f = 6200$ and $N_m = 34{,}503$, while in Table 2 they were $N_f = 22{,}656$ and $N_m = 55{,}606$. In Sweden, the number of women and men under piece rates are $N_f = 43{,}594$ and $N_m = 74{,}241$, while in Table 2 they were $N_f = 62{,}174$ and $N_m = 112{,}709$. Under time rates we have $N_f = 63{,}795$ and $N_m = 75{,}611$, while in Table 2 they were $N_f = 107{,}597$ and $N_m = 130{,}179$. Information on age is not available in the U.S. data, so no wage gaps by age could be computed.

For Norway, the results are mixed. Among piece-rate workers the wage gap is smallest among those 31–40 while largest among those 41–50 years old. Among time-rate workers the expected pattern generally holds except that the gap is the same among those 61–70 and than those 31–40 years old. The theoretically expected pattern holds under both wage forms in 1984, the earlier year we have data for, with the largest gap in the age group 31–50, not shown in the table.

For Sweden, it is quite striking that the largest wage gap is among those 31–40 and 41–50 years old, precisely the years with highest family obligations. The same holds largely for time-rate workers. This pattern is consistent over time from 1970 to 1990, albeit with some variations, not shown in the table.[21]

There is thus evidence for the claim that family obligations impose a productivity penalty on female workers. The clearest evidence for this effect is from Norway as

[20] It is well established that there is a family gap in wages for women, mostly reflecting adaptations to family circumstances with time off from career to care for children (Waldfogel, 1998). This gap has yet to be computed at the occupation–establishment level.

[21] Meyersson Milgrom and Petersen (2006, Fig. 1) report a similar age pattern for the gap in occupational rank among white-collar employees in Sweden when birth cohorts are followed from 1970 to 1990.

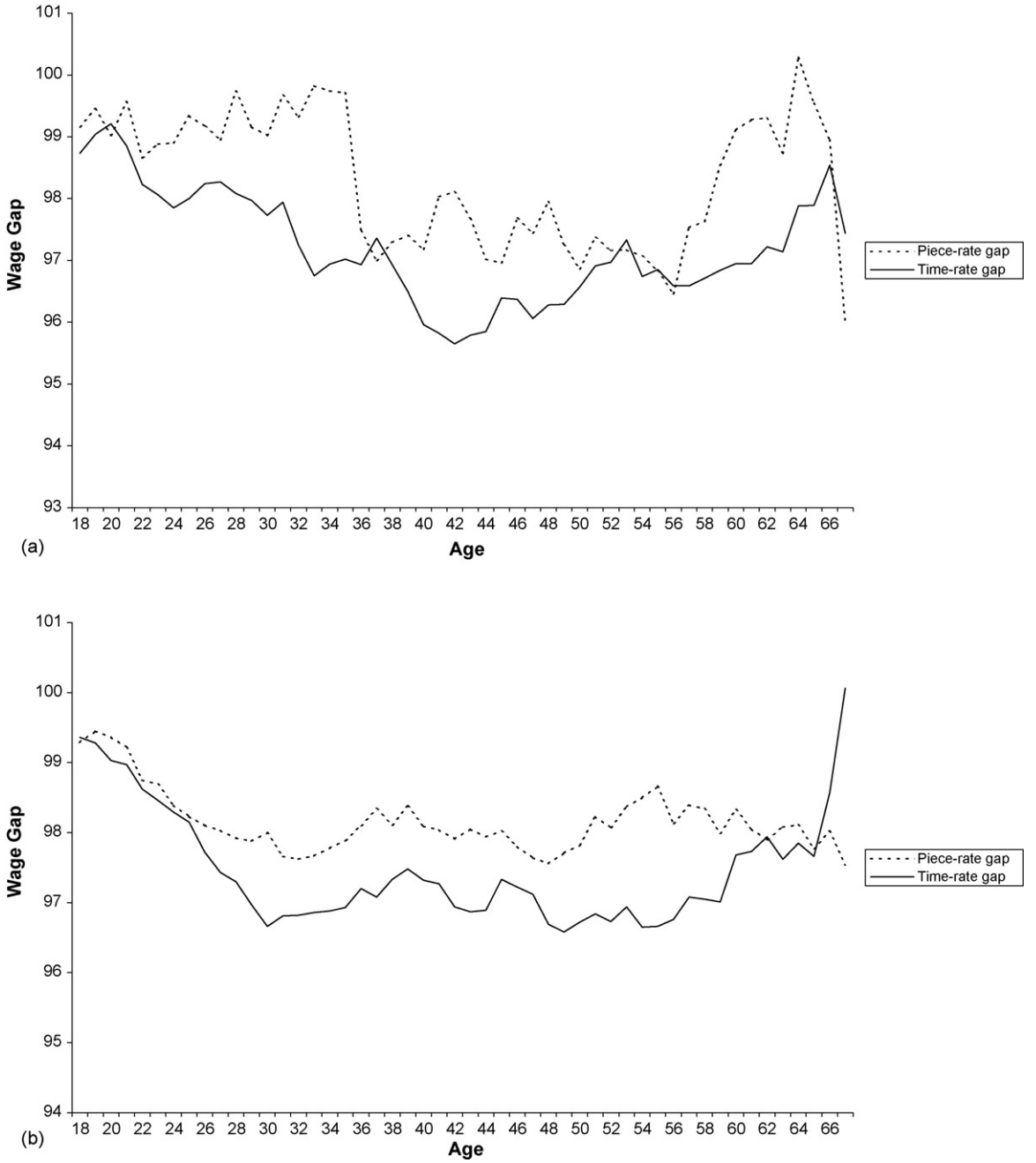

Fig. 1. Five-year moving averages for gender wage gap, under time- and piece-rate systems, respectively: (a) for Norway 1990 and (b) for Sweden 1990.

Notes: The graphs are computed as 5-year moving averages. We compare men and women working in the same occupation–establishment unit on the same payment form (piece vs. time rate) and that further are in the same age groups defined by 5-year intervals. The wage gap was computed separately for each of the groups, defined by same occupation–establishment unit, same age group, and same payment form. This was done first for the age group 18–22, then for the age group 19–23, and so on up until the age group 65–69 and finally for 66–70, so that age was increased by 1 year for each of the 5-year windows in which the wage gap was computed. Information on age is not available in the U.S. data, so no graphs by age could be computed.

given in Fig. 1. It would have been desirable had we been able to separate workers according to the family obligations they carry.

7. Results 3: male- versus female-advantageous occupations

As discussed in Section 2.3, which lays out the rationale for Question 3, one should expect women to be at a productivity advantage in some lines of work, while men to be at an advantage in other lines. Under piece-rate work, where pay is linked to productivity, women should earn more than men when they are at an advantage and less when they are at a disadvantage. These issues are now explored.

We selected some occupations (industry specific) where we thought men to be at a productivity advantage and some where women were thought to be at an advantage. The selections were made on the basis of external criteria, based on our best judgements, mirroring stereotypes about the kinds of skills needed in different occupations and industries, such as strength, dexterity, and so forth, and how the characteristics may be unevenly distributed between the sexes. Such stereotypes have been around for a long time and some are probably accurate statistical generalizations. To identify occupations with the relevant characteristics we relied on the detailed occupational descriptions for the data. See Appendix B, for examples.

Tables 4–6 report the gender wage gaps under time- and piece-rate systems for selected occupations, with male-advantageous occupations in Panel A and female-advantageous ones in Panel B. Column 1 gives the wage gap among piece-rate workers, while column 2 gives the gap for time-rate workers. Column 3 gives the productivity gap (column 1 minus 100) and column 4 the discrimination component (column 2 minus column 1), using the same format as in Table 2.[22] As underlined earlier, this component could also be due to other factors not accounted for, such as experience.

Starting with Table 4 for the U.S., it is striking that in male-advantageous occupations there is a large gap in favor of men under piece rates, on average of about 10%. In female-advantageous occupations, there is under piece rates either a gap of zero or one in favor of women, of about 2%. This mirrors precisely our assumption about productivity and sex in the two settings.

In contrast, under time rates, the wage gap is in favor of men in both settings, ranging from 3.08 to 5.67% (the weighted gaps). It is somewhat larger in male-advantageous occupations.

Furthermore, in male-advantageous occupations, where women are thought to be less productive, the gap is 3–5 percentage points larger under piece than time rates, with men failing to reap their productivity advantage under time rates. Conversely, in female-advantageous occupations, where women are thought to be more productive than men, they get penalized under time rates, earning 1–3% less than men, while reaping the benefits of their productivity advantages under piece rates, earning 0–2% more than men. Thus, under time rates, the more productive sex gets penalized, not reaping its full productivity advantage, in fact being discriminated against. The amount of discrimination is approximately the same for both sexes, about 3% (see column 4).

Continuing with Norway in Table 5, the pattern of results is exactly the same as in the U.S. Under piece rates it matters strongly for the wage gap whether one is in a male- versus a female-advantageous occupation. In male-advantageous settings, women suffer a wage gap of about 4%, while in female-advantageous settings they enjoy a wage premium, earning on average 4% more than men. Under time rates it does not matter much for the wage gap whether the setting is male or female advantageous. On average it is in favor of men, of about 2.0–2.5%. It is only slightly larger in male-advantageous settings.

As in the U.S., the more productive sex gets penalized under time rates. In male-advantageous settings, the gap is larger under piece than time rates. In female-advantageous settings, women get penalized under time rates, on average earning less than men, while reaping the benefits of their productivity advantages under piece rates, earning more than men.

For Norway note the female wage advantage among "filet cutters" on piece rates: women earn 7.77% more than men (in Panel B). Not only does this correspond to stereotypes, it corresponds also to perceived realities among employers, as reported in Section 2.3, which lays out the issues for Question 3. Norwegian employers are reluctant to hire men as filet cutters due to their lower productivity. Our data show that this stereotype appears to be a correct statistical generalization, one that is supported by the piece-rate data.

Turning to Sweden, the results in Table 6 follow closely those from Norway and the U.S. In male-advantageous settings, the gap is larger under piece than under time rates, with women earning about 5% less under piece rates, while earning only 2% less under

[22] Smith (1943) made similar computations, dividing work into male versus female advantageous, using data on subjective assessments of relative productivities in farming.

Table 4
Gender wage gap at the occupation–establishment level among workers on piece- vs. time-rate wage contracts in male- and female-advantageous occupations (U.S.)

Occupation by industry	Piece rate 1	Time rate 2	Productivity differential 3	Discrimination component 4
Panel A: male-advantageous occupations				
Nonferrous foundries				
Grinder	97.25	90.52	−2.75	−6.73
Core assemblers and finishers	92.85	98.00	−7.15	5.15
Filers, heavy (die casting)		90.48		
Polishers and buffers, metal	90.67	95.92	−9.33	5.25
Textile dyeing and finishing				
Layout workers, grey goods	83.05	100.00	−16.95	16.95
Men's and boys' shirts				
Cutters, machine	90.13	98.11	−9.87	7.98
Wood household furniture				
Complete furniture pieces, assemblers	94.90	94.73	−5.10	–0.17
Cut-off-saw operators, assemblers	73.59	94.24	−26.41	20.65
Double-end operators, assemblers	89.98	92.27	−10.02	2.29
Across occupations (unweighted)	89.05	94.92	−10.95	5.87
Across occupations (weighted)	91.53	94.33	−8.47	2.80
Panel B: female-advantageous occupations				
Nonferrous foundries				
Filers, light (die casting)	100.00	100.68	0.00	0.68
Textile dyeing and finishing				
Doubling-and-rolling machine operator	105.10	100.00	−4.90	−5.10
Cotton and manmade fiber textiles				
Card tenders (finishers)	103.26	103.89	3.26	0.63
Battery hands	103.31	99.09	3.31	−4.22
Loom winder tender	105.42	100.24	5.42	−5.18
Weavers, box looms, automatic	100.19	97.99	0.19	−2.20
Wool textiles				
Winders, yarn	104.35	100.00	4.35	−4.35
Men's and boys' shirts				
Dress shirts, sewing department	102.60		2.60	
Miscellaneous plastics				
Blow molding machine operator	99.97	96.61	−0.03	−3.36
Wood household furniture				
Subassemblies	97.05	95.12	–2.95	−1.93
Across occupations (unweighted)	102.13	99.29	2.13	−2.83
Across occupations (weighted)	99.95	96.92	−0.05	−3.02

Notes: In columns 1 and 2, the table gives the wage gap between women and men at the occupation–establishment level separately for workers on piece- and time-rate payment systems within selected occupations. The gaps were computed first for each sex-integrated unit where a given payment system was in use, and then an average of this number was taken across all sex-integrated units for the given payment system in the given occupation. The occupations were chosen in order to mirror stereotypes about sex-related productivity advantages. In selecting the occupations we used the detailed descriptions available for each occupation. Column 3 is computed as the number in column 1 minus 100. It gives the estimated productivity gap between women and men. Column 4 is computed as column 2 minus column 1. It gives the estimated discrimination component of the wage gap between women and men. A positive number means that men are discriminated against. A negative number means that women are discriminated against. The number of cases, in terms of occupation–establishment units (N_{oe}), number of women (N_f) and number of men (N_m), are as follows: in male-advantageous occupations, under piece rates—$N_{oe} = 46$, $N_f = 2186$, $N_m = 2023$, and under time rates—$N_{oe} = 143$, $N_f = 20{,}118$, $N_m = 13{,}286$; in female-advantageous occupations, under piece rates—$N_{oe} = 87$, $N_f = 15{,}748$, $N_m = 5849$, and under time rates—$N_{oe} = 156$, $N_f = 32{,}867$, $N_m = 10{,}141$.

Table 5
Gender wage gap at the occupation–establishment level among workers on piece- vs. time-rate wage contracts in male- and female-advantageous occupations (Norway 1990)

Occupation by industry	Piece rate 1	Time rate 2	Productivity differential 3	Discrimination component 4
Panel A: male-advantageous occupations				
General, maintenance				
Freight handlers, truck operators	96.09	97.69	−3.91	1.60
Mining and quarrying laborers	90.07	98.74	−9.93	8.67
Mining				
Miners	97.08		−2.92	
Meat				
Apprentice	94.07	96.61	−5.93	2.54
Butcher	92.75	99.58	−7.25	6.83
Machine operator	93.51	91.48	−6.49	−2.03
Fisheries				
Fish receiving	99.64	97.47	−0.36	−2.17
Forestry				
Sawmill worker	100.89	96.93	0.89	−3.96
Metals				
Skilled workers	98.98	98.38	−1.02	−0.60
Across occupations (unweighted)	95.89	97.11	−4.11	1.21
Across occupations (weighted)	95.48	97.17	−4.52	1.68
Panel B: female-advantageous occupations				
Fisheries				
Filet cutters	107.77	100.69	7.77	−7.08
Filet packing and weighing	103.42	99.59	3.42	−3.83
Thawing and cleansing of shrimp	98.54	86.57	−1.46	−11.97
Textiles				
Knitters	98.18	94.80	−1.82	−3.38
Clothing				
Seamstress whole cloth	106.07	97.96	6.07	−8.11
Assembly seamstress	109.96	104.47	9.96	−5.49
Across occupations (unweighted)	103.99	97.34	3.99	−6.65
Across occupations (weighted)	104.47	98.11	4.47	−6.36

Notes: For procedures, see text and note to Table 4. The number of cases, in terms of occupation–establishment units (N_{oe}), number of women (N_f), and number of men (N_m), are as follows: in male-advantageous occupations, under piece rates—$N_{oe} = 47$, $N_f = 210$, $N_m = 1610$, and under time rates—$N_{oe} = 202$, $N_f = 1841$, $N_m = 4865$; in female-advantageous occupations, under piece rates—$N_{oe} = 27$, $N_f = 463$, $N_m = 192$, and under time rates—$N_{oe} = 57$, $N_f = 627$, $N_m = 290$.

time rates. In female-advantageous settings, women earn about 2% more under piece rates, while 2% less under time rates.

As was the case in Norway, the gap under time rates is independent of whether one works in male- or female-advantageous settings, on average in favor of men with about 2%, whereas the gap reflects presumed productivity differences under piece rates.[23]

In summary, in all three countries, the wage gap under piece rates follows closely presumed productivity differences: in favor of men in male-advantageous occupations, in favor of women in female-advantageous occupations. Under time rates the gap is relatively independent of whether the work is male or female advantageous, mostly in favor of men. Under time rates the high-productivity group, be that men or women, gets penalized: its productivity advantage, which shows up in

[23] Note incidentally the big wage gap under piece rates among cutters in the food and beverages industry, where women earn 14.14% less than men. Then recall the Swedish report that pointed out a male productivity advantage in meat cutting "where women cannot manage the cutting knife as well as men" (Kock, 1938).

Table 6
Gender wage gap at the occupation–establishment level among workers on piece- vs. time-rate wage contracts in male- and female-advantageous occupations (Sweden 1990)

Occupation by industry	Piece rate 1	Time rate 2	Productivity differential 3	Discrimination component 4
Panel A: male-advantageous occupations				
Quarries				
Production workers	98.62	102.77	−1.38	4.15
Metals				
Adult workers	94.67	91.75	−5.33	−3.22
Machine shops				
Melters	99.27	104.25	−0.73	4.98
Metal drawers and extruders, production	98.84	98.99	−1.16	0.15
Metal workers	98.96	100.15	−1.04	1.19
Mining				
Miners	87.34	92.44	−12.66	5.09
Food and beverages				
Butchers	97.05	97.10	−2.95	0.05
Cutters	85.84	80.05	−14.16	−5.79
Truck operators	82.07	97.61	−17.93	15.55
Motor vehicles				
Automobile mechanics	97.95	85.47	−2.05	−12.49
Printing and bookbinding				
Truck operators	93.51	99.25	−6.49	5.73
Across occupations (unweighted)	94.04	95.44	−5.96	1.40
Across occupations (weighted)	97.81	99.06	−2.19	1.25
Panel B: female-advantageous occupations				
Food and beverages				
Production workers, fish processing	103.32	94.35	3.32	−8.97
Production workers, vegetable canning	101.50	95.81	1.50	−5.70
Packers, butcheries	98.85	96.72	−1.15	−2.13
Canners, butcheries	100.28	99.15	0.28	−1.14
Sorters, breweries	102.62	98.95	2.62	−3.67
Production workers, eggs	102.23	96.06	2.23	−6.17
Textile and clothing				
Textile workers	97.55	97.22	2.45	−0.33
Clothing	99.59	95.31	−0.41	−4.27
Across occupations (unweighted)	100.74	96.70	0.74	−4.05
Across occupations (weighted)	98.96	96.35	−1.04	−2.61

Notes: For procedures, see text and note to Table 4. The number of cases, in terms of occupation–establishment units (N_{oe}), number of women (N_f), and number of men (N_m), are as follows: in male-advantageous occupations, under piece rates—$N_{oe} = 351$, $N_f = 1716$, $N_m = 6446$, and under time rates—$N_{oe} = 259$, $N_f = 1038$, $N_m = 2411$; in female-advantageous occupations, under piece rates—$N_{oe} = 151$, $N_f = 3651$, $N_m = 2082$, and under time rates—$N_{oe} = 292$, $N_f = 4372$, $N_m = 2487$.

the wages under piece rates, does not appear under time rates.

8. Results 4: sorting into payment schemes

If there is wage discrimination against women under time but not under piece rates, women could sort into piece-rate work in order to avoid the discrimination. This could induce a wage gap against women under both time- and piece-rate work, even in the absence of any productivity differences between the sexes. The precise mechanism was explained in the theoretical discussion giving the rationale for Question 4 on sorting into payment schemes above.

This scenario gives rise to wage gaps under both payment systems, but for different reasons than those discussed above. We now investigate whether there is

Table 7
Distribution in occupations, establishments, and occupation–establishment units offering piece-rate work (Panel A) and percent being paid piece rate by overall, occupation, and occupation–establishment (Panel B) (by country)

	Overall		Occupation		Establishment		Occupation–Establishment	
	Men	Women	Men	Women	Men	Women	Men	Women
	1	2	3	4	5	6	7	8
Panel A: percent of men and women who work in occupations, establishments, and occupation–establishment units offering piece-rate work, by country[a]								
U.S.			93.1	99.4	43.5	64.5	19.9	47.8
Norway			98.0	99.9	21.0	30.5	16.3	25.9
Sweden			96.5	92.4	63.8	48.5	57.9	45.0
Panel B: percent of men and women being paid on piece rates, by overall, occupation, establishment, and occupation–establishment, by country[b]								
U.S.	19.1	45.8	20.9	25.1	12.7	27.8	13.4	32.3
Norway	12.6	18.2	17.5	19.2	7.5	8.6	8.4	10.3
Sweden	48.8	37.9	32.6	30.6	23.4	18.2	32.5	25.3

Notes: See text for explanation. The number of women (N_f), men (N_m), and workers (N) on which these analysis are based are: in the U.S., $N_f = 142{,}222$, $N_m = 156{,}775$, $N = 298{,}997$; in Norway, $N_f = 31{,}437$, $N_m = 133{,}812$, $N = 165{,}249$; in Sweden, $N_f = 188{,}540$, $N_m = 445{,}809$, $N = 634{,}349$. Across the three countries the analyses are based on information for 1,098,595 workers. In Sweden, the number of workers for which the sorting into payment systems analysis is based is somewhat higher than the number of workers for which we compute the wage gap, 634,349 vs. 612,252. For the latter analyses 20,147 observations with incomplete wage information were dropped. There are no numbers in columns 1 and 2 of Panel A because the panel pertains to percentages "controlling" for occupation, establishment, and occupation–establishment, not to overall percentages, which would be 100% for both sexes in each of the three countries.

[a] Each occupation, each establishment, and each occupation–establishment unit where at least one worker was employed on piece rates is defined as offering piece-rate work to its employees. The numbers in Panel A then give the percent of the men and the women who worked in such units. For example, at the establishment level, the number 43.5 for the U.S. (column 5) means that 43.5% of the male workers in the U.S. worked in establishments offering piece-rate work.

[b] In Panel B, the numbers are computed as follows. Columns 1 and 2 just give the percent of the men and women who were paid on piece rates. At the occupation level (in columns 3 and 4), first we computed the percent of the men and the percent of the women who were paid by piece rate for each occupation. Then an average of this percent was taken across the occupations. The computations for establishment and occupation–establishment are similar.

evidence for the corresponding differential sorting of men and women.

Table 7 gives in Panel A the percent of the men and women working in occupations, establishments, and occupation–establishment units where piece-rate work is available. Availability means that at least one worker is employed on piece rates at the relevant level. Panel B gives the percent who actually are paid on piece rates, first for all workers, then at each of the three levels, occupation, establishment, and occupation–establishment. At the occupation level, we first computed the percent on piece rates in the occupation. Then we took an unweighted average of this percent across the occupations, with analogous computations for the other two levels.

In the U.S., 19.1% of the men and 45.8% of the women are paid on piece rates, according to Panel B. Once one "controls" for occupation, this large difference between men and women becomes smaller. Across the occupations, on average 20.9% of the men and 25.1% of the women work on piece rates. At the establishment level, the percent on piece rates is much higher for women than men and the same is true at the occupation–establishment level. Looking at the presence of settings offering piece rates (Panel A), both at the establishment and occupation–establishment level it is much higher for women than men.

There is thus clear sorting of women into piece-rate work in the U.S. This sorting is to a large extent due to women being present in occupations where piece rates are common. This in turn reflects the distribution of men and women in industries, with much higher percentages of women in classic 19th century piece-rate industries such as men's and boys' shirts, wool textiles, and so forth.

For Norway, the situation is the same as in the U.S.: proportionally more women than men are paid on piece rates. This is to a large extent due to women being in occupations (and industries) where piece rates are common. Controlling for occupation, establishment, and occupation–establishment, the average percent on piece rates is about the same for men and women.

For Sweden, the situation is the opposite. Men are more likely to be paid on piece rates. Again this

is mostly due to their distribution into occupations. Men are more present in occupations, establishments, and occupation–establishment units offering piece rates.

So, in the U.S. and Norway, women sort more often into piece-rate work than men, whereas in Sweden the opposite is the case. The pattern of the wage gaps under time and piece rates is however the same across the countries. And in the U.S. and Sweden, where sorting of men and women on payment schemes is extensive but with exactly opposite patterns, the wage gaps are still very small. Though hardly definitive, the unresponsiveness of the pattern of wage gaps to sorting indicates that sorting into payment schemes does not account for the gender wage gaps observed. Even with opposite sorting patterns across countries, the wage gaps remain similar.[24]

9. Discussion: the 1% solution

It is extraordinarily difficult to determine the extent to which the gender wage gap reflects discrimination from employers or differences in productive capacities between men and women. We noted that where piece-rate work is performed, wages should in principle reflect productivity differences and that it is more difficult to discriminate on the basis of gender since one is paid for what one produces as opposed to being available to produce under time-rate work. With this as our point of departure, we compared the wages of men and women working in the same occupation in the same establishment, the level at which productivity differences most meaningfully can be assessed.

First we compared the gender wage gap at the occupation–establishment level among piece- and time-rate workers. If there is a wage gap under piece rates, women are less productive than men. If the gap is smaller under piece than time rates, then part of the time-rate wage gap is due to discrimination. There is also the possibility that the gap is larger under piece than time rates, in which case men may be discriminated against under time rates. Second, we studied the degree to which the gap varied with life-cycle stage, postulating that women may suffer a productivity penalty during years with extensive family obligations. Third, we studied the wage gap in lines of work that are female versus male advantageous with respect to assumed relative productivity, hypothesizing that women will do comparatively better than men in female-advantageous settings and comparatively worse in male-advantageous ones. This comparison also gives an indirect "test" of whether wage differences under piece-rate work reflect productivity differences. Fourth, we studied the extent to which females tend to sort themselves into piece-rate schemes more often than men.

9.1. Results 1: overall productivity differences

Our findings are easy to summarize. First, the gender wage gap, at the occupation–establishment level, is smaller under piece than under time rates, in each of the three countries. According to the argument put forth here, about one-third of the rather small wage gap at the occupation–establishment level is therefore due to discrimination, while about two-thirds of the gap is due to productivity differences. The discrimination component is a miniscule 0.5–1.0%, and could, to repeat earlier qualifiers, be due to other factors not accounted for here, especially experience. Were men and women to be paid according to their productivity, women would at the occupation–establishment level earn about 1% (Sweden), 2% (U.S.), or at most 3% (Norway) less than men. These conclusions hold across three countries and are based on accurate occupation–establishment wage data on about 1.1 million workers covering the period 1970–1990.

The extensiveness of the data, their quality, matched with identical patterns of results across countries, all combine to make the findings more than plausible. And plausibility is about all one can expect to attain in a broad study of an important topic that has eluded exact investigations from Max Weber's time to the present.

[24] A related concern is that if indeed women are more productive than men in some kinds of work and less productive in other kinds, one may speculate whether the sexes tend to concentrate their employment where they have their respective productivity advantages (e.g., Filer, 1989, p. 154). We also investigated this concern. Productivity advantage was measured by the gender wage gap in the occupation. Concentration in occupations was measured several ways, for example, by the proportion of the women who are employed in an occupation and by the proportion of the employees in an occupation who are women. Regressing the latter two measures, as well as other measures of female concentration in an occupation, on the gender wage gap yielded no results. The coefficients were small in substantive magnitude, so that a major change in the gender wage gap, by for example, 40%, yielded a negligible change in the concentration of women in an occupation. Moreover, less than one of three coefficients reached statistical significance at the 10% level. Additional evidence on sorting into occupations can be assembled from the notes to Tables 4–6. They show that in all three countries the percent female is always higher in female- than male-advantageous occupations: In the U.S., 75% female in female-advantageous occupations versus 59% female in male-advantageous occupations; in Norway, 69% versus 31%; and in Sweden, 64% versus 23%. For analyses of sorting into occupations, see Bielby and Baron (1986) and for complex econometric analyses see Foster and Rosenzweig (1996).

One can thus conclude that men and women for all practical purposes are equally productive in the jobs investigated here. It is in fact somewhat surprising that the wage gap among piece-rate workers is as small as it is, given women's well-documented higher efforts in household work, which may take its toll in terms of productivity in the labor market and which ceteris paribus may translate into a large gap (e.g., Becker, 1985).

9.1.1. Discussion of Results 1

It is instructive to discuss our first finding in light of a unique study by Mastekaasa and Olsen (1998). It reports differences in sick days taken among approximately 16,000 employees in the public sector in Norway, comparing men and women working in the same occupation–establishment unit, thereby keeping working conditions constant, unlike all other studies of sick days. They find that women working in the same occupation–establishment unit as men take about 50–70% more sick days. On average men spend about 2% of their possible working days sick while women spend an additional 1–2% days as sick. In the aggregate this may show up as a productivity difference between men and women of 1–2%, close to the 3% found for Norway in the current study. The comparison is unquestionably speculative, but lends credence to the overall argument and results put forth here.

Our first finding does however contrast sharply to the conclusions in three across-establishment comparisons of gender productivity differentials. When regressing the value added at the establishment level on the percent female in the establishment, controlling for other relevant variables, using careful econometric formulations matched with excellent data, the robust finding is that women are about 15% less productive than men in the U.S. and Norway while 18–25% less productive in Israel (Hægeland & Klette, 1999, chap. 9; Hellerstein & Neumark, 1999; Hellerstein et al., 1999). Comparing an establishment that is 100% male to one that is 100% female, the latter on average produces a value of output that is 15% lower.[25]

While not disputing the correctness of these analyses, in terms of the relationships they report, they cannot separate the effects of innate productivity differences, stemming from ability, effort, diligence, and so forth, from the effects of establishment-level technology, market conditions, etc. The latter may be correlated with the percent female, resulting in lower value of output. Cohn (2000, p. 132) puts it nicely: "Women can be forced into occupations where they simply cannot produce economic value for their employers, no matter how hard they try or how much talent they bring to the endeavor." He continues: "There are, however, structural determinants of productivity that are just as important as effort, skill, or competence; . . .."

Only a within-job analysis can establish whether women and men are equally productive in same jobs, which is what we have provided, in contrast to the between-establishment analyses in these studies. Though not stated in their conclusions, in explaining their methodology Hellerstein et al. (1999, pp. 420–421) point out as much: "If we find evidence suggesting that, for example, women are less productive than men, the plant-level data do not enable us to determine whether the estimated lower productivity of women comes from segregation of women into low-productivity plants, with the productivities of women and men within plants roughly the same, or instead from the lower productivity of women relative to men within plants."

The findings in the present article make it clear that within jobs – that is, same establishments (i.e., plants) and occupations – women and men are more or less equally productive. The broader question arising from the three establishment-level studies of why, how, and whether women sort into low-productivity establishment and occupations is very difficult and perhaps even impossible to settle. Data requirements may be too demanding, and no complex statistical technique can compensate for insufficient data.

The productivity gaps reported here of 1, 2, and 3% are also much lower than the gap of 10–13% found using similar data from the U.S. on piece-rate workers and wages from the 1950s (see Phelps Brown, 1977, p. 158). The latter gaps were closer to those found by Goldin (1990, p. 104) for U.S. blue-collar workers using identical types of data from around 1890 of about 15%, or for those computed by Weber (1908[1924], p. 163) from a German textile factory around 1900, of about 17%. It is possible that women have increased their productivity relative to men over the last century. That would be consistent with our additional findings from Sweden where the wage gaps under piece rates declined from 1970 to 1990 (not shown in tables).

9.2. Result 2: productivity gap by life-cycle stage

Our second finding is that the wage gap under both time and piece rates is smaller among younger employees, then increases with age for age groups 31–50, and

[25] Similar comparisons were done for the French textile industry using establishment-level productivity data from 1839 to 1845 in Cox and Nye (1989), reporting productivity gaps of 50–60%.

thereafter decreases again for employees 50 or older. This finding was especially striking in Norway when based on computations of 5-year moving averages. It illustrates that family obligations may impose a productivity penalty for women. If such is the case, this penalty does not amount to much, 1–2 percentage points at the most, and may moreover likely be removed by a more equal distribution of work in the family.

9.3. Results 3: male- versus female-advantageous occupations

Our third finding is that under time-rate work, the wage gap is more or less independent of supposed productivity differences between men and women, while under piece-rate work, the wage gap mirrors closely assumed productivity differences, with women receiving a wage premium in female-advantageous settings and a penalty in male-advantageous ones. Under piece-rate work, the high-productivity group gets rewarded. Under time-rate work it gets penalized, not reaping its productivity advantage in terms of higher wages.

9.4. Results 4: sorting into payment schemes

Our fourth finding is that in the U.S. and Norway women sort more often into piece-rate work than men, whereas in Sweden the opposite is the case. The pattern of the wage gaps across time- and piece-rate work is the same across the countries. The unresponsiveness of the pattern of the gender wage gaps to sorting indicates that sorting into payment schemes does not account for the observed gaps. Even with opposite sorting patterns, the wage gaps remain the same. There could obviously be sorting of men and women into different occupations, which in turn might depend on productivity differences, with low-productivity employees sorting into low-paying occupations. But this was not investigated here and is difficult to study. As pointed out in Section 1, in most employment relationships productivity gets determined neither by the person nor the job alone but jointly by the two (Granovetter, 1981). This makes across-job comparisons hard to interpret.

9.5. Implications

To repeat first the central finding, women are slightly less productive than men in these blue-collar manufacturing occupations, with 1% in Sweden, 2% in the U.S., and 3% in Norway. For all practical purposes, in terms of how to remunerate men and women, this may be taken as evidence of equal productivity. According to the interpretation put forth here, an entire two-thirds of the wage gap at the occupation–establishment level in these kinds of occupations is due to productivity differences, while one-third of the gap reflects discrimination. The latter amounts to a tiny 0.5–1.0%, and could clearly also be due to other factors. In the absence of discrimination, the gap would be reduced by another 0.5–1.0%, to 1–3%, rather than the current 1.5–4% gap as found under time rates. In terms of reducing the gap, it would clearly be advantageous if more work was to be performed under piece rates, because under this wage form it becomes harder to discriminate on the basis of gender, which in our data showed up as a smaller wage gap.[26] The main problem under piece-rate work is who gets to do it, not what happens once it is being done. Under time-rate work, according to the present analyses, a gap of about 1–3% would overall be justifiable on the basis of productivity differences, but these differences are so small to start with that they may as well be reduced to no difference. Under piece-rate work, the differences may remain whatever the differences in productivity dictate, being legitimate regardless of whether they are to the advantage of men or women.[27]

But do the results extend to other occupations? We have studied blue-collar work, the setting where women stereotypically, with some exceptions, have been seen to suffer their greatest productivity disadvantages, thus stacking the case in favor of men. But only negligible male advantage was found.

One may therefore speculate whether women in the lines of work where they stereotypically are seen to be at a productivity advantage, such as in much clerical, office, and caring work, in fact are more productive than men.[28] This is the kind of work that has grown in importance over the last 50 years. As Joshi and Paci (1998, p. 1) write: “What may once have been

[26] Goldin (1990, pp. 117–18), discussing the period 1900–1940 and the shift from piece-rate (spot market) to time-rate wages, claims that “The origins of “wage discrimination” are thus to be found in various policies that transformed labor from the spot market of the manufacturing sector to the wage-setting of modern firms, in which earnings do not contemporaneously equal a worker’s value to the firm.”

[27] This is captured precisely in the U.S. Equal Pay Act of 1963, §206(d). It provides that paying unequal wages for the same work for the same employer is illegal “except where such payment is made pursuant to . . . a system which measures earnings by quantity and quality of work . . ..”

[28] SOU (1993, p. 142, Table 6.19) reports an overall wage gap in favor of women in some caring work in Sweden, as also reported in Petersen and Morgan (1995, Table 2) for a selection of occupations in the U.S. hospital industry.

an economic rationale for employers to prefer men has been outdated by the knowledge-based technology of the post-industrial economy. This puts more of a premium on the power of workers' brains than on their muscles."

Could this conjecture be settled by research? Much modern work allows for variation in and assessment of individual productivity. The central aspect of piece-rate work, differential pay for differential productivity, then easily reemerges: such as in sales, among some clerical and office workers, and among professionals. For example, in banking and insurance, number of customers served, policies sold, and claims processed are comparable to number of shirts stitched, and individual employees may be rewarded for these. The same issues arise in jobs in hotels, restaurants, hospitals, laundries, parts of transportation (taxis), garbage collection, the mortgage industry, and more. And among professionals, doctors diagnose patients and perform medical procedures, the number of which corresponds to piece-rate output, and the absence of medical malpractice complaints corresponds to quality. Professors advise undergraduate and graduate students, and are sometimes given what amounts to piece-rate credits for this. There is little reason to think that women are less productive than men in these types of jobs. Though our data do not speak to this, our conjecture amounts to more than informed speculation, given the wage data available for much white-collar work (e.g., Petersen & Morgan, 1995). And as the examples illustrate, for many white-collar and professional employees it should be entirely possible to investigate productivity differences by sex, as long as researchers can get access to the relevant personnel records (see e.g., Fernandez et al., 2000).

What are the implications of these findings for our understanding of the overall gender wage gap? Assuming the results can be extended to other types of jobs, the implication is that very little of the overall gender wage gap is due to productivity differences at the occupation–establishment level, strongly mirroring findings for the wage gap at that level. What is central for the overall wage gap is the segregation of men and women into different kinds of occupations and establishments that differ in their wage levels. With our data we cannot answer whether this occupational sorting is due to productivity differences by sex, where the sexes sort into occupations according to how productive they are in various settings, or whether it is due to employers hiring disproportionally from the more productive sex, or due to discrimination. But once sorting has occurred, there is little evidence of productivity differences by sex in the occupations studied here.

Acknowledgments

This article is based on individual-level wage data made available from several sources: for the U.S., by the Bureau of Labor Statistics in the U.S. Department of Labor and by Erica Groshen who provided data from several of the eight Industry Wage Surveys analyzed here; for Norway (SSB), by Statistics Norway and the main employer's association in Norway, the Confederation of Business and Industry (Næringslivets Hovedorganisasjon or NHO); for Sweden, by the main employer's association, the Swedish Employer's Confederation (Svensk Arbetsgivarforening or SAF). We are grateful to Coen Hendriks and Grethe Hoel at the SSB and Bjarne Thuv and Stein Omland in NHO for their cooperation in preparing these data for analysis. We are grateful to Ari Hietasalo and Marianne Lindahl at SAF for their cooperation in preparing these data for analysis. We are grateful for financial support from the Swedish Council for Research in the Humanities and Social Sciences. Parts of the paper have been presented at seminars at Stanford University, Stockholm University, the Institute for Economic and Social Research in Stockholm, Uppsala University, Stockholm School of Economics, University of Oslo, and the Annual Meetings of the American Sociological Association. We thank Erling Barth, Tore Ellingsen, Torbjørn Hægeland, Mark Granovetter, Assar Lindbeck, Donald Tomaskovic-Devey, Steinar Vagstad, and seminar participants for useful comments. We thank several anonymous referees and the Editor Kevin T. Leicht for comments. The research was supported by the Institute of Industrial Relations at the University of California, Berkeley.

Appendix A. Methods for computing relative wages

We give the equation used for computing the relative wages under time rates reported in Tables 2–6. The equations for the computations under piece rates are analogous. We compute each of the relative wages separately for time- and piece-rate workers.

For time-rate workers in occupation–establishment unit 'oe' employing both women and men on time rates in that unit, the average wages (1) for women, (2) for men, and (3) the relative wages are, respectively: (1) $\bar{w}_{\mathrm{oe,f}(T)}$, (2) $\bar{w}_{\mathrm{oe,m}(T)}$, and (3) $w_{\mathrm{oe,r}(T)} = \bar{w}_{\mathrm{oe,f}(T)}/\bar{w}_{\mathrm{oe,m}(T)}$. For time-rate workers the number of sex-integrated occupation–establishment units are $N_{\mathrm{oe}(T)}$.

For time-rate workers the relative wages controlling for occupation–establishment obtains as

$$w_{[\mathrm{oe,r}(T)]} = \frac{1}{N_{\mathrm{oe}(T)}} \sum_{\mathrm{oe}(T)=1}^{N_{\mathrm{oe}(T)}} w_{\mathrm{oe,r}(T)} \times 100$$

$$= \frac{1}{N_{\mathrm{oe}(T)}} \sum_{\mathrm{oe}(T)=1}^{N_{\mathrm{oe}(T)}} \frac{\bar{w}_{\mathrm{oe,f}(T)}}{\bar{w}_{\mathrm{oe,m}(T)}} \times 100$$

This is simply the average of the occupation–establishment unit wage gap among time-rate workers, denoted $w_{\mathrm{oe,r}(T)}$, computed over all occupation–establishment units that are sex integrated among time-rate workers, $N_{\mathrm{oe}(T)}$.

The relative wages among piece-rate workers obtains by a similar equation where time-rate wages gets substituted with piece-rate wages. The computations are identical when broken down by age groups and by male- versus female-advantageous occupations.

Appendix B. Male- versus female-advantageous occupations

To identify male- versus female-advantageous occupations in terms of productivity we relied on the detailed occupational descriptions for the data. To give a sense of the kind of information used we reproduce the descriptions of two of the occupations here, one deemed male, the other female advantageous, both from the U.S. nonferrous foundries industry (see U.S. Department of Labor, 1977a, p. 43). There is obviously an element of arbitrariness in this, in the same way as such distinctions used by employers often were arbitrary.

For the male-advantageous occupation – Filer, heavy (die casting) – we have the description (p. 43): "Works to close tolerances in removing excess metal and surface defects from a variety of large and intricately shaped die castings, using files and scrapers. May *also* knock off gates and flash or pound castings into alignment, using mallets, and remove excess metals from holes, using hand punches."

For the female-advantageous occupation – Filer, light (die casting) – we have the description (p. 43): "Removes excess metal and surface defects from small metal die castings, performing simple repetitive finishing operations. Work involves: Receiving instructions for finishing procedures; fastening castings in holding devices; and removing burrs, ejector pin marks, and flash, using files and scrapers. May *also* break flash and gates from castings, using mallets, and remove flash from holes with hand punches."

Note in the female-advantageous occupation how the word "light" is used and part of the work is described as "repetitive" and as being on "small" objects whereas in the male-advantageous occupation the objects are described as "large." This corresponds precisely to stereotypes used about women's work historically, often stressing light and repetitive work, some of which was reported in Section 2.3, which explained the issues for Question 3.

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