9

A Pollution Theory of Discrimination
Male and Female Differences in Occupations and Earnings

Claudia Goldin

It is not difficult to see how pollution beliefs can be used in a dialogue of claims and counter-claims to status.
—Mary Douglas, *Purity and Danger* (1966,3)

Women work in occupations that are different from those of men and get paid less for apparently the same personal and job characteristics.[1] These differences have, in part, been attributed to economic discrimination that some have ascribed to "tastes." The most cited treatise on the subject posits that some individuals desire to work and live apart from others and would require a premium to interact with them.[2]

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1. The ratio of the (full-time, year-round) weekly earnings of white women to white men increased from 0.631 to 0.792 between 1980 and 2010, and that for all twenty-five-to-thirty-four-year-olds with four years of college increased from 0.736 to 0.832 between 1980 and 2010 (Current Population Survey, Outgoing Rotation Groups). A standard measure of occupational segregation (the dissimilarity index) decreased from 64.5 in 1970 to 51.0 in 2009 using year 2000 codes and from 68.7 in 1970 to 50.7 in 2009 using year 1990 codes (Blau, Brummund, and Liu 2012). See also Jacobsen (1994). Despite these gains, most studies of wage and occupational differences find a substantial unexplained gap, although the unexplained portion has decreased over time. See the literature reviews in Altonji and Blank (1999) and Bertrand (2011); see Goldin (1990) for long-term trends. Bertrand, Goldin, and Katz (2010), however, demonstrate for a group of MBAs that when using detailed data even large raw differences in female-to-male earnings can be "explained" by hours, job experience, and pre-job characteristics such as education.

2. The earliest treatment, as well as the most cited, is Becker (1957).

Yet men and women seem to get along under a wide variety of circumstances. Men often have wives, sometimes daughters and sisters, and by necessity mothers. One cannot attribute to most men a desire for distance from women the same way one might interpret current or past discrimination between other groups, such as blacks and whites, Catholics and Protestants, Arabs and Israelis, and Hindus and Muslims. One might, however, attribute to men a desire for distance from women to protect their status as members of an occupational group.

The model developed here treats discrimination as the consequence of a desire by men to maintain their occupational status or prestige, distinct from the desire to maintain their earnings. (The reason for focusing on prestige rather than wages is later defended.) Prestige, in this setting, is conferred by some portion of "society," the bounds of which will be discussed, and is based on the level of a productivity-related characteristic (e.g., strength, skill, education, ability) that originally defines the minimum needed to enter a particular occupation. But prestige can be "polluted" by the entry of an individual who belongs to a group whose members are judged on the basis of the group's average and not by their individual merits.[3] Men in an all-male occupation might be hostile to allowing a woman to enter their occupation even if the woman meets the qualifications for entry. The reason is that those in the wider society will not know that the woman was qualified and might, instead, view her entry as signaling that the occupation had been altered. She will be seen as "polluting" the occupation.[4]

A woman's entry to an occupation might be a signal of change in the standards for admission because the economy is dynamic. Technological change can reduce the minimum level of the characteristic required for entry. For example, firefighters once had to be strong enough to carry heavy and unwieldy equipment. The advent of lighter hoses diminished the actual physical strength required (although it remains far higher than that for most jobs). Similarly, in certain bookkeeping trades, the ability to add up long columns of numbers in one's head was a skill that comptometers and calculators later replaced and made less valuable.

Society has imperfect information regarding changes in technology and infers change from certain observables. One of these observables is the sex (or any group descriptor, such as race) of new entrants. Thus men might want women barred from their occupation to protect their status even if *no* skill-reducing technological change affected their occupation. Whether or not men in a previously all-male occupation will want to bar the entry of women will depend on the distribution of the productivity-enhancing char-

3. The term "pollution," in this context, is from the anthropological literature and originates in the works of Mary Douglas (Douglas 1966). Women, across many cultures, are separated from men during menstruation, and sexual intercourse is thought to pollute men. These beliefs enforce, and perhaps reinforce, the separation of the sexes in production and consumption.

4. See Akerlof and Kranton (2000) for a related model on the protection of identity.

acteristic in the male and female populations and the minimum level of the characteristic initially required for the occupation in question. Asymmetric information is a key feature of the model.[5]

The model contains predictions about the relationship between occupational segregation by sex and earnings (or the level of the characteristic). The prediction is that sex segregation for men and women will be greater for occupations requiring a level of the characteristic above the female median and that segregation, perhaps surprisingly, will be nonmonotonic with respect to the characteristic.[6] Occupations are more likely to be segregated at the tails of the female characteristic distribution but integrated somewhere toward the middle, generally just below the median of the female characteristic distribution. Occupations requiring a high level of the characteristic will not be integrated unless society has verifiable information regarding qualifications.

The model also suggests how discrimination and earnings respond to changes in the distributions of the characteristic and why knowledge of past distributions helps explain current gender distinctions in the labor market. Evidence consistent with these predictions is presented for various time periods. The model is inherently historical: the past affects the present.

Similar models have been proposed elsewhere. In hierarchical models men require a premium to work with women who have higher occupational status or authority. Other frameworks posit that interactions between men and women reduce productivity because of communication obstacles or the precise opposite—flirting, jealous spouses, and sexual tension—may decrease output or profits.[7] Several versions of the statistical theory of discrimination exist in which men and women as groups differ in some actual or perceived characteristic.[8] Discrimination can reinforce these skill disparities or result in differences in promotion if certain workers are more visible than others.[9]

The pollution theory of discrimination is complementary to other models of discrimination and can be viewed as a hybrid of Becker's original "taste" model with that of statistical discrimination. Rather than assuming taste-

5. The type of "asymmetric information" in this model differs from that in most others in which managers have incomplete information about worker ability. In this model, the asymmetry comes from incomplete information by those who confer "prestige" on workers and the group who confers prestige is "society."

6. The median of the characteristic, not its mean, is the key factor because individuals often judge the ability of a group of people by the skills of a random individual drawn from that group.

7. See Lang (1986) on communication. Humphries (1987) considers the explicit problem of sex in the workplace. On the latter, Sophonisba Breckinridge (1906) noted: "It is well known that the unregulated mingling of men and women under conditions of darkness, fatigue, or the excitement due to the constant apprehension of danger may give rise to immoral intercourse. On this account we find women generally prohibited from working in mines, and . . . other forms of employment at night" (107).

8. On statistical discrimination see Arrow (1973) and Phelps (1972), and the interpretation given by Aigner and Cain (1977).

9. See Lundberg and Startz (1983) on discrimination and incentives to acquire skill, and Milgrom and Oster (1987) on visibility.

based discrimination, it seeks the reasons for it. It posits that male employees discriminate against prospective female employees as a way of protecting their prestige in an asymmetric information context. The pollution theory model contains various predictions that are not contained in other models and serves to explain historical features of the labor market that others cannot. A more formal version of the model will make the assumptions and implications clearer.

9.1 A Pollution Theory of Discrimination

9.1.1 Model Setup

Assume there is a productivity related, single-valued characteristic (C), such as ability, strength, skill, education, or determination. The attribute need not be inherent. It can be acquired and can be altered by complementary factors such as machinery.[10] The characteristic is continuously distributed, perhaps differentially, among men and women. The entire distribution of C for males and the median of the female distribution are known by all workers as well as all others in society.[11]

The model contains two periods. In period 1 only men have labor market jobs, known as "occupations," and women are in the home. Men remain in the *same* occupation in period 2 and women enter the labor force in period 2.[12]

Every occupation, i, requires a minimum level of the characteristic, C_i, and no one with a C below that level can produce at all in occupation i. In addition, productivity in occupation i does not rise with C above the minimum required in each occupation. For example, suppose the firefighting occupation requires a C of 100. An individual with a 90 cannot produce at all in that occupation and one with a 110 will be overqualified.

Workers are paid according to their productivity (that is their level of C) in each occupation and will therefore sort into occupations. In equilibrium,

10. The characteristic can be thought of as one's strength rating on a particular machine. Refinements to the machine can lead weaker individuals to be measured as stronger. The characteristic can also be a skill or an education level that can be augmented over time.

11. Knowledge of the full distribution for males and females might allow individuals to figure out the "correct" number or proportion of women who ought to be in each occupation, given that no occupations above it in the skill distribution are "discriminating." To get around that problem, individuals here have knowledge only of the female median. In the case of the symmetric form of the model, given below, in which both men and women enter in period 2 knowledge of each distribution is assumed.

12. I do not directly consider why women enter the labor market in period 2. One possibility is that the characteristic distribution for women shifts to the right because of an increase in education or more of a complementary physical capital. The justification for why men remain in their period 1 occupations in period 2 might be that specific skills are accumulated or that there are sufficiently large moving costs.

therefore, each value of C_i in period 1 defines one and only one occupation for men.[13]

Men receive utility from their income, (Y_i), and the prestige of their occupation, (C_i^*), where prestige is the minimum level of C required for the occupation as perceived by society.[14] Women receive utility from the income of their occupation in period 2 and the value of their home production in period 1, although that will be ignored here.

It is convenient to assume that the demand for all goods is perfectly elastic and that the production technology is characterized by constant returns to scale. The "small country" and production technology assumptions ensure that the wage does not depend on the number of individuals in the occupation and, consequently, that there can be no wage effects or "crowding."[15] These assumptions are relaxed below. They ensure that a simple version of employee discrimination—the protection of income—is not confused with the protection of prestige in the pollution theory setup.

But—and this is crucial—because the world is dynamic, an occupation may not require the same level of C in period 2. *Technology shocks*, $\Omega = 1$, that reduce skill requirements occur between periods 1 and 2. A value of Ω that is either 0 or 1 is randomly drawn for each occupation and if $\Omega = 1$ the shock lowers the minimum level of C required for an occupation. The realized value of Ω for occupation i is known only to those in occupation i in period 1. Women enter the labor market in period 2 and apply to the various occupations.

Thus the utility received by men in period 1 is $U^{M,1} = U^M(Y_i^1, C_i^{*,1})$, where $C_i^{*,1}$ is the prestige received by occupation i in period 1. The first period utility is equivalent to $U^M(C_i^1, C_i^{*,1})$ since income in period 1 is a function of the person's level of C and also the minimum needed for the occupation in period 1. In period 2, however, utility received by men is $U^{M,2} = U^M(Y_i^2, C_i^{*,2})$, which may not be equivalent to $U^M(C_i^1, C_i^{*,1})$ if $\Omega = 1$.

Whatever the value of Ω, men will want to maintain their level of prestige. Prestige, C_i^*, arises from how *society* views the C level of an individual's occupation. The level of C associated with an occupation in period 1 is known to everyone. But only those in the occupation know whether $\Omega = 1$. Because male workers remain in their period 1 occupation during period 2,

13. In this simple setup there is no capital, and the workers are "hired" by an entrepreneur who is the first entrant in the occupation.

14. Prestige is different from income or from one's position in the income distribution. But prestige might also be a signal of one's income-earning ability, as in the case of a man who is turned down for a loan because the loan officer thinks the man's occupation has undergone a loss in income-generating ability.

15. Assume the production function takes the form $Q = \lambda \cdot L \cdot C_i$, where L is the number of employees, and C_i is the minimum characteristic level of the occupation, and that each unit of Q sells at the exogenous price P. Therefore the value of the marginal product, and thus the wage, is a function only of C_i and λ.

if there was a technology shock ($\Omega = 1$), their income will decrease. Their characteristic is not being fully utilized and they are misallocated and overqualified for the job. But even if their income decreases, their prestige can remain just as it was in period 1. Though they are financially less well-off they can maintain equal status.

It is useful to review the informational asymmetries in the setup: what is known to all, to each individual, and to those in an occupation in each of the two periods. The variables known to all, that is, those that are common knowledge are: the distribution of C for men, the median of C for women, and the minimum value of C required for all occupations in period 1, that is C_i^1. Everyone knows his or her own C, but only those in occupation i in period 1 know the value of Ω, that is only they know C_i^2, the value of C required by that occupation in period 2.

Because of the informational asymmetry concerning Ω, the prestige or status associated with being a weaver, printer, doctor, bookkeeper, or widget maker depends on the identity of new workers even if there has been no actual "de-skilling" (even if $\Omega = 0$). The entry of an individual who comes from a group known to have a lower *average* (median) level of skill than that required in the occupation may signal the de-skilling of an occupation even if nothing has changed. Individuals outside the occupation do not know whether the "test" or criterion for entry has changed, and it is costly for them to obtain such information (e.g., trying out for the occupation). Society is the arbiter of prestige and updates its information about the C level required for the occupation by observing the median characteristic of a new entrant.

The C level of a woman is known only to her and can be discerned only by administering a test. Thus the employer for an occupation can determine whether a woman meets the minimum requirements and, once on the job, her fellow colleagues (all men) can also see that she is qualified. But society does not know her qualifications. Had no technology shock occurred between periods 1 and 2, society would know that the female applicant had precisely the same C level as the men already in the occupation. But society does not know the value of Ω. Technology shocks add uncertainty. The question, therefore, is whether male workers in occupation i will resist the introduction of a woman or whether they will be pleased to have her.

9.1.2 Model Equilibrium and Implications: Identical Characteristic Distributions

The characteristic or C distributions for men and women can be identical or can differ, as would be the case if strength were an important part of productivity. It is likely that these distributions changed over time, for example, with the introduction of machinery, the substitution of "brain" power for "brawn" power, and changes in educational attainment.

The C probability distribution for women is given by $g(C^F)$ and that for men is given by $h(C^M)$. Assume, for the moment, the gender-neutral case in

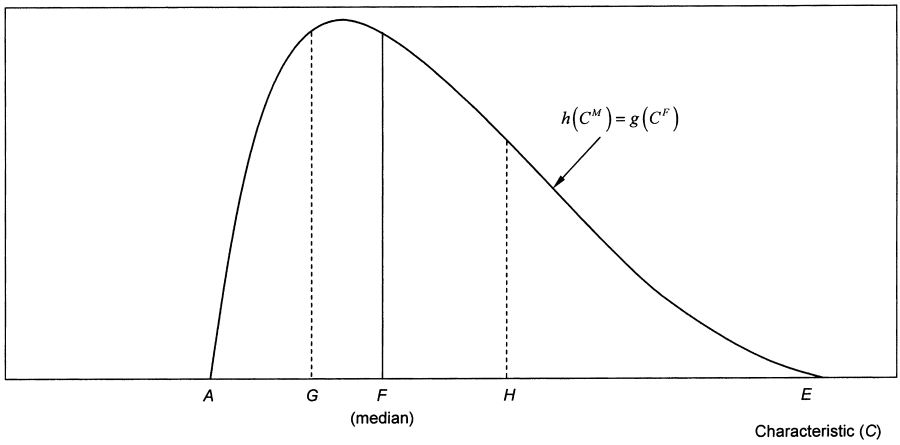

Fig. 9.1 The model with identical distributions of *C* for men and women

which the C distributions are identical for men and women, thus $g(C^F) = h(C^M)$, as in figure 9.1, where the median C level is given by F. Recall that only men are employed in occupations in period 1 and that each value of C_i defines an occupation and a wage in equilibrium. Because the characteristic distributions are identical for men and women, women can produce at the minimum required in each occupation. The question is whether men will allow women into their occupation in period 2.

Consider a male employee with a characteristic value somewhere in region FE, for example at H. What is his response to hiring a woman into his occupation? Recall that everyone knows that an H-level of the characteristic is required for the occupation in period 1, and the worker's status is related to society's perception of his characteristic value. Thus in period 1 his utility is given by $U_H^{M,1} = U_H^M(Y_H^1, C_H^{*,1})$.

The world is dynamic and an occupation's level of C can be altered by a technological shock that reduces skill requirements. Handloom weavers required considerably more skill than did factory weavers; cobblers were more skilled than workers assembling shoes after the introduction of the sewing machine; hand bookkeepers probably used more skill than their successors did after the introduction of calculators. One's status can actually be reduced in a dynamic world. But it can also be polluted in a manner that is more apparent than real—by the hiring of workers whose median level of the characteristic is lower than that currently required in the occupation. The introduction of such workers is a signal that the occupation probably underwent change in its skill requirement, even when it did not.[16]

16. This notion of pollution is similar to "tipping" in housing segregation models. See Pan (2011) on tipping models in occupational segregation by sex.

Returning to whether the worker at H would oppose a woman in his occupation, consider the type of signal that hiring a woman would provide and recall that the C level of a particular woman is private information. Assume that society picks a decision rule such that probabilities below 0.5 signal a technology shock for that occupation, that is they signal $\Omega = 1$, and that those above do not, that is they signal $\Omega = 0$. If a female applicant is accepted into the H occupation, society infers whether the occupation underwent change, between periods 1 and 2, by calculating whether:

$$\int_{i=H}^{E} g(C^F)\, dC_i \gtreqless 0.5. \tag{1}$$

Society calculates whether H is above or below the C value of the median woman; that is, the probability a female applicant has a C value above or below H.

In the case under consideration, occupation H requires a C level above the median. Thus if a woman is hired into this occupation society will infer that the occupation has drawn a value of 1 for Ω, and all men in the occupation will suffer a loss in prestige if a woman enters the occupation. Even if Ω were actually 0, women will be barred from entering occupations above the female median to protect that status of existing male workers. Thus male workers above the median of the female distribution will oppose the entry of women in their occupation and those below the median will not oppose their entry.

As in the classic Becker model of discrimination, men in the range FE will demand a premium to fully compensate them for their loss in prestige if women are hired. The premium would increase with the distance from F if the reduction in prestige was always to the value at the female median, thus independent of the initial C_i. The fewer the number of men in the occupation the less costly would be the total compensation.[17]

Rather than fully compensate the men in the occupation for their loss of prestige, it may be less costly to create another occupation for women (at the same level of C). Two occupations having the same minimum level of C can exist within a firm, one for men and another for women (e.g., waiter and waitress, seamstress and tailor, doctor and nurse practitioner, stenographer and accounting clerk). But there may be a cost advantage within each firm of having only one occupation for each level of C. Alternatively, one firm can have only men do a job and another firm can have only women do the same job.

In a competitive equilibrium women will be paid the same as men hav-

17. The wage premium demanded can be modeled as a function of the probability that the randomly drawn woman is less qualified, with lower probabilities demanding less compensation. The occupation could be defined by place, firm, or industry. If male machinists, for example, perceive their prestige to depend on the existence of female machinists in *any* firm, an externality could be imposed by one firm on the workers in another. Occupations that are rare across firms will be less likely to be segregated than those that are numerous within firms, since total compensation will be greater the more workers to compensate. In the model, however, the firm cannot provide additional compensation since goods prices are given.

ing equal characteristics, but they will be in a different firm or in a different occupation. Two occupations, or two firm-occupations, will exist that use the same level of skill. They will be found at levels of *C* above *F*. But the creation of these all-female occupations could take considerable time. In the meantime, women will be "crowded" into occupations for which they are "overqualified," and these overqualified women will have *C* levels above the median of the female distribution.

Consider, instead, a male worker at point *G*. That worker will not perceive his status or prestige polluted if a woman is hired into his occupation. Using the rule set down in equation (1), the probability that the new (female) worker has an attribute value exceeding that of the initial workers is greater than 0.5. Men in occupations below the median of the female distribution will find that women do not pollute their status and these occupations will be integrated. The model predicts that occupations will be segregated in range *FE* and integrated in range *AF*.

9.1.3 Model Equilibrium and Implications: Dissimilar Characteristic Distributions

The characteristic distributions may not be identical for men and women or may have been dissimilar in the past and then became equal. An extension of the basic model allows the distributions to be different at the start, but less so with time. The implications are similar yet more revealing about the historical process of sex segregation.[18]

At some distant time men and women may have had characteristic distributions that were so divergent as to be nonoverlapping. The ratio of female to male wages in New England farm communities around 1800, for example, was extremely low, probably below 0.30, and men and women were rarely employed at the same tasks.[19] Given the technology, crop, inherent differences between the sexes, and possibly social custom, women had considerably lower relative productivity in the work force.[20] The industrial revolution in America, beginning around the 1820s, may have shifted the female characteristic distribution to the right and possibly widened both distributions through the differentiation of tasks. A further shift can be associated historically with the increase in education in the first decades of this century and the

18. Various extensions of the basic form of the model are given in the model appendix. These extensions include a symmetric form of the model in which both males and females can pollute, but males are in the occupations earlier.

19. In places that used the plough, women had far lower relative productivity. See Alesina, Giuliano, and Nunn (2011); Bidwell and Falconer (1925); and Goldin and Sokoloff (1982, 1984).

20. Another way of justifying why the female distribution of the characteristic may be to the left of that of men is that until the 1940s both married and single women in the paid labor force (outside the home) were drawn from the less educated portion of the female population. Thus, even though the male and female populations had nearly identical levels of education, the two working populations did not.

evolution of occupations, such as those in the clerical, sales, managerial, and professional sectors, that had higher returns for schooling than did those in manufacturing. As brain power replaced brawn power, the two distributions may have become more similar, if not identical.

In this version of the model, given in figure 9.2, the two characteristic distributions are overlapping but not identical. Similar to the setup before, men are hired into jobs in period 1, say in the manufacturing sector, and they receive occupations depending on their level of C. Women try to enter occupations in period 2 and men respond.

Two regions in figure 9.2 are of interest and two are not. Only women will be employed in AD and only men in BE. Just DF and FB (where F = the female median) offer the possibility of integration. The model predicts that occupations will be segregated by necessity in range AD, integrated in range DF, segregated by design in FB, and by necessity in BE. Only in range FB will there be both male and female occupations, which can be segregated within a firm or firms, that can hire either men or women to perform the same occupation.

Now consider a shift of $g(C^F)$ to the right, resulting in $g'(C^F)$ in figure 9.3, as may have occurred with the increase in education during the first decades of the twentieth century. What is the response? At some point the result must be identical to that outlined above in section 9.1.2. Segregation will exist from the new female median at F' to E and the range of integration will be larger by FF'. Certain occupations, those in range AA', will disappear and others, those in range BB', might be added. But there are several reasons why this transition may take considerable time and why the path to it may be of great interest.

The areas of greatest change will be FF', the new integration range, and

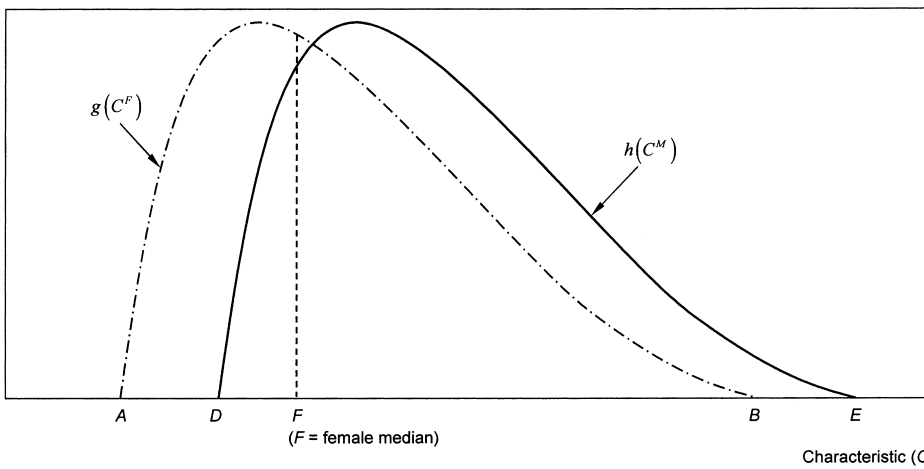

Fig. 9.2 The model with different distributions of C for men and women

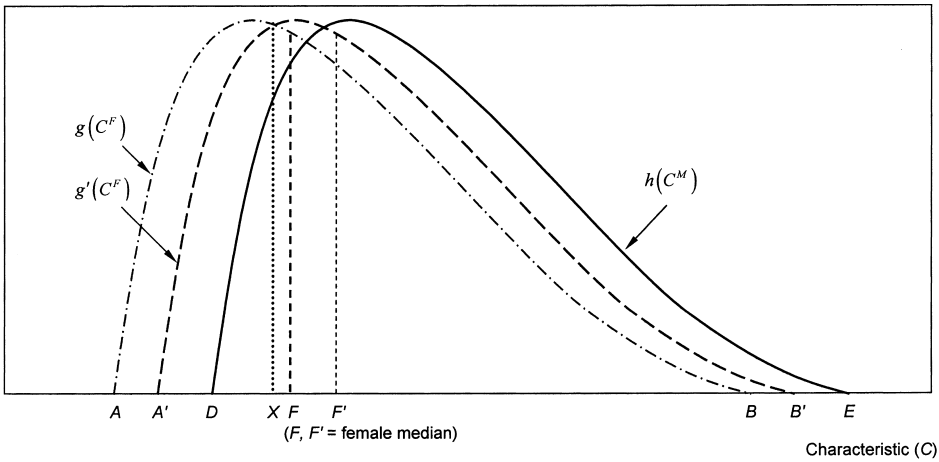

Fig. 9.3 The model with different distributions of *C* for men and women and a change in the *C* distribution for women

BB′, the new occupation range. Male workers in range *FF′* might resist integration with prospective female employees if they do not know that the median of the female characteristic distribution has increased, or if they believe that others do not yet know. Once everyone knows the median of the new female characteristic distribution, men in range *FF′* will not be polluted by the presence of women colleagues and will let them enter. In the interim, women in range *FF′* will remain in preexisting "female-only" occupations, should those occupations have been set up.

Women in the range *BB′* will not be able to enter the male occupations for which they are qualified and will have to enter newly created female-only occupations. If the creation of these occupations takes time, they will be "crowded" into the next best alternative in the interim—the occupation at point *B*. Under the "small country" and constant returns assumptions, wages will not change in those crowded occupations. But some female workers will be earning too little given their characteristics. Econometric studies of earnings differences by gender will reveal "wage discrimination" because women will be overqualified, but jobs will receive the correct remuneration given the requirements for the occupation.[21]

9.1.4 Feedback and Wage Effects

The absence of women from the upper tail of the occupational distribution, range *BB′*, even during an interim period may have a lasting impact

21. Under these circumstances, a comparable worth policy will not eradicate discrimination but an affirmative action policy might; however, see Coate and Loury (1993) on the potential for such a policy to backfire even when the two groups are identical.

on the perceptions of all workers about the characteristic distribution of women and about occupations that are "appropriate" for young women. If, for example, the characteristic is education and B is "teacher," then women with education levels in BB' will all be teachers rather than principals, lawyers, and doctors. Young women will not have an incentive to attain higher levels of education. The nurse in range FB may have been appropriately placed initially, albeit in a sex-segregated occupation. But at a subsequent date women with a higher level of the characteristic may be inappropriately trained to be nurses due to an absence of opportunities in range BB' or to perceptions of an appropriate career for women. Occupational segregation by sex may produce appropriate financial rewards at one date, but may lead to unfair rewards and incorrect expectations at a later date.

Occupations in range FB (and later in $F'B'$) may become "protected," either through actual barriers to entry or through rhetoric that creates an "aura of gender." Firms may be able to attract men into an occupation only if they can promise that the occupation will remain male only. Once in an occupation, men in range FB have an incentive to use rhetoric and construct a set of norms that inform prospective entrants (and employers) of the occupation's gender, even if the occupation can be performed by either sex. At times this involves the creation of, what may be called, "secondary sex characteristics."[22]

One of Becker's keenest insights in his classic discrimination model is that the economic marketplace has an ameliorative impact on prejudice and that occupational segregation can substitute for the wage effects of discrimination. But occupational segregation may not be a benign consequence if the past affects the present through the formation of expectations, through the appearance of "holes" in the occupational spectrum, and through the institutionalization of barriers. If men infer the median of the female characteristic, rather than knowing it, from the distribution of occupations containing women, adjustment lags—caused by preexisting norms, barriers, and slow informational flows—will lead to an underestimate of the new median for women. This underestimate will lead a greater proportion of men to be hostile to female entrants. Programs and policies that make highly educated and successful women, of the present and past, more visible, serve to counteract the effect.[23]

Dropping either the assumption of exogenous prices or that of constant returns to scale produces wage effects. Integrated and female-only occupations will have changed wages as the relative supply of workers is altered across the attribute spectrum. The number of workers will increase to the right of point X, the crossing point of the previous and new female distribu-

22. See Goldin (1990).

23. See, for example, Beaman et al. (2009) on the impact of exposure to female Indian village council chiefs on perceptions of women leader effectiveness.

tions in figure 9.3, and a decrease to the left. The increase and the decrease, as a percentage of previous workers, are greatest at the tails (A' and B') and diminish moving in from both to X. If the change in the wage depends on the percentage increase in workers, the wage will rise most at A' with diminishing impact as one moves toward X. Similarly, the wage will fall from X to B' in an increasing fashion. Male workers to the right of point X have the most to fear from the introduction of female workers and their fear should increase moving toward point B'. Note as well that if workers with similar skills produce goods that are close substitutes, even workers in range $B'E$ will face changed wages with a shift in the skill distribution.

There will be additional wage effects around point B if the female-only occupations in range BB' take time to emerge. Individuals in jobs located between F' and B and all female workers in range BB' will be paid too little given job requirements and individual attributes.

In sum, the implications of the model are that occupations above the median of the female distribution will be segregated and that occupations may be segregated in a nonmonotonic fashion with regard to the attribute and the wage. For some distributions of the attribute, occupations will be segregated in the tails and integrated in the middle of the female distribution. For other distributions, in which the male and female distributions fully overlap at the bottom of the characteristic range, there will be integration at the lower end and segregation at the upper end. And in the upper range, male-only occupations will develop barriers against female entrants and female-only occupations may be created in that range to use women's talents.

9.2 Taking the Model into the Real World

Exactly how one takes the model to the real world depends on the spatial boundaries of human association.[24] Male firefighters or police officers, to take two examples, may perceive their status to depend on the sex composition of their own police station or firehouse. Some, however, may believe that their stake encompasses a wider geographic area, such as the municipality or the state. Thus, if employees in an occupation are scarce within firms (e.g., bookkeepers in small offices, teachers in rural areas), there can be wide differences in the gender of an occupation across space. Much will depend on whether employees have knowledge of their counterparts in other firms and view them as equals, as well as whether their status is conferred by the same societal group.

Certain assumptions can be amended in application, in particular that a specific female entrant's C level is unknown to society. The degree to which her admission into the occupation will pollute the status of existing male workers is dependent on the assumption that she is viewed as a random draw

24. Frank (1985) would call these "frog ponds."

from the female distribution. Credentialization of occupations (e.g., degrees, licenses, admission tests) in the upper end of the characteristic distribution could eliminate the negative signal provided by hiring a woman particularly if the credential were well known and verifiable. The absence of occupations that fully use women's talents, resulting in "overqualified" women workers, can result in low wages ("wage discrimination") given characteristics and can reinforce discrimination. Credentialization could eliminate these effects.[25]

The model developed here explains why men object to women's entering their occupations apart from their desire to maintain wages. Several reasons have motivated the construction of the model in this fashion. For one, it is too obvious that individuals and groups object to having their earnings depressed and their jobs endangered. Union members erect barriers to entry even when the prospective hires are of the same sex, race, and ethnicity. Nationals want to restrict immigration to protect their earnings and jobs.

Men have objected to having women in their occupation even when earnings could not have depressed their entry and in cases even after earnings were eroded by changes in either supply or technology. Men objected to female manufacturing workers during World War II even though men were promised "equal pay for equal work."[26] In other cases the number of women attempting to enter the contested occupation was far too small to have depressed wages by more than a trivial amount. And there are examples of all-male occupations in which relative wages for the occupation decreased long before women were allowed to enter. Women were first employed as bank tellers as an emergency measure during World War II even though the relative wages of male bank tellers had already decreased a decade or more earlier.[27]

To demonstrate the potential importance of the pollution theory, I explore the historical record to find evidence concerning the empirical implications derived from the model. The implications are related to occupational segregation and its change over time, the relationship between occupational segregation and the characteristic (or earnings) distribution, the degree of and emergence of "wage discrimination," and the role of credentialization and incentive pay in integrating occupations by sex.

9.2.1 Occupational Segregation: Origins and Maintenance

Historically, occupations have been highly segregated by sex. A national index of dissimilarity by sex across all occupations remained fairly constant

25. Licensing, by restricting entry, could disadvantage women (see, for example, the literature review in Law and Marks [2009]). Kleiner and Krueger (2013), using recent data, conclude that licensing may restrict entry but does not appear to differentially impact women. Law and Marks (2009), using historical data, find that some licensed occupations (e.g., teaching) had reduced female representation but others (e.g., engineers, pharmacists) saw increased numbers.

26. See the discussion in Milkman (1987).

27. Strober and Arnold (1987) discuss the switch from male to female tellers in the 1940s.

at about 0.66 from 1900 to 1950 although that for the nonfarm labor force fell from 0.75 to 0.67. Since 1950 the index has steadily declined, especially in the decades of the 1970s and 1980s. It is now between a quarter and a third lower than it was a half century ago.[28]

Although some occupations have changed sex over time (e.g., librarians, bank tellers, teachers, telephone operators, sales positions), new occupations and new industries (e.g., clerical positions in the 1910s, electrical machinery operatives in the 1920s) as well as those experiencing substantial growth in demand (e.g., teachers in the nineteenth century, stenographers) are most likely to become "feminized."[29] Several occupations that were integrated by necessity during wartime were quickly feminized thereafter (e.g., bank tellers) whereas others returned to being male dominated (e.g., craft jobs in manufacturing). Some occupations were feminized slowly and incompletely (e.g., sales, teaching), whereas the process was swift and complete in others (e.g., telephone operators, typists, secretaries).

Most occupations are not inherently male or female. Instead, they often gain what I have termed an aura of gender through a rhetoric that surrounds the labor market, by the evolution of certain norms, and the use of particular forms of physical capital. The origin of these differences can often be found in factor endowments, as well as other factors.

Dairying in the early nineteenth century, for example, was considered men's work in the East but women's work in the Midwest, where a male milker was thought to be doing "women's work." Farmers in the East had smaller farms and less fertile land than in the Midwest. Thus male agriculturalists in the East had little else to do than milk cows and run the dairy. Factor endowments influenced gender roles.[30]

For example, when typists were primarily men, it was claimed that typing required physical stamina. But later, when typing became a female occupation, it was said to require a woman's dexterity.[31] Meatpacking and slaughtering establishments in the 1890s had labor forces that were virtually all male and who claimed that women should not be employed in the trimming room and cutting floor because "handling the knife" was not women's

28. On long-term trends in occupational segregation using a consistent set of occupations, see Jacobs (1989); for the 1970 to 2010 period, see Blau, Brummund, and Liu (2012). A more relevant index, particularly for the model developed here, would use firm- or city-level data. Blau (1977) analyzes the effects of sex segregation using data on the fraction female by firm for occupation-city cells.

29. According to Garrison (1979), male librarians became administrators during the period of demand growth. On more recent changes in occupational segregation, see Reskin and Roos (1990).

30. Earlier in US history, before the fertile lands of the Midwest were populated, native-born women did some dairying but did not work in the fields. "In [colonial] New England only men . . . were to be seen in the fields," according to Bidwell and Falconer (1925, 116). Recent arrivals from Germany, however, worked alongside their husbands and brothers in the fields. Once again, factor endowments and income levels altered gender roles.

31. See Davies (1982).

work. The use of female strikebreakers in 1904 ultimately led to the hiring of women in sausage making. But even though Slavic women were hired as meat trimmers, women were not given entrée to the cutting floor.[32]

As Caplow (1954) has noted in his insightful work on occupations, "Any job for which only women are employed is likely to be classified as delicate, or even as monotonous."[33] Occupations and industries acquire secondary sex characteristics that serve to reinforce small initial differences in the degree of strength, stamina, or intensity demanded on the job. "The use of tabooed words, the fostering of sports and other interests which women do not share, and participation in activities which women are intended to disapprove . . . all suggest that the adult male group is to a large extent engaged in a reaction *against* feminine influence."[34]

Union rules and firm policy have also been used to restrict the entry of women. Unions have erected barriers to the hiring of women in various crafts. Molders working in foundries in the 1910s were fined for instructing women in their trade.[35] The Cigar-Maker's International Union, organized in 1851, excluded women (and blacks) in its constitution.[36] Rigid, formal barriers have existed in many professions, such as law and medicine.[37] Firms hiring office workers had personnel policies not to hire women in certain occupations but to hire women exclusively in others.[38] Advertisements for jobs listed the gender of the job until sex became a protected group at the federal level through the Civil Rights Act of 1964.[39]

When women manage to slip through the barriers, intimidation is often a last resort. Female firefighters and police officers have successfully sued municipalities for sexual harassment with intent to create a hostile work environment and for tampering with tests to make women, but not men, fail. In *Berkman v. City of New York*,[40] two female firefighters were physi-

32. See the account by Abbott and Breckinridge (1911). "There seems to be a strong objection in the community to the employment of women in the trimming-room, on the ground that 'handling the knife' is not women's work. It is difficult to justify this prejudice on any logical ground since it has always been recognized that a woman could suitably handle a knife in her own kitchen" (639). Although women linked, twisted, and tied the sausage after the strike, the packing of sausage in the casing, which used machinery, remained men's work.

33. Caplow (1954, 233).

34. Ibid., 239, italics in original.

35. US Department of Labor, Women's Bureau (1920) reported: "The molders' union did not admit women even during the war. . . . By the rules of this organization members are fined for teaching a woman any part of a trade. . . . A further reason is the fact that core making . . . is regarded as one of the stages in the apprenticeship of a 'molder.' Unless all the stages . . . are open to women the introduction of woman core makers complicates and disrupts trade regulations" (34). See also Kanter (1977) on the training of managers by others within firms.

36. Abbott (1907, 16). The union altered its constitution in 1867 to allow the excluded groups to become members. A decade later, in 1877, women were used as strikebreakers.

37. See Morello (1986) on lawyers and Harris (1978) on professions in general.

38. See Goldin (2006) and the material in section 9.1.3.

39. See Darity and Mason (1998) for examples of advertisements with the specified sex and race and for a discussion of state laws that preceded the Civil Rights Act of 1964 and their lack of enforcement.

40. U.S. District Court, 626 F. Supp. 591, 1985.

cally harassed and the physical test for advancement from the probationary position was altered. Three female firefighters successfully sued the Reedy Creek Improvement District and Walt Disney World for harassment.[41] Male firefighters had displayed lewd pictures in the fire station and engaged in vulgarities with the goal of preventing female trainees from receiving instruction. In *Ramona Arnold v. City of Seminole, Oklahoma*, police officers sexually harassed a female officer with intent to create a "hostile and offensive working environment."[42]

Abbott tells of a woman and her daughters who learned to use the mule in a Waltham textile mill but were forced to leave when the "men made unpleasant remarks."[43] Firm managers and supervisors interviewed at the end of each of the world wars noted that it was virtually impossible to integrate occupations incrementally from 100 percent male.[44]

Even though credentials and tests may initially be barriers to women's entry, a woman who has earned a verifiable and known credential or passed a test of known quality cannot be viewed as a polluter. Thus the growth of credentials can increase integration and reduce "wage discrimination."

9.2.2 Manufacturing Occupations in the Early Twentieth Century

Occupations and industries have been overwhelmingly segregated by sex throughout history, although segregation was more extreme a century ago than it is today, particularly in manufacturing.[45] Integrated occupations in manufacturing around the turn of the twentieth century were found in a handful of industries (e.g., textiles, apparel, tobacco, shoes, printing, and paper). Further, when men and women occupied the same job in the same firm, remuneration was invariably by the piece, not time. Piece-rate work may have enabled firms to pay males and females different amounts despite having the same occupational title and working in the same firm. For example, male piece-rate compositors who worked in integrated firms—those having both male and female compositors—earned on average 36 percent more than did female piece-rate compositors.[46]

Many industries in the early 1900s had no integrated occupations and a large group of them (hiring more than 60 percent of all male operatives) had virtually no female operatives. Industrial segregation by sex in the manufacturing sector measured by an index of dissimilarity was 61 in 1890 and fell to 33 in 1960.[47] Industries were so highly sex segregated in 1890 that more than 60 percent of male operatives could not have shared the same

41. *Orlando Sentinel*, October 29, 1996, p. D1.
42. U.S. District Court, 614 V. Supp. 853, 1985.
43. Abbott (1909, 92).
44. See US Department of Labor (1920). This was particularly true of firms having a large number of men in an occupation.
45. See, for example, the discussion in Goldin (1990, chapter 3).
46. Goldin (1990, table 3.6, 81).
47. The index of dissimilarity is used where the unit of observation is the two-digit SIC industry in 1890 and 1960. See Goldin (1990, table 3.5, 80).

industrial-occupational title with a female. Virtually no female operatives were employed in twenty-three "male intensive" industries (e.g., agricultural implements, iron and steel, lumber) in 1890. Of the 230,000 production workers in foundry and machine shop products in the United States in 1890, just 1,200 were women. Almost 70 percent of all female operatives were in just two industries—textiles and clothing.[48]

Yet "wage discrimination" was rather small among male and female operatives across the manufacturing spectrum around 1900.[49] Attribute differences (e.g., total work experience, years in the occupation, tenure on the job) explain much (65 percent) of the disparity in earnings and another portion is due to differences in the productivity of unskilled men and women paid by the piece (15 percent).[50] Despite the introduction of machinery throughout the manufacturing sector, brute strength was still important and highly rewarded. All of this suggests that the male and female distributions of C were rather far apart in 1890. But these facts cannot explain all industrial and occupational segregation by sex.

Certain occupations and industries were integrated (e.g., in printing and publishing, textiles). Yet other industries were formed entirely around male workers, for whom entry-level occupations were often used as screening and training grounds for higher-level occupations to isolate the higher-level occupations from integration, and to ensure that selection to them was from a pool of male workers, entire industries were segregated.[51] These industries were organized in ways that differed radically from those in the female-intensive and mixed sectors. But it is not clear whether the differences were due to strength and skill requirements, the need for apprenticeships, higher costs of having division of labor, or the absence of piece-rate work.[52]

Because considerable strength was required in manufacturing work in the past, the male and female characteristic distributions may not have over-

48. US Census Office (1895), and also Goldin (1990, table 3.5, 80).

49. On "wage discrimination," see Goldin (1990, chapter 4).

50. The 15 percent figure comes from an analysis of the earnings of men and women in the same occupations (in this instance it was the bundling of kindling wood), paid by the piece in firms that hired both male and female workers. See Goldin (1990, 104).

51. One observer commented on the integration of certain parts of the metal industry: "The displacement of the boy has one serious disadvantage. When boys worked at these tasks it was possible to pick out the clever and ready, who might be expected to become leading men and foremen. The girls do not furnish material for this purpose. . . . This at first unforeseen development will, in the view of many superintendents, check the tendency to replace boys with girls in many of the lighter occupations" (US Senate 1910, vol. XI, 15).

52. Milkman (1987) demonstrates differences in the organization of work between the automobile and electrical industries around 1940. Greenwald (1980) documents hostility toward women workers during World War I. "Ordinarily, welding had been one stage in the apprenticeship of a machinist. During the war the process was separated for the first time from this larger training program. . . . The employment of women as core makers in railroad foundries presented molders with a similar challenge. . . . Since the production of cores was a distinct stage in the training of apprentices, the molders' union strongly objected to the separation of core making from the entire program of training" (117). It is not clear whether these apprenticeship stages were necessary to the entire production process or whether they were maintained to prevent female workers from entering lower-skilled positions.

lapped entirely and the male distribution may have had a longer right-hand tail, whereas the female distribution may have had a longer left-hand tail. In terms of the predictions of the framework regarding where occupational segregation would be found, the evidence corroborates the notion that segregated occupations in manufacturing were found at the tails of the female earnings distribution.

On average, female hourly earnings for occupations that were gender segregated were nearly identical to those that were integrated (weighted by the number of female employees). Among the few integrated occupations were some in printing and publishing, almost unique in early twentieth-century manufacturing in the employment of relatively well-educated production workers.[53] The segregated occupations, however, were found both at the very bottom and at the very top of the female earnings distribution. For example, in clothing and tailoring, women in the female-only trade of buttonhole maker "earn the highest wages among the female hand workers."[54] Most firms, in addition, had female supervisors who were among the highest paid female shop floor workers.

9.2.3 Office Work in the Mid-twentieth Century

With the shift from manufacturing to clerical and office jobs and the substitution of brains for brawn, male and female characteristic distributions began to have greater overlap. In the data set I will soon describe, male clerical workers in 1940 had just 0.4 more years of schooling than female clerical workers (11.5 years for women and 11.9 for men; see table 9.1 columns [5] and [6]). Men in these jobs had more years of college and advanced degrees, but the bulk of office workers at that time had only high school diplomas. Job experience was a bit different by sex. Men worked about 2.6 years more with the current firm (10.2 years for men and 7.6 for women) and 2.4 years more in office work generally (12.8 versus 10.4).

An important implication of the model is that when women first enter the labor force they will be barred from occupations that require skills above the median productive characteristic in the female distribution. Another implication is that firms will find it advantageous to use the talents of these women by creating "all female" occupations around that level of skill. Alternatively or in conjunction, occupations that had previously existed could be transformed into female occupations especially if employment in them was growing rapidly and there had been few men in them to protect the occupation.

To investigate these implications I examine an extensive set of data on clerical and office workers in 1940. The data were gathered from archival records relating to US Department of Labor, Women's Bureau Bulletin no. 188 (1942), which concerned the personnel policies of firms and the characteris-

53. See US Department of Labor (1905). Printing and publishing was also unique because its union enabled the integration by sex of occupations in the twentieth century.

54. On women's occupations and earnings in the clothing industry, see US Senate (1910, vol. I, 458).

Table 9.1 **Earnings functions for male and female office workers, 1940**

	Female		Male		Female	Male
Dependent variable	(1) Coefficient (s. e.)	(2) Coefficient (s. e.)	(3) Coefficient (s. e.)	(4) Coefficient (s. e.)	(5) Means	(6) Means
Log of full-time yearly salary					6.95	7.34
Total office experience	0.0320	0.0315	0.0507	0.0483	10.35	12.77
	(0.00220)	(0.00368)	(0.00240)	(0.00608)		
Total office experience squared $\times 10^{-2}$	–0.0588	–0.0577	–0.0804	–0.0766		
	(0.00613)	(0.0097)	(0.00507)	(0.0109)		
Experience with current firm	0.0154	0.0151	0.0131	0.0129	7.58	10.2
	(0.00155)	(0.00199)	(0.00155)	(0.00288)		
Years schooling	0.0393	0.0368	0.0605	0.0551	11.5	11.9
	(0.00364)	(0.00555)	(0.00343)	(0.00632)		
Married	–0.00760	–0.00774	0.140	0.131	0.197	0.484
	(0.0147)	(0.0186)	(0.0169)	(0.0197)		
Sex ratio (fraction female or male) of current occupation		–0.818		–0.588	0.711	0.733
		(0.350)		(0.233)		
Sex ratio squared		0.720		0.659		
		(0.305)		(0.182)		
Constant	6.151	6.339	5.978	6.184		
	(0.0472)	(0.115)	(0.0470)	(0.139)		
Number of observations	1,393	1,393	1,491	1,491		
R^2	0.484	0.504	0.626	0.648		

Source: 1940 Office Worker Survey (see data appendix). Goldin (1990) uses a smaller sample of records; Goldin (2006) uses the expanded sample used here.

Notes: Columns (2) and (4) clustered (by occupation) standard errors are in parentheses. "Total office experience" is the sum of all work experience in offices. "Sex ratio" is the fraction female for column (1) and fraction male for column (2) in each of the seventy-five occupations in the sample. Only observations with complete information on education were used; that is, missing values in any of the entries (e.g., years in high school) are excluded. Earnings use the "usual" salary per pay period and are "annualized" to get the (full-time) annual salary for a forty-hour per week and fifty-two-week per year worker.

tics of office workers in 1940. Two separate sets of related data were collected by the Women's Bureau and later deposited in the US National Archives in Washington, DC: individual worker records and firm-level information.

Individual worker information was collected by the Women's Bureau from personnel records and surveys of individual workers in firms across several major cities (see data appendix). I sampled almost 3,000 records for workers in Philadelphia. These records contain detailed information on the workers' office employment history including information on their first job, current job, marital status, education, and earnings. The number of workers surveyed by the Women's Bureau was so large that about one-fourth of all Philadelphia's office workers were included in the survey.[55]

55. See US Department of Labor, Women's Bureau (1942, no. 188-5, 2). The Women's Bureau noted that only the Philadelphia data had complete education and other personal information.

The Women's Bureau also surveyed firms about their personnel policies concerning office workers. The firm-level records contain information on the numbers of office workers hired and a host of personnel policies including the office occupations that were limited to men or to women by company policy and whether the firm discriminated on the basis of race, ethnicity, marital status, and age (see appendix figure 9A.1). I collected and tabulated all extant information from these surveys for three cities: Philadelphia, Kansas City, and Los Angeles.

Firm responses in these records were remarkably candid and reflected the norms of the day, the absence of regulations concerning protected groups, and, on occasion, the desire of firms to demonstrate generosity by their preferential employment of married men during the Great Depression. Few inhibitions were revealed about discrimination on the basis of race and religion. In Philadelphia, for example, of the ninety-seven firms having ten or more males and ten or more females in clerical positions, thirty firms, or 31 percent, specifically stated that they had a company policy not to hire "Negroes" or "colored."[56] Of the ninety-seven firms, sixty-five had at least one job that was reserved by company policy to men, sixty-nine had at least one job reserved to women, and fifty-nine reserved jobs to both. The data for each of the three cities in the sample are given in table 9.2.

Taking the model's implications to the data is complicated by the fact that, unlike in the model, the characteristic on which productivity is based in the real world is generally not single-dimensional. A weighted average of factors that impact productivity is used to obtain a measure of the level of the characteristic. I use the office worker sample from Philadelphia to estimate a full-time annualized earnings regression for males and females, as given in table 9.1, columns (1) and (3). Log of full-time annual earnings is regressed on a set of productivity enhancing factors: total office experience, its square, tenure with the firm, and years of education; marital status is also included.

Female employees were not necessarily paid their full marginal product due to various factors, including that their occupations were limited to those that did not involve much advancement in the firm. Therefore, I evaluate their aggregate skill level using their observables (e.g., education, experi-

Although they collected data from personnel records in other cities, their resources allowed them to do interviews with workers only in Philadelphia, it appears.

56. Many firms did not think they were discriminating when they barred blacks. For example, in answer to the question, "what are the firm's policies with regard to race and color?" the Pennsylvania Railroad stated, "no discrimination as to race; no colored people hired in office." Du Pont's statement "no negroes in clerical jobs" was echoed in many responses. Some firms may have been commenting on the fact that the firm currently employed "no negroes," but many specifically stated the reason why (e.g., Philadelphia Electric stated, "employees refuse to work with colored people in the clerical field") or that they barred a range of workers (e.g., "Jewish girls not for office"). Mr. Simpson, of the Philadelphia Gas Works, gave the fullest statement: "He said they get few Jewish or negro applications for clerical jobs. He doesn't feel that negroes can be placed with the whites on clerical jobs. There are some Jewish clerical workers but a very small percentage of the total. . . . He thought it was better not to have very many." 1940 Office Firm Survey; see data appendix.

Table 9.2 **Firms with restricted occupations by race and gender, 1940**

City	Firms having ≥ 10 male and ≥ 10 female office workers	Number of firms (%) with race restrictions	Number of firms (%) with any restrictions on occupations by sex		
			Female only	Male only	Both
Philadelphia, PA	97	30 (31)	65 (67)	69 (71)	59 (61)
Kansas City, MO	39	19 (49)	29 (74)	26 (67)	22 (56)
Los Angeles, CA	83	18 (23)	47 (57)	49 (59)	39 (47)

Source: 1940 Office Firm Survey (see data appendix).

Notes: Only firms with ten or more men and ten or more women in office or clerical occupations are shown. Race and gender restrictions were described on a form similar to that in figure 9A.1.

ence) weighted by the coefficients from the male equation. That is, I use table 9.1, column (3) coefficients combined with the female means given in column (5). This method essentially gives the earnings of a female had she been paid like a male. I then add to this value the residual calculated from the female earnings regression in column (1) to account for unobservable traits that made some individuals better suited to certain occupations. The overall mean is, of course, unchanged, but the mean for certain occupations is higher and for others is lower.

Computed in this way the median (full-time, annualized) income for female workers is $1,318 per year (1940 dollars), whereas the raw median for women was $1,020. About 35 percent of male office workers had annualized salaries below $1,318. The median for the male distribution is $1,560. The full-time annualized earnings distribution for all male office workers is given in figure 9.4. The median for females, according to the procedure just outlined, is drawn at $1,318. I now examine which occupations (in firms having ten or more males and ten or more females) were restricted to men only and to women only.[57]

A listing of the clerical occupations in the Philadelphia sample from the Women's Bureau is given in table 9.3. I have matched these occupations to those given in the firm-level surveys and also to those in the office worker sample from which I obtain the annualized earnings. But some of the occupations listed by the firms on the survey were specific to each firm and harder to match.

Firms in Philadelphia (with more than ten male and female office workers)

57. I limit the analysis to firms with ten or more employees by sex to have a sufficient number of employees in each occupation and to have both males and females employed in each firm. Although many of the surveyed firms were small, the vast majority of workers were in firms that met this restriction: 94 percent in Philadelphia, 93 percent in Los Angeles, and 78 percent in Kansas City.

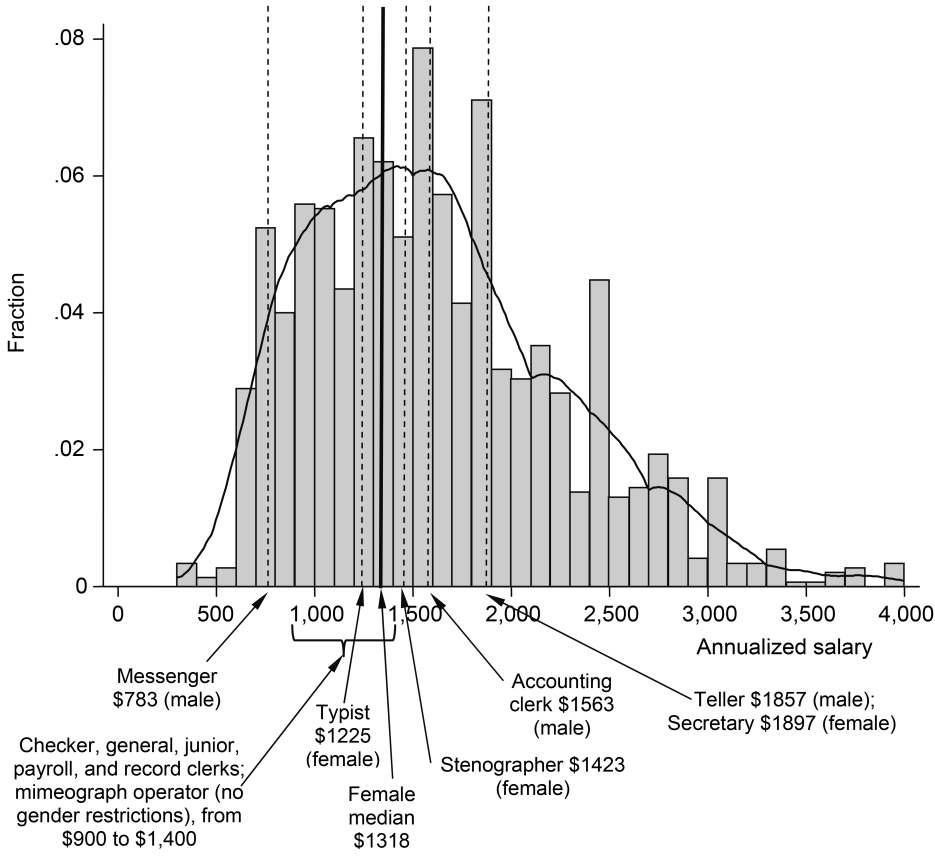

Fig. 9.4 Earnings distribution for male clerical workers in Philadelphia and mean earnings in certain gender-restricted and unrestricted clerical occupations among Philadelphia firms, 1940

Sources: 1940 Office Worker Survey and 1940 Office Firm Survey. See data appendix.

Notes: "Annualized earnings" assumes full-time workers (see notes to table 9.1). The male distribution is for annualized earnings in 1940 (histogram with 47 bins of $100 width). The line drawn is the kernel density. For drafting purposes, earnings in the graph are truncated at $4,000, which omits about 3 percent of the sample. The female median is computed by estimating a log earnings regression of the men in the sample who completed elementary school, where the regressors are education in years, office experience, office experience squared, firm experience, and whether currently married (see table 9.1, column [3]). Women's earnings are estimated by giving women the male coefficients. The residual from the equation for women (table 9.1, column [1]) is added to include the unobserved component. There were 1,393 men and 1,491 women in the sample who had completed elementary school. The occupations listed in the diagram above were among the more-common ones given in response to the question, "which jobs are open to men (women) only?" asked on the 1940 Office Firm Survey (see figure 9A.1 for a facsimile of the survey). Each occupation is listed with the group (male, female) to which it was often restricted and the mean annualized earnings for that group. The fraction of all female and male office workers in each of the occupations can be found in table 9.3.

Table 9.3 **Clerical occupations and restricted firms: Philadelphia firms, 1940**

	Women's Bureau Bulletin no. 188					Restricted firms	
Clerical occupations	(1) No. females	(2) No. males	(3) % of females	(4) % of males	(5) % female	(6) Male occs	(7) Female occs
Stenographic group							
Secretary	1265	58	0.107	0.009	0.956	0	10
Stenography	1721	109	0.145	0.016	0.940	0	20
Typist	1534	183	0.130	0.027	0.893	0	14
Dictating mach. transcriber	195	0	0.016	0.000	1.000	0	5
Correspondent	96	65	0.008	0.010	0.596		
Accounting group							
Accounting clerk	211	312	0.018	0.047	0.403	16[a]	0
Audit clerk	48	212	0.004	0.032	0.185		
Bookkeeping clerk	239	180	0.020	0.027	0.570	0	5
Bookkeeper, hand	125	176	0.011	0.026	0.415	5	0
Cashier, teller	140	294	0.012	0.044	0.323	6	2[b]
Machine operators							
Address	114	32	0.010	0.005	0.781	0	1
Billing	169	112	0.014	0.017	0.601	0	4
Bookkeeping clerk	430	0	0.036	0.000	1.000	0	6
Calculating	534	114	0.045	0.017	0.824	0	9
Duplicating	60	61	0.005	0.009	0.496		
Key punch	155	27	0.013	0.004	0.852		
Tabulating	57	83	0.005	0.012	0.407		
Other clerks							
Actuarial	54	35	0.005	0.005	0.607		
Bill, statement, and collect.	152	172	0.013	0.026	0.469		
Bond, security, draft	34	181	0.003	0.027	0.158		
Checker	89	71	0.008	0.011	0.556		
Circulation and subscription	153	0	0.013	0.000	1.000		
Claims examiner and adjust.	86	182	0.007	0.027	0.321	3	0

Coin counter	50	36	0.004	0.005	0.581		
Cost and production	34	317	0.003	0.047	0.097	2	0
Credit	112	64	0.009	0.010	0.636		
Draftsman	0	104	0.000	0.016	0.000	4	0
File	606	170	0.051	0.025	0.781	0	9
Mail	122	74	0.010	0.011	0.622	3	0
Messenger	111	385	0.009	0.058	0.224	14	1
Order and shipping	170	189	0.014	0.028	0.474	2	0
Payroll and timekeeper	174	129	0.015	0.019	0.574		
Rate	0	134	0.000	0.020	0.000		
Receptionist	95	0	0.008	0.000	1.000		
Record	287	174	0.024	0.026	0.623		
Renewal	0	45	0.000	0.007	0.000		
Route	0	62	0.000	0.009	0.000		
Service desk	122	0	0.010	0.000	1.000		
Sorter	108	0	0.009	0.000	1.000		
Statistical	178	226	0.015	0.034	0.441		
Stock	117	324	0.010	0.049	0.265	3	0
Telephone	356	0	0.030	0.000	1.000	0	14
Transit	99	213	0.008	0.032	0.317		
Trouble dispatcher	120	124	0.010	0.019	0.492		
Clerks, n.e.c.:	1309	1246	0.111	0.187	0.512		
TOTAL non-supervisory	11,831	6,675	1.000	1.000	0.639		
Supervisors	379	805			0.320	13	4

Sources: Columns (1) to (5) from the US Department of Labor, Women's Bureau (1942, no. 188-5); columns (6) and (7) calculated from the 1940 Office Firm Survey (see data appendix).

Notes: Columns (6) and (7) give the number of firms with ten or more male and female clerical workers that listed the given occupation as one that was restricted to males or to females. There were ninety-seven firms in the data set for Philadelphia that met the size criteria (see text).

[a]The restricted occupation was listed mainly as "accounting."

[b]These were "cashiers" not "tellers."

mentioned twenty-two of the clerical occupations itemized by the Women's Bureau to have been restricted to either males or females (rarely to both).[58] These occupations are noted in table 9.3, columns (6) and (7), which give the number of firms (out of ninety-seven) that mentioned having restrictions. As was noted before, the vast majority of the surveyed firms had some restrictions by sex on occupations. Some firms had just one restricted occupation and some had more than one. Therefore, the number of restricted firms in columns (6) and (7) can sum to more than the ninety-seven firms that had ten or more male and ten or more female clerical employees. Another clear fact is that the occupations that had restrictions were quantitatively important in terms of employment.

Most of the restricted occupations, as I will demonstrate, were those with substantial annual earnings. When a low-paying beginner job (e.g., messenger clerk, office boy) was reserved for males, the restriction was often stated as due to a desire by the firm to use the occupation as a means to select for upper-level positions. In some cases (e.g., stock clerk) the restriction was said to be due to the strength demanded. And in certain other cases (e.g., clerical workers in a steel plant) the position was deemed inappropriate for women who would have to walk through factory areas inhabited only by men.

But in a host of other cases, occupations were listed as being restricted to men with no stated reason. The quantitatively most important of these were in the accounting group. These restricted occupations include accounting clerks, bookkeepers (but not machine bookkeepers), cashiers, tellers, timekeepers, and teller window examiners. About 30 percent of male clerical workers in firms with ten or more male (and female) clerical workers restricted at least one accounting group position to males only. But some firms hired women in these occupations and we know that women were capable of performing these jobs but were barred in some firms. Accounting clerks, for example, were 40 percent female and hand bookkeepers were 42 percent.

Similarly, occupations were often restricted to women only. Among the most prominent were stenographers, typists, various machine operators such as comptometer operators, and secretaries. These, too, were quantitatively important. The three major occupations in the stenographic group that were often reserved for women were almost 40 percent of all employment for women office workers in Philadelphia.

Although I do not know what the earnings were in the precise firms that had occupational restrictions, I do know mean earnings for many of the occupations from the 1940 Office Worker Survey for Philadelphia (see data appendix). As can be seen in figure 9.4, some of the most quantitatively

58. I have listed only occupations that were specifically noted. In some cases the firm representative mentioned "all office jobs" or "all clerks" and in other cases an occupation was mentioned that was highly specific to the firm and probably grouped in table 9.3 in "Clerks, n.e.c."

important positions in the accounting group that were restricted to males had earnings that were higher than the (adjusted) female median.

More surprising is that many positions that were restricted to women also had mean earnings (adjusted female) above the female median. If talented women were barred from a range of positions occupied by men, then firms had an incentive to create positions that used these skills and were restricted to women. The position of accounting clerk was often restricted to males and stenographer to females. Both paid about the same amount and both paid above the female median. Similarly, tellers were a common occupation restricted to males and secretaries were also commonly restricted to females. Once again, they paid about the same amount and considerably above the female median.[59]

What about occupations not listed as restricted? Among the more numerous were certain clerks such as checker, credit, general, junior, payroll, and record clerks; also, correspondents and duplicating machine operators. Female mean earnings for these occupations, calculated in the manner described above, are lower than the median for female office workers; male mean earnings for these occupations are generally lower than the median. Thus there is some evidence that the occupations that were most restricted were those above the female median and the occupations that were least restricted were those below the female median. These occupations were often gender mixed and were not particularly high in the annual earnings distribution.

But I do not want to claim that the model fits the data perfectly. There are several anomalies in taking the data to the model. Typists were generally restricted to females and have earnings just below the female median. Typists for females, just like messenger boys for males, were occasionally used as part of an internal ladder. Telephone operators were almost always restricted to women and their pay was quite low.

To further explore the relationship between earnings and the fraction female in the occupation, I estimate a variant of the (log) full-time annual earnings regression in table 9.1 by adding the sex ratio of the occupation and its square (the sample includes seventy-five separately enumerated occupations). These estimates, and their standard errors clustered at the occupation level, are given in columns (2) and (4).

For women, earnings initially decrease with the sex ratio (females/total employees) of the occupation, hitting a minimum at 57 percent female, and then rise (column [2]). The turning point is almost identical if the controls for

59. Kuhn (1993) has developed a different and revealing model to explain the existence of occupations that are reserved for men and women separately. Kuhn's model has specific human capital and a higher mean exit rate for women than men. Employers must bar women from entering occupations that involve extensive training for which the firm will pay. Equivalently, employers have to bar men from entering occupations for which they will receive training but later discover that they would do better to quit and train for a different position.

characteristics (e.g., education, job experience) are excluded and if higher-order terms for fraction female are introduced. Because the average woman was in an occupation that was 71 percent female, female earnings generally increased with the sex ratio of the occupation.[60]

The relationship between the sex ratio (males/total employees) and earnings is similar for the male sample. The turning point occurs at 45 percent male and the average male was in an occupation that was 73 percent male (column [4]). Therefore male earnings, on average, increased with the fraction male in the occupation. Therefore earnings generally increase with gender segregation for women and the same holds for males.

It should also be mentioned that similar relationships are found if education rather than earnings is the dependent variable. The central finding here is that more segregated occupations in office work in 1940 employed women with higher levels of education than average and the same is true for men.[61] Both income and education produce findings that are consistent with the implications of the model that segregation by sex is greater above the median of the characteristic distribution for women.

World War II and the tight labor market of the 1950s were effective in altering gender distinctions in some occupations but far fewer than might have been expected. One of the most radical shifts was in banks. During the war women were employed as bank tellers, practically a male-only clerical occupation in 1926, but after the war men were rarely bank tellers.[62] Interestingly, the relative earnings of bank tellers had declined long before the feminization of the occupation. Thus any real de-skilling of the occupation preceded the entry of women and male bank tellers, it appears, managed to hold on to their occupation long after $\Omega = 1$.

9.2.4 Occupational Segregation Post-1950s

"Wage discrimination" evident in 1940 was strongest for those at the upper end of the education scale and for those with substantial work experience.[63] Occupations reserved for college-educated women were few in number and the list closed to them was extensive. A comprehensive personnel survey

60. This finding might appear to contradict that found in some studies using more recent data, such as Sorensen (1990), although see Filer (1989), who uses 430 occupations and a large group of occupational controls, O'Neill (1983) who estimates a nonlinear relationship, and Macpherson and Hirsch (1995) who use longitudinal data to account for unmeasured individual characteristics and preferences.

61. Among female employees having less than twelve years of schooling, the mean fraction female by occupation was 0.67, whereas the same for female employees having more than eleven years was 0.73.

62. On bank tellers in the mid-twentieth century, see Strober and Arnold (1987) and NICB (1926) for data on the sex composition of tellers and other clerical occupations.

63. Goldin (1986, table 3) reports the coefficients for the male and female earnings equations. "Years of education" has a higher coefficient for females than males, but the college, vocational, and high school dummies are considerably larger for males. Education has a more continuous impact for women, while the effect for men is in steps, possibly allowing them to begin on a different occupational ladder.

taken in the mid-1950s revealed that firms were not accommodating the rapidly increasing group of college-educated women.[64] In terms of figure 9.3, female-only or integrated occupations in the range of BB' did not expand and women were crowded into occupations around B. It is not surprising, therefore, that when discontent with the labor market was voiced by women in the 1960s the most discontented were the college educated.

Various empirical studies of discrimination in the 1970s and 1980s indicated that the labor market had finally responded and that "wage discrimination" was lower, not higher, among the more highly educated.[65] The decrease in discrimination over the long run may have been due to the emergence of credentialized occupations that could not be polluted by the presence of women. But some of the decline from the 1960s to the 1980s may also have been due to antidiscrimination legislation and to an environment in which discrimination was less tolerated.

There was a time when women with the highest levels of education were barred in subtle and more obvious ways from many high-prestige and high-income occupations and were hired in only a small number of female-dominated occupations, such as teacher, nurse, librarian, and social worker. The clerical data for 1940 demonstrated that higher-educated women in that particular sector were bookkeepers, secretaries, and stenographers, but were rarely found in a host of other occupations in which there were higher-educated men.

But barriers and fetters at the top of the income and education distribution have broken down and most top-earning jobs are far more integrated now.[66] Using the 2009 and 2010 American Community Survey I find that about one-third of all physicians and lawyers (the number one and four occupations by male income) are women and almost half of pharmacists (the number six occupation) are.[67] These fractions would be greater if a younger group were used. The pollution theory would claim that part of the erosion of barriers is due to increased credentialization of women and better information on the abilities of women as a group and of individual women. No stigma is attached to hiring a woman known to be as competent as the existing male employees.

But pollution may still be found in "frog ponds"—workplaces that have highly particular characteristics and skills and in which a group of outside arbiters exists.[68] Frog ponds would include the firehouses and police depart-

64. Goldin (1990) discusses Hussey/Palmer personnel surveys taken in 1956–1957 of the major employers in Philadelphia. The fifty interviews reveal that college women, except teachers and nurses, did not have a place in these firms.

65. See Filer (1983) and Blau and Beller (1988).

66. The group of well-integrated occupations still does not include many at the very top including Fortune 500 CEOs, the US Congress, and others at the pinnacle of various professions. See Sandberg and Scovell (2013) for a recent statement about women and leadership with a somewhat different reason for their absence.

67. These rankings use full-time, full-year wage, salary, and business incomes.

68. See Frank (1985) on "frog ponds."

ments mentioned earlier; they would also include trading floors and other parts of the financial sector.[69] But they are, thankfully, rarer now than ever. Pollution may never be eliminated entirely but it has been greatly abated.

9.3 Summary and Implications

I have suggested that discrimination against women is motivated, in part, by the desire of men to protect their occupational status. When work took more brawn than brain, the attribute distributions of men and women were rather far apart. "Men's work" was perceived as better than "women's work" and observing a woman doing a man's job signaled that the man's job had been downgraded, possibly because of a technological shock. In a static context the model predicts ranges of segregation and integration of occupations along the characteristic scale.

As machines substituted for strength, as brain replaced brawn and as educational attainment increased, the distributions of attributes narrowed by sex. The dynamic implications of the framework and the historical evidence are revealing. Important lags existed in the labor market, hampering its ability to devise jobs for new groups of workers. Some lags arose from the institutionalization of occupational barriers, as was the case for firms hiring office workers in the 1930s, and some came from worker expectations about which jobs were appropriate for male and female workers. Older industries remained highly segregated by sex, while newer industries took greater advantage of the newly available female labor supply.

The results of the model depend on the existence of asymmetric information. Women know their own characteristics, as do those who hire them, but others in the community do not. Any mechanism that increases information, such as the credentialization of occupations, will foster integration. Similarly, the visibility of successful women today and in the past may help shatter old stereotypes and increase knowledge about the true distribution of female attributes.

Data Appendix

1940 Office Firm and Office Worker Surveys

Two types of surveys were analyzed in US Department of Labor, Women's Bureau, *Office Work in [Houston, Los Angeles, Kansas City, Richmond, Philadelphia]: 1940*, Bulletins of the Women's Bureau, Nos. 188-1, 188-2,

69. On the financial sector, see Smith (2002) on the Salomon Smith Barney $3.2 million arbitration penalty regarding the claim of a sexually hostile work environment in the "boom boom room" case.

188-3, 188-4, 188-5. The originals for both surveys are housed in the US National Archives. These data, in various forms, have been used in Goldin (1990, 1991, 2006).

The surveys were done of firms and of the workers in some of those firms. The firm-level records were filled out by an agent of the firm, often a personnel officer. The individual-level records appear to have been drawn from the personnel records of the firm, although in some cases they appear to have come directly from interviews with the workers.

1940 Office Firm Survey

National Archives, Record Group no. 86, Boxes 496–500. Firms of all sizes were surveyed in the five cities and include those in manufacturing, real estate, retail, banking, insurance, government, telephone, public utilities, railroads, advertising, communications, and professional practices. The surveys covered a large fraction of firms in these cities. For example, fully one-quarter of Philadelphia's office workers were included in the survey (No. 188-5, 2). Records for 539 firms in Kansas City, Los Angeles, and Philadelphia were collected and information was coded on the number of clerical workers by sex employed in 1939, firm policies regarding the employment of women or men in particular occupations, and discrimination with regard to race and ethnicity. See fig. 9A.1 for a facsimile of a 1940 Women's Bureau firm-level survey.

1940 Office Worker Survey

A sample of 1,432 female office workers and 1,564 male office workers was collected for Philadelphia. Information was coded on each regarding age, marital status, education (years and whether individual graduated from each level), total work experience, experience with the current firm, experience in office work, current earnings (measured three ways: earnings last year in 1939, usual salary per pay period, and actual salary for the last pay period), pay period (e.g., weekly, hourly), earnings when the worker began at the firm, whether the worker had ever been furloughed, whether work with the current firm was continuous, current occupation and initial occupation with the firm, among other variables.

Model Appendix

Further Results and Clarifications to the Pollution Theory Model

In the simple form of the model, discrimination and occupational segregation will occur even if the distributions of male and female characteristics are the same. Male employees will treat a female applicant as a polluter in

Department of Labor
Women's Bureau

Agent _____
Date _____

OFFICE WORKERS' STUDY 1940

1. Firm name _____ 2. Business_____ 3. Address_____
4. Persons interviewed and positions _____
5. Who are the executives? _____ administrators? _____ professional workers?_____

	Men	Women	Total
6. **# clerical workers regularly employed 1939**	____	____	____
7. # clerical workers employed as extras 1939	____	____	____
8. # new clerical workers taken on in 1939	____	____	____

9. Hours of work: Daily ____ Saturday ____ Total weekly ____ Overtime ____
10. Office organization: list departments _____ types of machines used _____
11. Method of wage payment: monthly, semimonthly, weekly, daily, hourly, piece, bonuses

12. Employment requirements and practices (discuss by job where differences exist)
    a. Hiring: Who hires new employees? _____
       What are beginning rates of pay? _____ system of advancement? _____
    b. Source of applicants _____
    c. Age: Minimum ____ Maximum ____
    d. Marital status:
       Are married women employed? _____
       Are women who marry in service allowed to remain? _____
    e. Sex:
       Which jobs open to men only? _____
       To women only? _____
    f. Educational requirements:
       1. General _____ 2. Special business training _____
    g. Policies with reference to race and color _____

13. General policies:
    Vacations with pay _____ To whom? _____ Length? _____
    Sick leave _____ Dismissal wage and notice_____
    Promotional policy and salary increases _____ Retirement plans _____

Organization: Trade union or other _____

Other welfare activities _____

Fig. 9A.1 Facsimile of 1940 Women's Bureau Office Firm Survey
Note: Questions in bold are those discussed in the text.

occupations above the median and these will remain male-only occupations. The result arises because men enter the occupations in period 1 and women apply to enter only in period 2.

The model can accommodate a symmetric treatment in which both men and women apply for jobs in period 2, although only men enter in period 1. In this case, knowledge of the entire distribution for both men and women is

needed. As in the previous setup, no one outside the occupation knows the C level of the prospective entrant although everyone knows the C level of the occupation in period 1. Between period 1 and 2, there is a technology shock Ω that introduces uncertainty regarding an occupation's C level.

The more fully symmetric form of the model treats each new entrant, either male or female, as a potential polluter. Let β = the probability that a male does not pollute an occupation known to have a C level of λ, and α = the probability that a female does not pollute an occupation with a C level of λ. Therefore, using the notation of figure 9.2 where B and E are the upper bounds for the female and male characteristic distributions:

$$\int_{\lambda}^{B} g(C^F)\,dC = \alpha, \text{ and } \int_{\lambda}^{E} h(C^M)\,dC = \beta$$

where, generally, $\beta > \alpha$. Assume that preexisting male workers in the occupation require compensation for hiring a female and that this compensatory payment increases with $[(\beta - \alpha)/\beta]$. That is, the payment increases with the difference in the probabilities that a male and female will not pollute scaled by the probability that one of their own—a male—will. The level of compensation required to hire a female worker will rise with λ, the preexisting C level for male employees.[70]

The results, therefore, conform to those of the asymmetric form of the model, but the compensation demanded will go to zero as the two distributions approach each other and are zero when the distributions are the same. The results will be qualitatively identical to those obtained with the assumption that only women apply for the jobs in period 2. But in this case the range of integrated occupations will widen for any two distributions and will widen progressively as the two distributions approach equality.

The model can be extended to account for different probabilities that a technological shock, $\Omega = 1$, occurred, although there will be little change to the substantive results. Some occupations, firms, and industries can face a higher probability that $\Omega = 1$ and this could enter the likelihood that a female entrant is a polluter.

Similarly, the model can be extended to incorporate the total costs of hiring a woman. In the current model, even one female employee will pollute all male workers in the occupation. The cost of hiring would therefore have to include the total amount of compensation given to preexisting male employees and that would rise with the size of the occupation within a firm. Thus, occupations that are relatively large within firms will be more costly to integrate.[71]

70. As in the previous discussion, the amount of compensatory payment will depend on the number of male workers since the hiring of just one woman pollutes the prestige of all men.

71. Other model extensions include: (a) adding a third period to allow men to shift out of occupations experiencing a technology shock; and (b) technology shocks that are positive, as well as negative.

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