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MONITORING COSTS AND OCCUPATIONAL SEGREGATION BY SEX: AN HISTORICAL ANALYSIS

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Monitoring Costs and Occupational Segregation by Sex: An Historical Analysis

ABSTRACT

Supervisory and monitoring costs are explored to understand aspects of occupational segregation by sex. Around the turn of this century 47 percent of all female manufacturing operatives were paid by the piece, but only 13 percent of the males were. There were very few males and females employed by the same firm in the same occupation, and when they were, they were invariably paid by the piece. The group of industries that hired two-thirds of all male operatives, hired virtually no females. Males, but not females, were employed in teams across a variety of industries, and there was segregation by sex across various jobs requiring similar training and ability. Occupations in the clerical sector were rapidly "feminized" from 1900 to 1920 and an organization of work was employed resembling that used earlier in manufacturing. These findings can be understood by considering a model of occupational segregation in which monitoring is costly and males and females have different turnover rates.

Employers adopt one of two solutions to avoid shirking -- piece rates and deferred payment. Because females are only employed in one period, piece rates are used for them; males, however, might prefer deferred payment which causes their earnings profile to be steeper than otherwise. Occupational segregation by sex results even if workers are homogeneous with regard to ability and there are no costs of job investment. Males can also receive higher average wages per period than females. Under a reasonable set of assumptions, females would want to be employed in the male sector, but would be barred from doing so.

Establishment-level and more aggregated data for manufacturing around 1890 are examined with regard to the costs of supervising and monitoring male and female workers in time and piece-rate positions. The findings tend to support the assumptions of the model concerning the relative costs of monitoring workers of different sexes paid by different methods.

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1. Introduction

An index of sex segregation across about 300 occupations in the United States has remained roughly constant from the beginning of this century at a value of 66, implying that two-thirds of either the male or the female labor force would have to change occupations to achieve occupational equality (Gross 1968; Blau and Hendricks 1979; Beller and Han 1982 note a decline in the index during the 1970s). The origins and persistence of occupational segregation by sex have been explained within two general frameworks, one comprising a set of market forces and another a set of norms and ideologies circumscribing female roles. Neither paradigm, however, has yielded a universally accepted framework. It is the contention of this paper that both fail to explain certain aspects of male and female jobs, such as various differences in manufacturing occupations for males and females around the turn of this century and the swift emergence of females in the clerical sector somewhat later. Aspects of supervisory and monitoring costs are explored to understand long-term trends in occupational segregation.

According to the human capital model (Mincer and Polachek 1974; Polachek 1979, 1981; Zalokar 1982; although see England 1982), individuals choose occupations consistent with their life-cycle labor force participation. Because of their more abbreviated and discontinuous labor force activity women opt for occupations with lower investment costs and less depreciation with time away from the job than do men. This framework can explain a substantial portion of observed differences in occupations by sex across broadly defined categories, such a professionals and personal service workers. But it does less well in explaining occupational choice within groupings.

In terms of long-term trends, the following questions seem to remain only partly answered by the human capital model. Why was there segregation

by sex across certain jobs within manufacturing which required similar training and ability? Why were 47 percent of all female operatives in manufacturing paid by the piece (or some variant of incentive pay), while only 13 percent of all male operatives were in 1890? Why were males and females invariably paid by the piece and rarely by time when both worked at the same job in the same firm? Why were males, but rarely females, employed in teams within manufacturing? And of related interest, why do females frequently complain that they are exluded from certain occupations when there are no obvious entry barriers? Finally, if, as will be demonstrated below, the returns to specific human capital in clerical work were approximately equal for females and males, what accounted for the swift feminization of the clerical sector in the first three decades of this century?

The model that will be employed to explain these questions is a variant of a shirking model of the Salop and Salop (1976) and Lazear (1979, 1981) variety, although an incentive pay model of the Lazear and Rosen (1981) type is complementary to the analysis. Workers differ only by the amount of time they intend to stay on the job; males remain for two or more periods, but females only for one. In all other respects, with the possible exception of reservation wages, these workers are identical. The high cost of supervising the output of workers leads employers to adopt one of two solutions to avoid shirking -- piece rates and deferred payment. Because females are not employed in period 2, only piece rates can be used for them; males, however, could prefer deferred payment which causes their earnings profile to be steeper than otherwise.

Occupational segregation by sex results even if workers are homogeneous with regard to their ability and there are no costs of job investment. Because the monitoring of piece rates may be costlier to use in comparison with deferred payment, but may be cheaper than ordinary time rates, males can receive higher

wages in equilibrium than females.[1] Life-cycle labor force participation differences between males and females dictate the final result, but individual choice of occupations does not.[2] Under a reasonable set of assumptions, females would want to be employed in the male sector but would be barred from doing so. The exclusion of females from this sector would be efficient.

Establishment-level, as well as more highly aggregated data, for manufacturing around the turn of this century are examined with regard to the costs of supervising and monitoring male and female workers in time and piece-rate positions. Evidence on piece-rate workers across industries are presented to explore the predictions of the model.

Even though the entire occupational distribution has been widely segregated by sex, certain occupations have "changed sex" over time, and their study can reveal factors fostering segregation. Occupations in the clerical sector underwent this transformation in the early part of this century. The clerical sector was "routinized," as had occurred earlier in manufacturing enabling employers to hire females. Qualitative and empirical evidence are presented indicating that the cost of supervising workers was reduced, but not the firm-level specificity of human capital, as has been claimed. General training, acquired off the job, substituted for on-the-job training and enabled employers to

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[1] Added production costs might result from using piece rates. The production process would have to be altered to divide the good into component parts that could be easily counted and checked for quality. The model below will assume that these costs (or benefits in the case of economies from division of labor) are zero.

[2] Turnover, and not life-cycle labor force participation, is the actual variable of importance. Women could have discontinuous and abbreviated life-cycle labor force participation but have lower turnover than men; that is their length of time with firms could be longer. Most empirical evidence indicates, however, that women have considerably higher turnover and lower lengths of stay with firms. Higher turnover was evident in the 1920s (see, for example, Rogers 1929), and lower lengths of stay with firms are observed in 1980s data from the Current Population Surveys.

homogenize their labor forces based on various pre-employment tests. Secretarial services were thus supervised without the use of more costly piece rates.

2. A Monitoring Model of Occupational Segregation

Assume that good Q is the only good produced in the manufacturing sector and that it can be produced by one of two processes. (I) Q can be divided into (n-1) parts and put together in an nth operation. Each of the parts is made separately, and a piece-rate system of payment can be used to pay labor when output quantity is easily monitored and output quality is not an important variable. (II) Alternatively, Q can be made in one process, possibly using a time-rate system of payment particularly when input quantity can be easily monitored and output quality cannot be ascertained cheaply. Thus there will be (n+1) occupations if both processes coexist. Examples of goods which have been made by both types of processes simultaneously are coats and cigars, but it is generally the case that when both processes coexist the goods vary by quality with the higher quality good made on time. It will be assumed at present but considered in more detail later, that the nature of the good is independent of the production process.

Also assume that there are two types of labor L_f (female) and L_m (male), homogeneous and identical except that L_f is in the labor force for only 1 period and L_m is in for more than 1 period. They can also differ in their labor supply functions to this industry. It is critical, however, that both types of labor will shirk if their inputs and/or outputs go unsupervised.

Three combinations of payment and supervision can be used: (1) time-rate with supervision of input; (2) piece-rate with supervision of output; and (3) time-rate with an incentive pay structure having a rising pay scale with time on the job (Salop and Salop 1976; Lazear 1979, 1981; Guasch and Weiss

1981).[3] Method (3) involves the supervision of input and a monitoring of output. It will be assumed now, and explored empirically later, that the monitoring costs of method (3) are less costly than those in (2), and that the monitoring costs of method (1) are the most expensive. In the model below it is implicity assumed that there are neither costs nor benefits to dividing the good into component parts; that is, it is costless to invent piece rates and there are no gains from such further division of labor.

The first production process (1) for good Q can be represented by:

$$q_i = f_i(L_i, R_i, S_i) \qquad i = 1, \ldots, n-1$$

where L = labor, R = raw materials, and S = supervision. Assume, as well, that this production process is constant returns to scale in L, R, and S, fixed proportions, and identical across all i. Each q_i is part of Q such that the joining of the component parts of Q is defined as the nth process, $nQ = q$.

Each laborer on piece rates gets paid the following for each unit of output, under zero profit conditions

$$w_p = p - s - r,$$

where s = per unit costs of supervision, and r = per unit costs of raw materials.

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[3] The models in each of these articles differ from that presented below because each assumes that workers are heterogeneous in some factor relating to work effort or quitting and that the firm cannot determine this difference prior to hiring. The workers in the model below are homogeneous in their productivity and all will shirk if not monitored or given some incentive. But they differ in their turnover, which can be easily determined by the firm. Salop and Salop (1976) assume that workers differ by turnover and that firms cannot distinguish between slow and fast quitters before hiring. Their incentive compatible scheme is to withhold a fraction of earnings from workers in one period which are returned in the next. Guasch and Weiss (1981) assume that workers differ in ability and that, for risk-neutral workers, there always exists a self-selection mechanism in which workers pay for a test which, if passed, gives workers a known return. Lazear (1979) considers the impact of these types of implicit contracts on the date of voluntary retirement and generates a model of optimal mandatory retirement. Note that there is a close relationship between the results of these models and those of internal labor markets, although the motivation for each of the constructs might differ.

The price of each piece, p, is the price of Q, P, divided by n, $p = P/n$. It will be assumed that the price of Q, P, is fixed exogenously.

Assume that the supply of labor function for L_f, defined in terms of the number of pieces produced at each piece rate, is:

$$q = h(w_p) \qquad h' > 0,$$

and gives the number of pieces produced per period. As shown in Figure 1, when $P = P^*$ and the equilibrium piece rate is w_p^*, production will be q^* per worker or kq^* for all piece workers, if each has an identical piece supply function. That is, $(q^*/n)k = kQ^*$ units of the good will be produced. There will be n occupations and (k/n) persons per occupation. Each worker receives an income of $Y_p = q^* w_p^*$ per period worked.

Alternatively, or in conjunction with process (I), the industry can use process (II),

$$Q = g(L, R, S),$$

also assumed to be constant returns to scale and fixed proportions. In order to compare this production process with that given by (I), we must know the output per period produced by time workers. One assumption is that k time workers, given an amount of monitoring derived below, produce on average exactly what k piece workers do at a wage equivalent to a piece rate of w_p^*. In this case each time worker would have an accepted output standard of $Q^* n = q^*$ units per time period.

The zero profit condition implies that each time worker will receive:

$$Y_t = (P - nr - s')(q/n) - t,$$

where s' is the per unit output supervision cost and t is the per time period input supervision cost. The first term in parentheses is the per unit (short-run) profit and the second is the amount of final output produced. The last term, t,

is the cost per time period of supervising a time worker.[4] The standardization of the two methods implies that at the existing price of the output, P^*, there is an s' and a t such that q^* per worker is elicited per period. At that s' and t, firms would be indifferent between hiring time and piece-rate workers.

In general, therefore,

$$Y_t = Y_p + (sq - [s'q/n] - t),$$

and the difference in the earnings of time and piece workers, denoted as m, depends on the degree to which supervisory costs differ between the two methods. While it seems reasonable that $sq > s'q/n$, or that the monitoring of output is cheaper for time workers because there are fewer pieces, it is not clear that the magnitude of t will not swamp this difference. Furthermore, it is not clear whether the costs of monitoring a unit of the piece-rate good are less than the costs of monitoring a unit of the time-rate good, that is the relationship between s and s'.

Consider only the first two types of payment and supervision. The costs of monitoring for type (1), time rate with only input supervision, could be sufficiently high that all workers would opt for piece-rate work. That is, s' per unit and t per person as supervision costs to elicit q^*, might be high enough so that $Y_t < Y_p$, and then all workers would prefer to work on piece. An alternative to piece rates, however, is to hire only the L_m workers, all of whom will be in the labor force for at least two periods, and pay them:

$$Y_{t1} = (w_p{}^*q^* + m - e) < Y_p + m \qquad \text{for period 1, and}$$

$$Y_{t2} = (w_p{}^*q^* + m + e) > Y_p + m \qquad \text{for period 2,}$$

where $m = q^*(s - [s'/n]) - t = (Y_t - Y_p)$, e = an optimal deferred payment, and

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[4] Note that while one could use the time workers to produce using the piece-rate technology, it would generally be more expensive to do so because of the added number of pieces to monitor. That is, if s' = s, supervision costs would be higher employing time workers on the piece-rate technology.

there are zero rates of interest and time preference.

The incentive scheme of facing workers with an upward sloping wage profile works because employers can easily screen individuals who will not remain in the labor force for two periods, and there is sufficient monitoring of output that shirking can be detected prior to period 2. If time workers do not produce the required output level, they are dismissed after the first time period and can only be hired in the piece-rate sector in the second period. Because workers value only income, they would rather work in the time rate sector for both periods when $m > 0$. The firm promises the workers to pay Y_{t2} in the second period, giving the workers an incentive to produce the required level of output in the first period.

The time-rate experience profile rises with time on the job even though productivity does not. When $m > e$, the L_fs would want to enter the first period time-rate job, but are prevented from doing so because the threat of firing them would be of no consequence. The size of e can be determined in a more comprehensive model by two sets of factors, the stability and reputation of the firms and the cost of effort to the workers. (See Lazear 1979, 1981 for the determinants of the optimal profile.) Note that when $m > 0$, the L_ms receive higher lifetime average income than do the L_fs, when all n+1 occupations exist. This result holds even though all labor is intrinsically of equal productivity and even if when $m < e$, or the deferred payment is greater than the difference in supervision costs.

A final issue concerns the conditions under which both types of workers, and thus both processes (comprising the n+1 occupations), will coexist, and if so, which workers use which processes. The answer depends on the supply of labor. In the piece work case, it was assumed that all labor was identical and thus that $h(w_p)$, as drawn in Figure 1, was an aggregate of the individual

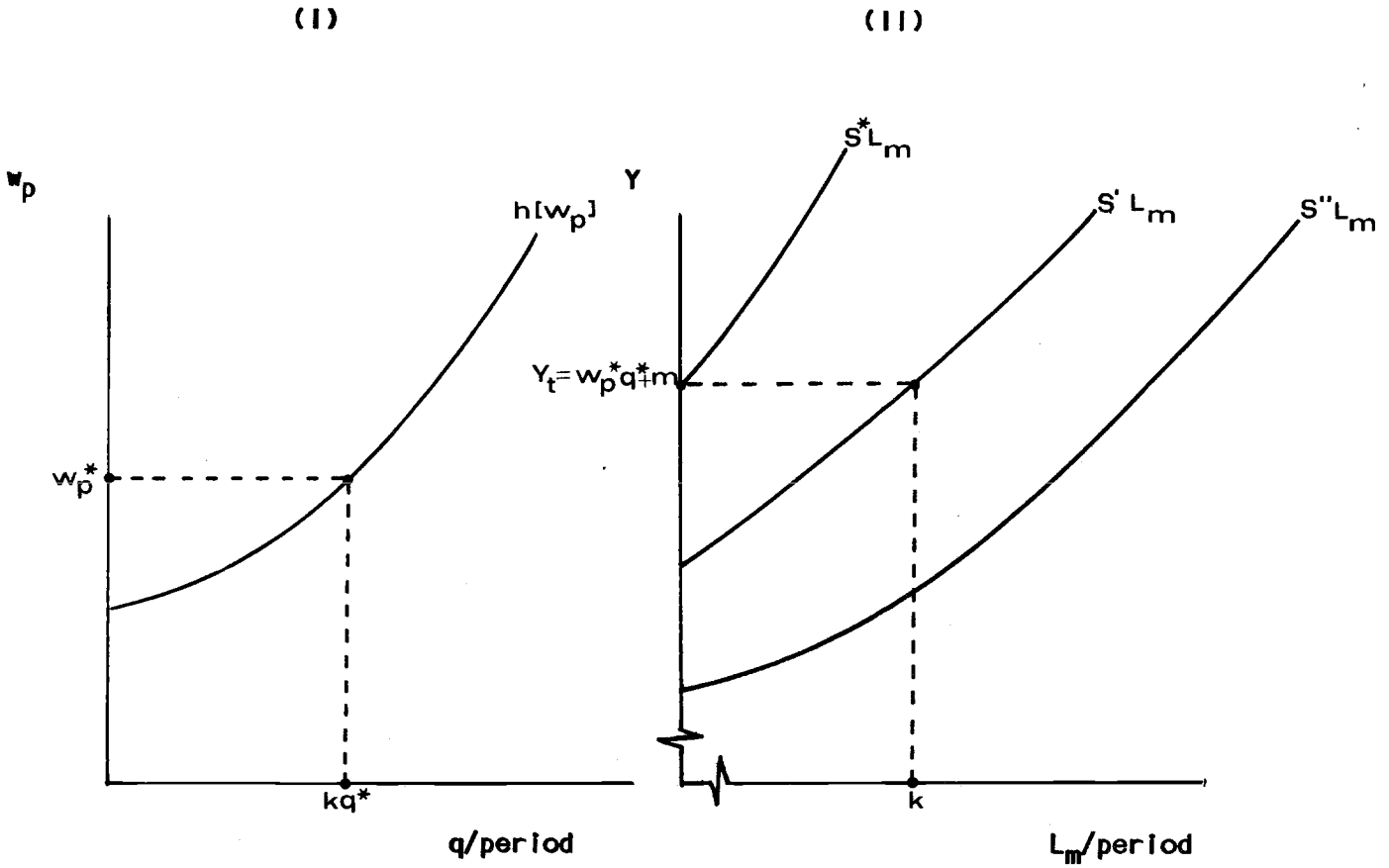

Figure 1: Piece and Time Supply Functions

functions, all identical. For time work, however, the simplest case would be one in which the opportunity cost for each worker differs, and thus the supply function gives the number of laborers supplied per time period at each Y. Because only the L_ms will never be chosen to work on the time-rate jobs if $m > 0$, time-rate workers will be called L_ms. In the case drawn in Figure 1, the supply function $S'L_m$ happens to lead to an equal number of L_m and L_f workers; $S''L_m$ leads to more L_m workers; and S^*L_m results in no L_m workers. Thus the ratio (L_f/L_m) depends upon the position of the male labor supply function and the level of m, given the piece-rate supply function.

When both processes are used and $m > 0$, the following results will obtain:

(1) Complete occupational segregation by sex;

(2) Females will all be paid by the piece and males by time;

(3) The ratio of female to males earnings will be $[Y_p/(Y_p + m)] < 1$, on average, although for first period employees it could be > 1 if $m < e$; and

(4) If $m < e$, females would want to enter the entry-level L_m occupation but will be prevented from doing so.

3. Monitoring and Supervision in Manufacturing, circa 1890

Only one type of good existed in the monitoring model, and the method of payment for labor was solely determined by the costs of monitoring and differences in life-cycle employment across workers. In the real world, however, there are other reasons for using different methods of payment that determine the types of goods made by piece and time and the types of workers that will be employed in each process.

Three additional cases must be added. Certain types of goods might be divided into pieces more easily than others, and in these the division of labor itself might reduce per unit costs. In these cases the piece-rate technology might dominate even in the absence of monitoring costs. Alternatively or in

conjunction, goods may differ by quality. It is generally presumed that one can monitor output quality more cheaply in low quality goods than in high quality goods (Pencavel 1977). In the latter, one may want to screen workers and hire only those who will produce goods of uniformly high quality output and then supervise only by input. Such was the case in the manufacture of clothing at the turn of this century; high quality coats, for example, were made by skilled tailors working on time, while lower quality coats were made by less skilled operatives working by the piece; (see the study of men's ready-made clothing, Volume 87, U.S. Senate 1910/11).

The last reason for the method of payment concerns the variance in skill level across the various pieces or stages in the production process. When the variation in the necessary skill is high, one may want to use the lower skilled operations to screen workers for the higher skilled operations. The method of screening might be more complex than merely monitoring the output of workers, the only observable aspect of piece-rate work. It may, instead, entail judging the inventiveness of workers, their ability to give orders and respond in a variety of situations. Ranking individuals in an ordinal sense may be far cheaper than grading them absolutely. It has been shown that when workers are risk-neutral a rank-order system of prizes can elicit the same effort as a piece-rate system (Lazear and Rosen 1981). Both this variant of the model and that elaborated on above imply that males will have a higher variance in earnings than will females, holding productivity constant, and thus it would be true even if males and females were equally productive in a deterministic or expected value sense.

The relative use of piece work across industries and among firms within an industry can be determined by factors that complement those in the simple supervisory cost model. The question is whether the division of workers between

the two types of payment is determined primarily by differences in supervising workers that arise from differences in life-cycle labor force participation. Within the context of the formal model above, one might observe females producing goods that are cheaper to divide into pieces while males produce other goods by time. Similarly, males might produce the higher quality good, and males might also be employed on time-rate pay in industries that screen workers at one level of production for jobs at another.[5] How male and female workers are sorted across industries might be related to the costs of supervision given these complementary factors. What are the facts concerning the employment of males and females in industries around the turn of this century?

The data in Table 1 demonstrate that 51 percent of all adult male employees in manufacturing in 1890 were in industries in which adult males were over 94 percent of the labor force. (Adult males were 79 percent of the total manufacturing labor force.) Because virtually all of the remaining 6 percent who were not adult males were boys, 51 percent of all adult male employees in manufacturing could not possibly have been in an occupational-industrial classification in which there were women.

At the same time, 74 percent of all female employees were in the industries classified in Table 1 as female intensive, those in which adult women were over 30 percent of all employees. (Adult women were 18 percent of the total manufacturing labor force and children were 3 percent.) It is primarily in the mixed industries, such as tobacco and printing, and some of the female-intensive industries, such as cotton textiles, that one finds substantial overlap in male

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[5] Other factors that might influence the cost effectiveness of using piece-rates, as opposed to time-rates, have been suggested in Pencavel (1977), Lazear (1981), and Roummaset and Uy (1980). Piece-rate payment might also dominate when technical change is not very rapid, when there is a large luck component in production or sales, and when there is low variability in the efficiency of complementary inputs.

Table 1
Sex Segregation and Piece Work Among 46 Large Industries, 1890

"Male-Intensive" Industries[a]

	% Total Mfg. Labor Force	% Adult Males in Labor Force[b]	% Adult Workers on Piece Rates[c]
Agricultural Implements	0.93	98	20.59
Blacksmithing & Wheelwr'ting	1.08	100	2.65
Boots & Shoes, custom work	0.75	98	36.34
Brick, Tile, Clay, & Pottery	2.75	94	3.80
Carpentering	2.97	100	1.62
Carriages, Wagons, and Cars	3.07	99	10.81
Cooperage	0.52	98	41.26
Flouring & Grist Mill	1.35	99	2.13
Foundry & Machine Shop	5.26	99	10.01
Furniture, factory	1.36	95	12.79
Iron and Steel	3.24	99	0
Leather, includes morocco	0.90	98	10.89
Liquors, malt	0.74	98	1.27
Lumber & Other Mill Products	6.07	98	3.47
Masonry, Brick, & Stone	2.30	100	1.76
Painting & Paper Hanging	1.19	100	4.94
Plumbing & Gas Fitting	0.90	98	0.74
Saddlery and Harness	0.64	95	21.59
Shipbuilding	0.55	100	4.58
Slaughtering & Meat Packing	0.86	96	3.53
Timber Products	0.98	99	21.51
Tin & Coppersmithing	0.82	94	6.38

Total % Manufacturing Labor Force, in These 22 Industries . .	38.0
% Adult Males Across All Industries	79
% Total Adult Male Workers in These 22 Industries.	51.2
% Adult Male Workers on Piece Rates Across All Industries . .	12.9[d]

"Female-Intensive" Industries[a]

	% Total Mfg. Labor Force	% Adult Females in Labor Force	% on Piece Rates[c] Females	Males
Boots & Shoes, factory	3.00	29	60.0	53.5
Boxes	0.40	65	58.0	23.0
Carpets	0.60	45	(17.8)	(14.9)
Clothing, men's	3.32	49	68.1	49.3
Clothing, women's	0.09	63	46.8	43.2
Confectionery	0.06	39	16.7	5.8
Corsets	0.02	81	(63.5)	(53.4)
Cotton Goods	4.70	51	73.4	31.7
Dressmaking	1.43	97	*	*
Fruits & Vegs., canning	1.08	48	49.7	19.8
Furnishing Goods, men's	0.05	74	65.7	51.7
Gloves & Mittens	0.02	59	(78.0)	(39.7)
Hats & Caps	0.06	34	(70.2)	(55.3)

Hosiery & Knit Goods	1.30	67	63.0	21.3
Millinery & Lace Goods	0.03	73	(41.4)	(29.7)
Millery, custom	0.05	93	*	*
Shirts	0.07	79	69.4	52.6
Silk	1.08	57	75.6	39.8
Woolen Goods	1.68	38	76.6	26.3
Worsted Goods	0.09	46	*	*
"Mixed" Industries				
Clothing, men's custom	1.83	23	(54.0)	(56.1)
Paper	0.63	23	(31.4)	(0.5)
Printing, book & job	1.23	17	(15.0)	(9.3)
Tobacco	2.75	27	(64.1)	(65.5)

Total % Manufacturing Labor Force, in These 24 Industries . . .	25.5
% Adult Females Across All Industries	18
% Total Adult Female Workers in These 24 Industries.	81.2
% Adult Female Workers on Piece Rates Across All Industries . .	46.9[d]

* Indicates that the figure for the percentage on piece rates is vastly understated.

[a] Male-intensive, female-intensive, and mixed refer to the actual percentage of males or females in each industry and not to an inherent characteristic of the industries.

[b] Male and female children comprise a separate category, not included here, and the figures for percent adult males and females do not exhaust the entire labor force.

[c] The percent of workers on piece rates includes only operatives and nets out clerical workers and other nonoperatives.

[d] Adjusted for the undercount of pieceworkers in various industries in the 1890 Census of Manufacturing.

Notes:
Male piecework percentages for female-intensive industries exclude clerical and supervisory personnel. The data for cotton goods, silk, and woolens are adjusted for the undercount of pieceworkers in these industries using Department of Labor (1897). Tobacco includes cigars and cigarettes; leather includes morocco; boots and shoes, factory includes rubber. Adult females are > 15 years old and adult males are > 16 years old.

Source: United States Census Office (1895).

and female occupations within late-nineteenth century industries. In what ways did these industries differ from others?

In looking at the industries in Table 1 that were exclusively male domains, several factors seem apparent in limiting the presence of females. Many of these industries required substantial apprenticeships (cooperage, masonry, plumbing, shipbuilding, custom boot and shoemaking). Still others were physically demanding (slaughtering, iron and steel, milling). Yet these considerations alone might not explain the almost complete exclusion of females from the list. The method of work organization may also have contributed to the exclusivity of these industries. It should also be pointed out that male earnings were not higher in the male-intensive industries, even adjusting for the more rural location of the male-intensive industries.

It was the method of payment and not the absolute level of wages that differed for males across the three groups of industries. All laborers in the female-intensive industries were more frequently paid by the piece. Females were overwhelmingly paid by the piece in comparison with male manufacturing laborers in both the female-intensive and mixed industries.

Firms were surveyed by the 1890 Census of Manufacturing (U.S. Census Office 1895) concerning the number of full-time equivalent workers by sex, age group (adult and child), as well as type of position (clerical, skilled operative, unskilled operative, piece rate worker). It is not until 1960 that we again have comparable data for the entire manufacturing sector. The data in the 1890 Census of Manufacturing indicate that 37 percent of all adult female manufacturing workers (> 15 years) were paid by the piece but that only 13 percent of all adult males (>16 years) were.

But the procedure used in the 1890 census to categorize piece-rate workers severely understates their number. Because so many occupations in the cotton

goods, silk, and woolens industries, among others, were piece-rate jobs, the census did not record them as such, but instead grouped these employees in the operative category. Only 10.1 percent of female employees were listed as being employed on piece-rates in cotton goods. The true figure is considerably higher.[6]

Corrected incentive pay figures across all industries indicate that 47 percent of all female operatives were paid by the piece while only 13 percent of males were. Females were therefore 3.5 times as likely to be employed on piece rates than were males. Furthermore piece-rate payment almost always prevailed when males and females occupied the same position in the same firm. Examples from the textile industry are instructive. In only one out of the six predominantly male occupations in cotton textiles was payment generally made by the piece, but among four in which both men and women were found only one was paid by time.

Female workers predominated in those industries in which piece-rate work was common for all workers. The piece-rate percentages in Table 1 are generally low for all of the male-intensive industries, but the piece-rate percentages are relatively high for males in the female-intensive industries. Females were also employed on piece-rate work with greater frequency than were males within the same industry, and they were invariably employed on piece-rates when males also occupied the same job title.

Certain institutional mechanisms, such as teams and inside contracting,

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[6] Stanley Lebergott's chapter in Davis, Easterlin, et al. (1972) also cites the 1890 Census of Manufacturing figures on piecework without corrections. Pencavel (1979), in turn, uses the Lebergott figures, although with reservations. On the undercount in the census, see U.S. Census Office, Manufacturing Industries, Part I, (1895, p. 173) which states that "an arbitrary rule was adopted that all pieceworkers whose earnings are limited by the speed of machinery were to be included with those paid a specific amount by the week, the day, or the hour."

also distinguish male-intensive industries from female-intensive ones. It appears that the length of stay in the labor force and on the job may have been critical in limiting the employment of women in those industries in which such institutions reduced supervisory costs. Teams were groups of workers organized by a contractor who dealt directly with the firm's management or owners and who was contracted to produce a certain amount of output or paid by the final piece. The agent in turn hired workers, who were frequently well known to the contractor and to the other members of the team. The type of work performed fell somewhere in between an intricate division of labor and a single production process for the good. Teams conserved on supervision costs for management because the contractors had knowledge of the productivity of individual workers and were able to increase effort through personal friendships and kin ties. Teams were generally found only in the male-intensive industries or among male workers in other industries. (See Buttrick (1952) who notes that contractors were frequently paid by the piece; Montgomery (1979) who discusses teams among molders, tailors, and miners; and Volume 87 of U.S. Senate, 1910/11, on male teams within men's ready-made clothing.)

In certain industries, in which virtually no women were employed, various aspects of the process could have been done by unskilled workers, and indeed were done by women during periods of labor shortage, such as World War I. In railroad foundries, for example, women were employed during the war in the production of cores and as machinists. The railroad union protested such employment after the war claiming that such tasks were an integral part of the apprenticeship program, and that while women could be effectively employed in these areas, they undermined the training and screening of skilled workers (Greenwald 1981, pp. 116-17).

The division of workers into piece and time-rate work, in the formal

model of Section 2, was a function of the costs of supervision and monitoring. Do supervision costs differ in the manner predicted by the observed differences in the form of payment by sex? That is, are supervision costs lower for piece-rate than time-rate workers in female-intensive industries but higher in male-intensive industries where other methods of monitoring and supervising were available?

Two sets of data having information on the form of payment and the costs of supervision are used to explore this issue. One set, from the 1895/96 Report of the Commissioner of Labor (U.S. Department of Labor 1897), contains firm-level data on female-intensive industries.[7] Another, from the 1890 Census of Manufactures (U.S. Census Office 1897, Part II), contains city-level observations across all industries. The first set of data has been used for the female-intensive industries and the second for the male-intensive ones, of which only foundries had a large enough number of observations to be usable.

Six industries -- boxes, cigars, clothing, cotton, food, and shoes -- have been selected from the 1895/96 Report for the female-intensive industries. These industries differed considerably in the degree to which female workers advanced in jobs over the course of their employment and in the variance in female wages across occupations. Clothing and cotton textiles had the highest variance in wages and, it appears from the qualitative evidence, the greatest degree of occupational shift. Because of these differences, industry form-of-payment dummies have been added to the female-intensive industry regression equation explaining supervisory inputs.

The equation in Table 2 explaining supervisory inputs across firms in

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[7] The 1895/96 Report includes information on approximately 68,000 male and 80,000 female employees, and of the 364 industries listed in the 1890 Census of Manufacturing, 57 percent were included in the report. The industries represented in the survey included, on a national scale, 40 percent of all male operatives but 96 percent of all female operatives, not a surprising finding given that the directive was "to investigate . . . the conditions attending the employment of women and children" (p. 11).

female-intensive industries indicates that supervisory costs were lowest for male and female piece-rate workers among the industries excluding clothing and cotton textiles. Male time workers and female time workers were next in order of lowest supervisory cost. A female time worker, on the margin, required almost eight times the supervisory input as did a female piece-rate worker. A male time worker required just one-third the supervisory input of a female time worker, but almost three times that of a male or female piece-rate worker.

These findings are consistent with the conclusions of the model. Female-intensive industries used piece-rate workers to conserve on supervisory costs. The absolute costs of supervision were nontrivial. The average weekly wage of a male supervisor was about $25.00. The marginal female time-rate worker required 0.0440 * ($25.00) = $1.10 worth of supervision per week or somewhere between 15 to 20 percent of her weekly earnings. The marginal female piece-rate worker required 0.00578 * ($25.00) = $0.145 or only 2 to 3 percent of her weekly earnings.

Consider now the two special female-intensive industries, cotton textiles and clothing. The coefficients on these two industries differ from those of the other four industries in two important ways: Female time workers were relatively inexpensive to supervise but male time workers were considerably more expensive to supervise. Cotton textiles and men's factory-made clothing, like the male-intensive industries, utilized screening on the job. Here, however, screening appears to have taken place within the piece-rate positions. These industries, however, did not offer much job advancement for their male workers, and the supervisory input, therefore, was high for male time-rate jobs.[8]

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[8] The male workers in these industries may very well have been less able or had high turnover and may have been sorted out of the male-intensive industries and those in the female-intensive sector which allowed advancement in wages and

Table 2
Supervisory Costs and the Form of Payment,
Manufacturing circa 1890

Dependent Variable: Number of supervisory personnel per firm

	Female-Intensive Industries	Male-Intensive Industry, Foundries
Constant	0.6538	1.277
	(1.67)	(10.98)
Number of Workers per firm:		
Male piece-rate	0.00506	0.0115
	(0.92)	(2.40)
Male time	0.0142	
	(1.76)	
Skill		0.00679
		(2.81)
Unskill		0.00697
		(2.02)
Female piece-rate	0.00578	
	(1.95)	
Female time	0.0440	
	(3.28)	
Industry Dummies:		
Boxes	0.313 (0.54)	
Clothing	0.070 (0.11)	
Food	-1.261 (1.78)	
Shoes	0.517 (0.70)	
Cigars	0.019 (0.03)	
Industry-Worker Interactions		
Cotton Male piece	-0.0019 (1.75)	
Cotton Male time	0.0425 (1.08)	
Cotton Female piece	0.0047 (0.69)	
Cotton Female time	-0.0508 (2.81)	
Clothing Male piece	0.0021 (0.28)	
Clothing Male time	0.0441 (3.91)	
Clothing Female piece	0.0028 (0.54)	
Clothing Female time	-0.0537 (3.38)	
R^2	0.936	0.203
Number of Observations	289	152

Sources and Notes: Male-Intensive Industry, from U.S. Census Office (1895), Part II: City Totals. The observations are city-industry cells and have been weighted by n, where n=the number of firms in the city. Female-Intensive Industries are from U.S. Department of Labor (1897), where the observation is a firm. t-statistics are in parentheses.

The results from the male-intensive industry are different from those for most of the female-intensive industries. Supervisory costs were greatest, at the margin, for the piece-rate workers and were only slightly higher for the unskilled than for the skilled workers. In the male-intensive industry an additional male piece-rate worker added about the same number of supervisors as did a male time-rate worker in the four female-intensive industries. A male time-rate worker in the male-intensive industries added about the same number of supervisors as did a female or male piece-rate worker in the four female-intensive industries. This reversal of the costs of supervision suggests that the formal model may have captured some of the intrinsic differences between the nature of production and work supervision in the two sets of industries. Male time workers in the male-intensive industries may have been supervised less expensively than were time workers in other industries because they were offered an incentive compatible contract or worked in teams or were given prizes at certain intervals.

It might also be asked whether the supervisors were male or female and whether the costs of obtaining able supervisors varied across industries. The first question can be easily addressed, but the second will have to await the collection of additional data on the earnings of both the supervisors and the workers. Both female and male supervisors were used in the female-intensive industries, but, as might be expected, the female supervisors were used almost exclusively to supervise female workers, although they were also used for male piece-rate workers. Female supervisors, however, did not oversee the male time-rate workers, a position, it appears, that was reserved for the male supervisors.

The implications of the formal model also concerned the shape of the

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position. It should be noted that the firms in the 1895/96 Report were generally larger firms and therefore did not include the outside contracting shops in men's clothing which hired skilled tailors organized into teams.

female and male earnings functions. The male earnings function would be expected to rise over the two periods while that for females is defined only over one period. In actuality, females stay in the labor force for a number of periods, some perhaps for as long as the average male. These females may be grouped with other females in terms of occupations and therefore have flatter earnings profiles than otherwise. Because piece work involves a degree of on-the-job learning, but not necessarily what is usually termed investment, the profile might be expected to rise initially and not be as flat as assumed in the model.

Empirical work substantiates the claim that male earnings rose more continuously with time on the job but that female earnings functions rose more steeply during the early period of employment. In a study of native-born male manufacturing workers in Michigan around 1890 (Hannon 1977), earnings rose for almost 30 years with time on the job. Studies of female earnings around that period (Goldin 1980; Eichengreen 1984) indicate that earnings rose more steeply for females than for males but peaked considerably earlier. While these findings are consistent with the monitoring model, they are also consistent with a human capital model of occupational segregation. Males may accumulate human capital over a longer period of time than do females, with their wages following their rising productivity. Females, on the other hand, could learn considerably in their early working lives, but decide not to invest in human capital having a longer gestation period. The true test between the two hypotheses, that of human capital and that of monitoring, is whether male productivity advances with their earnings. This test cannot be accomplished for the historical period being studied, but there is evidence for the current period that wages do not necessarily follow marginal products (Medoff and Abraham 1981; Lazear and Rosen 1981).

3. The "Feminization" of the Clerical Sector

The clerical sector was rapidly feminized and ranks today as one of the major employers of women. In 1870 fewer than 3 percent of all clerical employees were women, but as early as 1900 30 percent were, and by 1930 over 50 percent were women. It has been frequently claimed that this "feminization" was the result of technological changes, such as the mechanization of the office. A direct extension of this view is that the firm-specific component of clerical skills declined, particularly with the adoption of the typewriter (Rotella 1981). Nineteenth century clerks were managers in training, but twentieth century office typists had very limited occupational advancement. It seems clear that the new techniques and machinery changed the nature of the job and opened the way for the employment of females.

But was the "feminization" of the office a function of the reduced level of skill required with the division of office work into tasks or was it a function of a reduced level of supervision needed to elicit some level of output? Here again, the human capital model and the monitoring model have similar implications and could provide complementary explanations. But several implications of each are distinct. One is to be found in the history of typing and the attempts by managers to avoid expensive piece rate payments. The second concerns the returns to specific human capital. If the human capital model of office "feminization" is correct, one should find that females accumulated less firm-specific human capital than did males. Data from a 1940 survey of clerical workers indicate approximately equal returns to time spent with the current firm.

In the early history of the modern office various tasks were paid by the piece. Typewriters in the Graton and Knight Manufacturing Company, for example, were equipped with cyclometers, "240 depressions of the typewriter

keys or space bar [was] equivalent to one point . . . 600 points [were] considered base production and each point produced in excess [was] allowed for at the rate of one and one-half cents a point" (Coyle 1928, pp. 23-24). The use of these cyclometers increased the cost of labor, and other cost-saving methods were examined. Piece rates did not prevail, and their decline was a tribute to the ability of employers to pre-test employees whose training in commercial and high school courses was completed before job entry.[9]

Monitoring in the office became simpler and cheaper than in the factory, despite the general expectation in the 1920s that the office would develop along factory lines. Employers divided workers into homogeneous groups and paid each a set day rate. Standardization enabled employers to screen workers prior to employment. Commonwealth Edison Company, for example, claimed that its stenographers, typists, and dictaphone operators were "classed by temperament and ability. A dictator when he needs a girl telephones to the central bureau and one is sent who is adapted to his kind of work" (Coyle 1928, p. 23). At the same time, however, managers were aware that the benefits of easily supervised tasks cost them the ability to screen workers for higher level positions and cost them the accumulated human capital necessary to produce such workers. "The modern clerk knows one operation . . . He is, therefore, less prepared for larger responsiblity . . . The stenographer from a centralized bureau has no . . . continuous and responsible relationship to any one person" (Coyle 1928, p. 27).

Data from the original surveys of a 1940 Women's Bureau Bulletin of male and female clerical workers are used to analyze the returns to training and

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[9] Various studies published in the 1920s, utilizing Taylor's scientific methods, indicated in which clerical jobs managers could effectively screen workers prior to employment and in which they could not. See the discussion in Davies (1982), Chapter 6.

education in the context of the earnings function.[10] The findings in Table 3 indicate that the earnings function for females is similar to that thought typical today (Mincer and Polachek 1974). Earnings rise gradually with experience without peaking in the relevant range, education measured in years increases earnings, and "home time" decreases earnings by about 1.5 percent per year.

The comparisons with the male earnings function reveal that returns to total experience in clerical work were far greater for men, while returns to experience with the present firm were lower. Years of education were less valuable for men, although an advanced or special degree was worth more. That is, men accumulated relatively more general human capital on the job than did women, and women accumulated a relatively larger amount of specific human capital. Consider a man and a woman with five continuous years with their first employer, thus only five years of experience. The woman's earnings would increase by 13.4 percent because of an increase in general skills and she would receive an additional 6.6 percent because of skills specific to her current firm. The man would receive a 24.5 percent increase because of augmented general skills, but a 5.8 percent increase because of skills specific to his current firm.[11]

Analyses of the occupations of clerical workers in 1940 and at the time of their first clerical job reinforce the findings on earnings. Men typically began as clerks and rose through the ranks with experience. If they had college degrees, they began and remained in skilled positions. Women, however, were initially placed in jobs by years of education, far more so than were males,

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[10] These data were retrieved from the National Archives. For a discussion of the Women's Bureau Bulletin and the survey from which these data were obtained, see Goldin (1984).

[11] Note that these results are the most generous to the alternative hypothesis. Those using the regressions that exclude the schooling dummies indicate a barely significant and smaller coefficient on the tenure variable for men.

TABLE 3
Earnings Functions for Female and Male Clerical Workers, 1940

Dependent Variable: Log Full-time Salary

	Females		Males	
Constant	6.078*	6.085*	6.474*	6.518*
	(0.069)	(0.083)	(0.095)	(0.085)
Totexp	0.0290*	0.0290*	0.0518*	0.0535*
	(0.0033)	(0.0033)	(0.0042)	(0.0041)
$Totexp^2$	-0.000453*	-0.000447*	-0.000848*	-0.000889*
	(0.000078)	(0.000078)	(0.000083)	(0.000081)
ExpFirm	0.0135*	0.0133*	0.0081**	0.0115*
	(0.0024)	(0.0024)	(0.0042)	(0.0027)
Contin.	0.142*	0.139*	-0.0576	-0.0781
	(0.030)	(0.030)	(0.0615)	(0.0599)
Furlough	-0.0224*	-0.0234*	-0.0413*	-0.0471*
	(0.0097)	(0.0098)	(0.0189)	(0.0186)
Married	0.0131	0.0149	0.131*	0.119*
	(0.0213)	(0.0214)	(0.030)	(0.030)
YrsEduc	0.0380*	0.0371*	0.0260*	0.0171*
	(0.0049)	(0.0075)	(0.0052)	(0.00472)
CCDum		0.031		-0.014
		(0.026)		(0.046)
VocGrad		0.046		0.149*
		(0.034)		(0.063)
CollDum		0.054		0.165*
		(0.046)		(0.037)
HSDum		-0.007		0.067*
		(0.028)		(0.030)
HomeTime	-0.0147*	-0.0151*		
	(0.0051)	(0.0051)		
R^2	0.464	0.468	0.643	0.665
Number of Obs.	724	724	481	481

Sources: See Goldin (1984). These data are a sample of original schedules from Women's Bureau Bulletin No. 188-5, "Office Work in Philadelphia, 1940," (1942), housed in the National Archives, Record Group #86, Boxes 472-486.

Notes: Standard errors are in parentheses; * indicates significant at least at the 0.05 level; ** indicates significant at least at the 0.10 level.

Variable Definitions:

Totexp	Years since individual began first clerical job
Expfirm	Years since individual began work with current employer
Contin.	= 1 if years workers with current employer has been
continuous.	
Furlough	Number (or percent) of years individual had been furloughed
Married	= 1 if married
CCDum	= 1 if has a commercial course degree
VocGrad	= 1 if graduated from a vocational school
CollDum	= 1 if graduated from college
HSDum	= 1 if graduated from high school
HomeTime	Number of years unaccounted for, presumably spent out of the labor force; variable is defined as : Totexp - Expfirm - years spent at other clerical jobs.

and generally remained in their first positions or ones very similar, independent of experience. For example, 70 percent of all females who began as stenographers and dictaphone operators remained so to 1940; 57 percent who began as machine operators also stayed in that position. Both findings are invariant to years of office experience. One important exception to the absence of job advancement is secretaries, who frequently rose through the ranks beginning first as general office clerks. Among males, the situation seems much the reverse. Fully one-third of all the men in 1940 were classed in skilled positions (only 6 percent of the females were). One-third of these began in skilled positions, typically those with college educations men, but another 40 percent rose through the ranks beginning as general office clerks.

Thus it appears that women began to be employed in the clerical sector when its jobs could be more finely divided and its output more cheaply monitored. The presence of machinery and more task oriented jobs did not eliminate the accumulation of specific human capital among clerical workers, female or male, but did allow for a finer division of labor.

4. Concluding Remarks

The literature on occupational segregation by sex has focused on differences in the types of jobs held by males and females, particularly on those in different sectors of the economy and with emphasis on the degree and nature of the human capital required. But within various industries and even within certain occupations, male and female jobs have differed by the method of payment and the nature of the supervisory and monitoring input necessary to elicit output. The model that was offered in Section 2 explored the implications of various types of supervisory and monitoring methods, for which expected time on the job was an important determinant. These implications were explored with data from 1890 to 1940 regarding manufacturing and clerical work.

During this period the majority of female workers did have rather abbreviated labor force experiences. The labor force participation rate for white married women was low for all age groups until the 1950s. Most women entered the labor force sometime before they married but at the time of marriage exited the labor force permanently. Thus it appears that the assumption of the model concerning the relative length of stay with firms for the majority of males and females was reasonable.

Because so many women exited from the labor force at the time of marriage in the 1920s and 1930s various firms instituted prohibitions against their female employees marrying and had stated policies against hiring married women. One interpretation of such prohibitions is that they served a screening function. Firms wanted to attract women who would remain in the labor force for some period of time, and these prohibitions led to the self-selection of those who planned on marrying late or not at all. These prohibitions emerged at the time the clerical sector was expanding and were used to a great extent in the insurance and banking segments of this industry, a finding consistent with the notion that there were large fixed hiring costs in this sector.

But sometime after 1950 an expanding portion of the female population had rather continuous and lengthy stays in the labor force even after marriage (Goldin 1983; Smith and Ward 1984). The female labor force began to be populated by a more heterogeneous group with regard to life-cycle labor force participation, and an extension of the work of this paper would involve exploring the screening or revealing mechanisms that have been used to ascertain this aspect of employment where there are hiring costs, shirking, or specific human capital paid, in part, by the employer.

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