

Industrial Relations Section  
Princeton University  
Working Paper #43  
December 1973

Estimating the Effects on Cost and Price of the  
Elimination of Sex Discrimination:  
The Case of Telephone Rates

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\* This paper is a revised version of testimony presented before the Federal Communications Commission, Washington, D.C. on February 25, 1972, Docket No. 19143 in the matter of petitions filed by the Equal Employment Opportunity Commission, et. al. The authors are indebted to David A. Smith and William Wallace, of the EEOC, for extensive assistance.

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Employers may be said to discriminate in their hiring practices when, among workers of equal productive abilities, some workers have to offer their labor for hire at lower wages than others in order to gain employment. Firms are thus faced with the choice of employing the less favored workers at relatively lower wages or the more favored workers at higher wages. Among the least discriminatory employers, this difference in offered wages more than compensates the employer's reluctance to hire the less desired workers and these employers fill a particular job category with the less desired workers. On the other hand, the highly discriminatory employers hire the more favored workers, their higher wages notwithstanding. In this way, some firms will have some of their job classifications filled with those workers who suffer from wage discrimination while other firms employ individuals from that group who are paid the higher wages. Alternatively, among workers of different skills, a given firm will find the wage differential sufficiently large to overcome its discriminatory preferences in some job categories and employ the cheaper workers for these

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tasks; for other jobs, however, the wage differential does not fully overcome the employer's reluctance to hire the cheaper workers and the preferred, yet more expensive, workers are employed. Thus, within a firm, discriminatory employment policies tend to be revealed by some job categories being almost wholly filled with one group of workers and other jobs being performed entirely by another group.

This implies that the less discriminatory firms employ the cheaper labor and operate at lower pecuniary costs than more discriminatory firms. Put differently, where the extent of discriminatory practices differs among firms in a given market, production is inefficient with some resources being organized in firms with lower costs than in other firms. In such a market environment, a firm is able to reduce its costs and, therefore, the prices at which its output sells by ceasing its discriminatory practices. The size of the cost reduction partly depends upon how other employers behave at the same time. If each and every employer ceases discriminating against one group of workers, the wages of this group will rise relative to others. The fall in costs in such a situation will be less than that in which one firm ceases its discriminatory practices while all other firms do not alter their behavior in this respect. For in this second case, when the firm has a large pool of workers from which to hire, it may replace the more favored and expensive workers with the less favored and inexpensive workers without finding that the wage rates of the latter group rise to any significant degree.

The comments in the preceding two paragraphs are nothing more than a thumbnail sketch of the basic theory of the economics of discrimination as

advanced first by Gary Becker.<sup>1/</sup> The purpose of this paper is to trace out one of the main normative implications of this theory and ask "By what amount would the firm's costs be lower in the absence of discriminatory employment decisions on the part of its management?" Since in answering this question we shall assume that other firms' discriminatory practices do not alter and that market wage rates do not change as one group of workers is substituted for another in this firm, the solution to this problem may be regarded as the lower limit to which costs fall in situations in which wage rates do respond to these employment changes.

We want to emphasize that this paper does not contain new evidence for resolving the issue of the degree to which the overall observed differences in wages between individuals may be attributed to factors associated with their market productivity as distinct from factors that can be classed as discriminatory views held by employers. For our empirical purposes, with the available data we make the best estimates of differences between the market wage rates of male and female workers who have the same employment or productivity potential. Some readers no doubt will find our estimates large, while others will find them small. In either case the reader may want to modify the predicted cost decline accordingly. Nevertheless, as we have already stated, so long as these male-female wage differentials are not zero, production costs must eventually decline after females replace males in employment. Put differently, by the very definition of discrimination, an end to discriminatory employment practices by one firm in the presence of continued discrimination in the remainder of the economy must reduce that firm's pecuniary costs of conducting business. Alternatively,

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<sup>1/</sup>Gary S. Becker, The Economics of Discrimination, University of Chicago Press, second edition, 1971. See also Kenneth Arrow, "The Theory of Discrimination," in Orley Ashenfelter and Albert Rees (eds.), Discrimination in Labor Markets, Princeton University Press, 1973.

if a prescribed change in a firm's employment practices does not eventually lead to a reduction in the firm's pecuniary costs, then that change cannot have been remedying discrimination.

Turning now to the particular case of the American Telephone and Telegraph Company (hereafter called Bell Telephone), their employment data reveal that, at least until the last year or two, there are a number of occupations in which women comprise a very small fraction of the work force. For instance, in the Bell companies in 1969, 99.9 percent of the job category titled "foreman of telephone craftsmen among construction, installation and maintenance employees" were male while women constituted practically 100 percent of experienced switchboard operators.<sup>2/</sup> Recall that this pattern for women and men to congregate in particular job categories is exactly what is predicted on the assumption that management discriminates against female employees. Consider now the effects upon Bell Telephone's operating costs if female workers replace male in some or all job categories.

To arrive at conclusions about the change in costs that follows when Bell ceases discrimination and females are substituted for male workers, we require some behavioral model that describes the company's production decisions. Suppose that, in the face of given input prices, the company acts as if it minimizes the total costs of producing any given level of output. It is also useful to this analysis to discover if information is available on the technical relationship under which Bell combines different types of labor and services from physical capital to produce output, that is, the

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<sup>2/</sup> These data are taken from Statistics of Communications Common Carriers, Federal Communications Commission, year ended December 31, 1969, published 1971, Table 10.

form of the production function. To date, this evidence strongly suggests that there exists a very convenient form of the factor input-product output relationship for Bell Telephone, namely, that if each factor input is increased by a given proportion, then output will increase in the very same proportion (that is, constant returns to scale). Thus, Bert G. Hickman could not reject the hypothesis that, in the telephone communications industry, the production function is linearly homogeneous.<sup>3/</sup> Jorgenson and Handel assume that a Cobb-Douglas function holds in communications and find that use of such an assumption describes the data well.<sup>4/</sup> In their econometric model of A. T. and T., Davis, Caccappolo, and Chaudry report that, among a variety of functions, a homogeneous production function fits their data best. They also record slightly increasing returns to scale, namely, a returns to scale parameter of 1.09.<sup>5/</sup> Finally, Sankar fits a nonconstant returns to scale CES production function to the telephone industry, but finds that the hypothesis of constant returns (that is, linear homogeneity) cannot be rejected.<sup>6/</sup> In all these four studies, homogeneous production functions were selected to describe the input-output relationship

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<sup>3/</sup> Bert G. Hickman, Investment Demand and U.S. Economic Growth, Brookings, 1965, pp. 49-52.

<sup>4/</sup> D. W. Jorgenson and S.S. Handel, "Investment Behavior in U.S. Regulated Industries," Bell Journal of Economics and Management Science, Spring 1971, pp. 213-65.

<sup>5/</sup> B.E. Davis, G.J. Caccappolo, and M.A. Chaudry, "An Econometric Planning Model for American Telephone and Telegraph Company," Bell Journal of Economics and Management Science, Spring 1973, pp. 29-56.

<sup>6/</sup> U. Sankar, "Investment Behavior in the U.S. Telephone Industry: 1949 to 1968," Bell Journal of Economics and Management Science, Autumn 1973, pp. 665-78.

in A. T. and T. and, in the only case in which constant returns to scale were not estimated, the calculated parameter (1.09) was sufficiently close to unity to make the assumption of a linear homogeneous production function a good approximation.<sup>7/</sup>

Under these assumptions -- that Bell minimizes the costs of producing any given level of output and that proportional changes in all inputs yield the same proportionate change in output -- the eventual change in average costs that follows when the company substitutes female workers for male takes the following form:

$$\Delta \ln(c/q) = w_1 \Delta \ln p_1 + \dots + w_n \Delta \ln p_n \quad (1)$$

where  $\Delta \ln(c/q)$  is the proportionate change in average costs,  $\Delta \ln p_i$  is the proportionate difference between male and female market wage rates in each job category,  $w_i$  is the fraction of total costs that are paid to workers in each job category, and the subscripts (1 to n) index the n different job classifications.<sup>8/</sup> It is this equation (1) that constitutes the basis of our computations.

There are two types of estimates we have to make in order to arrive at a value for  $\Delta \ln(c/q)$ . First, there are estimates of male-female wage differentials in each job category. These were arrived at by making use of

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<sup>7/</sup> See Appendix 1 for the role of the assumption of constant returns to scale in the estimates that are to follow.

<sup>8/</sup> Equation (1) is the discrete approximation to equation (6b) of Appendix 1 and the reader is referred to this Appendix for the theoretical rationale of equation (1).

a sample of 13,085 working individuals from the Survey of Economic Opportunity for 1967. This sample of workers was classified into four groups: males living in large metropolitan areas (i.e., with populations of at least three-quarters of a million people); males in other metropolitan areas; females in large metropolitan areas; and females in other metropolitan areas. For each of these four groups, multiple regression equations were estimated relating the hourly earnings of each individual to sixty-two variables that measure characteristics of each of the individuals like their years of schooling, years of market experience, their occupation, industry, and region in which each lives and works.<sup>9/</sup> In effect, after removing the effect of schooling, experience, unionism, marital status, and industrial class on wage differentials the wages in each of the four groups (male, female, large and small metropolitan areas) were cross-classified by occupation and by region (living in the South or not) within the communications industry. By this method, male-female wage differentials are estimated for each occupation and region in the United States in the communications industry and these provide our values for the  $\Delta \ln p$ 's in equation (1).

To evaluate (1) we also require estimates of  $w_i$ , the proportion of total costs paid to each class of workers. These data are available for each of the major metropolitan areas and were submitted by A. T. and T. to the Federal Communications Commission as of 1970. An overall estimate of  $\sum_i w_i \Delta \ln p_i$  is obtained first by aggregating across job titles within a metropolitan area and second by aggregating across metropolitan areas.

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<sup>9/</sup>A summary of these estimated relationships is given in Appendix 2.

In the calculation of equation (1), we take cognizance of adjustment costs and on-the-job training. The replacement of a large fraction of the work force cannot be effected immediately without substantial cost. If Bell adopted the strategy of hiring female workers on a non-discriminatory basis as male workers voluntarily quit their employment, some job categories would be filled with women more quickly than others. For instance, Southern Bell Telephone and Telegraph Company reports in testimony submitted to the Federal Communications Commission<sup>10/</sup> that the overall separations rate in 1970 was as high as 30.9 percent per year and that for installer-repairmen and framemen, in particular, the separations rates were 57.8 percent and 47.0 percent respectively. In this case, the replacement of quitting male installer-repairmen and framemen by females would probably be substantially accomplished within several years. However, job categories that normally result from internal promotions can be filled with females only over a longer period of time. For these reasons, we allow for differential adjustment rates to a largely female labor force. Three types of job classifications are distinguished:

- (i) entry-level jobs which consist of framemen and installer-repairmen, operatives and service workers (except those with "head" or "senior" titles), and operators, service representatives, and all clerical jobs either with wage rates equal to or less than the operators' wage or which hired at least ten persons in 1970;

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<sup>10/</sup> See South Florida Plant Force Loss Study, Southern Bell Tel. and Tel. Co., November 1971.

- (ii) all other nonmanagement jobs; and
- (iii) management level jobs.

Clearly, we should expect a less rapid concentration of females as we move from the job titles classified from (i) to (iii) above. Hence, we distinguish in our calculations between the effects on average costs of women replacing men first in jobs categorized under (i), then under (i) and (ii), and finally under all three categories. The estimates of the decline in average costs obtained in this way using equation (1) are as follows:

Percentage Decline in Average Costs

Type of job category in  
which females replace males

entry-level jobs only	.77
all nonmanagement jobs	2.29
all jobs	3.91

Thus, if the end of discriminatory employment practices resulted in females being substituted for males in all nonmanagement jobs, Bell Telephone's average costs would have fallen by approximately 2.3 percent of their level in 1970. This means that the average price of Bell Telephone's services could also fall by 2.3 percent without affecting Bell Telephone's profitability.

Appendix 1

In order to quantify the impact of the wage rate changes that are implied by a decrease in discrimination on costs and price it is necessary to set out an approximate behavioral model of the cost and price behavior of the firm. The model that we draw on here is the conventional analysis of the behavior of the cost minimizing firm. Our goal is to construct a simple rule of thumb, useful where there is little opportunity to engage in substantial statistical analysis, that relates the firm's cost and price of output to the prices of the inputs it uses.

If we denote by  $p_i$  and  $x_i$  the prices and quantities of each of the factors used in production, then the firm's total costs,  $c$ , are

$$(1) \quad c \equiv \sum p_i x_i .$$

If we suppose that the production of the firm's output,  $q$ , may be described by a function

$$(2) \quad q = f(x_1, \dots, x_m)$$

of the  $m$  inputs  $x_i$ , then the firm that chooses its inputs so as to minimize (1) subject to (2) will always operate where

$$(3) \quad \lambda(\partial q / \partial x_i) = p_i \quad (i = 1, \dots, m)$$

That is, the marginal cost ( $\lambda$ ) times the marginal product of each factor will equal its price.

Now the total differential of the cost identity (1) is

$$dc = \sum p_i dx_i + \sum x_i dp_i$$

or, noting that  $z d \ln z = dz$  for any variable  $z$ ,

$$(4) \quad c d \ln c = \sum p_i x_i d \ln x_i + \sum p_i x_i d \ln p_i ,$$

where  $\ln$  denotes a natural logarithm. Likewise, the total differential of the production function (2) is

$$q d \ln q = \sum (\partial q / \partial x_i) x_i d \ln x_i ,$$

or, after substituting the equalities (3),

$$(5) \quad \lambda q d \ln q = \sum (p_i x_i) d \ln x_i .$$

Substituting (5) into (4) and dividing both sides of the result by  $c$  then gives the proportionate change in total minimized costs as

$$(6) \quad d \ln c = [\lambda / (c/q)] d \ln q + \sum [(p_i x_i) / c] d \ln p_i \\ = k d \ln q + \sum w_i d \ln p_i ,$$

where we set  $k \equiv \lambda / (c/q)$ , the ratio of marginal to average costs, and  $(p_i x_i / c) = w_i$ , the share of the  $i^{\text{th}}$  factor's costs in total costs.

There are two specialized assumptions that make equation (6) useful in practical matters. First, if we assume that the production function (2) is homogeneous of degree  $\eta$ , then  $k = \frac{1}{\eta}$ , a constant, in equation (6)\*. In this case  $d \ln \lambda = d \ln (c/q) = d \ln c - d \ln q$ , so that proportionate changes

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\* If the production function is homogeneous of degree  $\eta$ , then it is easy to show that  $\eta q = \sum (\partial q / \partial x_i) x_i$ . (See J.M. Henderson and R.E. Quandt, Microeconomic Theory, New York, second edition, 1971, p. 81). Substituting the equalities (3) this is  $\lambda \eta q = \sum p_i x_i$ . But as an identity  $c \equiv \sum p_i x_i$ , so that dividing the former by the latter gives  $\lambda \eta (q/c) = 1$  and hence  $\lambda / (c/q) = 1/\eta = k$ .

in marginal costs equal proportionate changes in average costs, and we may rewrite (6) as

$$(6a) \quad d\ln c - d\ln q = d\ln \lambda = (k-1)d\ln q + \sum_i w_i d\ln p_i$$

Second, if we assume that the production function possesses constant returns to scale, in which case equiproportionate increases in all factor inputs produce an equiproportionate increase in output,  $k = 1/\eta = 1$ , and (6) specialize to

$$(6b) \quad d\ln(c/q) = d\ln \lambda = \sum_i w_i d\ln p_i \quad .$$

Formula (6b) is extremely easy to use. It says that small proportionate changes in the cost minimizing firm's marginal (and average) costs are merely a weighted average of the small proportionate changes in the input prices the firm faces, with weights equal to the share of a factor's costs in total costs. The primary usefulness of (6a) is that it tells us by how much (6b) is amiss if some empirical information is available on the actual returns to scale in the firm. In practice, of course, the unobservable infinitesimal changes  $d\ln p_i$  must be replaced by finite changes  $\Delta \ln p_i$ , in which case (6b) is an approximation only. In addition, if we define  $\Delta \ln p_i = \ln p_{im} - \ln p_{if}$ ,  $w_i$  may be taken as either  $w_{im}$ ,  $w_{if}$  or  $\frac{1}{2}(w_{im} + w_{if})$ . Though the latter is perhaps preferred, it is unlikely that the results would differ appreciably no matter which procedure is used.

Finally, we inquire after a rule of thumb to indicate how output price,  $R$ , will change. Since the firm we deal with is a regulated monopoly we may consider two extreme assumptions. First, suppose that the regulatory

commission accomplishes its purpose and that, without disturbing the efficiency of the firm, it forces the firm to follow a rule of marginal cost pricing. In this case  $d\ln R = d\ln \lambda$  and (6b) is directly applicable. Alternatively, suppose that the regulatory commission has no effect whatever and the firm acts as a profit maximizing monopolist. Since total revenues are  $M = R(q) \cdot q$ , where  $R(q)$  is the product demand curve, marginal revenue is  $dM/dq = (dR/dq)q + R = R[1 + (1/\epsilon)]$ , where  $\epsilon = (dq/dR)(R/q)$  is the price elasticity of product demand. Since the profit maximizing monopolist sets marginal revenue equal to marginal cost we have

$$(6c) \quad d\ln R + d\ln[1 + (1/\epsilon)] = d\ln \lambda = \sum w_i d\ln p_i \quad .$$

So long as  $\epsilon$  is (nearly) constant for small changes in output price,  $d\ln R(1 + 1/\epsilon) \approx d\ln R$ , and proportionate changes in marginal revenue are equal to proportionate changes in output price, in which case (6b) is still a satisfactory approximation. The primary usefulness of (6c) is that it tells us by how much (6b) is amiss if some empirical information is available on how the elasticity of product demand varies.

Appendix 2

The estimates of proportional male-female wage differentials ( $\Delta \ln w$ ) were arrived at by making use of observations on the hourly earnings and other characteristics of individual workers (as compiled in the Survey of Economic Opportunity for 1967) to estimate multiple regression equations for males and females and for those living in small and in large metropolitan areas separately. These regression equations took the following general form within each group of workers (i.e., for males in large urban areas, for females in large urban areas, etc.):

$$\ln w = \text{constant} + \alpha Z + \beta_1 X + \beta_2 (XD) + \beta_3 (XDS) + \epsilon$$

where  $\ln w$  is the natural logarithm of the hourly wage rate and where  $\epsilon$  is a stochastic disturbance term.  $Z$  is a vector of variables that measure each individual's years of schooling (in quadratic form), years of subsequent labor force experience (in quadratic form), union membership status, seventeen dummy variables indicating the industry and type of employment in which each works, any health problems, information on any previous migration of the individual, marital status, and region of the country in which each lives and works. Our purpose in including so many righthand variables is not, of course, to conduct tests on particular determinants of the hourly earnings of workers, but simply to derive a prediction for the dependent variable that minimizes the residual variance (and thus also minimizes the variance of the prediction error).  $X$  is a set of occupational dummy variables that take the value of unity if the individual is classified in a given occupation and of zero otherwise. The occupations are categorized as professional workers, managers,

clerical workers, craftsmen, operatives, private household workers, service workers, farm workers, and laborers. Finally, D and S are dichotomous variables: D takes the value of unity if the individual works in utilities, transportation, and communication; and S takes the value of unity if the individual lives in the South. The coefficients  $\beta_2$  and  $\beta_3$  permit estimates of occupational wage differentials specific to the communications industry that also vary between the South and the rest of the country.

Let  $Z_1$  and  $Z_2$  refer to the education and experience variables in the vector  $Z$ . Let us also write  $\bar{Z}_m$  and  $\bar{Z}_f$  for the mean values of each of the other variables in  $Z$  for males and females, respectively, and  $\hat{\alpha}_m$  and  $\hat{\alpha}_f$  for the estimated regression coefficients (including the constant terms) for males and females. Then, for any single occupational category (that is, where one of the elements of  $X$  takes the value of unity and all other variables in  $X$  are set equal to zero), the proportional male/female wage differential in the communications and utilities industry outside the South is estimated as

$$\Delta \ln \hat{w} = (\hat{\alpha}_{1m} - \hat{\alpha}_{1f}) 12 + \hat{\alpha}_m \bar{Z}_m - \hat{\alpha}_f \bar{Z}_f + \hat{\beta}_{1m} - \hat{\beta}_{1f} + \hat{\beta}_{2m} - \hat{\beta}_{2f} ,$$

where  $\hat{\beta}_1$  and  $\hat{\beta}_2$  are the estimated regression coefficients relevant to the communications and utilities industry for that particular occupation. In the South, we add  $\hat{\beta}_{3m}$  and subtract  $\hat{\beta}_{3f}$  from this expression. Our calculations of  $\Delta \ln \hat{w}$  explicitly assumes a comparison of men and women who are high school graduates (that is, with 12 years of schooling) and have little or no labor market experience.

As an illustration of the order of magnitude of the estimates of  $\Delta \hat{\ln p}$ , the following table contains estimates for the ten largest Standard Metropolitan Statistical Areas of the standardized proportionate male/female wage differentials in the occupations that underly the calculations on the last page in the text.

<u>Occupation</u>	<u>Region</u>			
	<u>South</u>	<u>Northeast</u>	<u>North Central</u>	<u>West</u>
Professional Workers	.296	.256	.330	.288
Managerial Workers	.171	.131	.205	.163
Clerical Workers	.411	.271	.346	.303
Craftpersons	.397	.357	.431	.389
Sales Workers	.444	.404	.478	.436
Operatives	.088	.221	.295	.253