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ABSTRACT

This paper estimates the effects of systems of human resource management policies on the performance of U.S. manufacturing businesses. OLS results for labor productivity and Tobin's q models both reveal that nonunion businesses that employ a human resource management system with flexible job design, formal training, and workplace communication mechanisms have the highest levels of economic performance. Nonunion businesses with "Union-style" human resource management systems involving grievance procedures, seniority-based promotions, and no flexible job design exhibit significantly lower levels of performance. Statistical models are unable to determine whether the more "progressive" human resource management system stimulates economic performance or whether this system is the appropriate choice for better performing businesses. Still, the positive relationship between performance and this human resource management system suggests that this system will be more common in the future. In contrast, the "union-style" system appears to be a thing of the past. It is confined to unionized businesses in declining industries and very old nonunion businesses with low levels of economic performance.

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There is considerable popular support for the notion that the way a firm manages its workforce affects its performance. Evidence for this claim often comes from case study comparisons of personnel practices in successful Japanese firms with those in less successful American competitors. According to these popular accounts, "Japanese-style" employment practices such as job rotation and "team-oriented" communications systems are part of the formula for successful economic performance, while "American-style" practices such as narrowly-defined jobs and adversarial grievance procedures are ingredients for poor performance.

Unfortunately, a lack of firm-level data has precluded more systematic empirical investigations of the relationship between personnel practices and measures of economic performance. A broader-based econometric study of the relationship between personnel practices and economic performance of businesses would be a particularly valuable supplement to case studies. Unlike case studies, a broader-based empirical study can provide estimates of the magnitude and sign of any effects of personnel policies on performance as well as a greater degree of generality of results.

This study investigates the effects of personnel practices on productivity and stock market measures of business performance in a cross-section sample of approximately 200 U.S. manufacturing businesses. Unlike most previous personnel research which focuses on individual personnel practices, this paper instead classifies firms according to their sets of personnel policies, referred to as a firm's system of human resource management (HRM). The econometric models which test the relationship between HRM sys-

tems and economic performance are estimated with and without corrections for potential endogeneity between business performance and the choice of an HRM system.

I. HRM Systems and Economic Performance

The principal hypothesis tested in this paper is that a business's system of personnel policies can affect its economic performance. Because personnel policies encompass such a broad range of managerial decisions and practices including job design, recruiting and selection, training and development, reward structures, and communication systems, the number of potential theoretical mechanisms that might link personnel practices to performance is very large. While a study of a single personnel policy would undoubtedly allow for a more specific theoretical model of the effects of that policy on performance, limiting the scope of the investigation to a single policy would be misleading. In particular, there is strong agreement across diverse theoretical perspectives that personnel policies should be highly interrelated.

For example, from the perpective of human capital theory, personnel policies should affect business performance because certain policies are instrumental in the acquisition and development of valuable employee skills. At the same time, human capital theory also emphasizes relationships among personnel policies. While this theoretical perspective highlights the importance of training for jobs that require specific human capital, training should also be accompanied by a policy of "promotion from within". A merit-based reward structure is at least implicitly

assumed because the employee and employer must share the costs of training in earlier periods and the benefits of improved productivity in later periods. Furthermore, if worker ability and training are complementary, as suggested in certain job-matching models (see, e.g., Jovanovic, 1979; Topel,1986), then "productive" training efforts may also coincide with more extensive recruiting to identify high ability job applicants.

Models of workplace organization rooted in psychology draw on theories of motivation and commitment (e.g., Maslow, 1954; Herzberg, 1966; Vroom and Deci, 1970). These models argue that pay alone is not an effective tool for motivating workers because it does not satisfy many human needs. These models suggest that a set of reenforcing personnel policies that encompass broad and flexible job design, extensive communication mechanisms, merit-based reward structures, and employee training can promote economic performance through their effects on worker motivation and commitment (Hackman and Oldham, 1980; Kochan, Katz and McKersie, 1986, 93-96).

Institutionally-oriented analyses of labor unions suggest that personnel practices in unionized settings can promote performance when they enhance worker "voice" and reduce employee turnover. They can also reduce efficiency to the extent that they impose unnecessary restrictions on the definition and scope of jobs (Freeman and Medoff, 1984, 162-165; Brown and Medoff, 1978, 357-360). At the same time, institutional analyses of labor unions draw attention to a consistent set of personnel practices instituted under collective bargaining including quasi-judicial grievance procedures, seniority-based reward structures, and

narrowly defined jobs (Slichter, Healy and Livernash, 1960; Kochan, Katz, and McKersie, 1986).

Each of these different theoretical perspectives stresses two fundamental points. First, personnel practices can affect a firm's economic performance. These different theoretical frameworks emphasize different mechanisms that link personnel practices to business performance -- skill development and acquisition in human capital theory, employee motivation and commitment in psychological theories, and effective worker representation and voice in studies of trade unions. These different frameworks also share the intuitively appealing notion that personnel policies affect performance primarily through their effects on the contribution and quality of the labor input.

Second, each of the theoretical perspectives also emphasizes the logic of a systems approach to the analysis of personnel practices, although the different frameworks draw attention to different systems of policies. Estimates of the effects of individual policies on measures of performance will probably be misleading. If training and promotion-from-within, flexible job design and team-oriented communication systems, or grievance procedures and narrowly defined jobs are highly correlated, it will be misleading to attribute the performance effects of personnel management to individual policies. The performance models therefore include variables measuring sets of personnel policies, or HRM systems, rather than individual policies.

Specification of Performance Models

The empirical test of this study's principal hypothesis is

to measure directly whether the economic performance of businesses varies systematically with different configurations of personnel policies. Because different measures of performance may capture different effects of the policies, the empirical models investigate two different measures of performance -- labor productivity, and the stock-market value measure of Tobin's q. The data set for this study does not contain measures of "intervening" variables, such as workers' skills or motivation, through which personnel policies might affect performance.

In the productivity analysis, variables measuring different HRM systems are incorporated within an otherwise conventional production function. For simplicity of exposition, begin with a Cobb-Douglas production function:

$$Q = AK^{\beta}(EL)^{\gamma} \qquad (1)$$

where Q is output measured by "net sales" from the COMPUSTAT II data tape, K is capital stock measured by "identifiable capital assets" from COMPUSTAT II,[1] and EL is the "effective" contribution of labor to output. Let EL be some variable proportion of the average contribution of labor (L), where L is measured by business line employment from the survey of personnel practices in COMPUSTAT II businesses described below. Therefore, $EL = L(1+\lambda)$. Furthermore, let the HRM system (HRM) that a firm adopts affect the difference between EL and L according to:

$$EL = L(1 + \delta HRM). \qquad (2)$$

Substituting equation (2) for EL in equation (1), rearranging terms, and allowing for a random component in the determination of productivity, one obtains:

$$\ln(Q/L) = \ln A + \beta \ln K + (\gamma - 1)\ln L + \gamma^{*}\delta(HRM) + \varepsilon \qquad (3)$$

HRM systems have direct effects on labor productivity in this model if they cause EL to differ systematically from AL.

Systematic relationships between HRM systems and the simple sales-per-employee productivity proxy in equation (3) may not measure actual productivity differences. For example, the COMPUSTAT II survey does not report statistics on costs of purchased materials that would be needed to translate the sales variable into the preferred value added measure. This particular limitation is overcome to some extent by expanding the equation (3) specification to include the ratio of the cost of purchased materials to dollar value of shipments for the business's four-digit industry as reported in the Census of Manufactures.[2]

Estimates from equation (3) which control for the ratio of materials costs to sales in the business's narrowly defined industry group provide more assurance that estimates of the coefficients $\gamma^{*}\delta$ in equation (3) reflect productivity differences across businesses with different HRM systems. However, it is still possible that the $\gamma^{*}\delta$ coefficients are not measuring true performance differences. For example, businesses with certain HRM systems may be charging sytematically higher prices for reasons that are unrelated to the business's HRM system.

A second test of the relationship between HRM systems and economic performance investigates differences in firms' stock market values as measured by Tobin's q. Tobin's q is defined as the ratio of the expected discounted value of the net income derived from a firm's assets (V) to the replacement cost of the firm's capital assets (A).[3] Following the general approach of

several previous studies (e.g., Griliches, 1981; Jaffe, 1986), the Tobin's q model is specified:

$$q = V/A = \exp[\alpha + \beta_1(C4) + \beta_2(\%UNION) + \beta_3(C4*\%UNION) + \beta_4(HRM) + \xi] \quad (4)$$

where $\bar{C4}$ is the four-firm concentration ratio for the firm's industry classification and %UNION is the percent of the firm's workforce unionized. C4 is included to identify industries with greater monopoly power. %UNION allows unions to affect market value directly, while C4*%UNION allows for the possibility that unions capture some of the rents attributable to market structure (Salinger, 1984). Finally, ξ is a random firm-specific component. A logarithmic transformation of equation (4) gives the specification to be estimated.

Endogenous Determination of Performance and HRM Systems

Significant OLS coefficient estimates on the HRM variables could reflect real efficiency effects of different HRM systems. Conversely, OLS estimates of equations (3) and (4) will yield inconsistent estimates of the coefficients on the HRM system variables if system choice is dependent on economic performance.

For example, according to general models of investment, better performing businesses attract more investment. Certain HRM systems, such as those with formal employee training, reliance on internal employee development and promotion, and formal systems of job rotation and progression, may be a form of greater investment in employee skills. Businesses with high levels of performance, i.e., those with positive error terms in equations (3) or (4), can expect longer employment relationships and therefore are

in a better position to adopt a "high investment" system. In general, as long as there is a correlation between ϵ in equation (3) or ξ in equation (4) and the business's choice of its HRM system, selectivity bias affects the estimation of the coefficients on the HRM variables in the performance equations.

While cross-section data are far from ideal for correcting for selectivity bias, certain selectivity adjustments are possible. To develop a correction procedure that is consistent with this study's systems perspective on personnel policies, let each firm face H alternative personnel systems ($HRM_h = 1,\ldots,H$). For any choice h out of the H alternatives, profits for business i are expressed:[4]

$$\pi_{hi} = \beta_h(X_i) + \mu_{hi}. \qquad (5)$$

X_i is a set of firm, industry, and market characteristics that affects profits. The effects of the characteristics on profits may vary with the choice of HRM system. The business chooses the system that maximizes profits, so that the specific HRM system s is chosen if:

$$\pi_s > \max_{\substack{h=1\ldots H \\ h\neq s}} \pi_h \qquad (6)$$

The probability that the business chooses the specific system s is:

$$Pr(HRM_s) = Pr(\pi_s > \pi_h) \text{ for all } h\neq s.$$

Then define η_s such that:

$$\eta_s = \max_{\substack{h=1\ldots H \\ h\neq s}} \pi_h - \mu_s \qquad (7)$$

The condition in equation (6) for choosing system s is therefore equivalent to $\beta_s X_s > \eta_s$. Assuming that the error terms μ_h in equation (5) are independently distributed and follow a Gumbel distribution, McFadden (1973) demonstrates that the probability of choosing alternative s is:

$$Pr(HRM_s) = \exp(\beta_s X) \; / \sum_{h=1}^{H} \exp(\beta_h X). \qquad (8)$$

Results from the equation (8) multinomial logit model describe whether characteristics of a business and its workforce determine its choice of an HRM system. These results are also used to implement the instrumental variables (IV) method suggested by Dubin and McFadden (1984) and Dubin (1985) to correct for selectivity bias when a set of categorical variables are endogenous. In particular, estimates from the equation (8) multivariate logit model generate predicted probabilities that a business employs each of the H possible HRM systems. These probabilities are then used to estimate the performance equations by 2SLS. In this 2SLS procedure, each HRM system dummy variable in a performance equation is instrumented by the set of predicted probabilities from the multinomial logit model and the remaining exogenous variables in the performance equation.[5]

The empirical analysis therefore consists of three parts. First, commonly occuring combinations of personnel policies, or HRM systems, are identified. Then, the multinomial logit model estimates the determinants of HRM system choice. Finally, equations (3) and (4) estimate the effects of HRM systems on labor productivity and Tobin's q, respectively. These performance

equations are estimated first by OLS and then by the IV method that adjusts for possible selectivity bias in the choice of HRM systems.

II. Measuring Businesses' HRM Systems

The different theoretical perspectives that suggest that personnel policies should be viewed as systems draw attention to different possible relationships among personnel policies. For example, human capital theory suggests relationships among training, internal promotion, merit-based reward structures and recruiting strategies. Psychological models stress additional policies concerning the nature of job design and workplace communication mechanisms, while institutional investigations of unions introduce possible relationships involving grievance procedures and seniority-based personnel decisions.

These various models based on economic, psychological, and institutional analyses of workplace organization are not mutually exclusive. Therefore, the strategy of this study is to examine the broad array of personnel policies suggested by the various frameworks. The policies considered will provide some information on all of the principal areas of personnel management -- job analysis and job design; recruiting and selection; training and development; the nature of reward structures; and communication mechanisms.

Data on personnel policies and practices are taken from a 1986 survey by Columbia University's Industrial Relations Research Center covering 495 Compustat II business lines.[6] In many cases where firms operate only one business line, a "busi-

ness line" corresponds directly to the company. In cases where one parent company operates several business lines, a "business line" often corresponds to a division of a company.[7] The analysis focuses on personnel policies for production workers in businesses in the manufacturing sector.[8]

Eleven survey questions are used to create six personnel policy variables that provide a broad picture across the principal areas of personnel management.[9] The first variable, FLEXJOB, differentiates between broad, flexible job design and narrow, rigid job design. The two survey questions used to construct this variable are:

> Does your organization use a formal job design program to integrate work content and the qualifications required of employees to perform work?
>
> If yes, what type of job design program do you use?: (a) work simplification; (b) job rotation; (c) job enlargement (i.e., adding tasks to a job); (d) job enrichment (i.e., allowing employees more autonomy); (e) other (please specify).

FLEXJOB equals one for businesses that responded yes to either B, C, or D in the second question.

The second variable, MERIT, provides information on the nature of reward structures of businesses. This variable differentiates between promotions based on merit and seniority. The survey question used to create the MERIT variable is:

> In those case where nonentry job vacancies are filled by internal promotions, which one of the following decision rules do you use most often for each employee group? (Circle only one response.): (a) merit or performance rating alone; (b) seniority only if merit is equal; (c) seniority among employees who meet a minimum merit requirement; (d) seniority alone.

MERIT equals one for businesses that responded either A or B.

The third variable provides information on the extent of

internal versus external recruiting and selection and the extent to which the business's internal labor market is open or closed. The variable %INTPR is given by the business's response to the following survey question:

> To the best of your knowledge, about what percentage of your nonentry level jobs have been filled from internal sources in recent years?

The fourth variable, TRAIN, indicates the presence of a formal employee training program according to the business's response to the following survey question:

> Does your business have a formal employee training and development program?

The fifth variable, GRVARB, indicates the presence of a formal grievance procedure ending in third-party arbitration. This dummy variable is constructed from the businesses responses to the following two survey questions:

> Is there a formal grievance procedure or formal complaint resolution system?
>
> If yes, please indicate the nature of the last step in the grievance procedure/complaint system: (a) binding third-party arbitration; (b) other (please specify).

The sixth variable measures the presence of communication and information mechanisms other than formal grievance procedures that end in arbitration. A dummy variable COM equals one for any business that has either an attitude survey of its employees, or an employee complaint procedure without arbitration, or a formal information sharing program[10] as indicated by the responses to the following survey questions:

> Do you conduct attitude surveys among any of these groups of employees?
>
> Is there a formal grievance procedure or formal complaint resolution system? If yes, please indicate the nature of the

last step in the grievance procedure/complaint system: (a) binding third-party arbitration; (b) other (please specify).

Do you have a formal information sharing program with these groups of employees?

These survey questions on personnel policies were asked separately for a business's union and nonunion production workers. Therfore, the sample for the analysis that identifies systems of policies contains one observation for any business with only union or nonunion production workers and two observations for "double-breasted" businesses that have both union and nonunion production workers.

As the systems perspective on personnel policies would suggest, many of these six personnel policies, FLEXJOB, MERIT, %INTPR, TRAIN, GRVARB, and COM, are highly correlated.[11] Flexible job design often implies both training and communication mechanisms. A seniority system for promotions often implies a policy of promotion from within and the existence of a grievance procedure. These correlations suggest the importance of the traditional union system of human resource management. Formal training and the extent of promotion from within have a positive significant correlation as the human capital perspective would suggest.

Despite the evidence in the simple correlations for a systems perspective on personnel policies,[12] the total number of observed combinations of the six principal personnel policies is very large. For example, if the %INTPR variable is transformed into a dummy variable that equals one when %INTPR is greater than the mean value of %INTPR in this sample, then there are sixty-four possible combinations for the six dummy variables -- FLEX-

JOB, MERIT, TRAIN, GRVARB, COM, and the %INTPR dummy. Forty-three of the sixty-four possible combinations exist.

While the systems perspective suggests that analyses of the effects of individual policies will be misleading, the available data do not contain enough observations to test the effects of all interactions of the six personnel policies. To develop a more parsimonious set of HRM systems, a clustering algorithm was used to identify the more prominent and distinctive personnel policy combinations. Details of the clustering procedure are given in the Appendix. Intuitively, the clustering algorithm identifies similar groupings of businesses in six-dimensional "personnel policy space". It tries to minimize the variance in personnel policies within clusters, yet explain a large share of the overall variation in personnel policy space through a small set of clusters. As with all clustering procedures, identification of the number of clusters is somewhat arbitrary. However, the general purpose is to develop a meaningful grouping of businesses with similar HRM systems, but a smaller, more manageable taxonomy of HRM systems than is given by the set of all possible combinations of the six personnel policies.

Table 1 summarizes the HRM system "clusters" identified by the analysis described in the Appendix. The empirical analyses of determinants and performance effects of HRM systems focus on nine identified clusters covering 199 observations. A tenth group of 56 observations was not assigned to any of the clusters identified by the algorithm. Again, there are two observations in this analysis for any double-breasted businesses that report the necessary data, and one observation for businesses with only

TABLE 1

Average Values of Personnel Policy Variables by HRM System "Cluster"
(standard deviations in parentheses)

Cluster Number (observations)	1 (26)	2 (11)	3 (18)	4 (11)	5 (14)	6 (39)	7 (18)	8 (36)	9 (26)	10 (56)
Descriptive Name	Tradit. Union	Union-Like, but no Senior.	Union Like, but no Grvarb	Do-Nothing Find a-Body	Do-Nothing Keep a-Body	COM	COM + FLEX	COM + TRAIN	COM + TRAIN + FLEX hicomit	observ. not assigned
1. FLEXJOB	.038 (.196)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	1.0 (.000)	0.0 (.000)	1.0 (.000)	.536 (.503)
2. MERIT	.038 (.196)	1.0 (.000)	0.0 (.000)	1.0 (.000)	1.0 (.000)	1.0 (.000)	.667 (.485)	1.0 (.000)	.846 (.368)	.536 (.503)
3. TRAIN	.615 (.496)	0.0 (.000)	.222 (.428)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	1.0 (.000)	1.0 (.000)	.286 (.456)
4. %INTPR	.958 (.057)	.817 (.167)	.749 (.290)	.090 (.082)	.811 (.151)	.633 (.337)	.845 (.193)	.871 (.188)	.816 (.206)	.536 (.400)
5. GRVARB	1.0 (.000)	1.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.0 (.000)	0.038 (.196)	.607 (.492)
6. COM	1.0 (.000)	1.0 (.000)	1.0 (.000)	0.0 (.000)	0.0 (.000)	1.0 (.000)	1.0 (.000)	1.0 (.000)	1.0 (.000)	.357 (.483)

union or nonunion employees.

The nine HRM system clusters in Table 1 reflect the bivariate correlations among the six personnel policies, but also uncover other patterns obscured by the simple correlations. System 1 is the protypical union system with no flexible job design, seniority-based promotion, strict promotion from within, and grievance procedures ending in arbitration. HRM systems 2 and 3 are similar in most respects to the union system, except that system 2 has merit-based policies and system 3 does not have a formal grievance procedure. Across the nine systems, formal grievance procedures ending in arbitration and merit-based promotions are antithetical except for the 29 observations in systems 2 and 3.

HRM system 9 fits the description of a newer system of human resource management that is based on psychological models of employee behavior and designed to elicit higher levels of commitment and motivation from employees. This HRM system, labeled the "high commitment" system in Table 1, is typically associated with nonunion firms (Kochan, Katz, McKersie, 1986, 93-96). It includes flexible job design, a formal training program, some formal communication system other than a grievance procedure, and a generally high level of internal promotions.

Other than system 9, system 7 is the only other system that incorporates flexible job design. Businesses with system 7 or system 9 tend to pursue a practice of promotion-from-within. Businesses that have designed their jobs so that employees can perform a broader array of the required tasks tend to rely on employees who have experience with the system. Still, the system

7 and system 9 businesses do not promote-from-within to the extent that businesses with the traditional union system 1 do.

System 8, like system 7, has many policies in common with the "high commitment" personnel system 9. However, system 8 does not have a flexible job design policy, while system 7 does not provide formal training to employees. All businesses with either system 7, 8 or 9 have some formal communication mechanisms other than a grievance procedure.

In sharp contrast to systems 7, 8, and especially 9, systems 4 and 5 generally have no formal policies. Businesses with system 4 hire largely from outside the firm, while system 5 businesses fill vacancies from within. The extent to which system 4 businesses rely on external candidates to fill vacancies is markedly different from businesses with any other HRM system.

III. Determinants of HRM Systems

Each business tries to choose the HRM system that will maximize its profits given the constraints imposed by its production technology, industry environment, and labor market environment. The analysis in this section considers eight characteristics of the business, its industry, or its workforce as possible determinants of HRM system choice: (1) total business line employment (EMPTOT); (2) average age of business line establishments (AGE); (3) the ratio of R&D expenditures by the business to net sales of the business (RDSALE); (4) average years of schooling of the three-digit industry's workforce (MGRADE); (5) capital intensity of the production process as measured by the ratio of the business' capital assets to employment (K/L); (6) the percent

of EMPTOT that are union members (%UNION); (7) union status of the production workers covered by the observation's personnel policies (UNION); and (8) growth rate in the business' four-digit industry's employment between 1977 and 1984 (GRWRAT).[13]

Businesses with large workforces and high values of EMPTOT should be more likely than businesses with few employees to implement HRM systems with large fixed costs. Businesses in growing industries with high values of GRWRAT may be more likely to invest in systems that develop worker skills since employment relationships should last longer. At the same time, older businesses that have historically used a system of workplace industrial relations patterned after the traditional union model may decide against implementing a more flexible workplace HRM system even when the prospects for the growth of their industries are bright. For businesses in this situation, the process of changing HRM systems may be too costly and the benefits of the change in systems too uncertain.

A more educated workforce may facilitate systems that include training if there is complementarity between worker education and training. Similarly, businesses may be more likely to seek out suggestions from more skilled employees through communications mechanisms. While a business-line specific measure of workforce education or skill levels would be the desired measure, such measures are unavailable. MGRADE measures the average education of workers in the business's three-digit industry from responses on the May 1985 CPS survey as a proxy for the education levels in the business's workforce.

R&D intensive firms may have rapidly changing production

technologies that require specific practices for managing their workforces. Capital-intensive firms may adopt systems appropriate for more skilled employees.

Before the equation (8) multinomial model of Section I is estimated to test the effects of these variables on HRM system choice, the mean values of these eight potential HRM system determinants by system cluster provide an instructive summary of the data. These statistics in Table 2 demonstrate that not only do these businesses have distinctive sets of personnel policies by design of the clustering algorithm, but different HRM systems also occur in distinctive business environments.

As expected, system 1 is clearly the system of choice for unionized workforces. However, the system 1 businesses are also the most capital-intensive with the lowest level of R&D activity. They are also old businesses and are the only group of businesses in Table 2 that are, on average, in industries with declining employment.

Interestingly, the union-like system 3 covers only nonunion employees. These businesses are on average even older than the union businesses in system 1, thus supporting the argument that the prototypical "union" workplace system covers nonunion employees in old establishments (Kochan et al., 1986, 94). However, this particular variant of the "union-style" system which covers nonunion workers in older establishments does not provide employees with access to a formal grievance procedure. These system 3 businesses are also considerably smaller on average than the system 1 union businesses. Despite the age of the establishments in system 3 businesses, the industry growth

TABLE 2

Means of Business Line Characteristics by HRM System Cluster
(standard deviations in parentheses)

Cluster Number (observations)	1 (24)	2 (11)	3 (15)	4 (11)	5 (12)	6 (37)	7 (17)	8 (30)	9 (19)
Descriptive Name	Tradit. Union	Union-Like but no Senior.	Union-Like but no Grvarb	Do-Nothing Find a-Body	Do-Nothing Keep-a-Body	COM	COM + FLEX	COM + TRAIN	COM + TRAIN FLEX hicomit
1. EMPTOT	17192 (31887)	4050* (7066)	4914 (8707)	499*** (709)	744*** (645)	3740** (7206)	21246 (37253)	14110 (45154)	8907 (14527)
2. AGE	17.3* (5.1)	15.6 (5.5)	16.1* (5.8)	13.8 (11.5)	13.7 (5.9)	16.1 (7.2)	14.8 (6.7)	13.9* (4.5)	13.4* (4.1)
3. RDSALE	.0049*** (.0134)	.0086** (.0178)	.0163 (.0388)	.2721 (.6684)	.0337 (.0447)	.0384 (.0500)	.0450 (.0897)	.0324 (.0448)	.0296 (.0537)
4. MGRADE	13.58 (0.88)	13.54 (0.82)	13.95 (0.91)	14.14** (0.61)	13.27 (0.89)	13.52 (0.75)	13.87 (0.60)	13.63 (0.74)	13.77 (0.78)
5. K/L	.390 (1.412)	.059* (.062)	.100* (.055)	.173 (.107)	.100 (.074)	.139 (.342)	.153 (.212)	.350 (1.261)	.110 (.147)
6. %UNION	.436*** (.204)	.243 (.239)	.114 (.200)	.055*** (.096)	.136 (.247)	.133 (.221)	.217 (.284)	.153 (.206)	.062*** (.099)
7. UNION	.958*** (.204)	.636*** (.504)	0.0*** (0.0)	0.0*** (0.0)	.083 (.289)	.027*** (.164)	0.0*** (0.0)	.033*** (.183)	0.0*** (0.0)
8. GRWRAT(%)	-0.02*** (30.67)	13.3 (33.2)	22.0 (71.6)	30.3 (40.1)	8.9 (40.1)	26.0 (42.6)	29.7 (43.9)	24.9 (40.8)	23.9 (37.1)

*** -- Cluster mean is significantly different from mean of the pooled set of observations from the other eight clusters at the .01 level in a two-tailed t-test.

** -- Cluster mean is significantly different from mean of the pooled set of observations from the other eight clusters at the .05 level in a two-tailed t-test.

* -- Cluster mean is significantly different from mean of the pooled set of observations from the other eight clusters at the .10 level in a two-tailed t-test.

rates of system 3 businesses are on average considerably higher than the average growth rate of the system 1 union businesses.

The HRM systems with flexible job design or training, systems 7, 8, and 9, are not just nonunion businesses. They are also large nonunion businesses, possibly indicating some economies of scale in adopting systems with either flexible job design or training policies. However, many nonunion businesses employ very different HRM systems that in no way resemble the more "progressive", "high commitment" HRM systems in very large nonunion firms.

The most dramatic evidence of such alternative systems among new nonunion businesses comes from the system 4 cluster -- labeled the "Do Nothing, Find-A-Body" system. Businesses with system 4 are not part of some secondary labor market. Rather, they are young, high growth, small, nonunion, R&D- and capital-intensive businesses.

The only HRM system without any communication mechanisms besides system 4 is system 5. On average, this system is comprised of small firms. They have the lowest average education levels among their industries' workforces, although the average value of the MGRADE variable for the system 5 businesses is significantly different form the average value of MGRADE across all other observations at only the .12-level. Presumably the value of communications mechanisms to these businesses is low because their workforces have low levels of education.

Table 2 demonstrates distinctive environments of the different HRM systems. Union businesses are confined largely to systems 1 and 2 which are similar in most respects. However, the

systems employed by nonunion businesses are very diverse. HRM systems for nonunion production workers include a variant of the union system (i.e., system 3); the "high commitment" system with flexible job design, merit-based promotions, formal training and communications (i.e., system 9); and systems with merit-based promotions but no other formal personnel policies (i.e., systems 4 and 5). This diversity of HRM systems among nonunion businesses underscores the importance of collecting systematic survey data and the dangers of theoretical generalizations based on selective case studies of individual nonunion businesses.

Table 3 presents estimates from the multinomial model which estimates the independent effects of HRM system determinants on the choice of different systems. The variable UNION which did not vary within some system clusters was dropped from the estimation. Furthermore, the variable GRWRAT was also eliminated from this estimation to facilitate convergence. However, AGE, which is highly correlated with GRWRAT, should capture some of the effects associated with industry growth rates.

The relative magnitudes of the coefficients in Table 3 reflect some of the patterns observed in the means in Table 2. The results suggest that choice of system 1 is more a direct function of unionization than it is of establishment age. Establishment age, however, does significantly favor choice of system 3. Larger businesses tend to select either system 1, the union system, or a system such as number 7, 8 or 9 with several personnel policies. Small establishment size seems to preclude adopting a system that relies on formal policies. Small firms tend to pick systems 4 or 5. Among small firms, R&D intensity

TABLE 3

Multinomial Logit Estimates of Determinants of HRM System "Clusters"

[n = 176; asymptotically normal standard errors in parentheses]

Cluster Number (observations)	1 (24)	2 (11)	3 (15)	4 (11)	5 (12)	6 (37)	7 (17)	8 (30)	9 (19)
Descriptive Name	Tradit. Union	Union-Like but no Senior.	Union-. Like but no Grvarb	Do-Nothing Find-a-Body	Do-Nothing Keep-a-Body	COM	COM + FLEX	COM + TRAIN	COM + TRAIN + FLEX hicomit
1. EMPTOT	.0000004 (.00001)	-.00005 (.00005)	-.00002 (.00003)	-.00077 (.00052)	-.00074* (.00043)	-.00003 (.00002)	.000005 (.00001)	.000003 (.00001)	-0-
2. AGE	.032 (.073)	.006 (.077)	.111* (.063)	.096 (.066)	.029 (.066)	.090* (.053)	.051 (.067)	.008 (.057)	-0-
3. RDSALE	-2.062 (14.533)	-10.327 (16.316)	-2.351 (11.066)	17.789** (7.831)	8.196 (9.290)	12.710* (7.304)	15.980** (7.700)	7.371 (7.683)	-0-
4. MGRADE	.102 (.495)	.142 (.575)	.439 (.517)	.530 (.718)	-1.006* (.570)	-.509 (.419)	.153 (.510)	-.365 (.429)	-0-
5. K/L	2.062 (2.263)	-9.257 (7.184)	-1.440 (3.680)	1.205 (2.741)	-1.433 (4.484)	1.568 (2.280)	1.725 (2.299)	2.003 (2.259)	-0-
6. %UNION	8.707* (2.350)	4.592* (2.377)	2.244 (2.438)	5.347* (3.198)	4.128* (2.475)	3.145 (2.125)	5.985*** (2.303)	3.657* (2.157)	-0-

*** -- Parameter indicates a significantly different probability of variable on selecting the given cluster relative to the probability of selecting the omitted cluster #9 at the .01-level.

** -- Parameter indicates a significantly different probability of variable on selecting the given cluster relative to the probability of selecting the omitted cluster #9 at the .05-level.

* -- Parameter indicates a significantly different probability of variable on selecting the given cluster relative to the probability of selecting the omitted cluster #9 at the .10-level.

favors the system 4 choice, while low levels of education in the industry workforce favor the no communication system 5. All determinants in the model other than the capital-labor ratio have an independent statistically significant effect on the probability of choosing some cluster relative to the omitted system 9 cluster.

The absence of additional significant effects among the potential determinants of personnel system choice in the multinomial logit model may be due to the large number of personnel policy combinations revealed in Table 1. Even for the relatively small set of policies considered in this study, American manufacturing businesses employ many different combinations of these policies. The large number of system choices and the corresponding small cell sizes for the dependent choice variable probably contributes to the lack of more precise estimates in the Table 3 multinomial logit model.

IV. Effects of HRM Systems on Performance

To investigate whether HRM systems affect productivity, the equation (3) labor productivity model and the equation (4) Tobin's q model are estimated first by OLS and then with the instrumental variables method that allows for endogeneity beween the performance measure and HRM system choice. The samples for these estimations differ from the samples used to estimate the determinants of HRM systems. The sample for the analysis of determinants of HRM systems in Tables 2 and 3 contains 176 observations. These 176 observations correspond to less than 176 business lines because "double-breasted" business lines can have

two observations in the Table 2 and 3 analyses. The performance of double-breasted business lines is therefore determined by two HRM systems -- the system for its union production workers and the system for its nonunion workers. Other business lines have performance that is determined by either a union worker system or by a nonunion worker system.

Because the total number of observations of union systems is only about one-fifth of the sample of n=176 observations, and because union employees are almost all covered by either HRM system 1 or HRM system 2, the performance models focus on the effects of HRM systems covering nonunion employees. The sample for the labor productivity equation contains 126 business-line observations.

The sample for the Tobin's q analysis is even smaller. First, q is a company-level measure. For companies with more than one business line, the q measure is matched with the nonunion employee HRM system for the company's primary business line. Observations and information on non-primary business lines are not used in the q models. Missing data on the q measure for companies with personnel policy data reduce the sample for the q equation further. The q model is estimated for a sample of 65 company-level observations.

OLS Estimates of Performance Effects of HRM Systems

Column (1) of Table 4 presents OLS results for the equation (3) labor productivity model. There is a clear pattern in the column (1) specification. Relative to the omitted group, the "high commitment" HRM system 9, the point estimates of all coef-

TABLE 4
The Effects of Nonunion HRM Systems on Performance Measures
(standard errors in parentheses)

	OLS Results		IV Results	
	(1)	(2)	(3)	(4)
Dependent Variable	ln(Q/L)	ln(q)	ln(Q/L)	ln(q)
Sample Size	n=126	n=65	n=126	n=65
1. Ln(Capital)	.848***	---	.925***	---
	(.038)		(.201)	
2. Ln(Employment)	-.852***	---	-1.001***	---
	(.039)		(.212)	
3. Ratio of Materials Cost to Value of Shipments in Industry	.699**	---	.945	---
	(.256)		(1.300)	
4. %UNION	.304	.358	.875	-2.261
	(.256)	(1.400)	(2.047)	(2.725)
5. C4 -- Four-Firm Concentration Ratio	---	.023**	---	.024
		(.009)		(.066)
6. C4 * %Union	---	-.042	---	.056
		(.040)		(1.264)
7. HRM Systems[a]				
(a) #1 -- Traditional Union	.654	---	2.917	---
	(.456)		(11.745)	
(b) #2 -- Union-Like No Senior.	-.457*	-1.258*	-1.692	-10.322
	(.252)	(.752)	(8.895)	(36.189)
(c) #3 -- Union-Like No Grvarb	-.079	-.621*	-1.209	-3.756
	(.169)	(.370)	(5.827)	(15.331)
(d) #4 -- Do Nothing Find-A-Body	-.564***	.089	-3.832	.300
	(.201)	(.413)	(3.684)	(7.727)
(e) #5 -- Do Nothing Keep-A-Body	-.097	-.409	-.849	-3.577
	(.186)	(.420)	(4.557)	(25.764)
(f) #6 -- COM only	-.080	-.373	-1.476	-2.029
	(.143)	(.323)	(4.881)	(10.233)
(g) #7 -- COM & FLEXJOB	-.293*	-.738*	-1.032	-4.325
	(.169)	(.390)	(5.107)	(32.325)
(h) #8 -- COM & TRAIN	-.109	-.524	-1.746	-1.211
	(.151)	(.325)	(5.479)	(6.988)
R-Squared	.852	.254	.577	.062

*** - indicates significance at the .01-level, two-tailed test.
** - indicates significance at the .05-level, two-tailed test.
* - indicates significance at the .10-level, two-tailed test.
[a] - Effects of HRM Systems measured relative to HRM System 9 which inlcudes FLEXJOB, MERIT, TRAIN, and COM.

ficients for the other eight systems are negative except for the point estimate of the system 1 effect which is based on only one observation. Furthermore, the negative coefficients on the dummy variables for systems 2, 4 and 7 are each individually significant at the .10-level.[14]

Column (2) presents the OLS results for the equation (4) q model. The relative performance effects of the HRM systems in the q model are very similar to those in the column (1) productivity model. In particular, the OLS results from the q model reenforce the finding in the productivity equation that companies that adopt the union-like system without seniority, i.e. system 2, or the system with flexible job design but without any employee training, i.e. system 7, experience poorer economic performance than businesses with the high commitment system 9. In addition, all point estimates in the set of HRM system coefficients are negative with only one exception.

There are differences in the significance of two individual coefficients between the the column (2) q equation and the column (1) productivity equation. The system 3 effect is significantly negative in the q model, whereas the system 3 effect in the column (1) labor productivity equation was negative but insignificant. System 4, which had a significant negative effect in the column (1) productivity equation, no longer has a negative significant effect when q is the measure of performance. This difference in the effects of the "Do Nothing, Find-a-Body" system 4 across the labor productivity and q models is perhaps not surprising. These businesses are young, small, growing, R&D intensive firms according to the results in Tables 2 and 3. These

firms may have high market values if their R&D projects are valued by the market, even though they currently have relatively low levels of sales and sales-per-employee.

The OLS results help explain prescriptions for firms to adopt a "high commitment" HRM system with flexible job design, employee training, extensive communication systems, and merit-based reward structures. Businesses with the highest levels of performance have this system. There is also a suggestion that businesses need to adopt all of the policies in this system to enjoy its peformance advantages. In particular, system 7 businesses employ many features of the "high commitment" HRM system 9, but these businesses exhibit significantly lower levels of labor productivity and significantly lower market values than system 9 businesses.

These results also help explain the prescriptions for non-union firms to avoid union-like systems. One of the union-like systems (i.e., system 2) has significantly lower levels of productivity than system 9 businesses. Furthermore, the two union-like systems followed by some nonunion businesses (i.e., systems 2 and 3) are both associated with significantly lower market values.

IV Estimates of Performance Effects of HRM Systems

These results indicate systematic differences in economic performance across firms with different HRM systems. If these results are accurate estimates of the effects of these systems, they imply that many businesses would experience a significant increase in performance if they adopted system 9 and virtually no

business would be expected to experience a reduction in performance. The discussion in Section I suggests that firms may consistently operate without their optimal HRM systems because of limitations on management's ability to process and evaluate information on personnel practices and performance. Furthermore, the costs and uncertainty of making a transition from one HRM system to another system, such as system 9, may discourage managers from experimenting with a new system.

However, the Section I model also indicates that the results in the column 1 and 2 specifications may be misleading estimates of the performance effects of these systems. Specifically, the estimates from the OLS equations will be inconsistent if HRM system choice and performance are jointly endogenous. While cross-section data are far from ideal for testing for such selectivity, the labor productivity and q models are reestimated using the IV method for adjusting for this bias. Results of the IV estimations are presented in column (3) and (4).

The coefficients of the instrumented HRM system variables in column (3) and (4) consistently have the same signs as the estimated coefficients in the corresponding column (1) and (2) OLS specifications. However, the absolute value of all point estimates of the parameters in both the column (3) and (4) models are much larger than the corresponding column (1) and (2) point estimates, implying implausibly large performance differences across HRM systems. The estimated coefficients in the column (3) and (4) IV specifications are exceedingly imprecise. These results indicate that the direction of causation between HRM system choice and performance cannot be determined from these

data.[15]

These imprecise, generally unrevealing estimates are perhaps not surprising given the data limitations.[16] In particular, the IV method involves a system of eight equations for the HRM system variables and one performance equation. While the system is identified by the eight predicted HRM system probabilities, these probabilities are simply nonlinear transformations of the six variables that determine HRM system probabilities in the equation (4) multinomial logit model. In addition, the %UNION variable which is considered as a possible determinant of HRM system choice is also a determinant of the performance measures. Therefore, the identification of the system depends on the difference in functional forms between the estimated equation for HRM system choice and the estimated performance equations. In the absence of any evidence which justifies the logit as the appropriate specification of HRM system choice and without identification based on differences in the underlying determinants of the performance measures and HRM systems, the selectivity correction procedures that are possible with these data are unrevealing.

On the one hand, these IV results indicate that the data cannot support the conclusion that businesses will experience a significant improvement in labor productivity or stock market value after the implementation of an HRM system like system 9. On the other hand, the statistically different levels of performance associated with different HRM systems observed in the OLS models are important. As long as these relationships are not spurious, this empirical pattern implies that more businesses will probably have workplace systems like HRM system 9 in the future -- either

because this system stimulates economic performance or because it is the appropriate system for better performing businesses.

V. Conclusion

This paper uses new data on businesses' personnel policies to examine the relationship between sets of personnel policies and the performance of U.S. manufacturing businesses. This study's empirical analysis suggests three broad conclusions.

First, there simply is no "prototypical" U.S. style of human resource management. A large number of personnel policy combinations exist in U.S. businesses. However, significant correlations among certain personnel policies do exist so that some HRM systems are more common than others. This study's taxonomy of HRM systems provides a richer and more accurate description of these business policies than currently exists.

Second, certain characteristics of a business, including union status, size, and age, favor the choice of specific HRM systems. In particular, the HRM system with grievance procedures, seniority systems, and no flexible job design appears to be a thing of the past. It is confined to large unionized businesses in declining industries and very old nonunion businesses. Systems with some combination of flexible job design, merit-based promotions, and training are nonunion HRM systems. These "progressive" HRM systems are generally observed in larger nonunion businesses. Other personnel policy combinations are also observed among nonunion manufacturing businesses. For example, small, growing, high-technology firms have systems with few formal personnel policies.

Finally, HRM systems are related to business performance. OLS results help explain commonly heard prescriptions for firms to adopt HRM systems with flexible job design, formal employee training, merit-based promotions, and formal employee-management communication mechanisms and to avoid union-like HRM systems. The former system is associated with the highest levels of labor productivity and stock market value, while some union-like HRM systems among nonunion production workers are associated with relatively low levels of performance. Statistical models, however, cannot determine whether the more "progressive" HRM system stimulates economic performance or whether this system is the appropriate choice for better performing businesses. In either case, the positive relationship between performance and the progressive HRM system suggests that these employee-oriented HRM systems will be the workplace policies of the future.

Footnotes

1. COMPUSTAT II defines "net sales" as gross sales "reduced by cash discounts, trade discounts, returns of sales, and allowances for which credit is given to the customer". It defines "identifiable assets" as "tangible and intangible assets that are used by or directly associable with each industry segment". These are accounting statistics that business lines report in accordance with FASB principles.

2. All statistics on four-digit manufacturing sector industries from the Census of Manufactures used in this study are taken from a longitudinal data tape on manufacturing industry characteristics collected by the National Bureau of Economic Research. The author thanks Wayne Gray for supplying these data.

3. V and A are both reported in the National Bureau of Economic Research's "R&D Master File". The precise definition of V and A as well as all details of their construction are described in Hall, Cummins, Lademan, and Mundy (1988).

4. In the typical case of probabilistic discrete choice by individuals, the error term in the objective function can be ascribed to psychological factors that cause differences in individual preferences. For the case of firms, the error terms μ_{pi} in equation (1) can be the result of computational limits on the part of managerial decision makers sometimes refered to as "bounded rationality" (Simon, 1957), or to pursuit of personal objectives by managers sometimes refered to as "subgoal pursuit" (Cyert and March, 1963). Williamson (1981) argues that these behavioral assumptions that can give rise to a random component in the determination of profitability are in fact important reasons for the existence of the corporate form.

5. Dubin and McFadden (1984) and Dubin (1985) also develop two other methods for obtaining consistent estimates of the parameters in the equation (3) or (4) models when selectivity bias is present. In one method, the set of "reduced form" probabilities predicted by the multinomial logit equation replace the set of HRM dummy variables in the performance equation. Following Amemiya (1978) and Heckman (1976), the third alternative procedure uses the predicted probabilities of the choice of different HRM systems to construct a set of correction factors that augment the performance equation and adjust for the fact that the error in the performance equation conditional on a given HRM system choice is nonzero. These correction factors are of the form $[(P_j \ln P_j / 1-P_j) + \ln P_j]$ (Dubin and McFadden, 1984, 356). P_j is the predicted probability that a business has the j-th HRM system that is obtained by evaluating the multimnomial logit model, and P_i is the predicted probability for the omitted HRM system.

6. Of course, the 495 observations are not a random sample of all U.S. companies' business lines. No such business-level data set exists. It is the broadest existing data set ever with both performance measures and personnel practice data, representing approximately 10% of the full 1986 sample of COMPUSTAT II businesses. While the 495 responses closely match the industrial distribution of all 1986 Compustat II business lines (see

Delaney, Lewin, and Ichniowski, 1989), the results of this study are subject to the criticism that relationships between personnel policies and performance measures will not necessarily reflect the relationships that exist among all COMPUSTAT II business lines. Without data on the personnel policies for the COMPUSTAT II businesses that are outside the Columbia sample, there is no convincing way to explore this potential source of bias. For a more detailed description of the Columbia survey and the responding sample, see Delaney, Lewin, and Ichniowski (1989).

7. The Compustat II survey refers to business lines as a company's "industry segment". The formal definition of an "industry segment" is the one used in accounting principle FASB-SFAS no. 14: "Any component of an enterprise engaged in providing a product or service, or a group of related products or services primarily to unaffiliated customers (i.e., customers outside the enterprise) for a profit."

8. The survey provides information on personnel policies for each of seven employee groups: managers, union and nonunion professional and technical employees, union and nonunion clerical employees, and union and nonunion production workers. However, the market value data are confined to manufacturing companies. Limiting the analysis to manufacturing businesses should also reduce the problems of comparing simple productivity metrics across businesses in different sectors of the economy. Personnel policies for production workers should be particularly important for manufacturing businesses. In the subsample of this study's business-line observations that report employment by occupation, production workers are the dominant occupational group in manufacturing businesses.

9. In addition to the personnel policies described in Section II that were used to identify HRM systems, one other variable measuring recruiting intensity, interviews per hire, was also considered in preliminary analyses. However, including this variable in the clustering algorithm that identified personnel policy combinations produced a relatively large number of clusters with few observations per cluster. Once the parameter k in the clustering procedure was increased beyond even relatively small values, the number of observations that were left unassigned to a cluster was large. This measure of recruiting intensity was not strongly correlated with many other personnel policies. Therefore, for any given combination of other personnel policies, there is likely to be a "high recruiting intensity" and a "low recruiting intensity" variant for the given combination of other policies. To keep the number of policy combinations small, this measure was dropped from the analysis.

10. Correlations among the dummy variables for the presence of an attitude survey, complaint procedure, and information sharing policy are all positive and significant. This evidence that some businesses are "high communication" businesses while others are "low communication" businesses is the motivation for the use of a single dummy variable COM in the analysis that identifies different HRM systems.

11. More specifically, positive correlations significant at better than the .05-level exist between: FLEXJOB and TRAIN, FLEXJOB and COM, %INTPR and TRAIN, %INTPR and COM, %INTPR and GRVARB, and TRAIN and COM. Significant negative correlations

exist between: MERIT and %INTPR, and MERIT and GRVARB.

12. Several other personnel policy variables that were not included in the analysis further indicate strong relationships among personnel policies. Such variables were excluded from the identification of HRM systems below because other variables in Table 1 provide much of the information of these personnel policies. For example, FLEXJOB almost always implies formal job analysis. FLEXJOB and a dummy for the presence of formal job analysis have a correlation of .218 that is significant at the .001-level. 63 of 83 observations with FLEXJOB conduct formal job analysis. MERIT almost always implies the existence of a performance appraisal system. MERIT and a performance appraisal dummy have a correlation of .345 that is significant at the .001-level. 142 of the 190 observations with MERIT=1 conduct formal performance appraisals.

13. The data sources for the potential determinants of HRM systems are: EMPTOT -- the personnel practice survey; AGE -- personnel practice survey questions on percentage distribution of the business' establishments in different age categories; R&D expenditures and sales -- COMPUSTAT II data tape; MGRADE -- calculated from the May 1985 CPS data tape; K/L -- ratio of the identifiable assets variable in COMPUSTAT II and EMPTOT; %UNION -- ratio of total number of unionized employees from the personnel practice survey and EMPTOT; GRWRAT -- ratio of the 1984 and 1977 employment levels for the business's four-digit industry from the NBER Census of Manufactures data tape of industry characteristics described in note 2.

14. When the productivity equation is respecified to be translogarithmic in the labor and capital inputs, OLS coefficients and standard errors for the HRM dummy variables are very similar to the estimates in Table 4, column (1), lines 7(a)-7(h). However, in the translog specification, the effects of the HRM systems do not correspond simply to differences in the efficiency of the labor input as developed in the Section I model. Similarly, the inclusion of a dummy variable for nondurable manufacturing businesses has virtually no effect on the magnitude or significance of the estimated coefficients in either columns (1) or (2) of Table 4.

15. This conclusion is reenforced by the wide range of estimates obtained using the alternative methods to correct for selectivity bias described in footnote 5. For example, in the "reduced form" method, point estimates of the labor productivity effects of HRM dummy variables relative to the omitted HRM system 9 are consistently positive. The point estimates from the "conditional expectation correction" procedure fall between the large, but imprecise, negative estimates from the IV method and the positive point estimates from the "reduced form" method. Taken as a whole, the three procedures generate an exceedingly wide range of estimates of the productivity effects of HRM systems. Clearly, the direction of causation between HRM systems and labor productivity in these data cannot be determined by these methods. All three selectivity correction procedures were also implemented for the translog specification of the production function described in footnote 14 above. Parameter estimates for the HRM system variables in the translog specification were very similar for all three procedures to the estimates obtained from the corresponding

Cobb-Douglas labor productivity models.

16. In the same vein, Freeman and Medoff (1981) review studies which estimate OLS and selectivity adjusted models of union wage effects. They conclude that the results of selectivity adjusted models vary widely and are very sensitive to model specification.

References

Amemiya, Takeshi (1978) "The Estimation of a Simultaneous Equations Generalized Probit Model" Econometrica, vol. 46, pp. 1193-1205.

Brown, Charles, and James Medoff (1978) "Trade Unions in the Production Process" Journal of Political Economy, vol. 86, no. 3, pp. 355-378.

Cyert, Richard M. and James G. March (1963) A Behavioral Theory of the Firm (Englewood Cliffs, NJ: Prentice-Hall).

Delaney, John T., David Lewin, and Casey Ichniowski (1989) "Human Resource Policies and Practices in American Firms" Report submitted to the Bureau of Labor-Management Relations and Cooperative Programs, U.S. Department of Labor.

Dubin, Jeffrey A. (1985) Consumer Durable Choice and the Demand for Electricity (New York: North Holland).

_____ and Daniel L. McFadden (1984) "An Econometric Analysis of Residential Electric Appliance Holdings and Consumption" Econometrica, vol. 52, no. 2, pp. 1219-1240.

Freeman, Richard B., and James L. Medoff (1981) "The Impact of Collective Bargaining: Illusion or Reality," in J. Steiber, R. B. McKersie and D. Q. Mills, U. S. Industrial Relations 1950-1980: A Critical Assessment (Madison, Wisc.: IRRA), pp. 47-97.

Freeman, Richard B., and James L. Medoff (1984) What Do Unions Do? (New York: Basic Books).

Griliches, Zvi (1981) "Market Value, R&D, and Patents" Economic Letters, vol. 7, pp. 183-187.

Hackman, Richard and Greg Oldham (1980) Work Redesign (Reading, MA: Addison-Wesley).

Hall, Bronwyn H., Clint Cummins, Elizabeth Laderman, and Joy Mundy (1988) "The R&D Master File Documentation" National Bureau of Economic Research technical working paper no. 72, (Cambridge, MA).

Heckman, James J. (1976) "The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models" Annals of Economic and Social Measurement, vol. 5, pp. 475-492.

Herzberg, Frederick (1966) Work and the Nature of Man (Cleveland: World Press).

Jaffe, Adam B. (1986) "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value" American Economic Review, vol. 76, no. 5, pp. 984-1001.

Jovanovic, Boyan "Job Matching and the Theory of Turnover" Journal of Political Economy, vol. 87, pp. 972-990.

Maslow, Abraham H. (1954) Motivation and Personality (New York: Harper and Row).

McFadden, Daniel (1973) "Conditional Logit Analysis of Qualitative Choice Behavior" in P. Zarembka ed., Frontiers in Econometrics (New York: Academic Press), pp.105-142.

_____ (1974) "The Measurement of Urban Travel Demand" Journal of Public Economics, vol. 3, pp. 303-328.

Salinger, Michael A. (1984) "Tobin's q, Unionization, and the Concentration-Profits Relationship" The Rand Journal of Economics, vol. 15, no. 2, pp. 159-170.

Simon, Herbert A. (1957) Models of Man (New York: John Wiley and Sons).

Slichter, Sumner H., James J. Healy, and E. Robert Livernash (1960) The Impact of Collective Bargaining on Management (Washington, D.C.: The Brookings Institution).

Sneath, P.H.A. (1957) "The Application of Computers to Taxonomy" Journal of General Microbiology, vol. 17, pp. 201-226.

Topel, Robert (1986) "Job Mobility, Search, and Earnings Growth" Research in Labor Economics, vol. 8, pp. 199-233.

Vroom, Victor, and Edward Deci (1970) Management and Motivation (Baltimore: Penguin Books).

Williamson, Oliver E. (1981) "The Modern Corporation: Origins, Evolution, Attributes" Journal of Economic Literature, vol. 19, no. 4, pp. 1537-1568.

_____. (1985) The Economic Institutions of Capitalism (New York: Macmillan, Inc.).

Wong, M.A. and Thomas Lane (1983) "A K-th Nearest Neighbor Clustering Procedure" Journal of the Royal Statistical Society, Series B, vol. 45, pp. 362-368.

Appendix

The construction of a typology of businesses' according to their personnel policies is treated in Section II as a problem of uncovering an unknown number of "clusters" of unknown shapes in six-dimensional personnel policy space. Wong and Lane's k-th nearest neighbor clustering procedure (1983), unlike many other procedures, successfully retrieves known clusters with many different shapes in simulations. The k-th nearest neighbor procedure used to identify clusters in Section I consists of five steps.

1. Pick the parameter k -- the minimum number of observations per cluster.
2. Calculate the k-th nearest neighbor density, d_k, for each observation x_i as $1/[k/(NV_k(x_i)]$, where N is the number of sample observations and V_k is the volume of the sphere centered at x_i that contains at least k observations. The denominator of the expression for d_k therefore is an estimate of the probability density at point x_i for the underlying probability distribution that generated the observations.
3. For any pair of observations, x_i and x_j, observations are identified as "neighbors" if the euclidean distance between them, $d^e(x_i,x_j)$, is less than either $d_k(x_i)$ or $d_k(x_j)$.
4. Distances between observations, $D(x_i,x_j)$, are defined. For nonneighbors, it is infinite. For neighbors, $D(x_i,x_j)=(N/2k)(V_k(x_i)+V_k(x_j))$, so that the distance between neigbors is inversely proportional to a pooled density estimate at a point halfway between them.
5. Sneath's single-linkage clustering algorithm (1957) is then applied to the distance matrix created in step 4.

In the course of the step 5 single-linkage clustering, high-density or "modal" clusters are identified as those clusters with densities exceeding a threshold density f_t, where f_t is an increasing function of k. For the 255 business-line observations clustered in Section I, the number of modal clusters as a func-

tion of k are: 42 for k=3; 29 for k=4; 23 for k=5; 20 for k=6; 17 for k=7; 15 for k=8; 13 for k=9; 10 for k=10; 9 for k=11; 6 for k=12; 5 for k=13 through 22; 4 for k=23 and 24; and 3 for k>25. Wong and Lane (1983) suggest that the problem of picking the "actual" number of clusters be decided by looking for a stable number of modal clusters over long ranges of k. This will ensure that the density of these modal clusters is much greater than the next most dense cluster. For example, in the sample of 255 business line observations, the sixth cluster identified when k=12 should be considerably less dense than are the five modal clusters that are identified as k increases from 13 to 22, because five modal clusters continue to be indentified as the threshold cluster density f_t continues to increase over long ranges of k.

The analysis in Section I focuses on a slightly larger number of clusters (i.e., nine modal clusters for k=11) because several of the "lower density clusters" that are lost once k increases to 12 were distinctive and could potentially characterize businesses in distinct environments. These clusters include the 11 observation "union-like" system without seniority-based promotion system (cluster #2 in Table 1) and the 11 observation system without formal personnel policies with vacancies filled almost exclusively from external sources (cluster #4 in Table 1). Much larger numbers of clusters for lower values of k proved intractable in the multimomial logit analyses to predict determinants of personnel system clusters. Table 1 therefore presents the average personnel policy characteristics of the observations in the nine clusters obtained from the k-th nearest neighbor procedure when k=11.