Methodological Issues in Cross-Sectional and Panel Estimates of the Human Resource-Firm Performance Link

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Because companies differ in factors such as management ability that may lead to both high performance work systems and enhanced firm performance, conventional estimates of the effects of human resource (HR) management practices on firm performance may be biased upward. Alternatively, if HR management practices are measured with error, estimates of their effects on firm performance may be biased downward. We find that although longitudinal estimates that avoid the first source of bias are substantially smaller than cross-sectional estimates, the former are strongly influenced by errors in measuring HR management practices. Based on independent estimates of the measurement error, we calculate a range of estimates that correct for both biases. We estimate that a one standard deviation increase in our measure of high performance work systems raises the market value of the corporation by approximately $15,000 per employee.

THIS STUDY INVESTIGATES SEVERAL METHODOLOGICAL CHALLENGES inherent in survey-based analyses of the impact of high performance

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work systems on firm performance.[1] Drawing on a national panel survey of organizational human resource (HR) management systems, we compare the estimated relationship between HR strategy and firm performance in both cross-sectional and longitudinal data sets. Prior research relying on multifirm data sets has typically relied on cross-sectional estimates that are potentially subject to problems of unobserved firm-level characteristics, such as the quality of marketing or manufacturing strategies, that might bias the estimated HR strategy-firm performance relationship. Although panel data can mitigate such heterogeneity bias, such data are even more sensitive to the attenuating effects of error in the measurement of HR management practices. Thus, the principal focus of this article is to provide direct estimates of the likely magnitude of both heterogeneity bias and measurement error in cross-sectional estimates of the HR strategy-firm performance relationship.

The potential strategic impact of high performance work systems is consistent with a new focus in the literature on *behavioral* strategies that rely on core competencies and capabilities as sources of competitive advantage, not only because they provide the most effective response to market demands, but also because they are not easily copied by competitors (Prahalad and Hamel, 1990; Stalk, Evans, and Shulman, 1992). A key element in the implementation of such strategies is the extent to which a firm's HR strategy, as reflected in the adoption of a high performance work system, supports these larger strategic objectives (Huselid, 1995). As a result, the potential economic significance of a firm's HR management practices has increased substantially in this new role. In fact, the central thesis of this article is that a firm's HR strategy has a *strategic* impact that is reflected in organizational performance.

Our measure of HR strategy is based on work by Delaney, Lewin, and Ichniowski (1989) and Huselid (1995). In both cases, the measure of HR strategy focused on the adoption of progressive or high performance work practices. Although the literature emphasizing the importance of fit between HR and corporate strategies (Baird and Meshoulam, 1988; Milgrom and Roberts, 1995) might suggest that there is no true continuum of "best practices" in this area, given that the choice of HR strategy would be contingent on the larger corporate strategy, Delaney, Lewin, and Ichniowski (1989), Delaney (in press), Ichniowski (1990), MacDuffie (1995), and Pfef-

[1] By using the term "high performance work systems," we are referring to the full range of HR management practices that enhance both employee and firm performance (Huselid, 1995). Consistent with the focus of the articles in this special issue, high performance work practices include, but are not limited to, policies that facilitate employee involvement.

fer (1994) have focused more attention on a "best practice" approach. Our feeling is that such a distinction is largely overdrawn, given that one of the common themes in these "best practices" is the importance of a skilled, flexible, and motivated workforce, and it is precisely this type of workforce that will enable a firm to "fit" its HR strategy to changing firm strategies in an effective and timely fashion (Huselid, 1995; Huselid and Becker, 1995). Although our approach is more consistent with the "core" or "best practices" hypothesis, this study does not directly test these two competing conceptual frameworks.

Our results indicate that both heterogeneity bias and measurement error may have strong, but largely offsetting, effects on cross-sectional estimates of the HR management system-firm performance relationship. The net effects, based on a very conservative estimation procedure, suggest that a one standard deviation "improvement" in a firm's HR strategy is associated with a present value gain in cash flow and firm market value of $15,000–$17,000 per employee. Finally, we provide an indirect test of the potential for an implementation-to-benefit lag in the returns for investments in such systems, and find results consistent with the expectation that high performance work systems begin to provide returns that are reflected in firm profitability and market value one to two years after implementation.

Estimation Problems

The three prior studies (Huselid, 1995; Huselid and Becker, 1995; Ichniowski, 1990) that have examined both a broad measure of HR strategy *and* corporate financial performance have relied on cross-sectional data, as we believe will much of the future work in this area. One objective of this article is to provide a validity check on such an approach by specifically attempting to measure the magnitude of two potential biases, heterogeneity bias and measurement error, in these estimates. Consider the two-variable case based on pooled cross-sectional data (Hsiao, 1988) where β_{ols} is the estimated effect of x_{it} (HR strategy) on firm performance in the following single-equation model:

$$\text{firm performance}_{it} = \beta_{ols} x_{it} + u_{it}, \tag{1}$$

for i cross-sectional units overt time periods, where $u_{it} = \alpha_i + e_{it}$. While e_{it} is the conventional random error term, α_i is an unmeasured firm-specific constant that varies across the firms. In addition, rather than being an entirely accurate measure of HR strategy (x_{it}^*), x_{it} is subject to random measurement error such that,

$$x_{it} = x_{it}^{*} + v_{it}. \qquad (2)$$

Therefore, ordinary least squares (OLS) cross-sectional models are subject to two types of bias, where

$$plim\ \hat{\beta}_{ols} = \beta + \frac{Cov(X_{it}, \alpha_i)}{\sigma_x^2 + \sigma_v^2} - \frac{\beta\sigma_v^2}{\sigma_x^2 + \sigma_v^2}, \qquad (3)$$

and β is the true estimate of the effects of HR strategy. The second term on the right-hand side of the equation represents the correlation between the unmeasured firm effects (α_i) and x_{it}, in this case, HR strategy. The typical concern in this literature is that unmeasured firm effects are *positively* correlated with HR strategy because the adoption of such practices is either contingent on firm success or simply a reflection of firms that are better managed across all functions. The effect of this term is to upwardly bias β_{ols}. A less commonly mentioned, although not implausible, scenario would have the least profitable and most desperate firms turning to these policies as a solution to their predicament. In this case, the effect of the second term is to *downwardly* bias β_{ols}. The third term on the right-hand side reflects the effects of measurement error in x_{it}, which serves to bias the OLS estimates toward zero. The problem is that although panel data offer an opportunity to mitigate the heterogeneity bias in the OLS estimates, this approach may exacerbate the effects of measurement error.

Heterogeneity bias. The heavy reliance on cross-sectional data in this line of research inevitably raises a concern that any HR strategy-firm performance relationship reflects heterogeneity bias rather than substantive effects. This is a particularly important issue when researchers are attempting to isolate the effects of a particular set of organizational practices, as there is considerable evidence in the business press that firm reputations for a wide range of management practices are highly correlated. Whether these intercorrelations are genuine or merely reflect halo error on the part of outside observers is more difficult to determine (Brown and Perry, 1994). Nevertheless, it is certainly plausible that if the adoption of a high performance work system is a sign of good management, then the presence of such practices would not be the only stroke of wisdom. Unfortunately, access to measures of these other management practices is very limited, and therefore difficult to control statistically.

The existence of unmeasured management practices that are both positively correlated with the presence of a high performance work system and firm performance means that cross-sectional estimates of the HR strategy-firm performance relationship would be overstated. However, to the ex-

tent that the simultaneous occurrence of these practices is merely associational rather than causal, panel data offer an opportunity for a cleaner estimate of the true effects of HR strategies.

The "associational" explanation is particularly plausible for the wide range of functional strategies, such as those in marketing and finance, that are likely to be developed independent of an HR strategy. Consider the example of a company that does a lot of things well and has achieved an equilibrium position of excellence, but does not necessarily change all of its management practices at the same time in some overarching strategy. In such companies, we could expect to observe changes in HR strategies over time without corresponding changes in other functional strategies. The positive association of these strategies would then be much stronger across firms at a point in time than within firms across time. When this is the case, the effects of HR strategy on firm performance can be separated from the effects of other functional strategies using panel data. Specifically, we will rely on the familiar fixed effects model with constant slopes and intercepts that vary across firms (Hsiao, 1988). This least squares dummy variable model estimates the effects of HR strategies on firm performance from within firm variation compared to cross-sectional estimates that can reflect both within- and between-firm variation in HR strategies and firm performance.

Measurement error. The benefits of panel data sets come at a price, however. The risk is that panel estimates may be subject to even *greater* attenuation from measurement error than cross-sectional estimates, and that one is actually worse off using the panel estimates (Hsiao, 1988, p. 63). For example, one can eliminate individual effects (α_i) where there are two periods of data, by transforming the data into first differences. In this specification, the probability limit of the first difference estimator β_{fdif} is (Hsiao, 1988, p. 64):

$$plim\ \hat{\beta}_{fdif} = \beta - \frac{\beta\sigma_v^2}{[(1-\rho_x)/(1-\rho_v)]\sigma_x^2 + \sigma_v^2}, \tag{4}$$

where ρ_x and $_v$ are the first-order serial correlations for the independent variable and measurement error, respectively. Compared to the measurement error bias in a single cross-section OLS estimate, all that is required for measurement error to have a relatively greater attenuating effect on the first difference estimator is for the serial correlation of true values of *x* to exceed the serial correlation of the measurement error (e. g., $\rho_x > \rho_v$). Given that we would normally expect v to be nearly random, p, should be very close to zero. Even assuming $\rho_v = .1$ and $\rho_x = .7$, the relative impact of

true variance in our HR systems measure is diminished by two-thirds. In effect, the noise-to-signal ratio may be increased substantially in the panel estimate. Alternatively, ρ_{v} might be expected to increase where the same respondent provided the ratings at two points in time.[2]

Measurement error in the independent variables of interest is ubiquitous in economic and organizational research. Typically, it is either ignored or the researcher is able to make a reasonable assumption that, relative to the total variance of the measure, the impact of measurement error is modest. This would be particularly true in cross-sectional estimates that are otherwise economically and statistically significant. The tendency to ignore the problem is reinforced by the fact that even where measurement error is suspected to be a nontrivial presence, the researcher typically has few solutions available. Econometricians have recently developed methods to indirectly estimate the magnitude of measurement error (e.g., Griliches and Hausman, 1986; Hsiao, 1988; Hsiao and Taylor, 1991) that exploit the variety of data structures and error structures available in a panel data set. Although several of these methods provide estimates of both β and α^{2}_{v}, they require more than the two periods of data available in our sample.

Measures and Methods

Our analyses are designed to assess the validity of previously reported cross-sectional estimates of the HR strategy-firm performance relationship and to focus specifically on the results reported in Huselid (1995). The original cross-sectional analysis from the 1991 survey reported in Huselid (1995) includes 826 observations. Our panel replication has only 218 respondents with complete data in both years (1991 and 1993). As a result, part of any difference in results might be attributable to sample differences, apart from any heterogeneity bias. Therefore we provide four points of comparison:

- 1991 cross-sectional results *(n* = 826)
- 1991 cross-sectional results, panel subsample *(n* = 218)
- 1991-93 panel results *(n* = 218 per year, or *n* = 436)
- 1993 cross-sectional results, panel subsample *(n* = 218).

[2] For 171 of the 218 panel respondents in our data set, the survey was mailed to (and, presumably, usually completed by) the same individual in both periods. The simple correlation of our HR strategy measure at two points in time is .50 for the "same" respondents and .45 for the "different" respondents. Although there are a variety of reasons why these two estimates might differ (most notably, greater changes in the HR management system associated with a change in leadership of this function), the difference is not so large as to suggest that ρ_{v} is overwhelmingly greater for the "same" respondents.

Next we evaluate the extent of bias in the panel results attributable to measurement error in our measure of HR strategy. Drawing on well-developed correction formulas (Griliches and Hausman, 1986; Hsiao, 1988) and estimates of measurement error based on independent psychometric analysis of the HR strategy measures, we derive a range of corrected estimates for both the effects and statistical significance of those corrected coefficients.

The estimation model. There is a well-developed empirical literature focusing on the determinants of firm performance, using both capital market- and accounting-based measures of profitability (Brainard, Shoven, and Weiss, 1980; Hirsch, 1991; Hirschey and Wichern, 1984; Weiss, 1974). We draw on conventional econometric specifications from this literature as the basis for our estimation model. Measures of firm performance typically focus on market-based measures, such as Tobin's *q,* or accounting-based measures like return on equity. The former, which compares the capital market's valuation of the future cash flows associated with a firm's asset base to the replacement cost of those assets, is a forward-looking risk-adjusted measure of a firm's financial performance. Following Hirsch (1991), we specify a model of firm performance by focusing on the firm and industry variables that are likely to contribute to sustained competitive advantage. These include firm investments in physical (plant and equipment), intangible (R & D) and human assets (employment), and recent sales growth.[3]

The focus of this article is not a completely specified model of firm performance. Our goal is to develop a sufficiently specified model such that the estimated effects of HR strategy on firm performance are unbiased. The limited econometric studies that include both broad measures of HR strategy and firm performance for a large sample of firms in part reflect the challenges of data collection in this area of research. Our analyses draw on a unique panel data set on the subject. Although these data are not without their limitations, they provide a unique opportunity to test the validity of prior cross-sectional work by drawing on the methodological advantages of panel data.

[3] Typically, such models might also include firm and industry characteristics such as firm-specific risk, industry unionism, and industry market concentration. These variables were included in Huselid (1995) and had only minor effects on the HR strategy estimates. We have not included them in the panel because they were not available for the latter years at the time of the analysis. However, columns 2 and 3 in Table 4, which report the 1991 cross-sectional results with and without these additional controls, demonstrate that such an omission has no significant effects on the magnitude of our estimates.

Following Huselid (1995), we estimate a model of firm performance such that:

$$Firm\ Performance = f(HR\ Strategy_{iv} Firm\ \ Employment_{iv} Capital\ Intensity_{iv} Unionization_{iv} Sales\ \ Growth_{iv} R\text{-}D\ \ Intensity_{it}), \quad (5)$$

where the observations are described for the *ith* firm in period *t.* The exact definition, source, and descriptive statistics for each variable identified in equation 5 are included in Table 1.

Measures of human resource strategy and firm performance. Our measure of HR strategy is based on survey questionnaire data that focus on organizational HR management practices in 1991 and 1993. The items we adopt are broadly representative of the high performance work practices described in recent work (Levine, 1995; Pfeffer, 1994; U.S. Department of Labor, 1993). Huselid (1995) factor analyzed 13 items in an effort to identify separate dimensions of HR strategies that might be consistent across firms. Using principal components extraction with Varimax rotation, two factors consisting of eight and three items, respectively, were identified. Scales were constructed for each factor by averaging those questions loading unambiguously on each respective factor. All 13 questions and their respective factor loadings are reported in Table 2. The validation of this scale is described in Huselid (1995).

Following Huselid (1995), we refer to these factors as Employee Skills and Organizational Structures and Employee Motivation. An Employee Skills and Organizational Structures strategy focuses on the development of organizational capabilities both through employee skill development and through the provision of organizational structures that allow skilled and motivated employees to contribute directly to the performance of the firm. An Employee Motivation strategy emphasizes the formalization of pay-for-performance links and a merit-based philosophy in the organization. Although Huselid (1995) shows these scales to have acceptable convergent validity, the modest levels of reliability associated with each suggest that the development of improved measures of HR strategy should be a high priority.

Two dependent variables, Tobin's *q* and gross rate of return on assets (GRATE), were constructed to reflect capital market evaluations of firm performance as well as current accounting profits, respectively. Following Hirsch (1991), Tobin's *q is* defined as the natural log of the ratio of a firm's market value to the replacement cost of its tangible assets. In principle, a firm's market value is the sum of the market value of both equity and debt.

TABLE 1

VARIABLE DEFINITIONS, SOURCES, AND DESCRIPTIVE STATISTICS (n = 436)

Variable	Definition and Source	Mean (standard deviation)
Employee Skills and Organizational Structures	Mean of standardized survey items.	0.082 (0.480)
Employee Motivation	Mean of standardized survey items,	– 0.019 (0.731)
Tobin's *q*	Natural log of market value of common and preferred stock for *ith* firm divided by the book value of net property, plant and equipment (see Hirsch, 1991). *Compact Disclosure.*	0.578 (1.047)
Gross Rate of Return on Assets (GRATE)	Cash flow divided by gross capital stock (see Hirsch, 1991). *Compact Disclosure.*	0.078 (0.163)
Total Employment	Log of total employment, Survey item.	11.988 (0.776)
Capital Intensity	Log of property, plant, and equipment divided by total employment. *Compact Disclosure.*	4.132 (1.309)
Union Coverage	Proportion of nonexempt employees belonging to a union. Survey item.	12.970 (25.146)
R & D/Sales	Log of research and development expenditures divided by annual sales. *Compact Disclosure.*	0.020 (0.038)
Growth in Sales	(Sales $_{t-1}$ – Sales $_{t-5}$) /Sales $_{t-5}$. *Compact Disclosure.*	0.592 (1.143)
1991 and 1993 Values for Tobin's *q*, GRATE, and HR Variables (n = 218)		
Employee Skills and Organizational Structures, 1991	Mean of standardized 1991 survey items,	.0557 (.4643)
Employee Motivation, 1991	Mean of standardized 1991 survey items.	– .0476 (.7395)
Employee Skills and Organizational Structures, 1993	Mean of standardized 1993 survey items,	.1087 (.4951)
Employee Motivation, 1993	Mean of standardized 1993 survey items.	.0099 (.7228)
Tobin's *q*, 1991	Natural log of market value of common and preferred stock for *ith* firm divided by the book value of net property, plant, and equipment.	.591 (1.07)
Tobin's *q*, 1993	Natural log of market value of common and preferred stock for *ith* firm divided by the book value of net property, plant, and equipment.	.566 (1.02)
GRATE, 1991	Cash flow divided by gross capital stock.	.0859 (.177)
GRATE, 1993	Cash flow divided by gross capital stock,	.0701 (.147)

TABLE 2[a]

QUESTIONNAIRE ITEMS AND FACTOR STRUCTURE FOR HR STRATEGY MEASURES IN 1991

Questionnaire Item	Factor 1	Factor 2
Employee Skills and Organizational Structures *Alpha* = .67		
What proportion of the workforce are included in a formal information-sharing program (e.g., a newsletter)?	.54	.02
What proportion of the workforce hold jobs that have been included in a formal job analysis?	.53	.18
What proportion of the workforce is regularly administered attitude surveys?	.52	– .07
What proportion of the workforce participate in Quality of Work Life (QWL), Quality Circles (QC), and/or labor management participation programs?	.50	– .04
What proportion of the workforce is *eligible* for company incentive plans, profit-sharing plans, and/or gainsharing plans?	.39	.17
How many hours of training per year are typically received by an experienced employee (i. e., someone employed more than one year) ?	.37	– .07
Employee Motivation *Alpha* = .66		
What proportion of the workforce has their merit increase or other incentive pay determined by a performance appraisal?	.17	.83
What proportion of the workforce receives formal performance appraisals?	.29	.80
What proportion of the workforce is promoted based *primarily* on merit (as opposed to seniority)?	.07	.56
Items Not Loading Unambiguously on Either Factor		
What proportion of non-entry-level jobs have been filled from within in recent (i.e., over the last five) years?	.52	– .36
What proportion of the workforce has access to a formal grievance procedure and/or complaint resolution system?	.36	.13
What proportion of the workforce is administered an aptitude, skill or work-sample test prior to employment?	.32	– .04
For the five positions that your firm hires most frequently, how many qualified applicants do you have per position (on average)?	.15	.27

[a]*n* = 826. Taken from Table 1 in Huselid (1995).

In practice, the market value of debt and replacement value of assets are typically proxied with their book values (Hirsch, 1991). We consider *q* a measurement of management "value added" because it represents the premium the capital market will pay for a given portfolio of assets. If two firms have the same asset base, ceteris paribus, a higher Tobin's *q* would represent higher future income prospects for that particular firm. Clearly, the strategic impact of HR is on the market value of equity rather than on the value of debt, and is therefore the focus of our analyses. Reflecting this focus, Huselid (1995) restricted the numerator in his measure of *q* to the market value of equity as well. We have used both measures in this analysis with equivalent results (see Appendix 1).

GRATE divides *current* cash flows by gross capital stock and is superior to traditional return on assets or equity measures of accounting profits

because it is less subject to influence by depreciation and other noncash transactions (Brainard, Shoven, and Weiss, 1980). We include this measure of accounting profits to be consistent with prior work but consider it of secondary importance. The theoretical rationale for a strategic impact by the HR management system derives from its potential creation of sustained competitive advantage. Although higher accounting profits are consistent with such an effect, we believe the more direct measure is change in the firm's market value of equity.

Sample. The data for this study are taken from a survey questionnaire mailed to 3,477 firms in 1992 and 3,847 firms in 1994. In both surveys respondents were asked to describe organizational practices employed during the preceding calendar year (1991 and 1993, respectively). The initial survey in 1992 was based on a potential population of the nearly 12,000 publicly held firms listed on U.S. stock exchanges available in *Compact Disclosure,* a commercially available database containing annual 10-K reports. This larger set was reduced by excluding firms with less than one hundred employees, foreign controlled firms, holding companies, or publicly held divisions or business units of a larger firm. The result was a sampling frame of 3,477 firms representing a broad cross section of U, S. industries. Following extensive pretesting and pilot mailings, the survey was mailed to an individual whose name, position, and address had been verified by telephone. The result was 968 usable responses, or an overall response rate of 28 percent. In 1994, using an identical sampling methodology and a similar questionnaire, we surveyed 3,847 firms. Seven hundred forty responses were received in the 1994 survey, for an overall response rate of 20 percent. Two hundred ninety-four firms responded to *both* surveys. Missing financial performance data in one or both years, frequently market value, reduced the sample to the 218 firms that are the basis for this study.

One of the principal challenges inherent in this line of research is the problem of low survey response rates. Response rates in the 20–30 percent range raise genuine questions about response bias, particularly in the panel of joint respondents which is less than 10 percent of the population in any one year. Industry distributions of the sampling frame and respondents are similar in both years, with respondents slightly overrepresented in manufacturing. Similarly, a comparison of the panel sample means with the full sample in each respective year for *q,* GRATE, and the two HR measures indicates only two differences that are statistically significant. In 1991, the panel value for GRATE (.085) is higher than the full sample value (.055), and the 1993 panel value for Employee Skills and Organizational Structures (.108) is higher than the full sample value (– .002).

Even a comparison of population and sample means would not directly address the potential level of response or selectivity bias. The concern is not that the mean values of two variables may differ in the sample and population, but that the conditional means (i. e., those corrected for all relevant controls) are different. Our only estimates of response bias on this dimension is an evaluation of the 1991 survey data (Huselid, 1995) using the familiar Heckman (1979) approach, which generates an inverse Mills ratio that is included in subsequent regressions as a control. The estimates for the effects of HR strategy on firm performance were very similar with and without such controls. Later in the article we also replicate the 1991 cross-sectional models from Huselid (1995), based on the 218 panel respondents from 1991. Only the coefficient on Employee Motivation in the *q* model, which falls by nearly 50 percent, is meaningfully different in the two samples. We have spoken with a number of potential respondents throughout the survey process and on occasion discussed the study with members of the HR community. Our impression is that most firms that do not respond have a blanket policy of not responding to *any* surveys and/or have workload demands that preclude participation even when they would like to do so. It is anticipated that such policies will only make survey research on this topic more difficult in the future.

Results and Discussion

Cross-sectional comparisons. Comparing the 1991 and 1993 values for the two dimensions of HR strategy (Table 1) reveals slightly higher values on both measures in 1993, although the differences are not statistically significant. The sample means on the two dependent variables in the panel samples fall slightly over this period, although once again these differences are not statistically significant. The comparative cross-sectional regressions are reported in Table 3. The first column reports the effects of the two dimensions of HR strategy and controls (not shown) on both measures of firm performance in the full cross-sectional sample from the 1991 survey, based on Huselid (1995). Three of the four coefficients indicated positive effects on firm performance that were both economically and statistically significant at conventional levels. The second column replicates the Huselid (1995) model for the 218 respondents in the panel, and provides some sense of the potential response bias in our panel of firms. Only the magnitude of the coefficient on Employee Motivation in the *q* model is different in any meaningful respect, falling by one-half. As noted above, the last two columns report the cross-sectional estimates for the 1991 and 1993 surveys without several of the control variables included in Huselid (1995).

TABLE 3

CROSS-SECTIONAL RESULTS FOR HR STRATEGY FROM 1991 (FULL SAMPLE), 1991 (PANEL SAMPLE), AND 1993 (PANEL SAMPLE) SURVEYS (STANDARD ERRORS IN PARENTHESES)

HR Strategy Variables	1991 Cross-Sectional Sample[a] (n = 826)		1991 Panel Cross-Sectional Sample with *AMJ* Controls (n = 218)		1991 Panel Cross-Sectional Sample (n = 218)		1993 Panel Cross-Sectional Sample (n = 218)	
	q	GRATE	q	GRATE	q	GRATE	q	GRATE
Employee Skills and Organizational Structures	.165*	.043***	.162	.034	.152	.033	.074	.032*
	(.113)	(.016)	(.154)	(.029)	(.144)	(.028)	(.143)	(.023)
Employee Motivation	.277***	– .008	.141	– .003	.142	–.002	.184**	.011
	(.091)	(.013)	(.115)	(.022)	(.147)	(.022)	(.109)	(.018)
Adjusted R^2	.110	.064	.275	–.003	.279	.022	.233	.043
F	6.483***	3.356**	2.92***	.98	3.27***	1.13	2.78***	1.26
Joint F-test that coefficients on Employee Skills and Organizational Structures and Employee Motivation are equal in the q and GRATE models					$F_{1,180}$ = .0023 p = .96	$F_{1.180}$ = .904 p = .34	$F_{1,180}$ = .275 p = .60	$F_{1,180}$ = .400 p = .527
Reanalysis of models in columns 3 and 4 with Employee Skills and Organizational Structures and Employee Motivation summed together					.1479**	.0113	.1398**	.0194**
					(.0842)	(.0162)	(.0700)	(.0113)
Adjusted R^2					.283	.043	.2363	.0475
F					3.38***	1.27	2.86***	1.29

[a] SOURCE: Table 5 (column 9) and Table 6 (column 13) in Huselid (1995).
Unless otherwise noted model also includes all variables in equation 1.
* Significant at p < .10; ** significant at p < .05; *** significant at p < .01

In Huselid (1995), a factor analysis of the characteristics of the firm's HR management system identified two factors, Employee Motivation and Employee Skills and Organizational Structures. However, although various HR management system characteristics in the sample may load on two different dimensions, it does not necessarily follow that these two dimensions will have different effects on firm performance. There is no theoretical reason why a bundle of staffing-related practices should have a different effect than a bundle of practices that influence employee motivation. Therefore, we made no a priori assumptions about the appropriate specification and tested directly whether the HR management system should be specified multidimensionally or unidimensionally. Our results are consistent with a unidimensional approach. A joint F-test of the null hypothesis that the coefficients on the two HR management system dimensions were equal could not be rejected. The results of those tests are reported in Table 3 along with the effects of a unidimensional measure (HRTOTAL) of the HR management system that is the sum of the two dimensions described above. Given these results, we use the HRTOTAL variable as our measure of the HR management system in the remainder of the analyses. Thus, the interpretation is that the effect of a change in the HR system is irrespective of whether it occurs through a unit change in Employee Motivation or Employee Skills and Organizational Structures.

In three of the four cross-sectional models, HR strategy had an economically and statistically significant effect on our measures of firm performance. The *q* results indicate that firms with high performance work systems have higher ratios of market value to book value. Given that *q* is measured in natural logarithms, the effects in Table 3 suggest that increasing a firm's usage of high performance work systems by one standard deviation is associated with an increase in *q* of about 14 percent. For GRATE, the same change in high performance work systems resulted in a 13–28 percent increase in this ratio for the average firm.[4]

Panel results. The results of the OLS-pooled cross-sectional, fixed and random effects models are reported in Table 4. HRTOTAL had an economically and statistically significant effect on both dependent variables in the OLS-pooled cross-sectional model (column 1). However, the fixed effects results (column 2) are statistically insignificant, and are only 25–30 percent as large as the OLS estimates. For both models of firm performance, the Lagrange multiplier test rejects the OLS results in favor of the

[4]The sample means for GRATE were .085 and .07 in 1991 and 1993, respectively. The coefficients on HRTOTAL were .011 and .019 in those same years.

fixed effects models. This is equivalent to rejecting the hypothesis that the firm-specific intercepts (α_i in equation 3) are equal across all firms.

We also estimated the HR strategy-firm performance relationship within a random effects model. A fixed effects formulation is more appropriate when the inferences will apply only to the cross-sectional units in the sample, whereas a random effects approach is more appropriate when the inferences will extend to observations outside the sample (Greene, 1990, p. 486; Hsiao, 1988, p. 43). On that basis, the appropriate model for our analysis is a random effects model. The effects of HRTOTAL in the random effects models are approximately 70 percent as large as the OLS results and are statistically significant by conventional standards. Nevertheless, although a random effects model has the virtue of providing more efficient estimates, it also assumes that the firm-specific intercepts are uncorrelated with the regressors (Greene, 1990, p. 495). In effect, there is a trade-off between efficiency and consistency in the random and fixed effects models, and this trade-off provides an empirical basis on which to make the decision between them. The Hausman test (1978) provides a method to test whether the bias from the random effects model exceeds the gain in efficiency. On that basis, the results of the Hausman test reported in Table 4 clearly reject the random effects model in favor of the fixed effects models

The role of measurement error. If we accept the results of the fixed effects model in Table 4 as appropriately cleansed of heterogeneity bias, we next have to determine to what extent those panel estimates are attenuated by measurement error in HRTOTAL. Because our data set includes only two periods of data, we must rely on independent estimates of error variance in HRTOTAL (σ^2_v) and solve for (β in equation 4.[6] Unlike in conventional economic data sets, we are able to calculate the psychometric characteristics of our measures, including their reliability. We used Cron-

[5] We also evaluated the potential for nonlinearities in the panel estimates by transforming HRTOTAL into two spline functions. The first spline, HRLARGE, reflected positive changes in the HR management system in excess of one standard deviation. The second spline, HRSMALL, captured all changes smaller than those included in HRLARGE. For *q*, the coefficients (standard errors) were .079 (.075) and –.159 (.320) for HRSMALL and HRLARGE, respectively. For GRATE, the coefficients (standard errors) were .0122 (.0149) and –.0419 (.063) for HRSMALL and HRLARGE, respectively, Although the pattern of results suggests sharply diminishing returns to large changes over this time period, the estimates were not statistically significant either individually or in joint F-tests.

[6] Equation 4 is derived from:

$$plim\ \hat{\beta}_{fdif} = \beta\left(1 - \frac{2\sigma_v^2}{VarX_{fdif}}\right), \tag{4a}$$

which is the basis for the following calculations.

TABLE 4[a]

PANEL SURVEY RESULTS, 1991–93 (STANDARD ERRORS IN PARENTHESES)

	Pooled Data (no fixed effects controls)		Pooled Data (with fixed effects controls)		Pooled Data (random effects model)	
HR Strategy Variable	*q*	GRATE	*q*	GRATE	*q*	GRATE
HRTOTAL	.1826 ***	.024***	.0529	.0066	.1218 ***	.0194**
	(.0513)	(.008)	(.0642)	(.0126)	(.0486)	(.0083)
Sample Size	436	436	436	436	436	436
Adjusted R^2	.155	.067	.622	.393	.160	.076
F values	14.25***	.079***	4.21***	2.26***	NA	NA
Lagrange Multiplier Test of Fixed Effects			58.07***	13.07***		
Hausman Test of Fixed vs. Random Effects Model					18.44***	37.66***

[a] Unless otherwise noted, these models include all control variables described in equation 1. Unlike the OLS models in Table 3, the OLS-pooled cross-sectional model does not include a set of industry controls, given that this model was the comparison against which the fixed effects model was tested.

* Significant at p < .10; ** significant at p < .05: *** significant at p < .01.

bath's α as a measure of internal consistency reliability, and specifically as an estimate of the ratio of true variance to total variance in our HR strategy measures (Nunnally and Bernstein, 1994). The more appropriate measures would be test-retest intrarater reliability (e. g., between one manager at two points in time) or interrater reliability (e. g., multiple respondents at the same level). As a measure of intrarater reliability, Cronbach's α is generally an overstatement of interrater reliability because it "assigns specific error (unique to the individual rater) to true (construct) variance" (Schmidt and Hunter, in press).[7] There is little evidence regarding the interrater reliability of measures such as ours because the convention in this literature is to use a single managerial respondent (Arthur, 1992; Cooke, 1992). Other studies have shown that ratings of organizational policies will differ by organizational level (Barron and Black, 1996; Eaton, 1994). Although multiple respondents are the basis for interrater reliabil-

[7] We have other evidence on intrarater reliability for our sample, although it is for a very small subsample of our data set. It is the more conventional measure of intrarater reliability because it takes the form of two measures given to the same individual at two points in time. Another researcher surveyed this same sample six months after our second survey on another subject, and asked several questions that we also included, although only in a binary form. The one continuous measure collected in both studies was union coverage. The intrarater reliability for presence of a union was 1.00 (n = 15) (i.e., when both measures were coded as dummies) and .70 for percentage of the workforce unionized (when both measures were coded as continuous). Given the objective and generally stable nature of this question, these results probably represent an upper bound on intrarater reliability for this sample.

ity, the fact that these respondents were drawn from different levels of the organization makes these data less applicable to our analysis.[8]

Cronbach's α for Employee Motivation and Employee Skills and Organizational Structures are .66 and .67, respectively. Therefore, we evaluated our HRTOTAL results for the range of Cronbach's α from .6 to .7. For such α s, error variance in these measures (σ^2_{ν}) would range from .38 to .28, implying a ratio of error variance to true variance of .42–.67.[9] Although measures containing 30–40 percent error variance may seem excessive, they are actually quite modest for panel data. For example, Duncan and Hill (1985, p. 521) report ratios of error to true variance for purportedly objective measures such as hours worked and earnings in the Panel Survey of Income Dynamics (PSID) in the range of 1.4–2. 8.

Calculating the corrected estimates in equation 4 posed several problems. Bivariate regressions based on first differences were used because the correction formulas for these simple models are much more accessible. However, these simple models are more likely to yield biased estimates because the control variables have been omitted. For both *q* and GRATE, the HRTOTAL coefficient in this simple model was negatively biased compared to the fully specified model. The bias was so large in the first difference GRATE model that the bivariate coefficient was slightly negative. Given that the direction of the measurement error correction is always away from zero, beginning with a negative estimate that is biased would only further distort the results. Therefore, we only report results for the *q* models. Estimates of the corrected β 's for HRTOTAL as well as corrected standard errors are calculated for two levels of Cronbach's α (Table 5).[10]

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[8] This is in part a distinction between a particular policy and its implementation. We believe the chief human resource officer (CHRO) within each firm is in the best position to describe the combination of both policy and practice. Although the CHRO may not be aware of all of the variations in policy implementation throughout the firm, neither is the firstline supervisor likely to be well informed of implementation outside his or her responsibility. The ideal solution, multiple respondents from multiple levels of each organization, was beyond the resources available for this study.

[9] If Cronbach's α = .6, then the variance of the measure is 40 percent error variance. Given that the variance of HRTOTAL is .952, then .38 (.4 X .952) of that variance is due to measurement error. The ratios of error variance to true variance are, as an example, .4/.6 = .67.

[10] The correction for the standard error of a bivariate regression, s_b, is (Greene, 1990, p. 161):

$$s_b = \frac{s}{\sqrt{S_{xx}}},$$

where s is the standard deviation of residuals and s_{xx} = (n - 1) × Variance of x. The assumption is that the variance of x includes error variance (σ^2_{ν}) as well as true variance. Our assumption that Cronbach's alpha is a measure of the percentage of true variance allows us to calculate a "corrected" value for s_{xx}, For example, in Table 5 when Cronbach's α = ,6 the calculations are as follows:

TABLE 5

CORRECTED ESTIMATES OF $\beta_{HRTOTAL}$ BASED ON EQUATION 4 AND ESTIMATES OF σ_v^2 DERIVED FROM CRONBACH'S α (STANDARD ERRORS IN PARENTHESES)

	Dependent Variable: *q*
Models and Estimates	Model Estimated Without Controls
β_{fdif}	.0252
(standard error)	(.0639)
Assume Cronbach's $\alpha = .6$	
Implied σ_v^2	.380
Estimate of Corrected β	.1245*
Estimate of Corrected Standard Error	(.0825)
Assume Cronbach's $\alpha = .7$	
Implied σ_v^2	.285
Estimate of Corrected β	.063
Estimate of Corrected Standard Error	(.076)

* Significant at $p < .10$

The results in Table 5 indicate that even modest corrections for measurement error increase the first difference estimates of HRTOTAL by two to five times their uncorrected magnitudes. If Cronbach's α is .6, the corrected estimates are in a range similar to those observed in the cross-sectional estimates and statistically significant at conventional levels. Considering that these adjustments are based on a simple first difference estimate that appears to be less than half its true value, our summary conclusion is that attenuating effects of measurement error in the panel data are approximately equal to the positive heterogeneity bias.

The economic impact. Given the wide range of these potential estimates, it is difficult to provide an accurate evaluation of the economic magnitude of these effects. Nevertheless, given that the discussion of the HR management system has been placed within a strategic perspective, the ultimate test of the strategic impact of a high performance work system is the magnitude of its effect on the firm's financial performance. The cross-sectional results in Huselid (1995) implied combined effects of a one standard deviation change in Employee Skills and Organizational Struc-

$$\begin{aligned}
\text{Variance HRTOTAL}_{fdif} &= .95228 \\
s &= .919 \\
\sigma_v^2 &= .4 \times .95228 = .38 \quad \text{(See Table 5)} \\
\text{Corrected Variance HRTOTAL}_{fdif} &= .5722 \\
s_{xx} &= 217 \times .5722 \\
s_{xx}^{1/2} &= 11.13 \\
\text{Corrected } s_b &= .0825 \qquad \text{(See Table 5).}
\end{aligned}$$

tures and Employee Motivation of $3,814 greater annual cash flow per employee and $18,641 greater market value per employee for GRATE and *q*, respectively.

We believe that a conservative approach to the generation of such estimates is to base them on coefficient values that are approximately midway between the cross-sectional estimates and the fixed effects results. This would imply a coefficient on HRTOTAL of . 10–. 12 and .012–.015 for *q* and GRATE, respectively. The estimates from the *q* models imply per-employee changes in firm market value of $14,350–$17,275. The predicted changes in net revenue per employee (GRATE) in the same firms was $1,468–$1,834. Given that these latter estimates are annual cash flows, they can be transformed into present values assuming a reasonable interest rate and time period. Assuming an 8 percent, fifteen-year period, the net present value of those cash flows would be equivalent ($14,570 and $16,953 per employee) to the market value estimates presented above.

The implementation-to-benefit lag. Our analysis to this point has not explicitly considered the potential for a lag between the implementation of a high performance work system and any subsequent change in firm performance. Specifically, our HR strategy measures in each year were matched with contemporaneous (1991 and 1993, respectively) measures of firm performance. This approach is justified by the assumption that we are observing an equilibrium relationship among firms and the effects of implementation have been fully realized. Cross-sectionally, we observe the results of the implementation process, and as long as the implementation process has largely run its course, the time between implementation and improved financial performance should have little effect on our results. Alternatively, the panel analysis examines contemporaneous changes in both the HR management system and firm performance. If in fact there is a lag before the effects of changes in the HR management system will be reflected in firm performance, as might be expected given the nature of the changes in question, our two-period panel may not be sufficient to capture those effects. This implies that the effects reported in the fixed effects and first difference models were considerably smaller than the cross-sectional results, not because they reflect heterogeneity bias in the cross-sectional results, but because it was simply too early to observe the full magnitude of the benefits.

Unfortunately, we have no way to directly estimate the magnitude of any implementation-to-benefit lag. We can, however, use our data to provide a very modest, but indirect, test of whether such a lag might indeed even

exist. For example, our 1991 cross-sectional data reflect the levels of HRTOTAL in that year. How much of those levels are due to recent changes that have not yet affected the firm's financial performance is impossible to estimate. However, it is reasonable to assume that some part of those 1991 levels include recent changes. Moreover, to the extent that the benefits of these changes are not realized immediately, we would expect that the effects of the 1991 "levels" would have a larger impact on firm performance in 1992 and 1993 than on firm performance in 1991. We present the results of these analyses in Table 6.

The pattern of results we report in Table 6 is consistent with our expectation of a lag between the implementation of new HR strategies and their subsequent effects on firm performance. For both *q* and GRATE, the benefits in the subsequent years are higher than in the contemporaneous years. The pattern is particularly dramatic for GRATE, where the effects in 1992 and 1993 average more than twice the magnitude of the 1991 contemporaneous effects. This result may in part reflect accounting convention, where investments in HR management systems are fully expensed in the current period, while their benefits can be reasonably expected to be realized across multiple periods. This relatively greater lagged effect for GRATE is also consistent with the fact that *q* is a forward-looking measure that should incorporate these subsequent increases in profitability over a shorter time period. These estimates also bear directly on two earlier results. First, the relatively greater lagged effect on GRATE means that the time period over which these cash flows will equal the market value effects *(q)* is much shorter than noted above. Second, these results imply that two-period panel estimates that rely on two-year windows are likely to understate the true effects of HR management systems on firm performance.

Caveats and implications for future research. These results seriously question whether the analysis of panel data will represent an improvement

TABLE 6

THE EFFECTS OF 1991 HRTOTAL ON 1991, 1992, AND 1993 VALUES OF THE DEPENDENT VARIABLES[a] (STANDARD ERRORS IN PARENTHESES)

Variable	1991 *q*	1992 *q*	1993 *q*	1991 GRATE	1992 GRATE	1993 GRATE
HRTOTAL	.1479**	.1899**	.1694**	.0113	.0266*	.0197*
	(.0843)	(.0815)	(.0847)	(.0162)	(.0177)	(.0137)

[a] These models are identical to the OLS-panel cross-sectional sample (n = 218) in Table 3, except that the year of the dependent variable changes as described above.

* Significant at $p < .10$; ** significant at $p < .05$.

over cross-sectional data in this line of research. At a minimum, our findings suggest that where measures of HR strategy require respondents to make broad judgments regarding both the nature and the depth of implementation of organizational HR strategies, the potential bias in panel estimates due to measurement error can be substantial. In principle, the richness of panel data can be exploited to recover the true effects of HR strategy, although the panel lengths necessary to provide those corrections will be difficult to generate. Likewise, our analyses of the potential for an implementation-to-benefit lag suggest that panels of four to five years could be required to fully specify this relationship. In the absence of such data, researchers can rely on independent evidence of measurement error, but there is no equally accessible method for estimating the possible implementation-to-benefit lags.

The value of panel data sets to assess the HR strategy-firm performance link can be legitimately questioned with respect to mitigating the heterogeneity bias discussed earlier. The argument in favor of panel analyses turns on the assumption that *other* firm characteristics that may be reflected in the cross-sectional estimates (e.g., the quality of financial or operating strategies) are fixed over time, while HR strategy is not. If in fact these other organizational practices are being appropriately modified along with the HR strategy, the result may be as much of an upward bias in the panel estimates as in the cross-sectional estimates. Rather than relying on such assumptions, future research should devote more attention to the identification and measurement of these *other* management practices so that they can be explicitly controlled in the estimation models.

Future research should proceed at multiple levels of analysis. Multifirm multi-industry data collection efforts should continue as a source of generalizable results that focuses on the effects of high performance work systems on firm performance. Ideally these efforts could begin to incorporate sufficient firm-level detail, via case study or intensive interviews, to provide a validity check on the HR system measures, and the nature of their relationship to firm performance. In addition to the improvement of multi-industry samples such as the one described in this study, we believe that much progress can be made by well-executed industry studies that utilize both conventional measures of firm performance and new work on the economic contribution of business units to overall firm performance, most notably recent work on economic value added (Stewart, 1991). Improving our understanding of the links between business-unit performance and firm performance would enable future research to incorporate the benefits of both levels of analysis.

APPENDIX

In our analyses we report results using a measure of Tobin's *Q* that does not include a measure of debt in the numerator. The purpose of this appendix is to report results from similar analyses that include the book value of long-term debt in the numerator of the *Q* variable (Q_{debt}). As we indicate in the text, the estimates for the HRTOTAL variable are equivalent in both specifications.

REPLICATION OF RESULTS WITH Q_{debt} AS THE DEPENDENT VARIABLE
(STANDARD ERRORS IN PARENTHESES)

	Table 5		Table 6	Table 7	
Variable	1991	1993	Fixed Effects	β_{fdif} Without Controls	β_{fdif} With Controls
HRTOTAL	.1441*	.1268**	.0436	.0266	.0519
	(.0714)	(.0500)	(.0552)	(.0554)	(.0551)

* Significant at $p < .05$; ** significant at $p < .01$

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