

received on these indicators of importance. For this purpose, the *citing* and *cited* responses were combined into one data set. In order to control for variations in citation practice by field and for changes in propensity to cite and extent of truncation over time, all regressions include technology field and grant-year dummy variables. In addition, based on the findings of Jean Lanjouw and Mark Schankerman (1999), we also included the log of the number of claims made by each patent, to allow for the possibility that patents that consist of more claims are more highly cited.

The results provide some evidence that citations are correlated with significance or importance as perceived by the inventors themselves. Each of the indicators is positively correlated with log citations, with the coefficients achieving  $t$  statistics that vary from just below to just above 2, depending on the question. There is no particular indication as to whether citations are more associated with technological versus economic significance. The claims variable is strongly significant, though its elasticity of about 0.25 suggests strong diminishing returns to increasing the number of claims, as distinct from the constant-returns relationship suggested by Lanjouw and Schankerman (1999). The claims variable is excluded from the regression, the effect of the perceived-importance variable increases, suggesting that importance, as perceived by the inventor, reflects both the "size" of the patents as indicated by the number of claims, and the importance or significance of each of the claims.

#### IV. Conclusion

Many of the important concepts in the economics of technological change are fundamentally unobservable. Therefore, we routinely rely on proxies or indicators for the concepts of interest. Offered our only test of the validity of these measures is the extent to which the proxies are correlated in the way that our theory says their underlying concepts should be. In this paper, we provide an additional kind of evidence

about the unobservable process of knowledge transfer, and the relationship of patent situations to that process.

The results suggest a "half-full cup" with respect to the validity of patent citations as indicators of knowledge spillovers. Taking the responses at face value, the likelihood of knowledge spillover conditional on the observation of a patent citation is significantly greater (in both the statistical and quantitative senses) than the unconditional likelihood. Nonetheless, a large fraction of citations, perhaps something like one-half, do not correspond to any apparent spillover. We believe that these results are consistent with the notion of citations as a noisy signal of the presence of spillovers. This implies that aggregate citation flows can be used as proxies for knowledge-spillover intensity, for example, between categories of organizations or between countries. Further work is needed, however, to refine our understanding of the mechanisms by which these flows move and the relationship of those mechanisms to the citation process.

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## Who Benefits Most from Employee Involvement: Firms or Workers?

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Employee involvement (EI) programs are the leading-edge form of personnel and labor relations in the United States. While many managers believe that these programs raise productivity and profits, the statistical evidence that EI improves the performance of firms is equivocal. The coefficients on measures of EI in production functions are usually positive but often insignificant or small (Commission on the Future of Worker-Management Relations, 1994; Ch. 2, Peter Cappelli and David Neumark, 1999) or contingent on other factors (Sandra E. Black and Lisa M. Lynch, 1997; Casey Ichinowski et al., 1997). A detailed case study of EI has further confirmed these small effects that were found in large data sets (Kleiner et al., 1999). If EI programs do not greatly affect productivity, why does business think so highly of them? In this study, we argue that the main beneficiaries of EI are workers and managers. We estimate the effects of EI on productivity using panel data on firms and the effects of EI on workers using a survey of employees and find that EI barely affects firm productivity but substantially improves worker well-being. We offer two explanations for this result.

#### I. Firm-Based Productivity

The data for our analysis of firm productivity comes from a 1993 mail survey of firms of the Society for Human Resource Management (SHRM) conducted by Cheri Ostroff. The SHRM survey was sent to 3,402 firms, of whom 373 responded, giving an 11-percent response rate similar to other studies that attempt to measure human-resource practices by mail survey (Takao

Kato and Motohiro Morishima, 1996). We matched these data with firm-level data on production and financial outcomes from COMPUSTAT from 1983 to 1993 and obtained 273 usable observations. We use a difference-in-difference design to compare the performance of firms year-by-year as their EI programs change, to contrast firms by EI status in the final year of the survey, and to examine changes in productivity and EI practices among firms over a decade.

The SHRM survey asked about eight EI practices: self-managed work teams, worker involvement in the design of EI programs, TQM, committees on productivity, worker involvement in work processes, suggestion or complaint systems, information-sharing with employees, and opinion surveys. The survey also asks whether the firms' use of the practice was "very great," covering at least 80 percent of jobs/workers; "great," 60-79 percent; "moderate," 40-59 percent; "some," 20-39 percent; or "little," 1-19 percent of workers. Finally, the survey asks when the practice was implemented: 10 or more years earlier, 5-9 years earlier, 1-4 years earlier, or within a year. Both the number and use of EI practices grew greatly between 1983 and 1993: in 1983 nearly half of the sample had no EI practices, and only four companies had all of the practices, whereas in 1993 virtually all had some practice, and 94 had all of them. In addition, firms extended the coverage of their programs over time. By 1993, practices introduced earliest, such as information-sharing or suggestion/complaint systems, were used more intensively than practices introduced later, such as opinion surveys or giving workers a role in designing work processes. Because firms that use rarer practices generally have the most common ones, the practices fall into a reasonably well-ordered single dimensional EI scale, per Guttman scaling or the more general Rasch-type models (David Bartholomew, 1996).

To measure firm EI activity over time, we constructed a summated rating scale of employee involvement based on the existence, intensity, and timing of the eight practices. We gave each

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practice a measure from 0 to 5, depending on its presence and extent, and then summed the eight measures. Firms that applied every practice to almost all workers in a particular year received the value 40. Firms with no practices received the value 0. If the practices fit a perfect (Guttman) scale, firms having the lowest scores would have the fewest/least-intensive practices while firms with higher scores would have the practices/intensity of those with lower scores and then some. Firms fit this pattern well enough to make the scale meaningful (Freeman et al., 2000).

Because the survey asked for a range of years when the program was implemented, we cannot identify the precise years when the firm has a program and when it does not. Our solution is to approximate the existence of a program in a given year by assuming that the program had a uniform probability of being introduced in one of the years in the reported range. For a program introduced 3–5 years ago, this leads to a one-third chance that the program existed five years ago, a two-thirds chance that it existed four years ago, and certainly that it existed three years ago. These figures estimate the probability that a firm had a program in year  $t$ . Because the survey asked for intensity of use only in 1993, we estimated the intensity of use in earlier years by exploiting the fact that intensity of use is highly correlated with the length of time a program has been in place. We regressed the intensity of use on the length of program life for all companies and programs taken together in 1993 (for the details of this estimation, see Freeman et al. [2000]) and used the estimated coefficients to predict the unobserved intensity in years prior to 1993.

Given the estimated probability that a firm had a particular EI program in a given year ( $p$ ) and the estimated intensity of use ( $U'$ ) in that year, we calculated a scale of EI activity for each year and program as the product  $p U'$  and then summed the values across programs for each firm in each year to obtain an EI variable that measures the number of programs and their intensity of use in a given year. Finally, we estimate the effect of EI using the following production function:

$$(1) \quad \ln Q = a + b(\ln K) + c(\ln L) + d(EI) + YR + FIRM + u$$

TABLE 1.—REGRESSION COEFFICIENTS (STANDARD ERRORS IN PARENTHESES) FOR PRODUCTION-FUNCTION ESTIMATES OF EFFECTS OF EI SCALE, EMPLOYMENT, AND ASSETS ON LN(SALES)

	Independent variable			$R^2$ (pseudo $R^2$ )
	LN Emp	LN Assets	EI Scale	
A. Annual Data ( $n = 2,127$ , with year and firm dummies):				
OLS	0.48 (0.02)	0.52 (0.02)	-0.000 (0.002)	0.93
Median	0.41 (0.01)	0.57 (0.01)	0.003 (0.003)	0.82
B. 1993 Cross Section ( $n = 237$ ):				
OLS	0.46 (0.05)	0.55 (0.05)	0.000 (0.005)	0.92
Median	0.42 (0.03)	0.56 (0.03)	-0.003 (0.003)	0.81
C. 1983–1993 Change ( $n = 229$ ):				
OLS	0.42 (0.05)	0.56 (0.05)	-0.001 (0.002)	0.84
Median	0.45 (0.03)	0.48 (0.03)	0.000 (0.001)	0.61

Notes: The 1983–1993 regressions include all years for which we have data. The 1993 regression covers 1993 in cross section; 1983–1993 change includes all companies for which we could get at least two years, with changes calculated as average annual changes over the longest period for which data exist. The 1993 and 1983–1993 regressions include seven industry dummy variables, which have no noticeable impact on the results.

Source: COMPUSTAT, various years.

where  $Q$  = sales,  $L$  = employment, and  $K$  = book value of assets, from COMPUSTAT. FIRM is a vector of firm dummy variables; YR is a vector of year dummy variables; EI is our scale; and  $u$  is a residual. With firm and year dummy variables, identification of an EI effect comes from the differential variation of EI over time within firms.

Table 1 gives the results of our analysis using two different estimating procedures: ordinary least squares (OLS) and median regressions. The OLS results in line 1 show little or no impact for EI. By contrast, there is a small noticeable effect of the EI scale on  $\ln(\text{sales})$  in the line-2 median regression, indicating that results are sensitive to the mode of estimation. These regressions make maximum use of our data but suffer from the possible problem that

EI programs require considerable time to bear fruit. The regressions in lines 3–4 deal with this, by focusing on the final year of our survey, 1993, by which time many of the programs should have been in a mature state. Here too the estimated coefficients on EI are negligible. Finally, in lines 5 and 6 we regress changes in EI sales on changes in inputs and the change in EI over the 1983–1993 decade, with the data transformed into average annual changes so that we could include firms for which we did not have data going back to 1983. Put differently, in this regression we took the longest period for which we had data and annualized the changes. Again, we find no EI effects.

Many analysts believe that a linear specification of the EI effect is incorrect. Rather, EI has a substantial nonlinear effect on productivity, so that firms that introduce one involvement activity may gain nothing or even lose because "a single tree does not a forest make," whereas firms that introduce a full spectrum of complementary policies gain from EI (Ichniowski et al., 1997). We mined our data in search of nonlinearities but found little evidence that any such patterns are confounding the EI impact. In sum, our data show that EI has little or no effect on productivity, with a positive effect in only one median regression. Perhaps a larger data set might uncover something that our data fail to reveal, but recent work by Cappelli and Neumark (1999) support our finding in a larger file.

## II. Effects on Employees

To find the effects of EI programs on workers, we turn to the Workplace Representation and Participation Survey, WRPS, (Freeman and Joel Rogers, 1999). This is a nationally representative survey of some 2,400 workers in firms with over 25 employees that focuses on employee attitudes toward various labor practices. The WRPS is a cross section, so that we cannot follow workers from a firm with an EI program to another firm or conversely. But we can contrast EI participants to nonparticipants in companies with programs and to employees in companies without programs, and we can determine how employees view their firms' EI program.

Table 2 presents cross-tabulations that summarize the responses of nonmanagerial employ-

TABLE 2.—INVOLVEMENT IN DECISIONS AND ATTITUDES OF NONMANAGERIAL WORKERS, BY EI STATUS

Category	Firm has EI program		Does not participate in EI program
	Participates	Does not participate	
A. Percentage Answering Have "A Lot" of Direct Involvement in:			
Deciding how to do job	68	52	50
Setting goals for work group	44	29	24
Setting work schedules	39	30	24
Deciding what training is needed	43	23	23
Setting safety standards and practices	44	31	30
Deciding how to work with new equipment/software	38	26	23
Average across areas:			
	46	32	29
B. Attitudes Toward Work (Percentages):			
Very satisfied with influence on decisions that affect job/work life	34	19	19
Look forward to work	74	63	61
Feel a lot of loyalty to firm	63	42	39
Trust firm to keep promises a lot	49	36	30
Rate system for resolving workplace problems as very effective	38	26	22
C. Perceived Impact of EI (Asked Only of Participants; Percentages):			
Benefited by greater influence on job	79		
Benefited from better wages or benefits	36		
Elimination of EI would be bad/very bad	71		

Source: Tabulated from Worker Representation and Participation Survey, Detailed Tabulations (see Freeman and Rogers, 1994).

ees by EI status to questions relating to employee decision-making at work and attitudes toward the firm, and it presents the views of EI participants toward the program. More detailed analysis controlling for covariates gives comparable results, justifying our focus on the cross-tabulations. Panel A compares the percentage of workers who report "a lot" of involvement in the company decisions that affect their work life in six different areas. In each area, workers on EI committees report greater involvement on decisions than other employees.

Averaging across areas, EI participants have a 14-percentage-point edge over nonparticipants in firms with programs and a 17-point edge over employees in firms without programs. The similarity between the responses of non-EI participants in firms with EI programs and those in firms without any program indicates that the EI impact is not a simple "good company" effect. Note that the survey asked about workers' influence on the job prior to the module on EI, so responses are not affected by questions about EI. In some areas the differences are striking. A substantial proportion of EI workers have a lot of direct involvement in setting goals for their work group, deciding what training is needed, or how to work with new equipment or software.

Panel B gives the responses to questions relating to satisfaction or attitudes toward work. A much larger proportion of EI participants report themselves as very satisfied with the "influence (they) have in company decisions that affect (their) job or work life" compared to other workers. In addition, proportionately more participants look forward to going to work (as opposed to not caring one way or the other or wishing they did not have to go), are more loyal to their employers, trust that their company will keep its promises to them and other workers, and view their firms' program for dealing with the workplace problems as being very effective.

Panel C examines the experiences of EI participants toward their firms' program. Over three-quarters say that they personally benefited by gaining greater influence on the job; over a third say they obtained better wages/benefits. Most important, the vast majority of EI participants said that getting rid of the firm's program would have had or very bad effects on them personally.

### III. Interpretation

What explains the negligible effect of EI in our (and other) production-function analyses compared to the strong effect that workers report EI makes on their working lives? One possible explanation is statistical. Firm-based studies of EI like ours may fail to find productivity effects because the "true" effects are too small for the production analysis to uncover with any degree of certitude given the sample

making, so that the growth of EI reflects technological change embodied in workers rather than managerial innovation.

Whatever the explanation, since EI has at worst a nonnegative effect on productivity and a positive effect on the lives of workers, it is a net benefit to the U.S. labor market.

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