What Do Unions Do to Productivity? A Meta-Analysis

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The impact of unions on productivity is explored using meta-analysis and meta-regression analysis. It is shown that most of the variation in published results is due to specification differences between studies. After controlling for differences between studies, a negative association between unions and productivity is established for the United Kingdom, whereas a positive association is established for the United States in general and for U.S. manufacturing.

The relationship between unions and productivity has attracted considerable attention from scholars in industrial relations and economics, as well as from policymakers, unions, and business in general. Despite voluminous theoretical literature, controversy continues regarding the impact of unions on productivity, as well as on other aspects of business, such as employment, research and development (R&D), profitability, and investment. In traditional economic analysis, unions are said to distort labor market outcomes through, for example, legal and custom-driven restrictions on relative wages, the imposition of employment restrictions, and protection against layoffs. Unions are said also to be a contributing factor to aggregate as well as sectoral unemployment and the associated output losses. In contrast to these arguments, Freeman (1976) and Freeman and Medoff (1984) argued that unions can raise productivity by providing workers with a means of expressing discontent as an alternative to "exiting," by opening up communication channels between workers and management, and by inducing managers to alter methods of production and to adopt more efficient policies.

The controversy in the theoretical literature is matched by controversy in the empirical literature. Empirical findings are divided between positive and negative union-productivity effects, and many studies cannot reject the hypothesis of a zero effect. Hence generalizations from the available evidence

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are not obvious using traditional literature reviews. The aim of this article is to make more lucid the relation between unions and productivity by using meta-analysis and meta-regression analysis. Meta-analysis is now used widely to identify and quantify patterns, draw inferences from the diversity of results, and detect possible regularities in the association between unions and productivity. Meta-analysis is used to implement a quantitative synthesis of the available research and, where possible, to generalize from the results derived from the numerous singular studies (Rosenthal 1984). Meta-analysis is a scientifically valid statistical procedure that has been developed to quantify associations drawn from an existing body of literature (Wolf 1986; Hunter and Schmidt 1990).

The meta-analysis presented in this article involves a comprehensive survey and quantitative analysis of the published empirical literature. Meta-regression analysis is used to examine the influence of methodologic features and data differences on reported estimates of union-productivity effects. Additionally, we explore the notion, prevalent in the empirical literature, of the existence of an invariant union-productivity effect.

While theoretical developments focus on efficient bargains—bargaining over wages and work practices as well as bargaining over wages and employment—empirical analysis of the net impact of unions on productivity remains of considerable interest. Hence meta-analysis of this empirical literature is important. For example, policymakers have maintained their interest in this area within the overall context of policy action and concerns over labor market flexibility and labor market deregulation. Even though the influence of unions has fallen and union membership has diminished in most countries, industry in general continues to be concerned about the impact of unionization, especially where productivity becomes important in offsetting any adverse effect on cost competitiveness arising from the higher wages of unionized labor. This has become even more imperative with the rapid expansion of global markets. Furthermore, applied research in this area continues, responding at least in part to these broader concerns. For example, 37 studies estimating directly the impact of unions on productivity were published in the 1990s compared with 31 published in the 1980s and 20 articles published in this area since 1995.

Previous Research and Reviews

There is now a sizable theoretical literature that explores both the hypothesized costs and the benefits of trade unions. Examples include Addison (1982, 1985), Addison and Barnett (1982), Freeman and Medoff (1984), Kuhn (1985), Hirsch and Addison (1986), Turnbull (1991), and Belman (1992). Details of the theoretical arguments can be found in these and other sources.

Conceptually, unionism can booster or hamper labor productivity. Because of the ambiguity over the net effect of unions, most of the existing studies begin their empirical investigation without presupposing a specific direction, leaving the conclusion to empirical findings. However, a common conceptual framework serves as a starting point for empirical investigation. This conceptual framework is the so-called two-faces view of unionism (Freeman and Medoff 1984): the monopoly face and the collective voice/institutional response face.

The *monopoly face* of unionism refers to a number of adverse wage and nonwage effects. One of the most well established effects of unions is the ability to increase wages above competitive levels (Lewis 1963). Another dimension is unfavorable effects on R&D spending and tangible and intangible investments. Union rent-seeking acts as a tax on the return on investment and limits innovative and investment activities (see Connolly, Hirsch, and Hirschey 1986; Hirsch and Link 1987). These can have a detrimental impact on the dynamic path of productivity.

Unions can have a direct negative impact on productivity by restricting managerial discretion. For example, unions may force firms to adopt inefficient personnel hiring and firing practices. Legal restrictions against layoffs and closed-shop arrangements have an impact on efficient factor usage and hence productivity. Unions also may favor restrictive work practices, curbing the pace of work, hours of work, and skill formation. They also may obstruct the introduction of new technology (see McKersie and Klein 1983). Productivity is affected also through strike activity. This arises through working days lost, as well as noncooperative behavior that precedes or follows strikes (see Flaherty 1987).

The other aspect of unions is the *collective voice and institutional response face* (CV/IR) emphasized by Freeman and Medoff (1984). The CV/IR model draws on the exit-voice dichotomy of Hirschman (1970). In this framework: "voluntary quits become the labor market expression of exit, and unions become the institution for the expression of (collective) voice" (Turnbull 1991:137). By providing workers with a means of expressing discontent at the workplace, unions can reduce the extent to which quits and absenteeism lead to a suboptimal degree of labor turnover. By presenting unions as an alternative to resignation and apathy, Harvard scholars delivered an argument in favor of union representation. This channel is important because high labor turnover can reduce productivity in a workplace through a direct loss of firm-specific training (see Addison and Barnett 1982; Freeman 1976).

According to Freeman and Medoff (1984), unions can enhance productivity by improving communication between workers and management. The opening of communications channels between management and workers can result in integrative rather than distributive bargaining (Dworkin and Ahlburg 1985). Unions may provide additional information to a firm about the preferences of employees, thus permitting the firm to choose a better mix among working conditions, workplace rules, and wage levels. These can result in a more satisfied, cooperative, and productive workforce.

In addition, unions may be responsible for a "shock effect." Unions can induce managers to alter methods of production and adopt more efficient personnel policies (Slichter, Healy, and Livernash 1960). Union activities also may improve worker morale and motivation. The potentially arbitrary nature of decisions such as promotions or layoffs can be reduced by the presence of unions. Consequently, the employee is more likely to see his or her employer as fair. Leibenstein (1966) emphasized that one of the major areas for improving X-efficiency in the firm is worker morale and motivation. Further, unions often stress seniority rules. There is a positive association between productivity and experience. Seniority rules exclude a system of subjective selection, and the seniority system emphasizes ability and merit. It also may reduce conflict between seniority and efficiency (Rees 1962).

The CV/IR approach offers new insights into the role of unions in labor productivity. This framework is based on a theory that "may be interpreted as a hypothesis that internal organization matters and as an extension of modern organization theory which abandons the standard textbook neoclassical economic perception of the firm as a machine . . ." (Addison and Barnett 1982:147).

The two faces of unions are not incompatible. Hirsch (1997:37) notes that "The monopoly and collective voice faces of unionism operate side-by-side, with the importance of each being very much determined by the legal and economic environment in which unions and firms operate. For these reasons, an assessment of union's effects on economic performance hinges on empirical evidence."

Union productivity effects have been studied in a variety of industries, including construction, manufacturing, mining, and services, as well as the public sector. Most of the studies use U.S. or U.K. data, with many conflicting results reported. Unfortunately, the existing empirical studies do not individually provide definitive answers on the relationship between unions and productivity. These studies use disparate variables, methods, and samples, and hence it is necessary to review the available studies and draw inferences from them. Moreover, it is important to investigate the extent to which the differences between studies serve as potential explanations for the disparity in the results across the studies. The differences between study results may reflect actual differences in the relationship between unions and productivity. The differences also could be due to the nature of the research process.

There have been a number of reviews of this literature, some conducted by leading experts. The conclusions drawn in the major reviews are broadly similar. For example, in their review, Addison and Hirsch (1989:79) argued that "Based on the extant evidence, we conclude that the average union productivity effect is probably quite small and, indeed, is just as likely to be negative as positive." They note also that ". . . there is no compelling evidence that, in general, the net effect of unions on productivity is positive or negative" (1989:83). In his review, Kuhn (1998:1048) concluded that "A fair summary of the industry studies is that most estimates are positive, with the negative effects largely confined to industries and periods known for their conflictual union-management relations, or to the public sector." Similar conclusions that the evidence supports neither a negative nor a positive relationship are drawn by many other authors (see, for example, Wilson 1995). Preempting the need for meta-analysis, in the course of her review, Booth (1995:223) noted that it is "necessary to have evidence on the union effects from a number of different studies before drawing any firm conclusions."

The problem with qualitative reviews of any literature is that they may suffer from what Stanley (2001) calls "casual methodological speculation." Since they are qualitative, they are based usually on opinion, and conclusions are drawn largely from subjective interpretation of the available evidence, even when specialists conduct them. This makes qualitative reviews prone to a greater degree of speculation than quantitative reviews. The absence of statistical investigation of empirical results means that qualitative reviews lack formal testing of a hypothesis. While qualitative reviews assist with the subjective assessment of a hypothesis, it is only through a quantitative review that a contentious hypothesis can be tested formally.

In contrast to existing reviews, in this article we present the first *quantitative* review of the union-productivity effects literature through meta-analysis. Meta-analysis is used to "summarize, evaluate and analyze empirical economic research" (Stanley 2001:131). It is well know that methodologic and data differences have an impact on empirical estimates. The issue is how to quantify that impact. Meta-analysis is based on a pronounced examination of differences in specification and datasets and is used to quantify the impact these have on productivity effects. Meta-analysis helps to make sense out of the substantial variation in union-productivity estimates. It is very difficult to evaluate the multidimensional nature of empirical investigations using traditional literature reviews. For example, reviewers are forced to assess the impact of specification differences without statistical tools that enable them to identify the impact of specification differences after controlling for, say, data differences.

Meta-analysis should be seen as complementary to traditional reviews, a way to analyze estimates and explain the variation of interstudy differences (see Espey 1998). Despite differences in the review process, we show in this article that the conclusions drawn from the existing reviews are correct with respect to the entire pool of evidence. However, we can draw different conclusions about the direction of the productivity effects for important subsamples of this literature. In particular, it is possible to conclude that unions have a negative impact on productivity in the United Kingdom and Japan and that unions have a positive impact on manufacturing in the United States. Importantly, in contrast to some of the qualitative reviews, the available evidence indicates that some of the productivity effects are of economic significance.

Meta-Analysis and Meta-Regression Analysis Methodology

Meta-analysis was developed to facilitate a *quantitative* research synthesis. There is now a burgeoning reference literature on meta-analysis [see, for example, Cook et al. (1992); Hedges and Olkin (1985); Hunter and Schmidt (1990); Wolf (1986)]. Stanley (2001) offers a recent review of the growing list of applications of meta-analysis in economics.

There are four steps in meta-analysis. Meta-analysis involves identification and calculation of the association between variables of interest (known as an *effect size*) by considering all the available relevant empirical literature. Hence the first step in any meta-analysis is identification of the relevant empirical literature. In the present study this is the published literature on union-productivity effects. The second step involves derivation of effect sizes from each study or calculation of effect sizes from information provided in each study. Two effect sizes are used in this article, the partial correlation coefficients between unions and productivity and the union-productivity effects. The third step is calculation of summary statistics relating to the effect sizes. The fourth step is moderator analysis—the identification of the sources of variation between published effect sizes.

The most common approach known as *meta-analysis* involves the calculation of summary statistics involving the associations of interest. The key statistics of interest are the mean, the weighted mean, a measure of homogeneity of research results, and confidence intervals constructed around the mean. A separate branch known as *meta-regression analysis* is used to uncover the sources of heterogeneity of research results. This involves regressing study characteristics on the effect size derived from the studies against a set of potential explanatory or moderator variables. Both types of meta-analyses are presented in this article, with the emphasis on meta-regression analysis.

The Database. The starting point for meta-analysis is compilation of the database. We compiled all the published studies exploring the relationship between unions and productivity. There are a number of unpublished studies exploring this relationship, but these have not been included. Results presented in unpublished material, such as manuscripts and working papers, can change by the time they reach their published form, and hence in many cases they may be less reliable than those found in published material.[1]

An extensive computer search was conducted for studies written in English or French. A total of 73 statistically independent studies was compiled, and these studies are used in the meta-analysis and meta-regression analysis.[2] In meta-analysis, studies are regarded as statistically independent if different authors produce them or when they are by the same author but different samples are used (see Hunter and Schmidt 1990). There are actually more than 73 published studies in this area. However, in some cases the same authors have produced more than one published work using the same dataset. These studies cannot be regarded as statistically independent. The approach taken in this article was to average these non-statistically independent studies and treat them as a single study. For example, Fitzroy and Kraft (1987a, 1987b) use the same data, as do Guthrie (2001) and Guthrie, Spell, and Nyamori (2002).

From the point of view of meta-analysis, when two different authors use the same dataset, both studies are regarded as statistically independent. This is standard practice in meta-analytic reviews [see, for example, Espey, Espey, and Shaw (1997) and Thiam, Brave-Ureta, and Rivas (2001)].

All the studies included in the meta-analysis provide direct measures of the association between unions and productivity, with productivity as the dependent variable and unionism as part of a set of explanatory variables.

[1] Moreover, the quality of working papers varies. For example, those from the National Bureau of Economic Research (NBER) are of a very high quality, and most of these have been published. However, there are working papers from other centers that have remained unpublished after many years and in some cases after decades. Nevertheless, it is the case that most of the working papers have been published and are included in the meta-analysis presented in this article.

[2] A number of databases were searched, including EconLit, Proquest/ABI Inform, and EBSCO.

A number of empirical studies were excluded from the meta-analysis. These include (1) the extensive body of literature exploring the impact of unions on wages, (2) studies that explore the links between unions and employment, profitability and/or investment, (3) studies that explore the links between unions and productivity but do not provide sufficient information from which effect sizes could be calculated, (4) macroeconomic studies that focus on the relationship between corporatist economic policies and economic performance, (5) studies that explore the association between labor relations climate and productivity through strike activities, grievances procedures, and quality of working life, (6) estimates of the union-productivity *growth* effect,[3] and (7) studies using probit models because they are not comparable with the included studies. A full list of excluded studies is available from the authors.

Effect Sizes. From each of the published studies we calculated the partial correlation coefficient, and from most of the studies we were able to collect some information on the union-productivity effect.[4] These are the preferred measures of the association between the variables of interest (the effect sizes). That is, the focus of the meta-analysis is the partial correlation between unionization and productivity, as well as the productivity effects. These measure the strength and, importantly, the direction of association between unionization and productivity while holding other factors constant. The techniques developed for traditional forms of meta-analysis are based on measures such as correlations. Meta-regression analysis can be used for both correlations and measures more favored by economists, such as elasticities. One of the benefits of analyzing partial correlations is that it facilitates comparisons with other meta-analyses of workplace interventions and performance. Examples where correlations are used include the meta-analysis of job satisfaction and productivity (Miller and Monge 1986); absenteeism and job performance (Bycio 1992); the impact of profit sharing, employee share ownership, and employee participation in decision making (Doucouliagos 1995); and board of directors size and financial performance (Dalton et al. 1999).

[3] Where studies reported results for both growth and levels, only the later was used.

[4] None of the 73 studies reported partial correlation coefficients. However, they do report regression coefficients, standard errors, *t*-statistics, or levels of statistical significance. The partial correlation coefficients are calculated by using the *t*-statistics reported in the primary studies. Where *t*-statistics are not reported, they can be calculated from the reported levels of statistical significance or from the reported regression coefficients and standard errors. The formula used to calculate partial correlations is: $\sqrt{t^2/(t^2 + df)}$, where t is the *t*-statistic and df is degrees of freedom. Note that this will always produce a positive number, so it is necessary to convert it to a negative number if the regression coefficient is negative (see Greene 2000:Chap. 6).

Most studies report more than one set of results. The approach adopted in this article is to use only the results deemed by the study's author or authors as the preferred result. Hence we ignore any results undertaken for sensitivity analysis, for exploration purposes, or just out of speculation. Where studies report more than one valid regression coefficient, we averaged these—in some cases the weighted average was used when the same author in the same article used different sample sizes.

Meta-Regression Analysis The principal use of meta-regression analysis is to identify moderator variables and to explore the impact of specification on the estimated union-productivity effect. Each of the 73 primary studies used regression analysis to estimate union-productivity effects. Meta-regression analysis is a regression analysis of the regression analysis reported in the existing pool of studies. The published studies used a number of different specifications, introduced different control variables, and used different datasets covering different levels of aggregation, different time periods, and different industries. Meta-regression analysis can be used to detect whether these study characteristics are associated in any way with the estimated study outcomes. This enables a *quantitative* assessment of the impact of differences in research design, methodology, data, and estimation on reported study outcomes that is not possible in a traditional narrative and qualitative literature review.

Meta-analysis also can be used to identify moderator variables. However, the advantage of meta-regression analysis is its multivariate context. Meta-regression analysis allows researchers to identify, for example, the association between data aggregation (e.g., firm-versus industry-level data) and estimated union-productivity effects while also controlling for other study characteristics, such as the time span of data. Meta-regression analysis offers a richer framework through which an existing body of empirical literature can be reviewed.

The basic meta-regression equation takes the following form:

$$Y_i = \alpha + \beta_1 N_i + \gamma_1 X_{i1} + \ldots + \gamma_k X_{ik} + \delta_1 K_{i1} + \ldots + \delta_n K_{in} + u_i \qquad (1)$$

where Y = the partial correlation (or elasticity) derived from the ith study

α = a constant

N_i = sample size associated with the ith study

X = dummy variables representing characteristics associated with the ith study

K = mean values of quantifiable variables, such as union density

u_i = the disturbance term, with usual Gaussian error properties (see Stanley and Jarell 1998)

Meta-Analysis Results

The 73 studies are presented in alphabetical order in Table 1 together with the country to which the data relate, the sample size N used in each study, the t-statistic (or the average t-statistic in cases where more than one estimate is used per study), the partial correlation coefficient r, and the associated union-productivity effect, as well as the publication outlet. The union-productivity effects are presented in three separate ways. In column 6 we list δ, the establishment effect or the elasticity of productivity with respect to union density. This is the preferred elasticity measure because it measures the percentage change in labor productivity for an increase in union density of 1 percent. As can be seen from Table 1, this elasticity is not available from most of the studies. For most of the studies that did report δ, we also present the mean union-productivity effect—that is, we evaluate the impact of unions on productivity at sample means. Finally, we also present the *total* productivity differential. This is available for most of the studies and hence will be the central focus of the meta-regression analysis. This effect measures the impact of unions in the case of 100 percent unionization. Studies are divided into those using density and those using a dummy variable to denote union presence. The regression coefficients on these are not comparable because the density studies measure δ, whereas the dummy studies measure the impact on productivity arising from 100 percent unionization. While it is true that 100 percent unionization is rare, by evaluating the total productivity effect, we can compare most of the studies.[5] It can be seen from Table 1 that there is a wide range of results, with both positive and negative findings. There is no apparent consistency in the results. The partial correlations from 29 of the 73 studies are not statistically significant. In 45 of the 73 studies a positive relationship was found between unions and productivity, and the remaining 28 found a negative relationship. Of these, 26 found a positive and statistically significant effect, whereas 18 found a negative and statistically significant effect. The highest positive partial correlation is +0.47, whereas the largest negative partial correlation is −0.58. The weighted average (using sample size as weights) of only the negative partial correlations is −0.06, whereas the weighted average of only the positive partial correlations is +0.07. There is, however, no reason to separate the studies like this.

[5] For studies using the Brown-Medoff methodology, with unionization measured as a percentage, the total productivity effect is the coefficient on unionism after it is converted into a percentage. In the case where a union dummy variable is used, the total union productivity effect is calculated as the antilog of the dummy coefficient with 1 subtracted from it.

TABLE 1

EMPIRICAL STUDIES EXPLORING THE ASSOCIATION BETWEEN UNIONS AND PRODUCTIVITY (n = 73)

Author	Country	*N*	Average *t*-statistic	Average *r*	δ	Mean Union Effect	Total Union Effect	Outlet
Allen (1984)	USA	81	+2.12	+0.244**	+0.15	+5%	+15%	QJE
Allen (1985)	USA	102	+2.31	+0.237**	+0.12	+4%	+12%	RES
Allen (1986a)	USA	44	+1.38	+0.253#	—	—	+27%	JLR
Allen (1986b)	USA	151	+1.61	+0.190*	—	—	+35%	ILRR
Allen (1988a)	USA	306	+2.79	+0.223***	+0.20	+6%	+20%	ILRR
Allen (1988b)	USA	42	+2.69	+0.470**	—	—	+51%	IR
Argys & Rees (1995)	USA	3169	+1.60	+0.029#	—	—	+1%	RLE
Arthur (1994)	USA	30	+2.24	+0.416**	+0.15	+7%	+15%	AMJ
Baldwin (1992)	Canada	167	−1.70	−0.141**	−0.001	na	−0.1%	Book
Bartel (1994)	USA	155	+1.95	+0.160**	+0.42	+7%	+42%	IR
Batt (1999)	USA	202	−0.52	−0.038#	—	—	−3%	ILRR
Bemmels (1987)	USA	46	−1.19	−0.108#	−0.70	−18%	−70%	ILRR
Black & Lynch (2001)	USA	627	−1.91	−0.078**	—	—	−12%	RES
Boal (1990)	USA	249	+0.54	+0.035#	—	—	+3%	IRRR
Bronars et al. (1994)	USA	670	+1.04	+0.039#	+0.03	—	+3%	IR
Brown & Medoff (1978)	USA	204	+1.95	+0.139**	+0.16	+5%	+16%	JPE
Brunello (1992)	Japan	979	−3.23	−0.103***	—	—	−15%	ILRR
Byrne et al. (1996)	USA	128	−0.86	−0.075#	—	—	−11%	IR
Byrnes et al. (1988)	USA	197	+2.48	+0.241***	—	—	+69%	MS
Cavalluzzo & Baldwin (1993)	USA	83	+2.13	+0.239**	—	—	+38%	Book
Caves (1980)	UK/USA	47	−1.77	−0.270*	na	na	na	Book
Caves &Barton (1990)	USA	268	−3.32	−0.202***	−0.005	na	−0.5%	Book
Chezum & Garen (1998)	USA	8152	−1.75	−0.019*	—	—	−3%	AE
Clark (1980a)	USA	104	+2.00	+0.195**	—	—	+10%	ILRR
Clark (1980b)	USA	465	+0.05	+0.025#	—	—	−1%	QJE
Clark (1984)	USA	4681	−2.33	−0.034**	−0.03	−1%	−3%	AER
Conte & Svejnar (1988, 1990)	USA	155	+2.04	+0.170**	+0.37	+25%	+37%	IJIO
Conyon & Freeman (2002)	UK	932	−0.83	−0.068#	—	—	−4%	Book

Cooke (1994)	USA	841	+2.59	+0.090***	—	—	+29%	ILRR
Coutrot (1996)	France	4289	+2.77	+0.048***	—	—	+7%	TE
Craig & Pencavel (1995)	USA	170	+1.91	+0.152***	—	—	+29%	BP
Davies & Caves (1987)	UK/USA	86	−2.05	−0.236**	−0.133	—	−13%	Book
Dickerson et al. (1997)	UK	98	+0.88	+0.086#	+0.02	+0.2%	+2%	IRAE
Eberts (1984)	USA	3251	+0.56	+0.010#	—	—	+6%	ILRR
Edwards & Field-Hendrey (1996)	USA	96	+1.36	+0.146#	—	—	+18%	RLE
Ehrenberg et al. (1983)	USA	256	+0.36	+0.024#	—	—	9%	ILRR
Fitzroy & Kraft (1987a)	Germany	123	+2.85	+0.260***	+0.09	+3%	+9%	QJE
Freeman (1988)	USA	650	+0.86	+0.034#	+0.12	+4%	+12%	EER
Graddy & Hall (1985)	USA	60	−1.47	−0.193#	—	—	−11%	JLR
Grimes & Register (1991)	USA	2062	+2.26	+0.050**	—	—	3%	IR
Guthrie (2001)	New Zealand	136	+1.00	+0.090#	+0.13	+4%	13%	AMJ
Hirsch (1991)	USA	6248	−6.10	−0.077***	−0.08	−3%	−8%	Book
Holzer (1990)	USA	1320	+1.10	+0.196#	—	—	+0.03	IR
Huselid (1995)	USA	855	+1.00	+0.180#	+0.001	+0.01%	+0.1%	AMJ
Ichniowski et al. (1997)	USA	2190	+1.50	+0.032#	—	—	+1%	AER
Katz et al. (1987)	USA	33	+1.95	+0.380*	—	—	na	BP
Kaufman & Kaufman (1987)	USA	37	−0.64	−0.114#	—	—	−10%	JLR
Kleiner & Petree (1988)	USA	490	+2.64	+0.120***	+0.6	+7%	+60%	Book
Kleiner & Ay (1996)	Sweden	29	−0.85	−0.183#	−0.40	−34%	−40%	AILR
Kleiner & Lee (1997)	Korea	184	−0.13	−0.010#	—	—	−1%	IR
Koch & McGrath (1996)	USA	318	+0.68	+0.039#	+0.34	+7%	+34%	SMJ
Kurth (1987)	USA	50	−3.19	−0.464***	−0.08	−1%	−8%	JLR
Lee & Rhee (1996)	Korea	144	−2.33	−0.196**	−0.01	−0.2%	−1%	JLR
Lovell et al. (1988)	USA	26	−2.49	−0.486**	−0.68	−16%	−68%	JLR
Machin (1991)	UK	208	−0.89	−0.063#	—	—	−13%	ECO

TABLE 1 (cont.)

Author	Country	*N*	Average *t*-statistic	Average *r*	δ	Mean Union Effect	Total Union Effect	Outlet
Maki (1983)	Canada	183	+2.47	+0.182**	+0.33	na	33%	RI
Meador & Walters (1994)	USA	889	–1.99	–0.067**	—	—	–13%	JLR
Mefford (1986)	USA	126	+4.19	+0.360***	—	—	+33%	ILRR
Milkman (1997)	USA	2684	+1.38	+0.029#	—	—	+19%	JLR
Mitchell et al. (1990)	USA	886	+1.70	+0.084*	—	—	+5%	Book
Mitchell & Stone (1992)	USA	83	–3.00	–0.331***	—	—	–13%	ILRR
Morishima (1990)	Japan	69	+1.00	+0.131#	+0.001	+0.05%	+0.1%	IR
Muramatsu (1984)	Japan	515	+1.49	+0.094#	+0.12	+2%	+12%	Book
Noam (1983)	USA	1100	+0.33	+0.010#	+0.01	—	+3%	RLE
Pencavel (1977)	UK	56	–4.09	–0.501***	–0.22	–3%	–22%	BJIR
Register (1988)	USA	389	+3.86	+0.250***	+0.17	—	+19%	JLR
Register & Grimes (1991)	USA	1229	+2.01	+0.058**	—	—	5%	JLR
Schuster (1983)	USA	474	+2.35	+0.259***	—	—	17%	ILRR
Tachibanaki & Noda (2000)	Japan	2358	–3.02	–0.091***	—	—	–50%	Book
Torii (1992); Torii & Caves (1992)	Japan	124	–0.135	–0.013#	0	0	0	Book
Warren (1985)	USA	26	–3.12	–0.583***	–0.81	–19%	–81%	JLR
Wilson (1995)	USA	266	+0.96	+0.112#	+0.14	+5%	+14%	Book
Wilson & Cable (1991)	UK	260	–2.28	–0.146**	—	—	–18%	AE

*, **, *** correlation is statistically significant at the 10, 5, and 1 percent levels, respectively. # Not statistically significant. na denotes that the productivity effect cannot be derived from the study. Journal codes are as follows: AE: *Applied Economics*; AER: *American Economic Review*; AMJ: *Academy of Management Journal*; BJIR: *British Journal of Industrial Relations*; BP: *Brookings Papers*; ECO: *Economica*; EER: *European Economic Review*; IJIO: *International Journal of Industrial Organization*; ILRR: *Industrial & Labor Relations Review*; IR: *Industrial Relations*; JLR: *Journal of Labor Research*; JPE: *Journal of Political Economy*; MS: *Management Science*; RI: *Relations industrielles;* RES: *Review of Economics and Statistics*; RLE: *Research in Labor Economics*; QJE: *Quarterly Journal of Economics*; TE: *Travail et Emploi.*

In order to conserve space, only the key and more interesting meta-analysis results are presented and discussed. The traditional meta-analysis results are presented in Table 2 for five different groupings of studies. The table presents information on the number of studies included in each meta-analysis, the combined sample size of the included studies, and the unweighted mean, median, and sample size weighted mean partial correlations. The range shows the spread of actual results reported in the literature. The 95 percent confidence intervals are presented in brackets, and these incorporate the variance associated with the estimated average partial correlations. These can be used to test the hypothesis that the union-productivity effect is zero, positive, or negative. An important consideration is whether the partial correlations are drawn from a group of studies that is homogeneous. A chi-square test for this is presented in Table 2, testing the hypothesis that all the partial correlations are equal. If this hypothesis is rejected, then it is important to search for factors that lead to heterogeneity.[6]

There is also the issue of possible differences in the quality between studies. Our starting position was to rank all the studies equally. The issue of quality may be reflected in the publication outlet. Of the 73 studies listed in Table 1, 13 were published in the *Industrial and Labor Relations Review*, 11 in the *Journal of Labor Research*, 9 in *Industrial Relations*, and 13 in leading economics journals (such as the *Journal of Political Economy*, *American Economic Review*, and the *Quarterly Journal of Economics*).[7] We infer from this that the published empirical literature is of a very high quality and that there is no basis for distinguishing articles on the basis of publication outlet. That is, it is not valid to argue that there is a significant portion of the studies that were not good enough to get into "good journals."

As is common in meta-analysis, we use the sample size to construct weighted means. Thus a study with a larger sample size is given greater weight regardless of employment levels. There is no way of getting around this problem because few studies report employment levels. It is not possible to use employment levels as weights. This problem affects the meta-analysis but not the meta-regression analysis.[8] In addition to using sample sizes as weights, we also used two alternative weighing methods. The first involved using citations as weights. Citations were derived from the *Social Science Citations Index.* In effect, this is equivalent to using what the profession

[6] A technical appendix is available from the authors detailing the formulas (weighted mean, confidence intervals, and the heterogeneity test) used in the meta-analysis. All the meta-analysis calculations were made using MetaWin version 2. (Rosenberg et al. 2000)

[7] This does not imply that the studies published in the other journals are of inferior quality.

[8] For comparison purposes, we report both the unweighted and the weighted measures of central tendency.

TABLE 2

META-ANALYSIS OF UNION PRODUCTIVITY, PARTIAL CORRELATIONS AND PRODUCTIVITY EFFECTS

	All Studies (2)	U.S. Studies (3)	U.K. Studies (4)	Japanese Studies (5)	U.S. Manufacturing (6)
Number of studies	73	55	7	5	10
Total sample size	58 403	47 549	1 687	4 045	5 004
Mean *r*	+0.03	+0.05	−0.17	−0.01	+0.12
	(−0.21 to +0.26)	(−0.23 to +0.32)	(−1.00 to +0.75)	(−1.00 to +1.00)	(−0.59 to +0.84)
Median *r*	+0.03	+0.04	−0.15	−0.01	+0.11
Weighted mean *r*	+0.01	+0.02	−0.10	−0.08	+0.07
	(0.00 to +0.02)	(+0.01 to +0.03)	(−0.16 to −0.04)	(−0.13 to −0.04)	(+0.04 to +0.10)
Random effects weighted mean	+0.04	+0.06	−0.15	−0.03	+0.10
	(+0.01 to +0.06)	(+0.03 to +0.09)	(−0.28 to −0.01)	(−0.18 to +0.11)	(+0.01 to +0.20)
Range	−0.58 to +0.47	−0.58 to +0.47	−0.46 to +0.09	−0.18 to +0.13	−0.20 to +0.42
Heterogeneity	511***	395***	19**	28***	62***
			Productivity Effects		
Unionization elasiticity	+0.01 [+0.07]	+0.01 [+0.08]	−0.09 [−0.18]	na	+0.08 [+0.01]
Total productivity effect					
Unweighted	+4%	+7%	−11%	−13%	+10%
Sample size weighted	+1%	+3%	−8%	−32%	+10%
Ranking size weighted	+7%	+7%	−14%	−13%	+2%

NOTE: Figures in parentheses are 95 percent confidence intervals. **, *** Coefficient is statistically significant at the 5 and 1 percent levels, respectively, Chi-square test. na means sample size too small to calculate average elasticity.

thinks are the more important studies as weights, as opposed to using an objective measure such as sample size as weights.[9] An alternative approach to weighing studies is to use some measure of journal ranking. This is based on the notion that not all journals are of equal quality. We used the journal rankings reported in Laband and Piette (1994). These weights are based on impact-adjusted citations per article. That is, instead of weighing each study by the citations of that study, we weigh each study by the citations ranking of the journal in which the study was published. It should be noted that this ranking is biased in favor of economics journals at the expense of industrial relations journals. For example, the *American Economic Review* is given a weight of 40.2 compared with 4.4 for the *Industrial and Labor Relations Review*. However, there is a high degree of correlation between the study citation and journal ranking weights. Most of the leading studies have in fact appeared in economics journals. These studies have received the most citations, and the journals themselves are highly ranked. Existing literature reviews tend to ignore the issue of weighting studies formally. Nonetheless, the reviewers do weigh the studies according to a subjective notion of which studies are the most important, and it is interesting to note that this is roughly in line with citation and journal counts.

The average unionization elasticities, as well as the average total union productivity effects, are presented in the lower half of Table 2. The unionization elasticities are calculated using sample size as weights, as well as journal ranking (in brackets). Three different measures of the total productivity effect are presented: without weights, with sample size as weights, and with journal ranking as weights.

Taking all 73 studies together (column 2 of Table 2), the weighted and unweighted means are positive, very small, and similar, with the sample size derived from each study used as weights.[10] The mean can be interpreted as the central tendency of the findings of this group of studies. Is this also an estimate of the underlying and invariant association between unions and productivity? There is some disagreement on this issue. On the one hand, most authors of the studies themselves state that they are testing such an invariant relationship. On the other hand, the association between unions and productivity is likely to be a function of industry-, firm-, and plant-specific industrial relations practices and their interaction with particular production processes.

If it is assumed that there is one true effect size shared by all studies, then the appropriate meta-analysis is known as a *fixed-effects model.* These are

[9] We thank an anonymous referee for this suggestion and interpretation.

[10] Hence the absence of employment levels as weights may not be a problem for this dataset.

denoted as "Mean *r*" and "Weighted mean *r*" in Table 2. A fixed-effects model assumes that the only variation in partial correlations (and productivity effects) between studies is due to sampling error. However, if it is believed that there is a true random component of variation in partial correlations (and productivity effects) between studies, then a *random-effects model* can be estimated. A random effects meta-analysis allows for both sampling error and the random component of union-productivity effect variations (see Raudenbush 1994; Hedges and Vevea 1998). The random-effects model assumes that the union-productivity effect is a random variable that varies across studies. This random variable is assumed to follow some population distribution, usually a normal distribution.[11]

The 95 percent confidence interval around the weighted fixed-effects mean includes zero and for the random-effects mean is close to zero. That is, taking all the available published evidence, the conclusion is that the central tendency of the published results falls around *zero* or is a very small positive association between unions and productivity. This confirms, as well as quantifies, the conclusions reached by traditional qualitative literature reviews.

The impact of unions on productivity may be country-specific, industry-specific, and even time-specific. Indeed, since the studies measure the *net* impact of unions, there is no reason why the balance between productivity-enhancing and productivity-diminishing effects cannot vary over time and between firms, industries, and nations. Accordingly, separate meta-analyses also were conducted for country, industry, and time moderators.[12] For the group of studies using U.S. data (column 3), the average association is only slightly higher than when all studies are combined. However, it is statistically significantly different from zero. For the United Kingdom and Japan, it is clearly negative (columns 4 and 5). The confidence intervals for the studies using U.K. and Japanese data do not include zero, and we conclude that the literature establishes a negative association between unionization and productivity in these countries. Using qualitative review methods, a similar conclusion with respect to the United Kingdom was reached by Booth (1995). A positive association with productivity in U.S. manufacturing

[11] Note that the terms *fixed effects* and *random effects* in meta-analysis have different meanings from those used in panel data analysis. The meta-analysis literature offers very little guidance on the choice between random- and fixed-effects models (see Petitti 2000). Our view is that the fixed-effects model applies for country- and industry-specific subsamples of the literature and that the random-effects model applies only when all the studies are combined. The random-effects model thus is provided mainly as an illustration.

[12] Several other moderators can be considered, such as the type of data (time series, cross sectional, and panel) and econometric specification (Cobb-Douglas and translog). The results from these are not as interesting as those presented in the article.

but not in non-U.S. manufacturing is detected (the latter results are not presented in Table 2). Manufacturing in the United States is characterized by a positive association between unions and productivity. However, these positive union effects are not generalized into the experience of other countries. U.S. manufacturing emerges as the only group of studies with a modest and positive correlation between unions and productivity, whereas for the U.S. group of studies, a positive association is established, but this is small.

The average correlation between unionism and productivity is small. The next issue is whether this is of economic significance. This can be answered, in part, by analyzing the productivity differential. The union-productivity establishment and total productivity effects are presented in the lower half of Table 2. The unionization elasticities are very small, suggesting a very inelastic output response with respect to unions. However, the average total productivity effects in U.K., Japanese, and U.S. manufacturing industries are both statistically significant and of economic significance. Unions have a significant detrimental impact on productivity in the United Kingdom and Japan and are associated with a significant positive productivity differential in U.S. manufacturing. The productivity effect in the United States, however, falls short of the impact of unions on wages. Unions have been estimated to lead to wage increases on the order of about 15 percent (Kuhn 1998). When the productivity and wage effects are combined, we can conclude that unions have a negative impact on profitability. This is consistent with studies that have explored the impact of unions on profits (such as Hirsch 1991; Bronars and Deere 1990, 1994; Laporta and Jenkins 1996; Machin and Stewart, 1990, 1996).

When sample size is used, the weighted average partial correlation between unions and productivity is +0.03. When study citations are used as weights, this rises to +0.11, and when journal ranking is used as weights, the partial correlation becomes +0.10 (these are not reported in Table 2). The sample size weighted mean is much closer to the unweighted mean. In some cases, changing the weights dramatically changes the average productivity effects (see the lower half of Table 2). For example, the average total productivity effect is +1 percent when all the studies are combined, but this becomes +7 percent when journal ranking is used as a weight. We prefer to follow the standard practice in meta-analysis and use sample size as weights.

The literature indicates that the impact of unionism varies with product market structure, especially with the degree of competition. For instance, the union effect was found to be large where there was strong competition in the product market (Clark 1980a), whereas no significant effect was found in the public sector where there is relatively little competitive pressure (Ehrenberg, Sherman, and Schwarz 1983). Industries differ not only in terms of their market structure but also in terms of many other dimensions, such as the type of technology employed, the composition of the workforce, and growth rates. In the U.S. manufacturing industry, the productivity effect seems to be much greater than that for manufacturing in other countries, and this could reflect differences in market structure that moderate the association between unionism and productivity in other countries. In all cases, the chi-squared test indicates that the studies are heterogeneous. That is, the partial correlations and hence the union-productivity effects are drawn from studies where the union productivity is moderated in some fashion. Therefore it is important to explore differences between studies further. This exploration is presented in below.

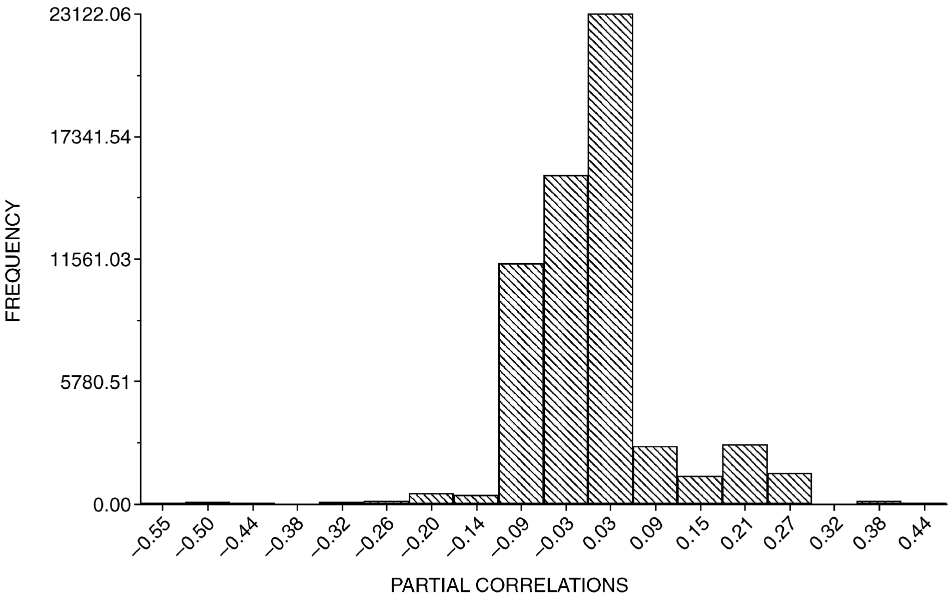
Sensitivity Analysis. In order to test the sensitivity of the results, the meta-analysis was performed also after eliminating some of the studies. We eliminated first the extreme partial correlations by deleting 5 percent of the largest negative partial correlations and 5 percent of the highest positive partial correlations. Elimination of these potential outliers has negligible effect on the statistics reported in Table 2. We also eliminated 5 and 10 percent of the studies with larger sample sizes because these can influence sample size weighted averages. After eliminating 5 percent of the studies with the largest sample sizes, the weighted average r rises to +0.04, with a 95 percent confidence interval of +0.03 to +0.05. When 10 percent of the studies with the largest sample sizes are eliminated, the weighted average becomes +0.05 with a 95 percent confidence interval of +0.04 to +0.06. The larger studies do influence the size of the union-productivity association, but there is no reason to exclude these studies from the meta-analysis.

Publication Bias. Publication bias can take one of two forms. First, authors may submit only research with statistically significant results, and journals may prefer to publish only statistically significant results. Second, there may be a tendency of certain authors to report certain types of results, and there may be a tendency for particular journals to publish certain types of results. We discuss the possibility of the first type of publication bias in this section and explore bias in the types of results reported (e.g., certain authors report only positive results) through meta-regression analysis.

Many of the published studies found no relationship between unions and productivity. This result is likely to have been experienced by other researchers. Hence it is possible that some authors removed the unionization variable from their published material if the unionization variable was not statistically

FIGURE 1

WEIGHTED HISTOGRAM, UNION-PRODUCTIVITY EFFECTS, PARTIAL CORRELATIONS.



significant. This is more likely to be the case when the author's primary research interest is not unionization. These insignificant results are important. There may be a bias in favor of statistically significant results, and if this is the case, then the available published literature will reflect this. If there are other insignificant results (in file drawers), then the omission of these results can have a negative impact on the results of meta-analysis, just as they would in *any* review of the literature. The situation is not improved by using unpublished material. In many cases the unionization variable may be omitted during the estimation stage and not even make it to the unpublished working paper/manuscript state. This problem plagues almost any empirical literature, and there is little that can be done about it.

There are a number of ways of exploring the suppression of insignificant results. First, Table 1 reveals that this is not an area where insignificant studies are not published. Indeed, about 40 percent of the studies reported an insignificant result. Second, we can explore this issue through the weighted histogram presented in Figure 1. The heights of the bars are the combined weight of the studies that fall within that class, using sample size rather than the number of studies as the frequency. The interesting thing about the histogram for this set of studies is that it is centered around the zero inclusive −0.03 to +0.03 partial correlation range. The large proportion of insignificant results suggests that publication bias (in the form of suppressing insignificant results) is not a significant problem for this literature. It also indicates a near-zero association between unions and productivity, on average. It is important to note that this is simply a measure of central tendency in a body of literature. It is tempting to argue that the outliers—those studies with relatively large positive or large negative correlations—are in some way misleading. However, while we can measure central tendency, it is possible (although not probable) that the outliers (such as the negative tail in the distribution) are correct and that most of the studies are incorrect.

Third, one very popular way of addressing this issue is by calculating what are known as *fail-safe numbers* [see Rosenthal (1979) for discussion and formula]. These are the number of unpublished studies that would need to exist, filed away and unavailable to researchers, to change the results. In order to change the meta-analysis results derived when using all the union-productivity effects studies combined, there would have to be about 494 unpublished studies. For the U.S. manufacturing subsample, there would have to be 94 unpublished studies (compared with the 10 existing published studies) in order to change the results. It is unlikely that there are so many unpublished studies. This suggests that publication bias is not a serious problem in this literature.

Fourth, Card and Krueger (1995) argue that if publication bias is not present, then the absolute value of the t ratio should vary proportionally with the square root of the number of degrees of freedom on the basis that standard error declines as sample size rises. They suggest a simple test of regressing the log of the t-statistic on the log of the square root of the degrees of freedom. The expectation is that this should yield a coefficient equal to 1. This test was performed for the 73 studies, and while the coefficient was positive, it was very low, suggesting publication bias. However, the power of this test is unknown. On the basis of the histogram, fail-safe numbers, and a large proportion of published insignificant results, our assessment is that the suppression of statistically insignificant results is not likely to be a major problem in this literature.

Meta-Regression Analysis

A number of econometric and measurement issues emerge concerning the estimation of union-productivity effects and the possibility of biased estimates [see Booth (1995) for a detailed review]. As in most areas of empirical investigation, diverse measures of inputs and outputs are used, and these can produce differences in the estimated effect of unions. Specification differences are an obvious source of potential differences in estimates of union-productivity effects. It is of course possible that there is no universal association between unionism and productivity. Unlike the physical sciences, where regular universal laws are established, this is less likely in the sphere of economics and industrial relations. There are many contextual variables that may help us to accept the conflicting findings in the literature. For example, in the collective voices model, the industrial relations climate is assigned a critical role (Freeman and Medoff, 1984). Another moderator could be competition. Competition is said to interact with unionism to bring a positive productivity effect (see Katz, Kochan, and Gobeille 1983; Schuster 1983; Mandelstamm 1965).

Obviously, measurement of both the dependent and explanatory variables can influence estimates. Most of the empirical investigations use a production function framework specifying a relationship between the key inputs, mainly labor and capital, and use physical output or value-added measures of productivity as the dependent variable. Control variables used include labor quality, market structure, and plant/firm/industry characteristics. In addition, the key variable of interest is some measure of unionization.

The major objective of the meta-regression analysis (MRA) undertaken here was to investigate the impact of the following on the estimates of the union-productivity association: (1) the impact of sample size, (2) the impact of the type of data (time-series, cross-sectional, panel data), (3) whether there is any identifiable pattern in the results attributed to individual authors, (4) whether individual journals and authors tend to publish certain results, (5) whether the year of publication plays a role, (6) the year the data relate to, (7) the links with union density, (8) the influence of control variables, (9) specification differences, (10) the impact of data aggregation, e.g., firm-level data as opposed to industry, and (11) the existence of cross-author effects, where the research of one author is influenced by that of another author publishing in the same area. We have no prior expectation about the influence of most of these differences across studies. For example, there is no reason to suspect that the use of time-series data will lead to systematic differences in results, as opposed to, say, using cross-sectional data. We do, however, suspect that certain features will be important. For instance, the restrictive nature of the Cobb-Douglas specification and the imposition of constant returns to scale may be problematic (see Bairam 1994; Booth 1995). Physical measures of output are preferable to value-added ones, and there is some debate about the relative merits of using a dummy variable to denote union presence as opposed to, say, using union density. Likewise, it is possible that the level of aggregation of data involved in using countrywide data may disguise important influences at the industry level, with a similar logic applying for industry-versus firm-level data. The exact magnitude and direction of bias are a matter of empirical investigation and the focus of meta-regression analysis.

There are a large number of potential moderator variables. For example, theory identifies factors such as closed-shop arrangements, recognition of unions by firms, existence of participatory mechanisms, existence of multiunionism, competitive pressures, establishment size, and industrial relations climate as important in moderating the impact of unions on productivity. The aim of meta-regression analysis is to identify moderator variables associated with the empirical literature and to explore the impact of specification differences. Unfortunately, many of the factors that theory identifies as important cannot be investigated. The meta-regression analysis is restricted to data drawn from the studies themselves. For example, there are not enough observations to explore the impact of closed-shop arrangements and multiunionism.[13]

With the exception of sample size, publication year, and union density, the explanatory variables undertaken in the meta-regression are dummy variables. Equation 1 (presented earlier) also includes variables that can be quantified (the K values). These are variables for which authors present the average value and include the establishment size, the capital-to-labor ratio, and union density. Unfortunately, too few studies provided information on establishment size and the capital-to-labor ratio. Hence the impact of these variables could not be tested. However, 24 studies did provide information on average union density. A separate meta-regression analysis was undertaken with union density as an additional explanatory variable.

With only 73 observations it is necessary to limit the number of potential moderating variables. The procedure adopted was as follows: First, after assembling all the available information from each of the published studies, a list of potential moderator variables was constructed. Second, the simple correlation coefficients were calculated for each of the potential moderating variables and the union-productivity effect. This helped to identify which potential moderator variables could be omitted as candidates on the basis of very small simple correlation coefficients. The simple correlation coefficients of all pairs of variables also were examined to detect the existence of high collinearity among potential explanatory variables. This process

[13] An additional issue concerns the possibility of selectivity. For example, unions may choose to unionize more productive firms (see Chezum and Garen 1998). This issue is not explored in the meta-analysis.

TABLE 3

Selected Characteristics of the Union Productivity Literature

Study Characteristic	Proportion of Studies
Used U.S. data	75%
Used manufacturing data	27%
Used density	44%
Used cross-sectional data	62%
Published in an industrial relations journals	48%
Controlled for employee participation	33%
Used Cobb-Douglas specification	64%
Controlled for capital stock	75%

produced 31 explanatory variables. The definitions of these variables are presented in Appendix A.[14]

Table 3 shows the proportion of studies possessing certain characteristics. For example, 75 percent of the studies used U.S. data, 62 percent of the studies used the Cobb-Douglas specification, and 64 percent of the studies used cross-sectional data.

The third step involved using the 31 potential explanatory variables in meta-regression analysis.[15] The dependent variable in all the models presented in Table 4 is the total productivity effect associated with each of the studies.[16] Initially, a base regression model was estimated. The results are presented in column 2 of Table 4. This is our starting meta-regression model. Not surprisingly, many of the variables in the base or general model are not statistically significant.[17] The base or general model was reestimated after sequentially eliminating variables until all remaining variables were statistically significant at the 10 percent level of significance. This process of sequentially eliminating statistically insignificant variables is known as the *general-to-specific modeling strategy* (see Hendry 1995). The final or specific

[14] In order to test the sensitivity of the results to the exclusion of a number of variables, meta-regression analysis also was undertaken with the addition of the excluded variables to the models presented in Table 4. In all cases, statistical tests show that these variables can be excluded from the meta-regression analysis.

[15] Eviews 4.0 was used for all the meta-regression analyses, as well as for the diagnostic tests.

[16] The meta-regression analysis results using partial correlations as the dependent variable are available from the authors. These are mainly similar to those presented for total productivity effects; e.g., all the variables that appear as statistically significant in the regressions reported in Table 4 are similarly significant when partial correlations are used as the dependent variable. Naturally, the partial correlations and the associated productivity effects are highly correlated (the simple correlation coefficient between the two is 0.74).

[17] Although most of the explanatory variables are not highly correlated, there is still the possibility of multicollinearity in the form of complex associations among the explanatory variables.

TABLE 4

META-REGRESSION ANALYSIS, UNIONS AND PRODUCTIVITY LEVELS (DEPENDANT VARIABLE = TOTAL PRODUCTIVITY EFFECTS)

Variable	General Model	Specific Model	Reduced-Sample Specific Model	Production Framework Studies	Union Density Studies
			Industry		
CONS	−2.15 (−0.16)	—	—	—	—
MANUF	5.22 (0.59)	—	—	—	—
EDUCAT	16.89 (1.26)#	—	—	—	—
			Specification		
CAPITAL	−3.28 (−0.33)	—	—	—	—
PRODFUN	3.75 (0.31)	—	—	—	—
FRONT	−1.24 (−0.08)	—	—	—	—
COBB	6.53 (0.71)	—	—	—	—
LABOR	31.76 (3.39)***	27.27 (5.03)***	17.45 (4.56)*** [25.58 (4.49)***]	28.22 (4.10)***	29.30 (1.62)
DENSITY	−15.16 (−1.31)#	—	—	—	—
			Data		
FIRM	−14.75 (−1.54)#	−7.01 (−1.75)*	−5.28 (−1.62)# [−7.23 (−1.92)*]	−10.67 (−1.91)*	−8.51 (−0.69)
INDIVID	−9.26 (−0.65)	—	—	—	—
UK	−10.14 (−0.80)	—	—	—	—
JAPAN	−12.10 (−1.06)#	—	—	−13.94 (−2.07)**	—
USA	11.99 (1.00)#	13.60 (2.49)***	15.79 (4.20)*** [17.20 (3.23)***]	12.77 (1.93)*	10.00 (0.98)
PRIVATE	14.10 (1.30)#	—	—	—	—
SAMPLE	−0.005 (−2.13)**	−0.003 (−2.35)**	−0.002 (−2.30)* [−0.003 (−0.86)]	−0.004 (−2.66)**	−0.02 (−3.17)***
			Publication		
BOOKS	−4.29 (−0.32)	—	—	—	—
ECOJ	−0.25 (−0.02)	—	—	—	—
MANJ	17.87 (1.35)#	12.65 (2.34)**	16.73 (3.79)*** [16.80 (2.21)**]	—	6.53 (0.43)
JLR	−29.00 (−2.59)**	−20.00 (−2.84)***	−9.90 (−1.80)* [−10.00 (−1.00)#]	−24.51 (3.62)***	−74.42 (−4.28)***
ILRR	−9.25 (−0.75)	—	—	—	—
INFLUEN	−13.35 (−1.86)*	−14.23 (−2.85)***	−11.38 (−3.73)*** [−8.03 (−1.59)#]	−13.16 (−2.23)**	−2.31 (−0.24)

			Time		
YEAR	0.25 (0.31)	—	—	—	—
1960	−12.84 (−1.53)#	—	—	—	—
1970	9.40 (1.09)	10.06 (1.82)*	8.06 (2.33)** [13.37 (2.29)**]	—	42.50 (2.53)**
1980	3.98 (0.49)	—	—	—	—
1990	−8.45 (−0.70)	—	—	—	—
			Measurement		
VALUE	−15.49 (−1.62)#	−17.84 (−2.49)**	−3.28 (−0.74 [−12.79 (−1.83)*]	−17.95 (−2.53)**	−59.29 (−3.82)***
PANEL	−2.68 (−0.36)	—	—	—	—
TIME	−20.94 (−1.70)*	−28.74 (−3.76)***	−19.75 (−2.73)*** [−11.47 (−1.51)#]	−33.27 (−3.45)***	−9.90 (−0.62)
			Others		
UFOCUS	−3.59 (−0.48)	—	—	—	—
# UNION	—	—	—	—	−39.61 (−1.25)
CONSTANT	−439.89 (−0.25)	6.12 (1.19)	−2.69 (−0.67) [−3.83 (−0.64)]	17.50 (2.97)***	30.27 (1.68)
R-Squared	0.64 (0.35)	0.55 (0.48)	0.53 (0.44)	0.56 (0.47)	0.84 (0.69)
(Adjusted R-Squared)			[0.47 (0.37)]		
F-Statistic	2.19**	7.47***	5.95***	6.12***	5.61***
Log-Likelihood	−291.64	−303.01	−238.96	−230.35	−97.37
Sample size	70	71	63 [63]	53	24

NOTE: *t*-Statistics in parenthesis. *, **, *** Coefficient is statistically significant at the 10, 5, and 1 percent levels, respectively. # *t*-Statistic is greater than 1.

model is presented in column 3. In order to test the sensitivity of the meta-regression analysis, the specific model was reestimated with some of the outliers removed. First, we removed 5 percent of the largest positive and largest negative total productivity effects. Second, we removed 5 percent of the smallest and 5 percent of the largest sample size studies. These results are presented in column 4 of Table 4, with the later estimates presented in brackets.

We concur with the body of literature that argues for the adoption of a production function as the preferred framework for investigating the impact of unions on productivity (e.g., Brown and Medoff 1978). Unions affect the production process, and hence empirical investigations should attempt to model this process. In particular, a sound modeling strategy should at least control for capital stock. In addition, it is desirable to control for the quality of the labor input and, where it is appropriate, to allow for technical change in the production process. Capital stock, labor quality, and technical change are all likely to vary in response to cost-minimizing responses by firms to unionism. Accordingly, the meta-regression analysis was carried out separately only on those studies which adopted a production process framework *and* which controlled for capital stock. This reduces the sample from 73 to 53 studies. In some ways this group can be regarded as a sort of best-practice group of studies. The meta-regression analysis was undertaken by first estimating a base model and then reducing this sequentially. The results of the final reduced model are presented in column 5.

The meta-regression results presented in column 6 relate only to studies that used union density as the measure of union presence. This allows investigation of the hypothesis that higher union density is associated with lower estimated union-productivity effects. One of the findings in some of the individual studies is that the association between unions and productivity is moderated by union density. That is, the association may be different at low levels of union density compared with high levels of union density. The key variable of interest is %*UNION*—which is the average union density associated with each study. This reduces the sample to only 24 studies and hence limits this analysis.[18] The coefficient on %*UNION* does have the expected negative sign. Studies using higher levels of trade union density tend to find lower union-productivity effects. However, %*UNION* is not statistically significant, and we can reject this hypothesis.[19]

It is useful to group the explanatory (moderator) variables. The first group of variables explores industry-specific effects through the *CONS*, *MANUF*,

[18] Many of the studies using union density did not report the mean density, and this information is not available from alternative sources.

[19] The inclusion of density squared does not improve these results.

and *EDUCAT* variables. None of these is statistically significant. Note that *MANUF* and *USMANUF* are highly correlated (simple correlation = 0.69), and hence *USMANUF* was not included at the same time. If the general model is estimated with *USMANUF* instead of *MANUF*, the coefficient on *USMANUF* is also positive but not statistically significant. If *USMANUF* is added to the specific model presented in column 3, it has a coefficient of 10.59 and a *t*-statistic of 1.17.

The next set of variables involves specification issues, most of which relate to characteristics of production functions. Of these, only the *LABOR* variable was statistically significant. Controlling for labor quality tends to increase the reported union-productivity effect. This is consistent with the argument advanced by Wessels (1994) that unionized firms do not hire better-quality workers. The *DENSITY* variable was included to capture any differences between studies that used union density to measure union presence and those which used a union dummy. Some studies measured union presence as union recognition for collective-bargaining purposes. These were grouped together with the union dummy studies. The way unionization is measured does not appear to make any difference to the estimated effects. Note that if *DENSITY* is added to the specific model presented in column 3, it has a coefficient of −10.02 and a *t*-statistic of −1.52.[20]

The third category of variables relates to data differences, exploring differences in productivity effects across nations, levels of data aggregation, and sample size. Studies that use firm-level data (as opposed to data aggregated at the industry level) report lower total productivity effects. Studies using U.S. data find positive union-productivity effects or lower negative union-productivity effects compared with other countries. This is consistent with the meta-analysis presented in Table 2 and is at odds with some of the qualitative reviews. For example, in her review, Booth (1995:197) argued that "unions in the USA do not appear to increase productivity *on average*" (emphasis in original). *JAPAN* emerges with a statistically significant negative coefficient in the production function group of studies.[21] *SAMPLE* is added to capture any association between the size of the database used and the estimated union-productivity effect. This association is revealed to be negative. In his review of the literature, Kuhn (1998:1048) argued that "a willing eye can detect a pattern in the results across studies: Negative effects may be more likely in the public sector." This hypothesis can be tested

[20] However, if partial correlations are used as the dependent variable, DENSITY has a negative and statistically significant coefficient in the production framework subset group of studies.

[21] If the *JAPAN* variable is added to the specific model presented in column 3, it has a coefficient of −10.10 and a *t*-statistic of −1.48.

through the *PRIVATE* variable. While it does have the hypothesized positive coefficient, it is not statistically significant.

As indicated earlier, the existence of publication bias can be explored through meta-analysis. Publication issues are examined through several variables. In unreported results, dummies were used for individual author effects, testing, for example, whether publications by Allen, Clark, and Kleiner generate distinct estimates. There is no evidence that this is so. However, Table 4 shows that three publication-related variables are important. Papers published in management journals (*MANJ*) tend to find positive productivity effects. The average union-productivity effect published in these journals is around +24 percent compared with +9 percent in economics journals and −4 percent in industrial relations journals (with a similar pattern in the partial correlations). After controlling for other study characteristics, the variable for *JLR* has a negative coefficient.[22]

There is no foolproof way to detect and measure the influence that one author may exert on another. While it is true that a number of authors have associated with each other, there is no reason to believe that their research is biased in any systematic manner. The existence of a cross-author effect is investigated through the *INFLUEN* variable, which attempts to capture the influence of any author over another.[23] This variable is statistically significant. The negative coefficient indicates that studies conducted by authors who have acknowledged receiving advice/comments/suggestions from other researchers who have published in this area tend to find lower union-productivity effects. Naturally, it is possible for authors to be influenced by other researchers whom they have not acknowledged. Such effects cannot be tested.

Do the *MANJ*, *JLR*, and *INLFUEN* variables indicate publication bias? Not necessarily. The results for *JLR* could, for example, reflect a self-selection process by the authors and possibly even more carefully prepared studies. The results for *INFLUEN* could reflect the execution of more accurate studies as a result of the influence of other authors. The results are nevertheless interesting. If we accept that studies published in other journals, such as the *Industrial and Labor Relations Review* and *Industrial Relations*, are also of high quality, then the negative coefficient on *JLR* may indicate publication bias. After controlling many other aspects of the studies, *JLR* is the only publication outlet with a negative coefficient. A similar conclusion

[22] Sixty-four percent of the studies published in this journal reported a negative productivity effect.

[23] The *INFLUEN* variable also can be divided into two separate groups—one that includes those studies acknowledging links with Freeman, Brown, and/or Medoff, and the other group involves studies acknowledging links with other authors. The use of these two separate variables produced unstable parameter estimates.

can be drawn for management journals, which are the only publication outlet that records a positive coefficient.

Time effects are explored through four year dummies with 1950 as the base. *YEAR* is included to capture the fad effect. Certain types of research become fashionable in journals at certain periods of time, and this variable is designed to capture this. There is no evidence that this is the case. Of the time dummies, only the *1970* variable was significant, suggesting that studies that used data relating to the 1970s found favorable productivity effects compared with other years. It is not clear why this is the case.

A number of measurement variables are included. Output measurement issues are investigated by the inclusion of *VALUE*, comparing these studies with those which used a physical measure of output. The type of data is captured by *TIME* and *PANEL*, with cross-sectional data as the base. *A priori*, the use of valued-added measures can be expected to overstate the union-productivity effect. Value-added measures of output may be influenced by the impact of unions on wages, which are then passed onto consumers through higher prices. Interestingly, after controlling for other study characteristics, the coefficients on *VALUE* are negative. Studies measuring output as value added report lower productivity effects. A similar effect emerges with respect to studies that use time-series data.

The other variable appearing in the regressions is *UFOCUS*, which is added to capture any differences between studies whose primary focus was estimation of the union-productivity effect versus those studies which included unionization merely as a control variable. It may be the case that studies that set out to investigate the impact of unionization may give more thought to the relevant issues and hence may produce different results than studies that include unions merely as a control variable. This variable is not statistically significant.

Diagnostic tests were conducted on each of the mega-regression analysis models in order to test their reliability. These were the Jarque-Bera test for normality of the residuals, White's heteroscedasticity test, and Ramsey's RESET test (a test for general mispecification). These are large-sample tests and hence should be interpreted with caution. Nevertheless, the diagnostic tests indicate that the meta-regression models appear to be free from heteroscedasticity and mispecification. This is comforting because it is important to pay particular attention to heteroscedasticity in meta-regression analysis.

What do the estimated models presented in Table 4 tell us about the union-productivity effect? First, it is clear that at least some of the variation in published results is artifactual. That is, it is the product of measurement, data, and specification differences rather than differences in the underlying union-productivity effect. This is evidenced by the statistical significance of variables such as *LABOR*, *FIRM*, *SAMPLE*, and *TIME*. We conclude that the way models are constructed and especially the type of data used does systematically influence the reported union-productivity effects. Second, the statistical significance of the *USA* and *JAPAN* variables shows that some of the variation in published results derives from real economic forces rather than the way the studies are conducted. Third, many control variables do not affect the union-productivity association. This does not mean that they should not be included in empirical investigations, only that the union-productivity association appears to be insensitive to them. Fourth, there is a tendency for positive results to be published in some parts of the literature and negative results in others, suggesting the possible existence of some publication bias in this literature. The results are suggestive only, but do raise the specter that at least part of this literature may present a misleading picture of the union-productivity effect. If the studies published in management journals and the *JLR* are deleted, the average unweighted union-productivity effect for the whole literature is about +4 percent. If sample size is used as weights, the average union-productivity effect is +10.5 percent for the entire literature. Clearly, the issue of publication bias warrants further investigation.

After reviewing the literature, we offer a number of comments regarding methodology and reporting of results. First, specification of the production function itself is of some interest. Most studies used the Cobb-Douglas specification. It is well known that the Cobb-Douglas specification is a very restrictive functional form. However, only a handful of studies reported (either in the text or in the footnotes) actually testing the appropriateness of this specification versus more flexible specifications, such as the translog.

Second, a production-function approach offers the best approach for modeling the production process and hence the role of unions within that. Most studies have in fact used this approach and have allowed for the influence of labor and capital to be controlled for. However, given the substantial evidence that inefficiency exists in the production process (Leibenstein 1966), it seems inappropriate to assume that the production process occurs with full technical and allocative efficiency. Kalirajan and Shand (1994:7) point out that use of ordinary least squares (OLS) is also at odds with economic theory because the conventional approach is estimating a "sort of average production function and observed outputs typically lie both above and below the estimated function" when economic theory is based on the notion of maximum potential output, so actual observations lie below the frontier. If there is inefficiency in the production process, then the use of OLS will tend to lead to inefficient estimates of the production function parameters (see Fried, Lovell, and Schmidt 1993; Coelli, Rao, and Battese 1998). Most studies, however, have used OLS.

It is not sufficient to use a production function; it is important to allow for inefficiency within that production function. Indeed, it seems inappropriate to investigate the impact of unions on productivity without allowing for inefficiency in specification of the production function. Only a small number of studies have allowed for this (e.g., Byrnes et al. 1988; Bronars, Deere, and Tracy 1994; Cavalluzzo and Baldwin 1993; Dickerson, Geroski, and Knight 1997).[24] Cavaluzzo and Baldwin (1993:211) compared the normal OLS approach with the frontier approach and concluded that "the estimated union effect obtained via maximum likelihood exceeds the OLS estimate in each case." A comparison of the traditional econometric and the inefficiency-based analyses, in those studies which provide this, reveals that *in all cases* the traditional methodology generates biased estimates of the union-productivity effect, but the bias is not in a consistent direction. Since there are such few examples, we need to be cautious about reading too much into this.[25] However, on theoretical grounds, the efficiency-based framework is more sound.

Finally, there is the issue of reporting standards. Many studies failed to report important information, such as sample means. This restricts comparisons between studies. With growth in both interest in the evaluation of a body of literature and techniques for doing so, authors should aim to increase the value of their work by providing enough information so that others can use their research in a manner that will facilitate the synthesis of research from various studies.

Concluding Remarks

As in many areas in economics and industrial relations, theory does not establish an unambiguous association between unions and productivity. Importantly, the empirical literature has not resolved the conflicting theoretical arguments. Meta-analysis and meta-regression analysis offer one way of synthesizing the available empirical evidence and drawing statistically valid inferences from it. Meta-regression analysis is useful in quantifying the impact of differences in study characteristics on research findings.

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[24] Inefficiency in the production process can be introduced by modifying specification of the error structure. For example, consider a Cobb-Douglas production function, with $\ln Y_{it} = \alpha_0 + \alpha_1 \ln L_{it} + \alpha_2 \ln K_{it} + \beta_1 U_{it} + u - v$. The u is a two-sided symmetric random disturbance term assumed to be iid $N(0, \sigma_u^2)$ and v is a nonnegative term that captures inefficiency in the production process. This has to be estimated using maximum-likelihood techniques.

[25] However, the coefficient on the dummy variable distinguishing those studies which explicitly modeled inefficiency in the production process (*FRONT*) is not statistically significant.

The results from meta-analysis presented here suggest that if all the available evidence is pooled together, measures of central tendency indicate a near-zero association between unions and productivity. However, there exist country- and industry-specific associations between unions and productivity. A negative association appears for the United Kingdom and Japan, whereas a positive one exists for the United States in general and for U.S. manufacturing in particular.

The meta-regression results suggest that at least part of the variation in the estimated association between unions and productivity across studies is due to differences in study characteristics rather than to differences in the actual union-productivity effect.

There are several issues that warrant further investigation. Additional empirical investigations are needed in countries other than the United States and the United Kingdom. A clearer picture of the role of unions and productivity within a framework of inefficiency is also important. There is also need for additional investigations on the role of industrial relations climate and the role of establishment size and union density in moderating the union-productivity association. If the underlying relationship between unions and productivity is not universal and, for example, changes over time as well as across industry, then a change in research direction is warranted. In particular, researchers need to allow explicitly for these changes to be captured in their modeling strategies.

Furthermore, unions have an impact on areas other than productivity. There is a significant literature on the association between unions and employment, unions and profitability, and unions and productivity growth. Meta-analyses in these areas would offer additional insights into the net impact of unions on performance. A number of studies have found that unionization has a negative effect on stock prices, whereas others have found that it can be detrimental to productivity growth. These are consistent with the results presented in this article. For example, unions can have a mild productivity-enhancing effect while also reducing profitability (higher-priced union labor) and productivity growth. The stock price effect is a reflection of profitability and concerns over future prospects rather than current productivity levels. Firms and financial markets are concerned not just with productivity levels but also with productivity growth. Indeed, the latter maybe given greater weight. Additionally, firms are likely to compare the returns from unionization with those from other interventions, such as profit sharing and employee stock ownership. These interventions may make greater contributions to productivity than unionization. These factors could help explain, at least in part, the decline in union density and membership numbers, even if unions have a positive impact on productivity.

Finally, it has to be noted that a balanced assessment of unions should consider not only output effects but also the value to union members, and society as a whole, of benefits such as employment security and a safer worker environment that may result from unionization.

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APPENDIX A
Definitions of Variables Used in the Meta-Regression Analysis

The following are the variables used in the meta-regression analysis, together with the means (M) and standard deviations (SD).*

CONS: Dummy variable, with 1 = data relates to construction industry, 0 = otherwise (M = 0.08, SD = 0.27).

MANUF: Dummy variable, with 1 = data relate to manufacturing industry, 0 = otherwise (M = 0.27, SD = 0.45).

USMANUF: Dummy variable, with 1 = data relate to U.S. manufacturing industry, 0 = otherwise (M = 0.14, SD = 0.34).

EDUCAT: Dummy variable, with 1 = data relate to education industry, 0 = otherwise (M = 0.11, SD = 0.31).

CAPITAL: Dummy variable, with 1 = a measure of capital stock was included in the study, 0 = otherwise (M = 0.74, SD = 0.44).

PRODFUN: Dummy variable, with 1 = a production function was used, 0 = otherwise (M = 0.84, SD = 0.37).

FRONT: Dummy variable, with 1 = a stochastic production frontier was estimated, 0 = otherwise (M = 0.09, SD = 0.29).

COBB: Dummy variable, with 1 if the Cobb-Douglas specification was used, 0 = otherwise (M = 0.65, SD = 0.48).

LABOR: Dummy variable, with 1 = a measure of labor quality was included in the study, 0 = otherwise (M = 0.23, SD = 0.42).

DENSITY: Dummy variable, with 1 = trade union density was used as a measure of union presence, 0 otherwise (M = 0.45, SD = 0.50).

FIRM: Dummy variable, with 1 = firm level/establishment data used, 0 = otherwise (M = 0.61, SD = 0.49).

INDIVID: Dummy variable, with 1 = individual worker data used, 0 = otherwise (M = 0.12, SD = 0.33).

UK: Dummy variable, with 1 = U.K. data was used, 0 = otherwise (M = 0.08, SD = 0.27).

JAPAN: Dummy variable, with 1 = Japanese data was used, 0 = otherwise (M = 0.07, SD = 0.25).

USA: Dummy variable, with 1 = U.S. data was used, 0 = otherwise (M = 0.76, SD = 0.43).

PRIVATE: Dummy variable, with 1 = the study uses private-sector data, 0 = the study relates to the public sector (M = 0.82, SD = 0.39).

SAMPLE: The sample size used in each study. This was scaled by dividing sample size by 1000 (M = 801, SD = 1454).

BOOKS: Dummy variable, with 1 = study was published in a book, 0 = otherwise (M = 0.16, SD = 0.37).

ECOJ: Dummy variable, with 1 = study published in an economics journal (e.g., the *Quarterly Journal of Economics*), 0 = otherwise (M = 0.34, SD = 0.48).

MANJ: Dummy variable, with 1 = study published in a management journal (e.g., the *Academy of Management Review*), 0 = otherwise (M = 0.05, SD = 0.23).

JLR: Dummy variable, with 1 = study published in the *Journal of Labor Research*, 0 = otherwise (M = 0.15, SD = 0.36).

ILRR: Dummy variable, with 1 = study published in the *Industrial and Labor Relations Review*, 0 = otherwise (M = 0.18, SD = 0.38).

YEAR: The publication year (M = 1990, SD = 6).

1960: Dummy variable, with 1 = study used data relating to the 1960s, 0 = otherwise (M = 0.15, SD = 0.36).

1970: Dummy variable, with 1 = study used data relating to the 1970s, 0 = otherwise (M = 0.57, SD = 0.50).

1980: Dummy variable, with 1 = study used data relating to the 1980s, 0 = otherwise (M = 0.50, SD = 0.50).

1990: Dummy variable, with 1 = study used data relating to the 1990s, 0 = otherwise (M = 0.15, SD = 0.36).

VALUE: Dummy variable, with 1 = value added measure of output, 0 = otherwise (M = 0.38, SD = 0.49).

PANEL: Dummy variable, with 1 = if panel data used and 0 = otherwise (M = 0.31, SD = 0.47).

TIME: Dummy variable, with 1 = if time series data used and 0 = otherwise (M = 0.11, SD = 0.31).

INFLUEN: One test for the existence of a cross-author effect is to construct a dummy variable taking the value of 1 if the author acknowledges in the study the comments/suggestions/assistance of another author included in the pool of studies (M = 0.32, SD = 0.47).

UFOCUS: Dummy variable, with 1 = if the principal focus of the study, was to investigate the union-productivity effect, 0 = otherwise (M = 0.76, SD = 0.43).

%UNION: The mean value of union density, expressed as a percentage.

* Other variables considered but not included in the final meta-regression analysis were the number of productivity effects drawn from each study; whether selectivity issues were explored; the use of a constant returns to scale specification; controlling for the influence of employee participation

schemes; the estimation technique (e.g., OLS and IV); whether the data related to perception of productivity and productivity relative to competitors; if dynamics were controlled for; if firm-specific characteristics were controlled for; workplace size; use of regional dummies; if control variables were used to reflect individual worker characteristics, such as education level, age, gender; and if a measure of market structure was included in the study. Many of these variables cannot be tested properly due to small sample size.