THE
QUARTERLY JOURNAL
OF ECONOMICS

THE EFFECTS OF UNIONIZATION ON THE
DISTRIBUTION OF INCOME:
A GENERAL EQUILIBRIUM APPROACH

HARRY G. JOHNSON AND PETER MIESZKOWSKI

A geometrical analysis, 540. — A numerical analysis, 547. — A model with two types of labor, 558. — Monopoly elements, 559. — Concluding remarks, 560.

Recent work by H. Gregg Lewis[1] and many others contains strong evidence that, as would be expected, unions increase the wages of their members relative to the wages of nonunionized workers. However, it does not necessarily follow that unions increase the *real* wages of their members. Even if union members gain from unionization, at whose expense do they make their gains? It is quite possible that unionization decreases the real wages of labor as a whole. It is even conceivable that union members are *absolutely* worse off than they would be in a competitive labor market. Those are the issues which we shall be dealing with in this investigation of the general equilibrium impact of unions.[2]

In the United States unions are concentrated in certain sectors of the economy, and the increases in money wages in those sectors result in a set of complicated general equilibrium adjustments. In the unionized industries the prices of the products rise relative to the prices of nonunion goods, output decreases, and capital is substituted for labor. The labor released by this process is then absorbed by the nonunion sectors of the economy, an employment readjustment that affects wages and prices in both sectors of the economy.

1. H. Gregg Lewis, *Unionism and Relative Wages in the United States* (Chicago: University of Chicago Press, 1963).
2. The issues are, of course, very old ones. See, for example, Fritz Machlup, *The Political Economy of Monopoly, Business, Labor and Government Policies* (Baltimore: Johns Hopkins Press, 1952), pp. 394–95.

To analyze these general equilibrium adjustments, we use the well-known two-factor two-commodity model commonly used in international trade theory. However, as a very wide range of results is possible, depending on the relative factor intensities of the union and nonunion sectors and on the elasticities of substitution between labor and capital, we have narrowed the range of possibilities somewhat by undertaking an empirical analysis of the problem.

In this part of the work we follow Lewis and aggregate heavily unionized industries, such as manufacturing, mining, construction, transportation, and public utilities, into a union sector and term the rest of the economy the nonunion sector. We also utilize one of Lewis' principal results, that unionization has increased the wages of unionized workers by about 15 per cent relative to the wages of nonunionized workers.[3]

The paper is divided into two main parts. In the first part we present a geometrical analysis of the problem and establish the main qualitative results. In the second we develop the algebraic and numerical analogue of this model. In addition to the results for this basic two-factor model, we present some results for a model in which the labor input is divided into white collar workers and blue collar workers.

A Geometrical Analysis

In this section we analyze the effects of unionization by means of an application of the geometrical analysis of general equilibrium commonly employed in international trade. For that purpose we assume an economy capable of producing two commodities, X and Y, by the use of two factors, labor and capital, in production functions characterized by constant returns to scale. The two factors are each assumed to be homogenous, perfectly mobile between industries, and given in total amount; those assumptions beg certain questions in capital theory, but the questions are not crucial for the present purpose. The production of commodity X is assumed to be capital-intensive, and that of commodity Y labor-intensive, in the sense that at any given ratio of factor prices the ratio of capital to labor employed in X will be higher than the ratio employed in Y. The economy is assumed to be perfectly competitive (aside from the effects of unionization itself). On the demand side, it is assumed

3. Lewis found that the effect of unions on the average wage of union labor compared to the average nonunion wage ranged from 25 per cent or more in the mid 1930's to less than 5 per cent from 1945 to 1949, rising to 10–15 per cent in the late 1950's.

that the preferences of the various sections of the community — the owners of capital, the "owners" of labor employed in the unionized industry, and the "owners" of labor employed in the nonunionized industry — can be treated as an aggregate community preference system. In other words, we ignore any effects on the relative quantities of the two goods demanded of redistributions of income among capital, unionized labor, and nonunionized labor. It is also assumed that this preference system has two characteristics plausible on a priori grounds: that a reduction in aggregate real income reduces the quantities of both goods demanded, and that a reduction in the relative price of one commodity causes substitution of that commodity for the other in consumption.

Unionization is assumed to consist in the introduction of a fixed proportional differential excess of wages in the unionized industry over wages in the nonunionized industry. The object of the analysis is taken to be the effect of unionization on the prices of the services of capital, unionized labor, and nonunionized labor in terms of the two products. It is to be noted that an analysis of these effects is not equivalent to a full analysis of the effects of unionization on the distribution of real income, which will depend also on the preferences of the various groups. This point is elaborated on in the subsequent analysis.
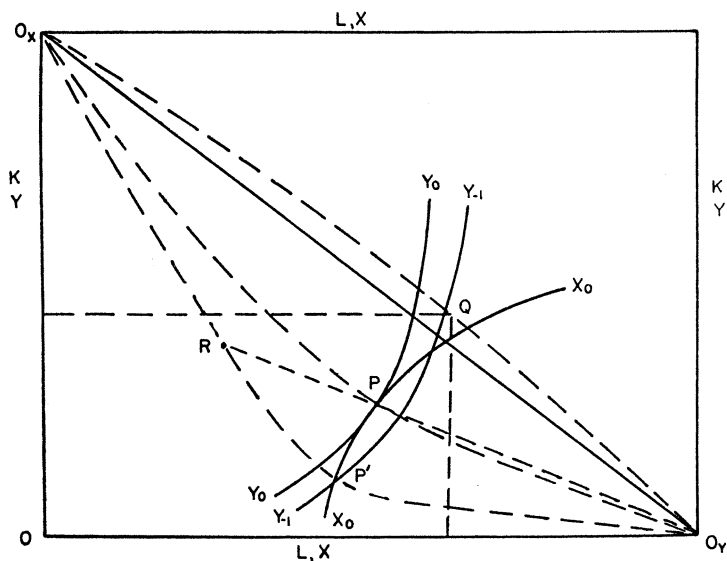

FIGURE I

In the absence of the union, the production possibilities open to the economy can be depicted by means of the Edgeworth-Bowley production contract box, as shown in Figure I. The vertical sides of the box represent the quantity of capital available to the economy, and the horizontal sides the quantity of labor. Production isoquants are sketched into the box with origins O_x and O_y, respectively. The locus of tangency points of these isoquant systems is the contract curve, or locus of efficient allocations of factors of production between the industries. Since X is assumed to be capital-intensive and Y labor-intensive, the contract curve will lie southwest of the diagonal O_xO_y. The transformation curve, or production possibility curve, of the economy can also be represented in the box by means of a technique invented by K. M. Savosnick.[4] Owing to the constant returns to scale assumption, the quantity of X produced at any point P on the contract curve can be measured by the distance along O_xO_y from O_x cut off by the X-isoquant through P; similarly, the quantity of Y produced can be measured by the distance along O_xO_y from O_y cut off by the Y-isoquant through P. By dropping perpendiculars to OO_y and to OO_x, respectively, these outputs can be measured in the box with reference to the common origin O, and used to plot the transformation curve; the point on the transformation curve corresponding to the point P on the contract curve is represented in Figure I by Q.

We now assume that unionization occurs. By the definition of unionization, the wage rate (value of marginal product) in the unionized industry must exceed the wage rate (value of marginal product) in the nonunionized industry by a certain proportion. The values of the marginal products of capital in the two industries must, however, be equal. In diagrammatic terms, at any point of equilibrium in the allocation of factors between the industries, the slope of the tangent to the isoquant for the unionized industry must be steeper than the slope of the tangent to the isoquant for the non-unionized industry (the slopes being taken with reference to the horizontal, so that they represent the price of labor in terms of capital). Figure I shows such an equilibrium point for unionization in the X industry, the point P' corresponding to an unchanged quantity of X produced and a lower output of Y. P' is a point on a new contract curve, corresponding to the existence of unionization. For every point on this new contract curve, the output of one of the goods must be less than it would have been in the absence of union-

4. K. M. Savosnick, "The Box Diagram and the Production Possibility Curve," *Ekonomisk Tedsskrift*, LX (Sept. 1958), 183–97.

ization: in other words, unionization makes the allocation of re-
sources less efficient. (It will be evident from earlier argument that
the transformation curve must be shifted in toward the origin O,
except at its extreme points, and it may even become convex to the
origin.) Moreover, owing to the effects of unionization in making
the value of the marginal product of labor in Y less than its value
in X, the private marginal cost of X will exceed its social marginal
opportunity cost. Hence consumers will be led to choose to consume
less of X and more of Y than they would if they were able to choose
on the basis of true social opportunity costs: in other words, not
only will the allocation of factors among industries be inefficient, but
so will the allocation of production and consumption among indus-
tries.

   The points P and P' serve as a convenient point of reference
for the analysis of the effects of unionization of the capital-inten-
sive industry; for this purpose, it is assumed that P corresponds to
the general equilibrium of the economy (the production and con-
sumption pattern and the corresponding set of goods and factor
prices) in the absence of unionization. At P', the capital-labor ratio
has risen in the X industry and fallen in the Y industry, as com-
pared with the situation in the absence of unionization. The mar-
ginal product of unionized labor in terms of X has risen, while the
marginal product of nonunionized labor in terms of Y has fallen.
The marginal product of capital, on the other hand, has fallen in
terms of X and risen in terms of Y. Since the price of X in terms of
Y must have risen, it follows that at point P' labor in the X in-
dustry (unionized labor) must be receiving wages with a greater
purchasing power in terms of both goods, while labor in the Y in-
dustry (nonunionized labor) must be receiving wages with a lower
purchasing power in terms of both goods. The earnings of capital,
on the other hand, are lower in terms of X and higher in terms of Y.
Thus, if production were to be maintained at P', unionized labor
would be definitely better off, and nonunionized labor definitely
worse off, while the owners of capital might be better or worse off
depending on the relative quantities in which they consumed X
and Y.

   By assumption, however, production cannot remain at P', be-
cause at that point the community's real income is less than it was
at P, so that the demand for X would tend to be reduced by the
adverse income effect caused by the inefficiency introduced by
unionization, reinforced by the increase in the price of X relative
to Y caused by the introduction of the differential excess of wages

in X over wages in Y. To restore equilibrium, the allocation of factors among the industries must shift toward producing more Y and less X. In other words, the economy must move along the new contract curve from P' toward O_x. As it does so, however, the ratio of capital to labor in both industries must rise. This in turn means that the wages of labor in both the unionized and the nonunionized industries must rise, while the earnings of capital must fall. In other words, the gains of unionized labor will in the final equilibrium be larger and the losses of nonunionized labor will be smaller, than at P', while the owners of capital must suffer a loss of income by comparison with P'. It is even possible that nonunionized labor as well as unionized labor will gain from unionization, while the owners of capital bear the whole or more than the whole gain to unionized labor plus the loss of efficiency in production.

This possibility may be investigated more fully by reference to Figure I. In the figure, a vector from O_y through P is drawn to intersect the new contract curve at R. For any equilibrium point lying between P' and R, the capital-labor ratio in Y is below what it was at P (in the absence of unionization), so that the marginal product of capital in Y is higher, and the marginal product of labor in Y lower, than they would have been in the absence of unionization. Thus for any equilibrium in this range, it is possible for owners of capital to be better off than they would have been in the absence of unionization, while nonunion labor is necessarily worse off (the relative price of X at R must obviously be higher than at P, since the cost per unit is the same and the price of labor in X is higher, owing to the wage differential). For any equilibrium between R and O_x, however, the capital-labor ratio in Y is higher than at P, so that the owners of capital are necessarily worse off; while nonunion labor may be sufficiently better off, owing to its higher marginal productivity in Y to compensate it for the relatively higher price of X. The significance of R as a dividing line between these two possible outcomes is most easily appreciated by assuming alternatively that the owners of all the capital, or the owners of nonunion labor, consume only commodity Y. Whether the equilibrium point in the presence of unionization falls in the range PR or the range RO_x depends, of course, on the demand conditions, the precise parameters of which have not been specified in this analysis.

The foregoing analysis relates to the effects of unionization in the capital-intensive industry. In that case, labor in the unionized industry must gain from unionization, while capitalists may gain or lose and nonunionized labor lose or gain, a gain for one of the latter groups necessarily being accompanied by a loss for the other.

We now consider the effects of unionization in the labor-intensive Y industry. By reasoning similar to that employed in the previous case, the wage differential shifts the contract curve (the direction of shift being opposite to that in the previous case) and also pulls the transformation curve in toward the origin.

These shifts are illustrated in Figure II, where P'' is the point on the new contract curve resulting from unionization of the Y in-

FIGURE II

dustry corresponding to an unchanged output of that industry. (It should be noted that in this case there exists a wage differential just sufficient to make the contract curve, and therefore the transformation curve, coincide with the diagonal $O_x O_y$; for any greater wage differential the transformation curve will be convex to the origin O. The critical wage differential is that which makes the capital-labor ratio equal in the two industries.)

As in the previous case, if production remained at P'', unionized labor would be definitely better off and nonunionized labor definitely worse off, while the owners of capital might be better or worse off depending on their consumption preferences with respect to the two goods. Production cannot, however, remain at P'', since real output is reduced by the loss of efficiency due to unionization, and the relative price of Y (the product of the unionized industry) has risen. The allocation of resources to production must shift toward pro-

duction of more X and less Y, that is, along the contract curve from P'' toward O_y. A shift in this direction, however, entails a lowering of the capital-labor ratio in both industries, thereby raising the marginal productivity of capital and lowering the marginal productivity of labor in both industries. Thus nonunionized labor is made still worse off than it was at P'', and must necessarily lose as a result of unionization. Further, unionized labor itself may lose as a result of unionization, while the owners of capital may gain.

These possibilities may be investigated further with the aid of Figure II, by drawing the vector O_yP, which intersects the new contract curve at S. At this point the ratio of capital to labor in the Y industry is the same as it was at P, the equilibrium position in the absence of unionization; therefore the marginal products of capital and labor in terms of Y are the same as at P. Since capital's marginal product in the X industry is necessarily higher at S than at P, the owners of capital must be at least as well off at S as they were at P. For equilibrium points lying between S and O_y, capital's marginal product is higher in both industries than it was at P, and the owners of capital must be better off as a result of unionization; the owners of unionized labor must be worse off in terms of Y than they were at P, and their loss on this account may outweigh any gain from the relatively lower price of X resulting from the differential between wages in the two industries. Thus, for equilibrium points in the range from P'' to S, union labor is necessarily better off than in the absence of unionization, whereas owners of capital may be worse or better off; for equilibrium points in the range S to O_y, owners of capital are necessarily better off, while owners of unionized labor may be worse off, than in the absence of unionization. As in the previous case, whether the general equilibrium point lies in one range or the other depends on the demand conditions, the parameters of which have not been specified in this analysis. (Parenthetically, it may be noted that if the wage differential is large enough to reverse the factor intensities of the two industries and make the transformation curve convex, there is no range SO_y and unionization must make the unionized workers better off.)

To summarize, this analysis has demonstrated that the effects of unionization depend crucially on whether the unionized industry is capital-intensive or labor-intensive relative to the other industry — in more general terms, on whether the unionized sector is more or less capital-intensive than the nonunionized sector of the economy. If it is more capital-intensive, unionized labor must gain,

while nonunionized labor may also gain; if it is more labor-intensive, nonunionized labor must lose, while unionized labor may also lose. In the former case owners of capital must lose if nonunionized labor gains, and in the latter case owners of capital must gain if unionized labor loses. The difference between the two cases stems from the fact that unionization is in effect a tax on the labor of the unionized industry, and therefore has the effect of shifting demand away from that industry. If such a tax is imposed on a capital-intensive industry, the result is a fall in the demand for and price of the services of capital and an increase in the demand for labor, from which both sections of the labor force may gain. If the unionized industry is labor-intensive, the result is a rise in the demand for capital and a fall in the demand for labor, from which both sectors of the labor force may lose.

A Numerical Analysis

Although geometrical analysis is a very efficient way of developing major qualitative results, it is of no help in empirical investigation and cannot be used with any degree of precision to determine the importance of factor substitution effects.

In this section we develop an algebraic analogue of the geometrical analysis and present some numerical estimates of the impact of unions on the distribution of income. The basic difference between this model and the geometric approach is that the full range of values of production and consumption possibilities is not considered. For convenience, the analysis refers to small changes from an initial equilibrium. That is, we determine the changes in the output of X, using the relation $dX = F_L dL_x + F_k dK_x$, where F_L and F_k are the marginal products of labor and capital in industry X at the original equilibrium. Similarly, the change in the output of Y is equal to $dY = G_L dL_y + G_k dK_y$. One of the shortcomings of this approach is that it cannot account for the effect on demand of a removal or introduction of a distortion in factor markets. All output changes are evaluated on the basis of original marginal products, and the increased or decreased real income arising out of a more or less efficient allocation of resources is not accounted for. The basic difficulty is that differentiation is only a first-order approximation.

Initially we assume that all groups have the same spending propensities and that each group, regardless of income size and type of income received, spends a constant proportion of its *money* in-

come on each of the two goods. This is the Graham demand function for which the income and price elasticities of demand are equal to one. These assumptions are not essential to the analysis and can easily be weakened. However, all reasonable demand functions imply that the output of the union sector will fall when wages rise in that sector. Since the capital goods industries, such as construction and machinery, are concentrated in the union sector, the level of capital formation will fall. Thus, by assuming that the total supplies of labor and capital are fixed and studying the problem only by means of comparative statics, we do not allow for the long-run effects of unions on the distribution of income and the real wage. These effects may be small if the change in the price of capital goods is offset by an increase in the return on capital. Nevertheless, it should be recognized that we err to the extent that the formation of unions changes the level of investment.

The first step in determining the impact of unions is to calculate the change in the price of labor relative to the price of capital. The price of capital, p_k, is taken as the numeraire. Only industry X is unionized. The unionization of this industry results in a wage differential adjusted for skill differentials of an amount Z. We shall investigate the effects of a change in this union "markup." In the original equilibrium the wage rate in the nonunion sector, Y, is is equal to p_L, while the wage rate in the union industry is equal to $p_L + Z$. A change in Z, the union markup, will change the nonunion wage by an amount $\dfrac{dp_L}{dZ} dZ$, while the change in the union wage will be equal to $\dfrac{dp_L}{dZ} dZ + dZ$. As the price of capital is taken as the numeraire, $\dfrac{dp_K}{dZ}$ is equal to zero.

The relations required to solve for $\dfrac{dp_L}{dZ}$ are a demand function, a supply function that relates the output of one of the two industries to changes in the factor inputs in that industry, a factor demand function for each of the two industries that relates factor proportions to relative factor prices, and two price equations that relate commodity prices to factor prices.[5]

5. Except for the specialized demand function, this is the same model used by Harberger in work on the incidence of the corporate income tax. For a detailed exposition and solution of this model, see A. C. Harberger, "The Incidence of the Corporation Income Tax," *Journal of Political Economy*, LXX (June 1962), 215–240.

The derivative of the price of nonunion labor, with respect to Z, is given by the relation

(1)

$$\frac{dp_L}{dZ} = \frac{\dfrac{L_x(1-m)}{X}\left(\dfrac{K_x}{K_y}-\dfrac{L_x}{L_y}\right)+\dfrac{S_x}{p_{Lx}}\left(\dfrac{L_x}{L_y}f_k+f_L\dfrac{K_x}{K_y}\right)}{\left(\dfrac{m(L_x+L_y)}{X}-\dfrac{L_x}{X}\right)\left(\dfrac{K_x}{K_y}-\dfrac{L_x}{L_y}\right)-\dfrac{S_x}{p_{Lx}}\left(\dfrac{L_x}{L_y}f_k+f_L\dfrac{K_x}{K_y}\right)-\dfrac{S_y}{p_{Ly}}}$$

where L_x and L_y are the original amounts of labor employed in industries X and Y, respectively; K_x and K_y are the original amounts of capital; X is the original amount of X produced; f_k and f_L are the original shares of capital and labor, respectively, in the unionized industry; p_{Lx} and p_{Ly} are the original prices of labor in industry X and Y, respectively; S_x and S_y are the elasticities of substitution between labor and capital in industries X and Y, respectively, the presumptive signs of which are negative; and m is the proportion of money income spent on X (i.e., if N is the total value of income measure in terms of the numeraire, $p_x X = mN$).

It is useful for purposes of interpretation to "associate" the terms in the numerator with the impact of a change in Z, the union markup, and the terms in the denominator with the effects of a change in the basic wage rate relative to the price of capital. An increase in the union markup (dZ positive) will increase wage costs in X and will lead to the substitution of capital for labor. This factor substitution will result in a decrease in the demand for labor in X and will always tend to decrease the price of labor relative to the price of capital. The other term in the numerator, $\frac{L_x(1-m)}{X}\left(\frac{K_x}{K_y}-\frac{L_x}{L_y}\right)$, captures the effect of the markup on change in output mix. The effect of the increase in X is to decrease the demand (output) for (of) X. If X is capital- (labor-) intensive, the output effect will increase (decrease) the price of labor. Consequently $\frac{dp_L}{dZ}$ will be unambiguously positive only if the unionized sector is capital-intensive.

The terms in the denominator that contain S_x and S_y are factor substitution terms that indicate what will happen to the demand for labor relative to capital in response to changes in factor prices. It is eminently clear that if factor proportions in the nonunionized sector of the economy are very sensitive to changes in relative factor prices, factor prices will not change substantially. S_y, the elasticity of substitution between labor and capital in the non-

unionized sector, appears only in the denominator of expression (1), and thus the larger the value of this parameter, the *smaller* will be the change in relative factor prices.

As S_x appears in both the numerator and the denominator of expression (1), contrary to common sense it remains uncertain whether a large response in factor proportions to changes in factor prices in the unionized sector tends to increase or decrease the change in relative factor prices.

The reason for the ambiguity is that, although an increase in the union markup leads to a decrease in the demand for labor in the union sector, a high elasticity of substitution in that sector precludes a very large drop in the "base wage," p_L, relative to the price of capital, as a change in relative factor prices offsets the effects of a change in the markup. This does not mean that $\dfrac{dp_L}{dZ}$ cannot be substantial. For example, when S_x is so large that the factor substitution effect in the unionized sector dominates all of the other terms in expression (1), $\dfrac{dp_L}{dZ}$ will be equal to one so that the increase in the union markup will result in a decrease in the nonunion wage equal to the change in union-nonunion differential.

The term $\left(\dfrac{m(L_x + L_y)}{X} - \dfrac{L_x}{X} \right)\left(\dfrac{K_x}{K_y} - \dfrac{L_x}{L_y} \right)$, which represents the "demand effect" of a change in factor prices, is more difficult to interpret. As the size of this term in ambiguous, the sign of the denominator is ambiguous, making possible a number of paradoxical results. For example, when S_x and S_y are small relative to the demand terms in the numerator and denominator, $\dfrac{dp_L}{dZ}$ may be negative (positive) when X is labor- (capital-) intensive, implying that the output of X will increase, not decrease, when the union is formed in this sector. To have produced this result, the original equilibrium must have been unstable, and we exclude it from further consideration.

Although expression (1) clarifies the interaction of the various effects that determine the impact of unionization, it is clear that the analysis cannot proceed very far without quantitative estimates for the variables that appear in the general expression for $\dfrac{dp_L}{dZ}$.

We have estimated the value of the relative amounts of labor and capital employed in the two industries by using information on average factor payments for the years 1935–59. The union industry

consists of construction, manufacturing, transportation, public utilities and communications, government enterprises, and mining except for crude petroleum. In 1953, 52 per cent of the people engaged in production in these industries were unionized. The nonunion industry, which was 6 per cent unionized in 1953, is made up of agriculture, crude petroleum, trade, finance, real estate (the services of residential structures), and services. General government and public education, which are only 6 per cent unionized, are excluded on the assumption that output and employment in these sectors are determined independently of wage rates and capital costs.

Averages for 1953–59 for the two industry groups in billions of dollars are as follows.[6]

	Income originating (net of depreciation and excise taxes)	Before-tax profits	After-tax profits	Wage income
Union (X)	165.6	36.5	17.8	129.1
Nonunion (Y)	152.3	47.1	34.4	105.2

Accepting Lewis' result that unions raise union money wages by 15 per cent relative to nonunion wages,[7] we calculate $\dfrac{L_x}{L_y}$ as (0.85) $129.1/105.2 = 1.03$. In adopting this procedure we assume that, apart from the effects of unions, wage differentials are due to skill differentials and therefore labor can be measured in efficiency units rather than in numbers of men.

We also assume that capital markets are perfect and that after-tax rates of return per unit of capital are equal throughout the economy. Hence $\dfrac{K_x}{K_y}$ is estimated as $17.8/34.4 = 0.52$.[8]

6. Industries were classified as union and nonunion on the basis of information on the degree of unionization by industry presented by Lewis, *op. cit.*, Tables 74 and 76. Basic data for income, wages, and profits by industry come from the Commerce publication *U. S. Income and Output* (1958) and subsequent July issues of the *Survey of Current Business*. We used L. Rosenberg's estimates on noncorporate profits by industry and estimates of property tax paid by industry. Like Rosenberg we believe that property taxes are profit taxes. See L. G. Rosenberg, "Taxation of Income from Capital, by Industry Group," in A. C. Harberger and M. J. Bailey (eds.), *Taxation of Income from Capital* (Washington, D. C.: Brookings Institution, 1969).

7. As all workers in industry X do not belong to unions, this is an overestimate of the union differential. While the absolute size of the union gain depends on the size of this differential, the results on the distribution of gains and losses, resulting from unionization, are virtually independent of the size of the union markup.

8. It may seem surprising that the industry is labor-intensive relative to the nonunion industry $\dfrac{L_x}{L_y} - \dfrac{K_x}{K_y} = 0.51$, but residential real estate and farming are both highly capital-intensive, and 4 billion of the 34.4 billion dollars of after-tax profits in the nonunion sector is interest on consumer loans.

[cont.]

Taking the above figures at their face value in the first instance, we calculate the value of m as 0.49, after a minor adjustment for the fact that government purchases more union than nonunion goods. This estimate, along with the estimates of the factor intensities, gives us the following expression for dp_L in terms of the two elasticities of substitution, S_x, S_y:

$$\frac{dp_L}{dZ} = \frac{-0.1750 + 0.5492 S_x}{0.0138 - 0.5492\ S_x - S_y}.$$

The most difficult parameters to pin down are the elasticities of substitution. Even for a narrowly defined industry, the range of estimates is often quite wide, as Marc Nerlove shows in his recent review of empirical studies of production functions.[9] A number of different studies contain results relevant to establishing a likely range of values for these parameters. Time-series studies of the U.S. Aggregate Production Function have yielded estimates that fall between 0.5 and 0.7, although there is one of 1.16. The estimates for manufacturing vary considerably. Most work based on cross-section data suggests that for most two-digit industries S is not significantly different from one. On the other hand, time-series studies yield estimates that are significantly less than one. For example, R. E. Lucas found that for 13 out of 14 industries, the elasticity of substitution was less than one, with most point estimates falling below 0.5.[1]

For mining and agriculture, the work of G. S. Maddala [2] and Z. Griliches,[3] respectively, suggests that the elasticity of substitution is equal to one. In electrical utilities P. Dhrymes and M. Kurz [4]

Of the remaining 30.4 billion dollars, 13.2 billion originate in real estate and 6.8 in agriculture. Although some skeptics argue that investment in owner-occupied homes should not be treated on a par with investment in capital in manufacturing, we assume that the implicit or explicit rate of return on houses will be very closely related to rates of return in other sectors. Nevertheless, as agriculture and real estate are both heavily land-intensive (over 50 per cent of capital income in agriculture is land rent) and it is questionable that land can be substituted for labor in the union sector, the difference in the factor intensities of the two industries is undoubtedly overestimated.

9. Marc Nerlove, "Recent Empirical Studies of the CES and Related Production Functions," in Murray Brown (ed.), *The Theory and Empirical Analysis of Production*, Studies in Income and Wealth, Vol. 31 (New York: Columbia University Press for the National Bureau of Economic Research, 1967).

1. R. E. Lucas, Jr., "Substitution between Labor and Capital in U.S. Manufacturing 1929–58," Ph.D. thesis, University of Chicago, 1963.

2. G. S. Maddala, "Technological Change in the Bituminous Coal Industry, 1919–54," Ph.D. thesis, University of Chicago, 1963.

3. Z. Griliches, "Research Expenditures, Education, and the Aggregate Agricultural Production Function," *American Economic Review*, LIV (Dec. 1964), 961–974.

4. P. Dhrymes and M. Kurz, "Technology and Scale in Electricity Generation," *Econometrica*, XXXII (1964), 287–315.

found that there is virtually no possibility of substituting labor for capital. And it is also highly likely that the elasticity of substitution is very close to zero in real estate. There is no information for any other industries.

If we rely heavily on the aggregate time-series studies and take the overall value of S to be equal to 0.6, then even if S for manufacturing and mining is equal to one, S_x would not be very different from the aggregate value if S for the regulated industries and construction is very low. If, however, S for the latter industries is as high as 0.4, S_x for the union sector might be as high as 0.8, as manufacturing and mining make up 65 per cent of the union sector. An overall value for S of 0.6 and a value for S_x of 0.8 imply that $S_y = 0.4$. Of course different assumptions would reverse the results, and we could just as easily conclude that $S_x = 0.4$ and $S_y = 0.8$. The point is that *we* have no information which would allow us to conclude that S_x and S_y do or do not differ significantly from each other, and we are therefore inclined toward the view that S_x and S_y both fall in the range $0.5 - 0.7$.

The significance of the relative sizes of S_x and S_y emerges from column $\dfrac{dp_{L(H)}}{dZ}$ in Table I. Here we present the calculated values of $\dfrac{dp_{L(H)}}{dZ}$ for different values of S_x and S_y on the assumption that $\dfrac{K_x}{K_y} = 0.52$.

TABLE I

S_x	S_y	$\dfrac{dp_{L(H)}}{dZ}$	$\dfrac{dp_{L(L)}}{dZ}$
-2	-2	-0.41	-0.35
-1	-1	-0.45	$-\ .35$
-0.6	-0.6	-0.53	$-\ .35$
-0.5	-0.5	-0.57	$-\ .35$
-0.1	-0.1	-1.36	$-\ .35$
-0.7	-0.5	-0.62	$-\ .43$
-0.5	-0.7	-0.45	$-\ .28$
-1	-0.1	-1.10	$-\ .85$
-0.1	-1	-0.22	$-\ .05$
-0.5	-0.1	-1.16	$-\ .73$
-0.1	-0.5	-0.40	$-\ .10$

As these results show, when the union markup Z is increased, the wage (the wage rate in the nonunion sector) falls relative to the

return on capital (recall that the price of capital is taken as the numeraire), so that nonunion members surely lose relative to the owners of capital. Labor that previously belonged to unions gains or loses, depending on the sizes of the elasticities of substitution. In most cases it gains. For example, when $S_x = S_y = -0.6$ and $dZ = 0.01$, the union member wage will increase by $0.01 - 0.0053 = 0.0047$.

In other words, when the union markup in industry X is equal to 0.15, labor in X earned 1.15, labor in Y earned 1.0, and the return on capital was to 1.0. After an increase in the union markup by approximately 1 per cent of the original wage, the union wage rate rises about 0.5 per cent and the nonunion wage rate falls by about 0.5 per cent and capital (by definition) continues to earn 1.0. As originally there were approximately the same number of workers in both industries, $L_x = 109.7$, $L_y = 105.1$, the increase in the union markup in X has virtually no effect on the distribution of income between *total* wages and *total* profits. The gain to union labor due to the increase of the union markup equals the loss to nonunion labor from the fall in the "base" wage. The rise results from the decrease in the demand for labor in X, the substitution of capital for labor in that sector, and from the contraction of X, which is labor-intensive relative to Y.

It should be emphasized that the result depends on the choice of S_x and S_y. Had we assumed that $S_x = -0.5$ and $S_y = -0.1$, we would have come to the much more dramatic conclusion that an increase in Z would decrease the money income of *both* nonunion and union labor, since in this case dp_L would exceed the increase in the union markup. On the other hand, if S_x, the elasticity of substitution in the union sector, is small relative to S_y, then the loss to the nonunion workers resulting from an increase in the union markup is likewise small, and labor as a whole will gain if Z is increased.

These, of course, are extreme assumptions, and although we have no firm estimates of S_x and S_y, we believe that these extremes are highly unlikely and that the most probable range of $\dfrac{dp_L}{dZ}$ is between -0.40 and -0.60.

We presented a second set of estimates of the change in the base wages in Table I because there is reason to believe that the values of $dp_{L(H)}$ are overestimates of the impact of unionization. As was explained above, the value $\dfrac{K_x}{K_y} = 0.52$ probably overstates the amount of capital used in Y relative to the capital used in X.

Second, when we assume that consumers spend a constant proportion of their income on each of the two commodities, we are in effect assuming that the uncompensated price elasticity of demand for X is equal to one. Actually, of course, many of the goods and services produced in the two sectors are complements rather than substitutes — furniture and other household durables, for example, complement housing services just as new automobiles and petroleum refining complement automobile repairing and crude petroleum. There is, therefore, reason to believe that a Graham demand function overstates the responsiveness of demand to relative price changes. Accordingly we have experimented with other demand functions, as well as with modified assumptions about the relative factor intensities of the two industries.

We did not consider that the union sector might be capital-intensive, and so we obtained our lowest estimates for $\dfrac{dp_L}{dZ}$ on the assumption that the relative factor intensities of the two industries are the same, i.e., $\dfrac{K_x}{K_y}-\dfrac{L_x}{L_y}=0$. These are the results reported in Table I as $\dfrac{dp_{L(L)}}{dZ}$, and they constitute a lower bound for $\dfrac{dp_L}{dZ}$.[5]

The assumption that the two sectors are of the same factor intensity eliminates the output effect, with the result that the esimates of $\dfrac{dp_{L(L)}}{dZ}$ are all lower than those labeled $\dfrac{dp_{L(H)}}{dZ}$. The reason for this decrease is that the output effect had previously worked against labor's favor since the union sector, which contracts upon the increase of the union markup, is calculated to be labor-intensive. The decrease is especially dramatic when both elasticities of substitution are small. In this case the output effect dominates the factor substitution effect, and the results are very sensitive to changes in estimates of the relative factor intensities of the two industries. Although there is considerable range in the estimates of $\dfrac{dp_{L(L)}}{dZ}$, if the elasticities in the two sectors are equal, i.e., $S_x=S_y$, the estimates are independent of changes in the elasticity

5. The results for $\dfrac{dp_L}{dZ}$ derived on the assumption that the income-compensated price elasticity of demand for X is -0.1 are virtually the same as those derived on the assumption that $\dfrac{K_x}{K_y}-\dfrac{L_x}{L_y}=0$.

of substitution. In this case the value of $\dfrac{dp_L}{dZ}$ is always equal to about -0.35.

Given these two sets of estimates for $\dfrac{dp_L}{dZ}$, it seems very likely that the actual value of $\dfrac{dp_L}{dZ}$ lies somewhere in the range $0.25-0.50$. Values of $\dfrac{dp_L}{dZ}$ outside of this range require significant differences in the elasticities of substitution in the two industries. For example, if the elasticity of substitution in the union sector is much higher than the elasticity of substitution in the nonunion sector, the change in wage rate relative to the return on capital resulting from an increase in Z will be considerable. On the other hand, if the elasticity of substitution in the nonunion sector is higher than the elasticity of substitution in the union sector, the changes in relative factor prices will be very modest.

Subject to qualifications, related to the crudeness of our parameter estimates, we suggest the following interpretation of our results up to this point. Some of the gains of union members, measured in money terms, are always offset by the losses of nonunion labor. When we take the lowest of our probable range of values for $\dfrac{dp_L}{dZ}$ (0.25), and when we bear in mind that the amounts of union and nonunion labor are 109.7 and 105.1, respectively, an increase in Z by 1 per cent of the original nonunion wage rate increases the union wage rate by 0.75 per cent and decreases the nonunion wage rate by 0.25 per cent. Hence the overall wage bill increases by approximately 0.25 per cent. When $\dfrac{dp_L}{dZ} = 0.5$, the highest in our probable range of values, the gains of union members are completely offset by the losses of nonunion labor.

It is useful to restate the results somewhat differently by placing stress on the changes in the distribution in money income among union labor, nonunion labor, and capital that occurs when the union markup is increased. For purposes of exposition, we shall make these calculations on the assumption that originally X is not unionized and that the formation of a union introduces a wedge equal to 0.15 $(dZ = 0.15)$ between union and nonunion wages. Strictly speaking, these calculations of factor price changes are

accurate only if the derivative $\dfrac{dp_L}{dZ}$ is constant, as introduction of a 15 per cent markup — this is not a "small" change.[6]

As we measure all prices in terms of the price of capital, the real income of a factor may fall even though its "money" income measured in terms of the numeraire increases. This will happen when total money income rises by a proportionately larger amount so that the share of the factor in total income falls. Consider the case where $dp_L = dp_k = 0$ and $dZ = 0.15$ when a union is formed in industry X. As $L_x = 109.7$, the money income of nonunion labor increases by $109.7 \ (0.15) = 16.4$ billion. Total money income also increases by 16.4 billion. The original share of union labor, s_{Lx}, was $129.1/318.0 = 0.406$, so the "adjusted gain of union labor" is equal to $16.4 - 16.4 \ (0.406) = 9.7$ billion. As there has been no change in the money income of nonunion labor and capital, their loss of real income is measured by the change in total money income multiplied by the original shares, of each of the two factors, in total income. The original shares of nonunion labor and capital were 0.330 and 0.264, respectively, and so the loss to nonunion labor is $16.4 \ (0.330) = 5.4$ billion and the loss to capital is $16.4 \ (2.64) = 4.3$ billion. Thus 55.6 per cent $(5.4/9.7)$ of the gain of union labor is made at the expense of nonunion labor.

When $\dfrac{dp_L}{dZ} = 0.27$ and $dZ = 0.15$, the money income of union labor increases by $(0.15 - 0.04) \ L_x = 12.06$ billion; the money income of union labor falls by $0.04 \ L_y = 4.20$ billion; and so the change in total money income, dN, is 7.86 billion.

The balance sheet for these groups is as follows.

Union labor	$12.06 - s_{Lx}dY =$	8.86
Nonunion labor	$-4.20 - s_{Ly}dY =$	-6.80
Capital	$0 \ \ -s_k dY \ =$	-2.06

Thus in this case 77 per cent $(6.80/8.86)$ of the gain of unions is made at the expense of nonunion labor. When $\dfrac{dp_L}{dZ} = 0.40$, 88.7

6. We might attempt to argue that $\dfrac{dp_L}{dZ}$ is constant. As long as S_x and S_y are constant, such an argument may be fairly accurate. For *small changes in the union markup* the assumed value of dZ has no bearing on the calculation of the *relative* gains and benefits resulting from such a change. However, unless $\dfrac{dp_L}{dZ}$ is constant, an accurate estimate of the distributive implications of the formation or elimination of a union in X requires the explicit solution of a well-specified (numerically) general equilibrium system which underlies the derivatives used in this paper.

per cent of the gain of union labor is at the expense of nonunion labor; and when $\dfrac{dp_L}{dZ} = 0.50$, the increase is entirely nonunion labor's loss. In this case formation of unions in one broad sector of the economy has no effect on capital's share in money income, and merely redistributes income from one group of labor to another.[7]

A MODEL WITH TWO TYPES OF LABOR

One of the shortcomings of the two-factor model developed above is that labor is assumed to be homogeneous, and all labor in industry X is assumed to be unionized. In fact, of course, there are many types of labor, and most white collar workers — professionals, managers, sales workers, and clerical workers — do not belong to unions.

Accordingly, we made some calculations with a two-commodity, three-factor model in which labor is divided into white collar workers and blue collar workers. All white collar workers are assumed to be nonunion, and all blue collar workers in industry X are assumed to be unionized. In this model the demands for factors of production depend on partial elasticities of substitution that are defined for pairs of factors.

Apart from its more complicated production structure, the three-factor model is essentially the same as the one developed for homogeneous labor. We assume that unions maintain a 15 per cent differential between wages for unionized blue collar workers and nonunionized blue collar workers. By assuming that there is no movement between occupations, we overstate the changes in factor prices that result from a change in the union markup. As before, we estimated relative factor proportions in the two industries on the basis of factor payments.

The results on changes in relative factor prices are remarkably similar for different assumptions about the elasticities of substitution when these parameters are the same in both industries. Just as for the two-factor model, it is not particularly important to know

7. An alternative way of measuring the effects of unionization on the distribution of income is to calculate the change in real income and consumption of labor as a whole by calculating at the original set of commodity prices the value of the change in quantities consumed. As we are assuming that workers and capitalists have the same spending propensities, it makes no difference, qualitatively, whether we calculate changes in the distribution of income in money terms or in real terms. If, on the other hand, we were allowing for differences in spending propensities, the money measure would no longer be adequate.

the absolute size of the production parameters. The significant question is whether they are the same for different industries.

As before, the principal conclusion is that unionized labor gains primarily at the expense of nonunion labor. Our most representative results are that for an increase in the union markup of 10 per cent, nonunion wages fall by 6 per cent and white collar wages rise by about 1 per cent relative to the return on capital. About 83 per cent of the gains of unionized blue collar workers and white collar workers are at the expense of nonunionized blue collar workers.

MONOPOLY ELEMENTS

Our analysis has been based on the assumption of competition in product markets, and it might be objected that the introduction of monopoly elements would substantially change our results: in effect, that the gains of unions come not at the expense of other labor but at the expense of monopoly profits. There is a certain amount of truth to this point, but its actual importance depends on the degree of monopoly profits and on how labor goes about attempting to share in them.

Our characterization of the impact of unions has been formulated in such a way that the unionization of an industry is equivalent to a tax on labor in a particular sector of the economy. Although this "tax" increases union wages relative to nonunion wages, it leads to a substitution of capital for labor in the union sector and also may have an unfavorable output effect if the union sector is labor-intensive. The analysis of the formation of a union in a monopoly industry is really no different from the analysis of a competitive situation as long as labor simply attempts to increase its wage in that industry relative to wages elsewhere in the economy.

On the other hand, if wage demands by unions are determined on the basis of the level of profits in the monopoly industry, a wide range of results is possible. Conceivably, the union could be aware of factor substitution effects and output effects and could attempt to share in monopoly profits without changing the level of employment in that industry. If it had sufficient power it might demand a profit-sharing plan under which it would receive, possibly in the form of a contribution to a union pension fund, a certain percentage of the monopoly profits earned in the industry. If the union chose the "tax base" correctly, the level of employment, output, and prices in a profit-maximizing monopoly would remain unchanged, and the union would gain at the expense of the stockholders.

Our previous analysis applies in all essential respects when the union attempts to obtain part of the monopoly rents in the form of higher wages, rather than through a procedure which is equivalent to a tax on monopoly profits. For example, if the competitive p_L is equal to one and monopoly profits are equal to 0.2 per worker, a demand for a wage increase equal to 50 per cent of monopoly profits is equivalent to a 10 per cent tax on labor. Thus the introduction of monopoly elements in product markets does not add anything new to the analysis unless the union formulates its wage demand in such a way that the demand for labor in the unionized industry is not affected.

CONCLUDING REMARKS

In this article we have analyzed the impact of unions on the distribution of income and shown that a general equilibrium approach is essential for an understanding of this problem. Although our empirical estimates are subject to a number of qualifications and limitations, they strongly suggest that most, if not all, of the gains of union labor are made at the expense of nonunionized workers, and not at the expense of earnings on capital.[8]

These conclusions are for a partially unionized economy, and in large measure this distribution of gain and loss occurs because decreases in the level of employment in the union sector depress wages in the nonunion sector. Our analysis suggests, therefore, that if unions are formed in some industries, nonunionized labor should

8. Another experiment that we carried out was the estimation of the dead-weight (efficiency) loss to the economy resulting from the distorting union wage differential. In making the estimates we adopted the methodology developed by A. C. Harberger ("The Measurement of Waste," *American Economic Review, Papers and Proceedings*, LIV (May 1963)) in his analysis of the excess burden of various non-neutral taxes.

An approximation of the dead-weight loss associated with an increase in the union markup is given by the formula $1/2 \; dL_x dZ$, where dZ is the change in the union markup and dL_x is the union-induced change in employment of labor in the union industry. The rationale for this formula is as follows. At the original equilibrium a transfer of one unit of labor from the nonunion industry to the union industry would increase real income by dZ. As more and more labor is transferred, the value of the marginal product of labor falls in X and rises in Y. By assuming that the *change* in the additions to real income that result from transferring small amounts of labor from Y to X until the distortion is decreased to its original level is constant, we are able to write the welfare expression in the linear form $1/2 \; dL_x dZ$.

As dL_x is proportioned to dZ, the estimates of dead-weight loss are very sensitive to different values of dZ. However, our estimates of dead-weight loss are all quite small. For a value for Z of 0.15, it is around one-half billion dollars, which was one-third of one per cent of national income. For $dZ = 0.25$ the loss is about 1.5 billion, while for $Z = 0.05$ the dead-weight loss is less than 100 million dollars.

organize to maintain its relative position. What effect the extension of unionization has depends on whether it is complete or incomplete. If the change in degree of unionization is marginal, the gains of "new" union members will come in large measure at the expense of the workers who remain unorganized. If, on the other hand, all industries become unionized, and the bargaining power of all unions is the same in all industries, then, so long as there are no monopsonistic rents and unions are not able to "tax away" a share of monopoly profits, the distribution of income will be essentially the same as the distribution in an economy in which unions do not exist.

Unions may well make positive contributions apart from the wage increases that they obtain for their members; however, the implication of this analysis is that partial unionization of labor *in fact* does not benefit labor at the expense of capital.

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE
AND THE UNIVERSITY OF CHICAGO

YALE UNIVERSITY