*RISING WAGE INEQUALITY IN THE UNITED STATES: CAUSES AND CONSEQUENCES*[†]

# Time-Series Evidence on the Sources of Trends in Wage Inequality

*By* GEORGE J. BORJAS AND VALERIE A. RAMEY*

Changes in wage inequality have long been a concern of labor economists and public policymakers. When the wage premium for college graduates fell during the first half of the 1970's, many researchers blamed the decline on the increase in the relative supply of college graduates. When the college wage premium increased dramatically during the 1980's, researchers offered a variety of explanations, such as skill-biased technological change and the internationalization of the U.S. economy.

In this paper, we use time-series analysis to evaluate the most common explanations given for the trends in wage inequality. Using cointegration techniques, we evaluate the link between the trends in the candidate explanatory variables and wage inequality. We show that the only variable that consistently shares the same long-run trend with our wage-inequality series is the durable-goods trade deficit as a percentage of GDP. This variable not only follows the same trend as wage inequality during most of the 1980's, but also for the period from 1949 to 1979. No other single explanation shows the same long-run consistency.

[†]*Discussants:* Steven Davis, University of Chicago; Richard Freeman, Harvard University; Claudia Goldin, Harvard University; James Smith, Rand Corporation.

*Department of Economics, University of California-San Diego, La Jolla, CA 92093-0508, and the National Bureau of Economic Research. We gratefully acknowledge support from the National Science Foundation.

## I. An Analysis of Trends in Wage Inequality

The wage data for the study are from the 1964–1991 annual demographic files of the Current Population Survey (CPS). The wage variable is the natural logarithm of average weekly earnings in the calendar year prior to the survey and is adjusted for experience. In Borjas and Ramey (1994) we give complete details on the construction of the wage series. Our analysis focuses on explaining the secular trend in two measures of the experience-adjusted returns to skills: (i) the average log wage differential between college graduates and high-school dropouts, which, for convenience, we call $w_{dp}$; and (ii) the average log wage differential between college graduates and high-school graduates, which we call $w_{hs}$. We initially focus on the period 1963–1988 and then perform tests of out-of-sample predictions.

Figure 1 illustrates the secular trend in the two relative wage series. Both series show similar patterns; the college premium rises during the 1960's, falls during the 1970's, and then rises dramatically during the 1980's. This basic pattern has been documented for other measures of wage inequality as well.

The behavior of relative wages in the graph appears to be nonstationary, meaning that the series are not mean-reverting. Two commonly assumed forms of nonstationarity are unit roots and deterministic trends. To determine which form is the best approximation, we test the null hypothesis of a unit root in relative wages against the alternative of trend stationarity. For both relative wage series, we find that we cannot reject the

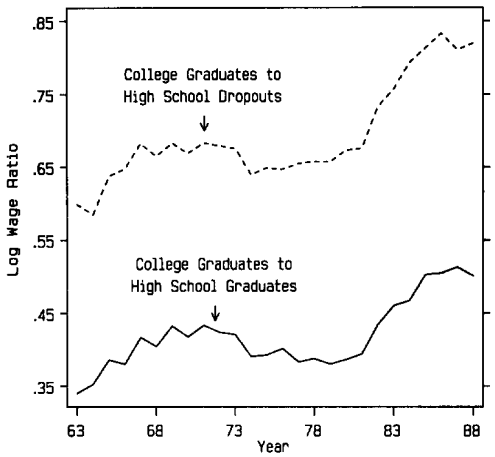



FIGURE 1. SECULAR TREND IN COLLEGE WAGE PREMIA, 1963–1988

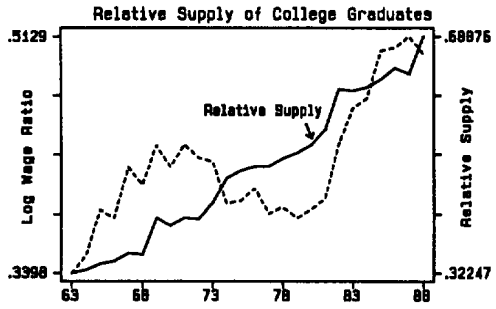
hypothesis of a unit root against the alternative that relative wages follow a deterministic trend; the $p$ value is 0.70 for $w_{dp}$ and 0.59 for $w_{hs}$. These results imply that it is reasonable to characterize relative wages as being difference-stationary rather than trend-stationary. Thus, relative wages appear to contain a stochastic trend rather than a deterministic trend.

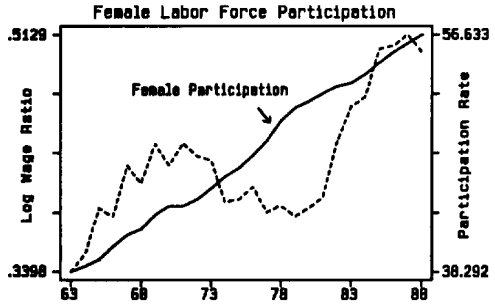
Much of the literature that has sought to explain fluctuations in relative wages has analyzed only first differences or deterministically detrended data. First-differencing or detrending the data, however, *eliminates the trend component*. Clearly the key question that economists wish to address is the source of the long-term persistent movements in relative wages. By analyzing first-differenced data, researchers are in fact only analyzing variations in the year-to-year growth rates of relative wages.

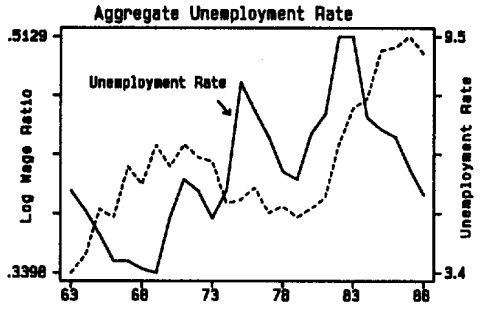
The best way to proceed is to analyze the *levels* of the relevant variables and to test whether they share common stochastic trends. This sort of test is equivalent to a test for *cointegration* (Robert Engle and Clive Granger, 1987). If two nonstationary variables share the same trend, then there exists a linear combination of the two variables that is stationary. Thus, to determine whether two variables are cointegrated, one simply runs a regression of one variable on the other and then tests whether the residual is stationary. Since a unit root is the null hypothesis, the null hypothesis for the cointegration test is that the variables are not cointegrated and thus do not share a common stochastic trend.

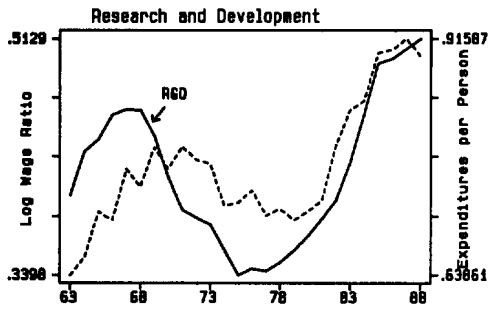
We begin our analysis with graphs of some of the candidate explanatory variables discussed in the literature. Figure 2 shows graphs of (i) the relative number of college graduates to high-school graduates; (ii) the unemployment rate; (iii) the percentage of workers *not* in unions; and (iv) the percentage of immigrants in the population. Figure 3 shows graphs of (i) the labor-force participation rate of females; (ii) research and development expenditures per person in the labor force; (iii) net imports of nondurable goods as a percentage of GDP; and (iv) net imports of durable goods as a percentage of GDP. The relative number of college graduates to high-school graduates is calculated from the CPS. The unemployment rate, the female participation rate, real net imports, and real GDP are from Citibase, with quarterly and monthly data averaged to yield annual numbers. The unionization data are drawn from Barry Hirsch and John Addison (1986) and Hirsch and David Macpherson (1993). The immigration data give the fraction of the adult population that is foreign-born, as calculated from the 1960, 1970, and 1980 censuses and the 1989 CPS; intervening points are interpolated. The data on research and development expenditures are drawn from *National Patterns of R&D Resources* (National Science Foundation, 1990 table B-5). Each series in Figures 2 and 3 is plotted against the wage ratio of college graduates to high-school graduates for easy reference.

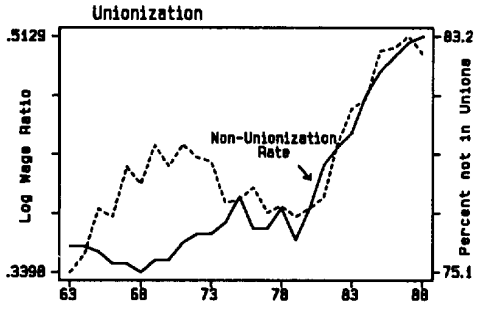
Each of the eight variables in Figures 2 and 3 has been mentioned in the literature as a possible source of movements in relative wages. The survey by Frank Levy and Richard Murnane (1992) gives a complete motivation and description of the leading explanations. Some very clear results emerge from the graphs. Most of the variables shown in Figures 2 and 3 appear to follow patterns

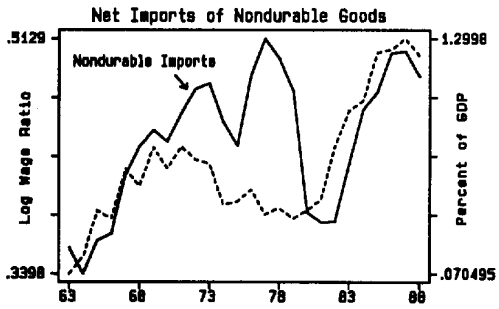


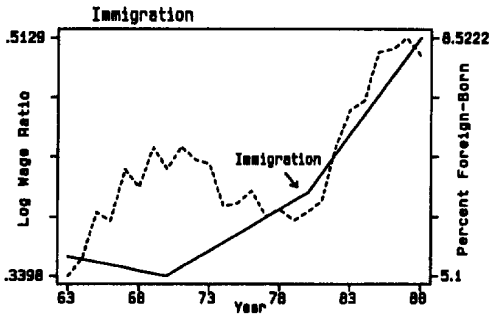



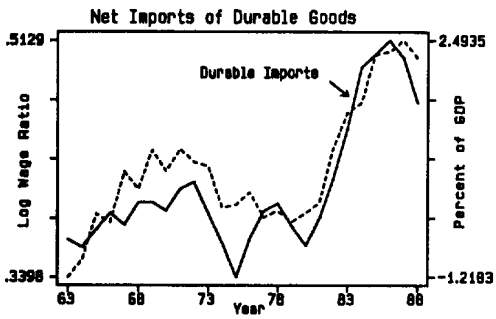




FIGURE 2. POSSIBLE SOURCES OF TREND IN COLLEGE WAGE PREMIA

FIGURE 3. FURTHER POSSIBLE SOURCES OF TREND IN COLLEGE WAGE PREMIA

TABLE 1—UNIT ROOT AND COINTEGRATION TESTS, 1963–1988

| Variable | $p$ values for hypothesis tests: Unit root | Noncointegrated with C/HS-dropout wage | Noncointegrated C/HS-graduate wage |
|---|---|---|---|
| C/HS-dropout supply | 0.662 | 0.698 | |
| C/HS-graduate supply | 0.016 | | 0.722 |
| Unemployment rate | 0.268[b] | 0.886[b] | 0.899 |
| Percentage not in unions | 0.621 | 0.272 | 0.266 |
| Percentage immigrants | 0.850[b] | 0.481 | 0.420 |
| Female participation | 0.314[b] | 0.853 | 0.784 |
| R&D per person in labor force | 0.752[b] | 0.352[b] | 0.485 |
| Nondurables trade deficit[a] | 0.122[b] | 0.960 | 0.886 |
| Durables trade deficit[a] | 0.285[b] | 0.054 | 0.028 |

*Note:* C and HS denote college and high school, respectively.

[a]Percentage of GDP.

[b]One lagged difference was included in the test because it was significant.

that are distinctly different from the pattern of the relative wage. While some move in the right direction during the 1980's, they show no close link in the earlier periods. In contrast, net imports of durable goods as a percentage of GDP seem to follow the relative wage particularly closely, and research and development expenditures per worker tend to follow the relative wage somewhat closely. The trade deficit in durable goods not only shows the same dramatic rise during the 1980's, but also follows the same behavior as the relative wage before 1980.

Table 1 presents the results of formal statistical tests on the variables. The first column shows $p$ values for the test of the null hypothesis that the variable in question contains a unit root. The values indicate that all variables, except for the relative supply of college graduates to high-school graduates and perhaps the trade deficit in nondurable goods, are well described as unit-root processes.

The second and third columns show the $p$ values for the test of the null hypothesis that the variable in question has a different trend from the one in the wage series. Our general impressions from the graphs are borne out by the statistical tests. The only variable for which we can reject noncointegration is net imports of durable goods as a percentage of GDP, with $p$ values of 0.05 and 0.03. On the other hand, research and development expenditures do not appear to share the same trend as wage inequality.

Kevin M. Murphy and Finis Welch (1992) argued that after removing labor-supply fluctuations, the durable-goods deficit as a percentage of GDP and the unemployment rate could explain many of the demand-induced movements in relative wages. We find a much stronger result: the durable-goods deficit as a percentage of GDP has the same long-run trend as the college wage premium from 1963 to 1988.

In our companion paper (Borjas and Ramey, 1993), we develop a theory that can explain why trade in durable goods in particular has an impact on wage inequality. We argue that the durable-goods industries involved in trade have two key characteristics: they are more concentrated than other industries, and they pay higher wages, even after accounting for observable differences in workers. We argue that these industries have historically made high rents, which the unions have compelled them to share with their workers in the form of wage rates that were higher than those paid in other sectors. When these industries are exporting heavily and when import competition is low, they employ more workers and pay higher wages. Increased import competition lowers the rents and hence the total wage bill paid to workers. The decrease in employment forces more workers into the competitive sectors, pushing average wages down.

## II. Extended Analysis of the Impact of Trade in Durable Goods

We now investigate the relationship between trade in durable goods and the relative wage in more detail. We first determine whether imports and exports have differing impacts. In the analysis above we constrained the coefficients on imports and

exports (as a percentage of GDP) to be equal but opposite in sign. When we allow for different coefficients, we obtain the following estimates ($t$ statistics are given in parentheses):

$$(1a)\quad w_{dp} = \underset{(34.7)}{0.608} + \underset{(16.7)}{0.059}\ [\text{durable imports}] - \underset{(-5.1)}{0.036}\ [\text{durable exports}]$$

($R^2 = 0.935$, DW = 1.7, $p$ value for test of noncointegration hypothesis = 0.025);

$$(1b)\quad w_{hs} = \underset{(21.1)}{0.378} + \underset{(10.8)}{0.039}\ [\text{durable imports}] - \underset{(-4.0)}{0.029}\ [\text{durable exports}]$$

($R^2 = 0.851$, DW = 1.2, $p$ value for test of noncointegration hypothesis = 0.097).

In both cases, the estimates of the coefficients show that imports have more of an impact on the relative wage than do exports. The coefficients are significantly different from each other (in absolute value) at nearly the 0-percent level for $w_{dp}$ and at the 7-percent level for $w_{hs}$. Furthermore, the residuals show little serial correlation. The coefficient of the regression of the residual on its lag is significant only at the 70-percent level in the case of $w_{dp}$ and at the 8-percent level in the case of $w_{hs}$.

This discussion of residuals brings us to the issue of technological progress, an explanation offered by several researchers. Any technological progress that works independently of trade movements should appear in the residual. The residuals of the equations above, however, do not look like technology levels, because they have little correlation over time. Therefore, our results lead us to doubt the importance of technological change (aside from its effects on the trade flows) on relative wages.

The evidence presented above uses the 1963–1988 time series to ascertain the possible sources of the secular trend in the returns to skills. We now seek to answer two questions: (i) how much of the link between durable-goods trade and wage inequality is due to their joint behavior during the 1980's?; and (ii) how well does this relationship hold out-of-sample? To answer these questions, we reestimate the equations (1a) and (1b) for the period 1963–1979. We then use the estimated coefficients to produce predicted values for the period 1980–1990, and also for the years 1949 and 1959, using the data on wages from the U.S. decennial census for the two early years.

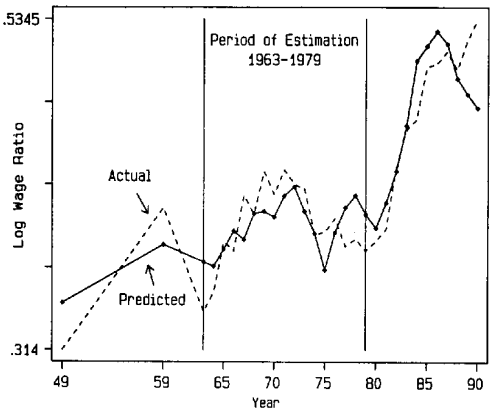



FIGURE 4. OUT-OF-SAMPLE PREDICTED VALUES, COLLEGE–HIGH-SCHOOL-GRADUATE WAGE REGRESSED ON DURABLE IMPORTS AND EXPORTS

Figure 4 plots the predicted values of the college–high-school-graduate wage premium against the actual values; the graph is similar for the other wage series and is not shown because of space limitations. The closeness between the actual and predicted values is surprising. The results show that, using the comovements of trade and wage inequality during the period 1963–1979, one could have predicted the rise in wage inequality during the 1980's had one known the path of durable exports and imports as a percentage of GDP. The link between durable-goods trade and wage inequality was the same during the 1960's and 1970's as it was during the 1980's. In fact, the model fits well even for 1949 and 1959.

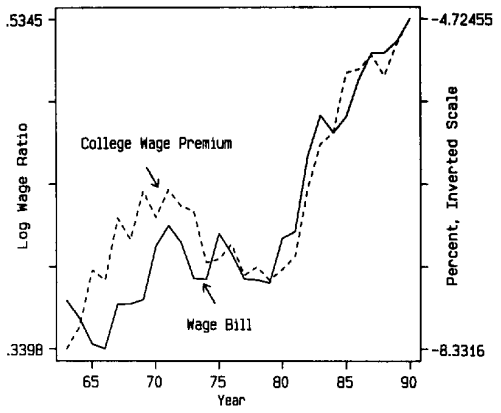



FIGURE 5. WAGE BILL IN TARGET INDUSTRIES (AS A PERCENTAGE OF THE AGGREGATE WAGE BILL, INVERTED SCALE)

The only significant divergence between the actual and fitted values occurs in 1989 and 1990, when the trade deficit improved, but wage inequality kept rising. To gain insight into why this divergence occurs, we again appeal to the theory in our companion paper (Borjas and Ramey, 1993). According to the theory, the propagation mechanism for the impact of import competition on wage inequality is the decline in the wage bill of the concentrated industries as a fraction of the aggregate wage bill. Thus, it is useful to examine the behavior of the wage bill in some of the target industries.

Figure 5 shows a graph of the wage bill paid in several concentrated, high-import sectors as a percentage of the aggregate plotted against the college–high-school-graduate wage premium. The wage-bill fraction is graphed on an inverted scale. The sectors and standard industrial classifications (SIC's) included are motor vehicles and parts (SIC 371), primary metals (SIC 33), and nonelectrical machinery (SIC 35). All three sectors contain industries that are concentrated and that faced significant import competition during the period, with the most noteworthy being automobiles, steel, and capital goods. The graph shows that the wage-bill variable also appears to be highly correlated with the wage-inequality variable and continues to rise with it in 1989 and 1990. For the period 1963–1990, one can reject noncointegration of the wage-bill variable and wage inequality at the 2-percent level. Thus, this variable too shares a stochastic trend with wage inequality, and the relationship has not broken down during the last few years.

These results still leave open the question as to why the trade deficit is now moving differently from the wage-bill and wage-inequality measures. One possible explanation is that import competition may have a lagged effect on industry restructuring. Further research is required to determine exactly what happened.

Overall, the results show that the high correlation between wage inequality and trade in durable goods is not just a 1980's phenomenon. In fact, these variables have shown a close link for most of the 40-year period under study. No other leading explanation shares this feature.

## REFERENCES

**Borjas, George J. and Ramey, Valerie A.** "Foreign Competition, Market Power, and Wage Inequality: Theory and Evidence." Unpublished manuscript, University of California-San Diego, 1993.

_____. "The Relationship between Wage Inequality and Trade," in J. H. Bergstrand, T. F. Cosimano, J. W. Houck, and R. G. Sheehan, eds., *The changing distribution of income in an open U.S. economy*. New York: Elsevier, 1994 (forthcoming).

**Engle, Robert F. and Granger, Clive.** "Cointegration and Error Correction: Representation, Estimation, and Testing." *Econometrica*, March 1987, *55*(2), pp. 251–76.

**Hirsch, Barry T. and Addison, John T.** *The economic analysis of unions: New approaches and evidence*. Boston, MA: Allen & Unwin, 1986.

**Hirsch, Barry T. and Macpherson, David A.** "Union Membership and Coverage Files from the Current Population Surveys: Note." *Industrial and Labor Relations Review*, April 1993, *46*(3), pp. 574–78.

**Levy, Frank and Murnane, Richard J.** "U.S. Earnings Levels and Earnings Inequality: A Review of Recent Trends and Proposed Explanations." *Journal of Economic Literature*, September 1992, *30*(3), pp. 1333–81.

**Murphy, Kevin M. and Welch, Finis.** "The Structure of Wages." *Quarterly Journal of Economics*, February 1992, *107*(1), pp. 285–326.

**National Science Foundation.** *National patterns of R&D resources: 1990*, NSF 90-316. Washington, DC: National Science Foundation Press, 1990.