Accounting for the Causes and Consequences of Industrial Employment Shift

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This paper analyzes the 1981–87 employment shifts away from high-wage industries, using a shift-share framework, coupled with a two-sector general equilibrium model. I find that (1) the shift-share drag on average pay growth was unprecedented in the postwar period, on the order of 1/4–1/3 percent per year, for hourly compensation; and (2) output shifts, including the trade deficit, were a more important cause of the employment shifts than were rapid productivity growth in manufacturing and other contracting industries. As a result, the shift-share drag on average pay growth should be interpreted primarily as coming out of aggregate productivity growth, rather than as a redistributional phenomenon.

Introduction

What caused the rapid employment shifts of the 1980s away from high-wage industries? Specifically, which was more important: an unusually rapid shift of output away from these industries (due, in part, to the widening trade deficits), or the long-term phenomenon of uneven productivity growth between expanding and contracting industries? What were the consequences of these shifts? Did they constitute a drag on average productivity growth, or were they primarily redistributional in nature? In this paper, I address these questions using a simple shift-share framework for wage growth, coupled with a two-sector general equilibrium model.

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The shift-share framework is a descriptive device that separates out the effect of shifting employment weights among industries, from wage growth within industries, with fixed employment weights:

$$\begin{array}{ccccc} \dot{W}/W & \equiv & \Sigma\dot{\alpha}_i W_i/W & + & \Sigma\alpha_i \dot{W}_i/W \\ \text{Average Wage Growth} & \equiv & \text{Shift-Share Effect} & + & \text{Fixed-Weight Growth}, \end{array} \quad (1)$$

where W is the real wage and α_i is industry i's employment share. This paper is organized around the first term of equation (1), the shift-share effect on wage growth: I will measure its magnitude, examine its causes, and consider its consequences.

The analysis differs from previous literature, first, in its methodology for measuring the shift-share effect on wage growth. A regression methodology is developed, which has many advantages over earlier studies based on selected endpoints.[1]

The analysis of the causes of the shift also differs from previous literature, by using a two-sector model and, I shall argue, a more appropriate weighting scheme within sectors. Both of these help reconcile opposite findings in the literature regarding the causes of the employment shifts. On one side are regression studies that associate industry employment losses with adverse trade variables.[2] On the other side, it is inferred from manufacturing's constant share of output that employment shifts out of contracting industries are due to rapid productivity growth in those industries, rather than to trade-induced output shifts.[3] This argument is not directly engaged by the regression studies.

I will argue that the inference drawn from manufacturing's output share is unwarranted on several counts. These include an implicit weighting scheme that gives too much weight to industries that were not involved in the employment shifts (such as computer manufacturing), and also an implicit assumption that the elasticity of substitution in demand is close to zero. Replacing either the weighting scheme or the assumed elasticity results in the rather robust finding that uneven productivity growth was, in the 1980s, a less important cause of the employment shifts than were exogenous output shifts, including the trade deficits.

Finally, I use the two-sector model to round out the analysis of the effects of employment shifts on average wage growth (which cannot be

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[1] The first section summarizes and slightly extends methodology and results from Costrell (1988a). The earlier studies include Kosters (1986), Kosters and Ross (1987), and Costrell (1988b).

[2] Revenga (1992), Freeman and Katz (1991), and Branson and Love (1986, 1988) find large employment effects of import prices, export sales and import share, and the real exchange rate, respectively.

[3] Lawrence (1987), among others, makes this argument, both for the long run (1960–85) and the short run (1980–85).

fully answered), and also the effects on overall income and productivity growth (about which more can be said).

The paper is organized as follows: the first section measures the shift-share effect; the second section uses the two-sector model to analyze the causes of the employment shifts; and the third section considers the consequences for wage and productivity growth. The results are summarized in the conclusion.

The Shift-Share Effect on Pay Growth: 1981–87 vs. 1948–81

Methodology. This section presents measurements of the shift-share effect on average pay growth, $\Sigma\dot{\alpha}_i W_i/W$ in (1), the effect of shifting employment weights among industries with different wages. The main methodological issue is the measurement of trends in industry employment shares, the $\dot{\alpha}_i$'s. These are estimated with a regression methodology, rather than comparing endpoints of selected intervals as in earlier studies. This has the obvious advantage of exploiting the full postwar time series, not just selected years. It also allows systematic control for the business cycle, better than the ad hoc practice of restricting attention to nonrecession endpoints. Moreover, it allows the data to find breaks in trend, based on goodness-of-fit. The sensitivity of the results to the methodology will be explored below.

Specifically, each industry's employment share, α_i, is fitted to a varying trend, controlling for the cycle with the unemployment rate. The trend is allowed to vary over several intervals of the postwar period, while continuity is imposed on the fitted share at the join points, by a transformation of regressors equivalent to a linear spline. The coefficient on unemployment is also allowed to vary, again imposing continuity. For example, using BEA data, the equation for primary metals (with $\bar{\alpha}_i = 2.06$, $\bar{R}^2 = 0.992$) is

$$\begin{aligned}\alpha_i = \underset{(0.76)}{4.06} &- \underset{(0.014)}{0.018}\,T1 - \underset{(0.007)}{0.048}\,T2 - \underset{(0.004)}{0.038}\,T3 - \underset{(0.007)}{0.044}\,T4 - \underset{(0.009)}{0.118}\,T5 \\ - \underset{(0.024)}{0.061}\,U1 &- \underset{(0.018)}{0.082}\,U2 - \underset{(0.017)}{0.042}\,U3 - \underset{(0.017)}{0.021}\,U4 - \underset{(0.015)}{0.057}\,U5.\end{aligned}$$

The trend join points are 1954, 1962, 1973, and 1981, so the regressors are T1 = [48, . . . , 54,54, . . . , 54], T2 = [0, . . . , 0,1, . . . , 8,8, . . . , 8], and so forth, and the unemployment join points are 1953, 1964, 1971, and 1979, so the unemployment regressors are U1 = $[u_{48}, \ldots, u_{53}, u_{53}, \ldots, u_{53}]$, U2 = $[0, \ldots, 0, (u_{54} - u_{53}), \ldots, (u_{64} - u_{53}), (u_{64} - u_{53}), \ldots, (u_{64} - u_{53})]$, and so forth. The coefficients on the T's are the $\dot{\alpha}_i$'s. Thus, primary metals lost employment share over the interval 1981–87, at the rapid clip of .118 percentage point/year.

Imposing the same set of join points on all industries forces the estimated employment shares to sum to 100 percent—that is, OLS here is equivalent to estimating seemingly unrelated equations (Kmenta, 1986, p. 639). Join points are chosen to minimize the sum of squared residuals across industries.[4]

The number of intervals is chosen somewhat arbitrarily. For the BEA data set 1948–87, five intervals were selected for the time trend (and five others for the unemployment rate). However, dropping an interval makes little difference to the results for the 1980s: 1981 is consistently identified by the data as a trend turning point. This is of some interest, since it is not picked up by endpoint studies, which are confined to nonrecession years.

The estimated trend coefficients for industry employment shares, the $\dot{\alpha}_i$'s, are taken from these regressions to measure the shift-share effect on average pay growth, $\Sigma\dot{\alpha}_i W_i/W$.

Estimates of Shift-Share Effect Using Annual and Weekly Data. Results from several sets of annual and weekly data, with different measures of pay, and different degrees of disaggregation, are presented in Table 1. They all indicate a marked deterioration in the 1980s (i.e., 1981–87) of the shift-share effect of industry employment patterns on average pay growth, to about −1/2 percent/year.

The data set considered most closely in this paper (because it also provides congruent output data, used below) is the BEA NIPA data on 58 nonfarm private industries. Line 1 shows that the shift-share effect on compensation growth (wages and benefits) reached −.48 percent/year in the 1980s, substantially more negative than before 1981.[5,6] Lines 2 and 3

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[4] The set of join points found is a local optimum, but the computational requirements to be sure it is a global optimum are prohibitive (see Poirier, 1976, pp. 118–19).

In principle, it might be preferable to find the maximum likelihood set of join points, by minimizing any $n - 1^{th}$ principal minor of the covariance matrix of the residuals across industries. However, in practice, if the number of industries is at all large (e.g., 58, as in the BEA data), then these minors are computationally indistinguishable from zero. This procedure was tried for a 12-sector model, using the BLS OPT data, and compared with the least-squares join points. A few of the join points differed, but, most important, the last break in trend was found at the same year using both methods. Since this is the join point of most interest, this provides some reassurance for using the least-squares criterion, for the BEA data set.

[5] For purposes of comparison, the fixed-weight average compensation growth within industries (the second term of equation [1]) for the intervals given are 3.02, 2.33, 1.90, .37, and 1.01. Obviously, the slowdown in compensation growth has been primarily a within-industry phenomenon rather than a shift phenomenon. Still, the shift-share effect in the 1980s of -.48 offset about half the within-industry growth of 1.01, thus substantially retarding the recovery in compensation growth.

[6] The BEA data since 1987 reflect new SIC codes, and no consistent series across the break is available. Bearing that in mind, it is nonetheless striking that over the period 1987–92 the shift-share effect dropped back to -.21 percent/year, from -.48 over the period 1981–87. Much of this diminution is real, rather than a statistical artifact of the changed SIC codes. For example, there was an important

TABLE 1

SHIFT-SHARE EFFECT ON ANNUAL (WEEKLY) PAY GROWTH, $\Sigma\dot{\alpha}_i W_i/W$, EQUATION (1)

	1948–54	1954–62	1962–73	1973–81	1981–87
BEA NIPA Data, 58 Industries					
(1) Compensation Shift-Share Effect	.04	−.28	−.02	−.03	−.48
(2) Wages and Salaries Shift-Share Effect	.05	−.24	−.01	.00	−.38
(3) Nonwage Benefits Shift-Share Effect	−.15	−.72	−.18	−.21	−.98
BLS OPT Data, 12 Industries					
(4) Compensation Shift-Share Effect	−.01	−.14	−.18	−.20	−.47
BLS CES Data, Production Workers, 323 Industries					
(5) Wages Shift-Share Effect[a]				−.24	−.61
ES-202 Data, 372 Industries					
(6) Wages Shift-Share Effect[b]				−.06	−.53

SOURCES: Lines 1–3: BEA NIPA data, Tables 6.4B–6.6B. Line 4: BLS Office of Productivity and Technology. Line 5: BLS Current Establishment Survey, published and unpublished. Line 6: BLS Current Wages and Employment program. All data refer to nonfarm private payroll employment, except line 4 which includes government enterprises. Lines 1–3 include private household workers. Line 4 excludes nonprofits.

[a] 1972–81 and 1981–86.

[b] 1975–81 and 1981–86.

show that this deterioration of the shift-share effect occurred both for wages and salaries, and particularly for nonwage benefits. The rest of Table 1 corroborates this deterioration with other data sets.[7]

The Rate of Employment Shift and the Pay Gap. The deterioration of the shift-share effect on pay growth can be decomposed into two proximate

slowdown in the decline of high-paying employment in mining and primary metal manufacturing, industries that were not affected by the change in SIC codes. Similarly, the very rapid rise of low-paying employment in retail trade (also unaffected by the SIC change) actually came to a halt for the first time in the postwar period. Thus, it seems that perhaps we are no longer becoming "a nation of hamburger-flippers." These results, for a period of narrowing trade deficits, are consistent with the evidence below that the wider deficits of 1981–87 were an important cause of that period's rapid employment shifts.

[7] Comparing lines 2 and 5 suggests that in the 1980s the effect of industrial shift has been most pronounced for production and nonsupervisory workers, consistent with direct evidence from the Displaced Workers Survey (Podgursky and Swaim, 1987). This comparison of lines 2 and 5 holds up after aggregating the BLS CES data to the same level as that of the BEA NIPA, and restricting the data to the same years. Costrell (1990a) presents full distributions by wage of industry employment gains and losses for the BLS CES data.

factors: (1) the acceleration of the rate of employment shift among industries; and (2) the concentration of those shifts from particularly high-paying to particularly low-paying industries, resulting in a wide gap in pay between contracting and expanding sectors.

Formally, the shift-share effect on pay growth can be expressed as the product of the rate of employment shift and the pay gap between expanding and contracting sectors:

$$\begin{array}{ccccc} \Sigma\dot{\alpha}_i W_i/W & = & (\sum_{i \in e}\dot{\alpha}_i) & \times & (W_e - W_c)/W \\ \text{Shift-Share Effect} & = & \text{Rate of Shift} & \times & \text{Pay Gap.} \end{array} \tag{2}$$

Here, industries have been categorized as expanding (e) or contracting (c) in employment shares, according to whether the estimated trend coefficient for the industry, $\dot{\alpha}_i \gtrless 0$, for the interval in question. Summing these estimated share changes over all expanding industries (or, equivalently, all contracting industries) gives the rate of industrial employment shift:[8]

$$\text{Rate of Shift} \equiv \sum_{i \in e} \dot{\alpha}_i \equiv -\sum_{i \in c} \dot{\alpha}_i \geq 0. \tag{3}$$

The second term in (2), the pay gap, is the difference between average pay in the expanding and contracting sectors, as a proportion of average pay overall. The weights used in calculating W_e and W_c need some explanation, especially since these weights come up again in the second section. Equation (2) requires that within each sector, e and c, each industry's pay is weighted by the employment share *change* of that industry ($\dot{\alpha}_i$), in absolute value:

$$W_e = \sum_{i \in e} W_i \,(\dot{\alpha}_i / \sum_{i \in e} \dot{\alpha}_i) \qquad W_c = \sum_{i \in c} W_i \,[-\dot{\alpha}_i / \sum_{i \in c} (-\dot{\alpha}_i)]. \tag{4}$$

These weights are all nonnegative. They contrast with employment share *levels* (the α_i's), which are appropriate weights for the second term in (1) but not for the present purpose of explaining the first term in (1), the shift-share effect of changing weights—that is, the $\dot{\alpha}_i$'s. Loosely speaking, the pay gap measures the loss in pay for the average worker shifting from a contracting industry to an expanding one (or his or her successor in later cohorts, in the case of shift through attrition). The average worker shifting from one industry to another is not necessarily a worker from one of the larger contracting

[8] This measure of industrial shift is used by Lawrence (1984, p. 52). It will, of course, depend on the level of disaggregation: more finely disaggregated data necessarily exhibit a higher rate of shift (though not necessarily a larger shift-share effect). Still, at a given level of disaggregation, one can meaningfully note the acceleration of the shift in the 1980s.

TABLE 2

RATE OF EMPLOYMENT SHIFT AND ANNUAL PAY GAP, EQUATIONS (2)–(4)

	BEA NIPA Compensation Data, 58 Industries				
	1948–54	1954–62	1962–73	1973–81	1981–87
(1) Shift-Share Effect $\Sigma \dot{\alpha}_i W_i / W$, eq. (2)	.04	−.28	−.02	−.03	−.48
(2) Rate of Shift $\Sigma_{i \epsilon e} \dot{\alpha}_i$, eq. (2), (3)	.91	.78	.78	.80	1.09
(3) Pay Gap $(W_e - W_c)/W$, eq. (2), (4)	.04	−.35	−.03	−.04	−.44

industries going to one of the larger expanding ones (industries with large α_i's) but is, instead, typically going from one of the more rapidly contracting industries to one of the more rapidly expanding ones (industries with large $\dot{\alpha}_i$'s). That is why the logic of equation (2) dictates employment-share-*change* weights, rather than employment-share-*level* weights.[9]

Table 2 decomposes the shift-share effect, using the BEA NIPA data. Line 1 reproduces the shift-share effect from line 1 of Table 1. As equation (2) states, it is the product of the rate of shift (line 2) and the pay gap (line 3). The deterioration of the shift-share effect in the 1980s reflects both the acceleration in the rate of shift[10] and a wider pay gap.[11,12] These results are corroborated by the other data sets from Table 1 (not shown).

The Shift-Share Effect, Hourly Pay, and Labor Rents. The shift-share effect discussed so far, about −1/2 percent per year in the 1980s, overestimates the loss from industrial shift, since some of the lower pay in expanding industries reflects shorter hours.[13] Also, some of the lower pay represents compensating differentials and different levels of human capital rather than lower labor rents, the true loss of displaced workers. This section scales down the estimate for these reasons.

[9] In a rather different context, to find a wage index relevant to labor supply, Juhn, Murphy, and Topel (1991) calculate an elasticity-weighted log wage, averaged over individuals, which has some similarity to the weighted average discussed here.

[10] For most industries, the increase in size of $\dot{\alpha}_i$ between 1973–81 and 1981–87 (i.e., the shift acceleration) is statistically significant, conditional on the join points.

[11] Empirically, the widening pay gap reflects the changing mix of expanding and contracting industries, rather than a widening of the pay gaps between specific industries. Line 3's indirect estimate of the loss from displacement is roughly consistent with direct evidence from the Displaced Worker Survey supplement to the Current Population Survey (CPS) (Podgursky, 1988; Krueger and Summers, 1988).

[12] Bearing in mind note 6's caution regarding the break in data after 1987, it is nonetheless suggestive that the shrinkage of the shift-share effect over the period 1987–92 reflects both a slower measured rate of shift, 0.82, and a narrowing of the pay gap to −.26.

[13] Some of the shorter hours are a loss, too, to the extent that they are involuntary.

TABLE 3

PORTION OF SHIFT-SHARE EFFECT DUE TO HOURLY PAY, EQUATION (5)

		1948–54	1954–62	1962–73	1973–81	1981–87
BEA NIPA Data, 58 Industries						
(1) Shift-Share Effect	$\Sigma\dot{\alpha}_i W_i/W$	.04	−.28	−.02	−.03	−.48
(2) Due to Hourly Pay	$\Sigma\dot{\alpha}_i w_i/w$	.05	−.21	−.02	−.02	−.37
BEA NIPA Data, 11 Industries, Hours Worked						
(3) Shift-Share Effect	$\Sigma\dot{\alpha}_i W_i/W$	−.07	−.32	−.20	−.20	−.55
(4) Due to Hourly Pay	$\Sigma\dot{\alpha}_i w_i/w$	−.06	−.26	−.14	−.13	−.34
BLS OPT Data, 12 Industries						
(5) Shift-Share Effect	$\Sigma\dot{\alpha}_i W_i/W$	−.01	−.14	−.18	−.20	−.47
(6) Due to Hourly Pay	$\Sigma\dot{\alpha}_i w_i/w$	.00	−.11	−.12	−.11	−.24
BLS CES Data, Production Workers, 323 Industries						
(7) Shift-Share Effect[a]	$\Sigma\dot{\alpha}_i W_i/W$				−.24	−.61
(8) Due to Hourly Pay[a]	$\Sigma\dot{\alpha}_i w_i/w$				−.14	−.34

SOURCES: Lines 1, 5, and 7 are drawn from Table 1, lines 1, 4, and 5. Line 2 uses Table 6.7B of the BEA NIPA accounts, which is based on household data on work hours. Line 4 uses Table 6.11 of the BEA NIPA accounts, based on a special BLS Survey of hours *worked*. Lines 6 and 8 are based on the hourly data of the establishment survey.

[a] 1972–81 and 1981–86.

The shift-share effect can be reexpressed to disentangle the effects of lower hourly pay and shorter hours. Consider

$$\Sigma\dot{\alpha}_i W_i/W = \Sigma\dot{\alpha}_i(w_i h_i) / (wh)$$
$$= \Sigma\dot{\alpha}_i w_i/w + \Sigma\dot{\alpha}_i\, h_i/h + \Sigma\dot{\alpha}_i(w_i/w - 1)\,(h_i/h - 1), \qquad (5)$$

where W is annual or weekly pay, w is hourly pay, and h is hours per week or year. This decomposition gives the effects of lower hourly pay, shorter hours, and a small interaction effect.

Table 3 shows the portion of the shift-share effect due to lower hourly pay in expanding industries for various data sets. Lines 1 and 2 consider the BEA NIPA data once again, using data on full-time equivalent employees in line 2 (based on CPS data on work hours). Most of the recent shift-share effect on compensation growth (−.37 of −.48) is due to lower hourly pay in the expanding industries, rather than to shorter hours. The remaining panels of Table 3 show that other data sets corroborate this finding.[14]

[14] The reason that these other data sets attribute less to lower hourly pay and more to shorter hours is that their data on hours are not drawn from the household survey, as in line 2. Line 4 is based on a one-time survey (at the 1-digit level) of hours *worked* rather than hours paid, while lines 6 and 8 are based on the establishment survey's hourly data, which are usually considered more reliable than the household survey (Mellow and Sider, 1983).

Finally, what portion of the shift-share effect reflects lower labor rents rather than compensating differentials and human capital? Recent research has attempted to isolate that portion of hourly pay differentials that cannot be explained by the usual earnings equations, and which may represent labor rents. Katz and Summers (1989a, 1989b)[15] provide controlled and uncontrolled pay differentials, which I use with the BEA NIPA estimates of industrial shift in the first term of equation (5). For the interval 1981–87, the controls reduce the shift-share effect on compensation growth attributable to hourly pay from −.34 to −.24 percent/year.[16]

The conclusion to this part of the analysis is that in the 1980s, rapid employment shifts from particularly high-paying industries to low-paying ones led to an unusually large shift-share effect on average pay growth, about 1/4 to 1/3 percent for hourly compensation and 1/2 percent for annual compensation.

Sensitivity of Shift-Share Estimates to Methodology. The key distinctions between my methodology and previous studies are the use of complete time series rather than endpoints, the use of cyclical controls, and the determination of turning points from the data rather than selection of nonrecession years. To analyze the impact of this methodology, I compared my BEA NIPA shift-share effect on annual compensation growth for the 1980s (given in line 1 of Tables 1–3) with other calculations on the same data.

The first part of Table 4 shows modest sensitivity of the shift-share effect to the choice of final join point (1981 was selected by the goodness-of-fit criterion). The second part, compared to the first, shows the effect of eliminating cyclical controls from the regressions. The third part shows the effect of eliminating interior years by relying only on endpoints. As it turns out, endpoint methodology gives almost identical estimates to cyclically controlled regression estimates. Of course, those who use endpoint methodology feel obliged to confine their attention to nonrecession years like 1979 in lieu of cyclical controls. My analysis suggests that this tends to understate the more pronounced industrial shift starting around 1981.

[15] Dickens and Katz (1987a,1987b), Krueger and Summers (1988), Dickens and Lang (1988), and Bound and Johnson (1992) also find large residuals, which they interpret as labor rents. A dissenting view is found in Murphy and Topel (1987).

[16] The Katz-Summers differentials for 1984 are mapped onto a 38-sector aggregation of the BEA NIPA data. The controlled differentials are given in column 3 of (Katz and Summers 1989a, Table 2) and of (Katz and Summers 1989b, Table 1). They provided me with unpublished uncontrolled differentials for total compensation. The uncontrolled estimate of −.34 given above essentially reproduces the result of −.37, reported in Table 3, line 2, since the BEA NIPA FTE measures are based on the same CPS data on hours used by Katz and Summers.

TABLE 4

SHIFT-SHARE EFFECT, VARYING ESTIMATION

All Years, Cyclical Controls, Varying Join Point	
1982	−.58
1981	**−.48**
1980	−.41
1979	−.37
Without Cyclical Controls	
1981	−.42
1979	−.33
Endpoints Only	
1981	−.47
1979	−.37

Causes of Industrial Employment Shift, 1981–87

Having established that the 1980s shift-share effect was unusually large, I now attempt to weigh two oft-cited potential causes of the employment shift and, therefore, of the shift-share effect. The first candidate is a shift in output demand away from the contracting industries, including the trade deficits in manufacturing. Regression studies cited above support this view.

The other main candidate is uneven productivity growth between expanding and contracting industries. Relatively rapid productivity growth can displace labor from contracting industries without reducing those industries' share of output. This has been the dominant explanation of long-run trends in manufacturing versus service employment (Baumol, 1967; Fuchs, 1968), and some view the 1980s as a continuation or acceleration of this phenomenon. Manufacturing's constant share of real output during the period is interpreted as supporting this explanation. I will argue below that this interpretation is misleading.

The Two-Sector Model. As a framework for analyzing the causes of the employment shift, consider a standard two-sector model, with expanding sector e and contracting sector c. There are two inputs, constant returns, and competitive product and capital markets. But in the labor market a noncompetitive wage gap exists between sectors, $w_e < w_c$, which is taken to be proportionally constant—that is, the growth rates $\hat{w}_e = \hat{w}_c$.[17] Relative demand Q_e/Q_c follows a standard function:

[17] This is Magee's (1976) modification of Jones (1965). The assumption $\hat{w}_e = \hat{w}_c$ rules out possible effects of employment shifts on industry wage differentials. However, the available evidence suggests

$$\hat{Q}_e - \hat{Q}_c = -\sigma_d(\hat{p}_e - \hat{p}_c) + \hat{E}, \qquad (6)$$

where p's are prices, σ_d is the elasticity of substitution, and $\hat{E}$ represents exogenous (non-price-related) shifts in demand toward sector e, including shifts in domestic tastes and trade deficits.

To weigh the two disputed causes of the employment shift, consider the solution for the rate of shift:

$$\begin{aligned}\dot{\alpha}_e = \; & (\sigma_e\,\mu_e + \sigma_c\mu_c)\hat{E}/\sigma^* + (1 - \sigma_d)(\sigma_e\mu_e + \sigma_c\mu_c)(A_c - A_e)/\sigma^* \\ & + (\sigma_c\theta_{Kc} - \sigma_e\theta_{Ke})\hat{k}/\sigma^* + \sigma_d(\theta_{Kc} - \theta_{Ke})(\mu_e B_e + \mu_c B_c - \hat{k})/\sigma^* \\ & + (\mu_e\theta_{Kc} + \mu_c\theta_{Ke})\sigma_e\sigma_c(B_c/\sigma_c - B_e/\sigma_e)/\sigma^*, \qquad (7)\end{aligned}$$

where μ_i is sector i's share of the capital stock, σ_i is the elasticity of substitution, A_i is the rate of total factor productivity growth, B_i is the bias of technical progress, θ_{Ki} is capital's share in the sector, and σ^* is an expression (not given) that is assumed positive, to rule out pathologies (Magee, 1976). The two causes of employment shift under consideration, exogenous output shift and uneven productivity growth, are the first two terms in equation (7). The rest of equation (7) concerns capital deepening and bias in technical progress, which may be important, but bias is difficult to estimate and these are not our concerns here.

Even the first two terms are sensitive to a number of parameters. Thus, I confine my attention to the relative importance of these terms, which depends on only one parameter, σ_d:

$$\hat{E}/[(1 - \sigma_d)(A_c - A_e)] = [(\hat{Q}_e - \hat{Q}_c) + \sigma_d(\hat{p}_e - \hat{p}_c)]/[(1 - \sigma_d)(A_c - A_e)], \qquad (8)$$

using equations (6) and (7). If this ratio exceeds unity, the output shift is more important than the productivity gap in explaining the employment shift. The rest of this section evaluates this ratio.

Note also that, by equation (2), the shift-share effect is simply the wage gap times equation (7). Therefore, the causes of the employment shift that we are evaluating are, by the same token, the causes of the shift-share effect on wage growth.

Aggregating Within the Expanding and Contracting Sectors. The 58 BEA NIPA industries are divided into the two sectors, e and c, according to industry employment share changes, $\dot{\alpha}_i \gtreqless 0$. Then, in calculating sectoral

that these differentials have been relatively constant. See, for example, Bound and Johnson's (1992, Table 2) estimated industry wage effects for 1979 and 1988. Also, little impact of trade on relative wages among industries is found by Revenga (1992) and Freeman and Katz (1991), or among plants, by Davis and Haltiwanger (1991). Murphy and Welch (1991) and Katz and Murphy (1992) examine the effect of industry shifts and trade on skill differentials, but our focus is on noncompetitive wage differentials by industry for equally skilled labor.

growth rates of output, price, and productivity, for equation (8), the first issue is how to perform the aggregation. I will argue for using the same employment-share-change weights, $\dot{\alpha}_i/\Sigma\dot{\alpha}_i$, for i ∈ e,c, used in the first section's calculation of W_e and W_c, but other weighting schemes are also considered.

Consider the output growth rates, $\hat{Q}_e$ and $\hat{Q}_c$. At first glance, it might seem appropriate to simply add up output in the industries of each sector, and then calculate sector growth rates. However, this can give misleading conclusions for the causes of employment shifts. To see this, consider the following relevant example.

Suppose trade deficits reduce steel output substantially, leading to employment losses. At the same time, an equivalent growth in demand raises computer output, but even more rapid productivity growth slightly reduces computer employment. Thus, we have two industries with contracting employment, though by very different amounts and for very different reasons: steel employment contracts greatly due to the trade deficit, and computer employment contracts slightly as productivity outpaces demand. Taken as a whole, it would be reasonable to conclude that the employment shift out of steel, and into the expanding sector, is the dominant story here and is accounted for by the trade deficit.

However, that is not the conclusion reached by using sector aggregates of output. Taken together, steel and computers maintain output, as computers' gain washes out steel's loss. This leads one to erroneously attribute the loss of employment (mostly in steel) to productivity gains (in computers). In effect, this suggests that employment losses in steel, due to output losses, are absorbed by computers, due to output gains, and then bounced out of computers to the expanding sector, due to productivity. The large net employment shift is attributed to computer productivity, even though computers hardly lost any employment.

Formally, this approach is equivalent to using output weights to calculate $\hat{Q}_{c,e} = \Sigma\hat{Q}_i(Q_i/\Sigma Q_i)$, for i ∈ e,c. This gives most weight to the largest industries, even if they are only marginally involved in the employment shifts.

Using instead employment-share-change weights, $\hat{Q}_{e,c} = \Sigma\hat{Q}_i(\dot{\alpha}_i/\Sigma\dot{\alpha}_i)$, for i ∈ e,c, gives most weight to the most rapidly expanding and contracting industries rather than to the largest ones, as discussed in the first section. In the example just given, these weights give the reasonable result that since most of the employment loss is from steel, with negative output growth, then $\hat{Q}_c$ would be negative rather than $\hat{Q}_c = 0$, as with output weights.

In sum, for the purpose of explaining employment shifts, employment-

TABLE 5

1981–87 OUTPUT, PRICE, AND PRODUCTIVITY GROWTH GAPS

		Employment Change Weights	Employment Level Weights	Output Level Weights
(1) Output:	$\hat{Q}_e - \hat{Q}_c$	5.04	1.90	1.70
(2) Price:	$\hat{p}_e - \hat{p}_c$	5.35	2.69	3.81
(3) TFP:	$A_c - A_e$	3.25	1.65	1.90

share-change weights are most pertinent. This is consistent with the first section's calculation of the pay gap, dictated by the logic of equation (2), and for similar reasons: they give most weight to the industries most heavily involved in the employment shift. For purposes of comparison, however, equation (8) will also be calculated using output weights and employment weights.

Accounting for the Employment Shift. To calculate equation (8)'s output, price, and productivity growth rates, the BEA NIPA two-digit data for industry output, deflators, FTE's, and capital stocks are used, with one relevant adjustment concerning computers. The adjustment is necessary because the two-digit data lump computers in with other nonelectrical machinery. This aggregates output in the same way I have just argued is inappropriate for the present exercise, since the three-digit employment share of computers was constant. I use Denison's (1989) adjustments to nonelectrical machinery to avoid attributing the two-digit decline in employment share of nonelectrical machinery to the extraordinary productivity growth in its only three-digit industry without declining employment share, computers.

Line 1 of Table 5 presents cyclically controlled estimates of $\hat{Q}_e - \hat{Q}_c$, the gap in output growth, between those industries with expanding and contracting employment shares in the 1980s. The first column, using employment-share-change weights, gives a gap of 5.04 percent/year. This contrasts markedly with the growth gap of 0 percent between manufacturing and nonmanufacturing implied by manufacturing's constant share of real output.

There are three elements to reconciling these figures: the weighting scheme, the adjustment to the computer data, and the different partition between expanding/contracting industries versus manufacturing/nonmanufacturing industries. The weighting scheme implicit in tracking manufacturing's share of output is simply the output weights discussed above, and it is used in the third column of Table 5. This is the most important of the three

TABLE 6

IMPORTANCE OF EXOGENOUS OUTPUT SHIFT, RELATIVE TO UNEVEN PRODUCTIVITY GROWTH, IN 1981–87 EMPLOYMENT SHIFT, EQUATION (8)

	Employment Change Weights	Employment Level Weights	Output Level Weights
$\sigma_d = 0.0$	1.55	1.15	0.89
$\sigma_d = 0.1$	1.91	1.46	1.22
$\sigma_d = 0.25$	2.62	2.08	1.86
$\sigma_d = 0.5$	4.75	3.93	3.79
$\sigma_d = 1.0$	∞	∞	∞

factors, reducing the output growth gap from 5.04 percent to 1.70 percent. The other two factors essentially eliminate the remaining gap (reducing it to 0.12 percent, not shown), corresponding to constant shares of manufacturing and nonmanufacturing output.

Now we can ask which is more important in explaining the employment shift: the exogenous output shifts or uneven productivity growth? The results from Table 5, plugged into equation (8) for various values of σ_d, are reported in Table 6. The preferred estimates, using employment-change-weights, are unambiguous: output shifts were considerably more important than was uneven productivity growth. The rest of Table 6 shows that the conclusion is fairly robust. Except when using output level weights in the extreme case of $\sigma_d < 0.05$, output shifts are still more important, regardless of weighting schemes. The main reason is that although alternative weighting schemes reduce the estimated output growth gap, they also reduce the estimated productivity growth gap.[18]

The Role of Manufacturing Trade Deficits. Having established the importance of output shifts, I now try to distinguish between exogenous shifts in domestic demand and increased trade deficits. This exercise is more tentative, since the best available trade data (NBER data on shipments, exports, and imports) are on manufacturing only. Nonetheless, these data can roughly suggest the size of the effects of the deficits, since most of the contracting industries were manufacturing and trade imbalances were still limited in most of the expanding industries.

These data are used to construct two-digit industry ratios of domestic demand (shipments + imports − exports) to domestic output (shipments). Positive growth rates of these ratios represent the shift in domestic demand away from domestic output. For the average contracting manufacturing

[18] This means that the alternative weights increase the amount of the employment shift attributed to the other terms in equation (7), estimated as a residual, and involving the bias in technical progress.

industry (using employment-share-change weights), this ratio grew at a rate of 2.71 percent over the period 1981–85, due to increased trade deficits.

To estimate the effect of trade in shifting demand, one needs to assume something about the contracting nonmanufacturing industries and also about the expanding industries. A conservative estimate, assuming no deterioration in trade for contracting nonmanufacturing and no improvement in trade for the expanding industries, gives 2.02 percent as the rate of demand shift, due to trade. This is probably an underestimate on both counts. It ignores adverse trade developments in the contracting energy industries, and it ignores the favorable trade developments of expanding business and financial services.

In sum, a ballpark estimate from these data suggests something on the order of a 2–3 percent annual shift in demand due to the increased trade deficits. By comparison, the total exogenous output shifts, for $\sigma_d < 0.5$, are 5–8 percent. That is, 25–60 percent of the exogenous output shifts appears to represent the effect of the trade deficits. This rough exercise is consistent with the regression studies cited above on the substantial employment effects of trade during the 1980s.

Consequences of Industrial Shift

Finally, how shall we interpret the negative shift-share effect on pay growth, in light of these causal results?[19] Does it represent a loss to labor as a whole, or to the economy as a whole? Or does it simply represent a redistribution from displaced workers to nondisplaced workers and/or capital?

If whatever caused the employment shift were to raise overall wage growth, then the effect on wage growth within industries (the second term of equation [1]) would offset the negative shift-share effect among industries (the first term). In the context of labor alone, then, the shift-share effect would be redistributional, from displaced to nondisplaced workers.

This would likely have been the case if it had turned out that the major cause of the employment shifts had been accelerated productivity growth in contracting industries. Nor can a rise in overall wage growth be ruled out by the fact that output shifts, rather than productivity growth, were the major cause. If the expanding sector were more labor-intensive than the contracting sector, then such output shifts would raise the wage-rental ratio, and possibly wages overall. In either case, whether the shifts were caused by output shifts or productivity growth, the shift-share effect could be redistributional within labor alone.

[19] A more formal presentation of this section's analysis can be found in Costrell (1988b, 1990b).

However, for the whole economy (capital and labor together), the interpretation of the shift-share effect critically depends on the cause of the employment shift. The model's solution for overall income or productivity growth is

$$\hat{q} = (\lambda_e A_e + \lambda_c A_c) + \theta_K \hat{k} + \theta_L \dot{\alpha}_e (w_e - w_c)/w, \qquad (9)$$

where q is aggregate labor productivity (Divisia index), λ_i is sector i's share in the value of output, and $\dot{\alpha}_e$ is given in equation (7). The first two terms correspond to the Solow (1957) equation, and the last term is simply $\theta_L \times$ the shift-share effect.

The reason the last term affects productivity is this: noncompetitive wage differentials leave the economy at a suboptimal point on the production possibility frontier, a point where the price line is not tangent; a shift to the low-wage sector moves the economy further from the optimum, and at market prices, the value of output declines—measured productivity drops.[20]

The question is whether there is anything to offset this effect on productivity. If the employment shift is due to rapid productivity growth in the contracting sector, then obviously there is, as indicated in the first term of equation (9). In fact, it can be shown that this must outweigh the negative shift-share effect, raising overall productivity. However, employment shifts due to exogenous output shifts—domestic and trade—generate no offsetting effect on productivity. Here, most of the shift-share effect (θ_L of it) comes straight off measured productivity growth.[21]

Conclusion

This paper has shown that employment shifts in the 1980s, from high-wage industries to low-wage industries, had an unprecedented shift-share effect on average pay growth, on the order of 1/4—1/3 percent per year for hourly compensation. The evidence indicates that shifts in output, away from contracting industries, were more important in explaining the em-

[20] The effect of employment shifts on aggregate productivity growth is discussed by Thurow (1979; 1980a,1980b), Gollop (1985), and Wolff (1985). Dickens and Lang (1988) also discuss the relationship between trade deficits, industrial shift, and productivity, based on noncompetitive wage differentials.

[21] Thurow (1980b, p. 89) has pointed out that the portion due to shifts in domestic tastes does not necessarily represent a reduction in welfare, however, since welfare judgments hold tastes constant. Nor is the welfare effect of the trade deficit straightforward. The effect on productivity is a reduction in the real value of national output, but welfare improves in the short run by virtue of increased borrowing from abroad. The increased borrowing represents partially the higher value of what is consumed domestically, and partially the lower value of what is produced. Repayment and servicing, of course, affect welfare intertemporally.

ployment shift than was the traditional explanation, uneven productivity growth.[22]

Conclusions based on the constancy of manufacturing's share of output are misleading for a number of reasons, of which the most important are an inappropriate weighting scheme and an implicit assumption of zero elasticity of substitution in demand. Even so, the result that output shifts were more important than uneven productivity growth is robust with respect to either assumption.

More tentative calculations indicate that the unprecedented trade deficits in manufactured goods constituted some 25–60 percent of the exogenous demand shifts away from the contracting industries. This result is qualitatively consistent with regression studies that have found significant employment effects of the trade deficits. The remainder of the output shifts appear to be exogenous (non-price-related) shifts in domestic demand.

The importance of output shifts in explaining the employment shifts suggests that the income losses of displaced workers largely came out of measured productivity growth rather than out of a redistribution from nondisplaced workers and capital.

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