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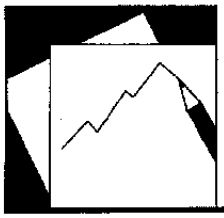

IMF Working Paper

The Unbearable Stability of the German Wage Structure: Evidence and Interpretation

Eswar S. Prasad

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The Unbearable Stability of the German Wage Structure: Evidence and Interpretation

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Abstract

This paper uses micro data from the German Socio-Economic Panel to document that the wage structure in West Germany was remarkably stable during 1984-97, with little variation over time in wage or earnings inequality between and within different skill groups. Empirical evidence suggests that this stability is attributable to institutional factors rather than market forces. The rigidity of relative wages, despite relative shifts in labor demand that favor skilled workers, has resulted in sharp declines in employment rates for unskilled workers. The microeconomic evidence is shown to have important implications for interpreting trends in wage shares, capital-labor ratios, and aggregate unemployment.

JEL Classification Numbers: J31, E24

Keywords: Wage and earnings inequality; returns to human capital; labor market outcomes across skill groups.

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I. INTRODUCTION

The objective of this paper is to document the evolution of the German wage structure over the period 1984-97. The paper also investigates the roles of various factors that could have influenced patterns of changes in the wage structure. While a documentation of the evolution of the wage structure in Germany is interesting in its own right, the analysis in this paper, by facilitating comparisons with changes in the wage structures of other industrial countries, could potentially provide important clues to understanding the poor functioning of the German labor market in recent years. In particular, the analysis sheds light on the reasons behind and possible solutions for a particularly troubling problem, the high and rising rate of nonemployment among low-skilled workers.

First, I use data from the German Socio-Economic Panel (GSOEP) to characterize the key features of and changes in the West German wage structure. Over this period, the wage structure in Germany has remained remarkably stable, with little change in inequality within or between groups. Returns to observed skill attributes such as education and experience have remained essentially unchanged and, if anything, declined marginally during the 1980s. There is, however, some evidence of a modest increase in wage inequality during the mid 1990s. These results stand in stark contrast to the evolution of wage inequality in the United States, where inequality has risen sharply, although at varying rates, over the last three decades.

In the second part of the paper, I examine a number of factors that could explain the stability of the German wage structure. These include shifts in the relative supplies of skilled and unskilled workers and changes in the sectoral composition of employment. I also exploit certain unique features of the GSOEP dataset to control for the effects of nonwage compensation, as well as selection and cohort effects. None of these "market factors" appears capable of explaining developments in the wage structure.

That leaves "institutional factors" as the residual claimant. Indeed, for Germany, anecdotal and more formal evidence abounds that the wage bargaining system is the proximate cause for the rigidity of relative wages. Unions have traditionally set effective wage floors (there is no legislated minimum wage in Germany) and have negotiated uniform relative wage increases for workers of all skill levels, thereby constraining the flexibility of the wage structure. While these "solidaristic" policies may have served Germany well in previous decades, they have had a deleterious effect on labor market performance over the last 15 years, a period during which the economy has been buffeted by a number of adverse shocks.[2]

As has been well documented for many other industrial economies, it is plausible and likely that there has been a substantial shift in the relative demand for skilled workers in

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[2] See van der Willigen (1995) for a description of the wage bargaining structure and Jaeger (1999) for a discussion of how it may have been well suited to the *Wirtschaftswunder* era of the 1960s and 1970s.

Germany. Factors that have accentuated this demand shift in other countries include skill-biased technological change, increased openness to international trade and de-industrialization, all of which are forces that appear to operate in Germany as well. For instance, Machin and Reenen (1998), using an industry-level database that is comparable across countries, provide persuasive evidence that skill-biased technological change has resulted in relative demand shifts favoring skilled workers in virtually all OECD industrial countries including Germany (Manacorda and Petrongolo, 1999, reach a similar conclusion).

The rigidity of the German wage structure, coupled with these relative demand shifts that have been accentuated by a series of adverse macroeconomic shocks, has resulted in marked increases in unemployment rates and a deterioration of employment prospects for unskilled workers. In other words, given the inflexibility of the relative prices of skills in response to market forces, employers have had to adjust the relative quantities of skilled and unskilled labor that they employ, to the detriment of unskilled workers. Indeed, employment and retention rates for unskilled workers have continued to fall during the recent recovery, in sharp contrast to the rising employment rate for skilled workers.

In the third part of the paper, I provide a synthetic perspective on recent developments in the German labor market. In particular, I argue that it is essential to draw a distinction between skilled and unskilled labor in order to reconcile the micro evidence on the wage structure presented in this paper with macroeconomic phenomena such as the decline in the wage share, capital-labor substitution and rising aggregate unemployment.

II. The Wage Structure

A. The Dataset

The data used in this paper are drawn from the public use version of the German Socio-Economic Panel (GSOEP) for the years 1984-97. This is a representative sample of German households and individuals, including immigrants without German citizenship. The sample was expanded to cover unified Germany in the 1990s. The dataset includes details on individual workers' net and gross monthly earnings; hours of work; educational and demographic characteristics; sector and category of occupation; and numerous other individual-specific variables.

One of the features of the dataset is that it has a large and relatively stable panel. Nevertheless, the non-response rate for repeat interviews is large enough that attrition bias is a serious concern. New individuals are added to the survey from existing households as they enter the labor force. To reduce the effects of attrition bias and to make the results in this paper reasonably representative of the population, the dataset is treated here as a set of repeated cross-sections rather than as a longitudinal survey. This also has the virtues of yielding a larger sample size and keeping the sample size relatively stable over time.

To maintain a uniform sample and to minimize distortions from sample selection, much of the analysis below, except where explicitly noted otherwise, is limited to full-time

male workers from the West German sample. This also facilitates comparisons with studies for industrial countries that have focused on samples based on similar selection criteria.[3]

The wage variable used in this paper is the real gross hourly wage (excluding end-of-year bonuses), constructed using reported gross monthly earnings and "usual number of weekly hours" worked, and using the consumer price index for West Germany (1991=100) as the price deflator. The GSOEP also provides data on the number of contracted weekly hours and overtime hours for the month of the survey. There were some discrepancies between the sums of these two variables and the usual weekly hours variable. This latter variable is interpretable as actual hours worked per week in the survey month and is the variable used in this paper. Sensitivity tests indicated that none of the results reported below were much affected by the choice of the hours variable.[4] The hourly wage is the appropriate measure of the price of labor inputs that is relevant for the analysis in this paper. Nevertheless, the sensitivity of the results to the choice of an alternative measure—monthly earnings—is also examined below.

The GSOEP contains a generated variable on years of education for individuals in the West German sample. This variable is constructed based on information about educational attainment. However, there is a strong tradition of apprenticeship and vocational training in Germany and a variable such as years of schooling would not adequately capture the returns to such training. Hence, I define four education dummies—general schooling; apprenticeship; vocational training; university degree—and group workers on the basis of this classification. Since the focus of this paper is on changes over time in skill premia rather than their levels, this choice turned out not to matter for any of the results reported below. In particular, the time profiles of the skill premia were virtually identical when the years of education variable was used.[5] Nevertheless, this discussion should be kept in mind should the results from this paper be used for cross-country comparisons of the *levels* of skill premia.

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[3] Part-time workers and apprentices account for a relatively small fraction of the sample and including them did not have much affect on any of the results discussed below. Results for the sample including part-time workers and apprentices are available from the author. An analysis of wage growth in East Germany following unification constitutes an interesting topic in its own right (see Hunt, 1999b).

[4] As noted by Hunt (1999a), using the sum of the contracted weekly hours and overtime hours variables is problematic. This sum would not capture "under-time" since only positive overtime hours are reported in the survey.

[5] Results using the years of education variable were reported in an earlier version of this paper and are available from the author. The classification used here is similar to that adopted by other authors who have used this data, including Hunt (1999a). Haisken-DeNew (1996, pp. 110-111) has an extensive discussion of the mapping between educational attainment and years of schooling for this dataset and notes that, regardless of the mapping used, when estimating wage equations "...the differences are typically minor, and the results for education and experience remain very robust."

Labor market experience, which is to be interpreted as potential rather than actual labor market experience, is defined as age minus years of education minus 6.

Finally, it should be noted that non-citizens are over-represented in the GSOEP sample relative to their share of the West German population. Where appropriate, I use the GSOEP cross-sectional weights that are intended to control for this feature of the sample. In the regression results, I directly include controls for citizenship.

I restricted the sample to workers between the ages of 17 and 65 and excluded self-employed workers and workers who report less than 35 or more than 60 weekly hours of work. I also excluded workers who report hourly wages of less than 5 DM (at 1991 prices; these observations accounted for only 0.3 percent of the sample). Some summary statistics for the final sample used to analyze the wage structure are shown in Table 1. Figure A1 shows the evolutions of the relative sizes of different education and experience groups in the wage analysis sample.

B. The Overall Wage Structure

Figure 1 displays some summary statistics for real wages for all full-time workers, including women. The top panels show that the median wage increased by a total of about 20 percent over the period 1984-97. Although a significant gender gap remains, the relative female-male wage differential narrowed significantly during this period. The bottom panels of this figure show 3-year moving averages of two summary measures of wage dispersion—the standard deviation and the coefficient of variation. Both measures of dispersion declined slightly during the latter half of the 1980s, stayed flat through about 1994, and then rose slightly after the mid-1990s.[6] The remainder of this paper will focus on results for the male sample, but it should be noted that preliminary results for the sample of women indicate very similar patterns of changes in wage dispersion here, and as described below, for men.

To abstract from any distortions that might arise from year-to-year variation in the results, most figures and tables in the remainder of the paper report results for 3-year moving averages of the relevant statistics centered on the years shown, although all statistics are first computed using the underlying annual data. Where annual results are reported, this will be noted explicitly.

Which part of the wage distribution has accounted for the apparent stability of the overall distribution? One way to approach this issue, following Juhn, Murphy and Pierce (1993; henceforth referred to as JMP), is to examine the cumulative change in real wages across the entire distribution. The first (top left) panel of Figure 2 shows the change in real wages from 1984-97 at each percentile point of the aggregate wage distribution for full-time male workers.[7] Over this period, there has been a marginal increase in inequality. However,

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[6] Other summary measures of inequality such as Gini coefficients revealed a similar pattern.

[7] The top and bottom 5 percentiles have been trimmed out in the figures. A fitted regression line for the cumulative wage changes across percentile points is shown in each panel.

Table 1. Summary Statistics

Variable	Mean	Standard Deviation
Log hourly real wage (gross)	3.00	0.36
Log monthly real earnings (gross)	8.21	0.37
Age (in years)	39.60	11.28
Experience (in years)	22.38	11.48
Tenure (in years)	12.05	9.61
Education dummies:		
General schooling	0.22	0.41
Apprenticeship	0.41	0.49
Vocational training	0.26	0.44
University degree	0.11	0.32
Citizenship dummy	0.69	0.46
Weekly hours worked in survey month	42.54	5.41

Notes: The summary statistics reported here are for West German workers with full-time employment and for whom data on all of the variables listed above are available. Nominal wages were deflated by the CPI for West Germany (1991=100). The total number of observations over the period 1984-1997 is 32,713 (average of about 2,340 per year). The results reported in this table are weighted by cross-sectional sampling weights.

Figure 1. Median and Dispersion Measures for Hourly Wage

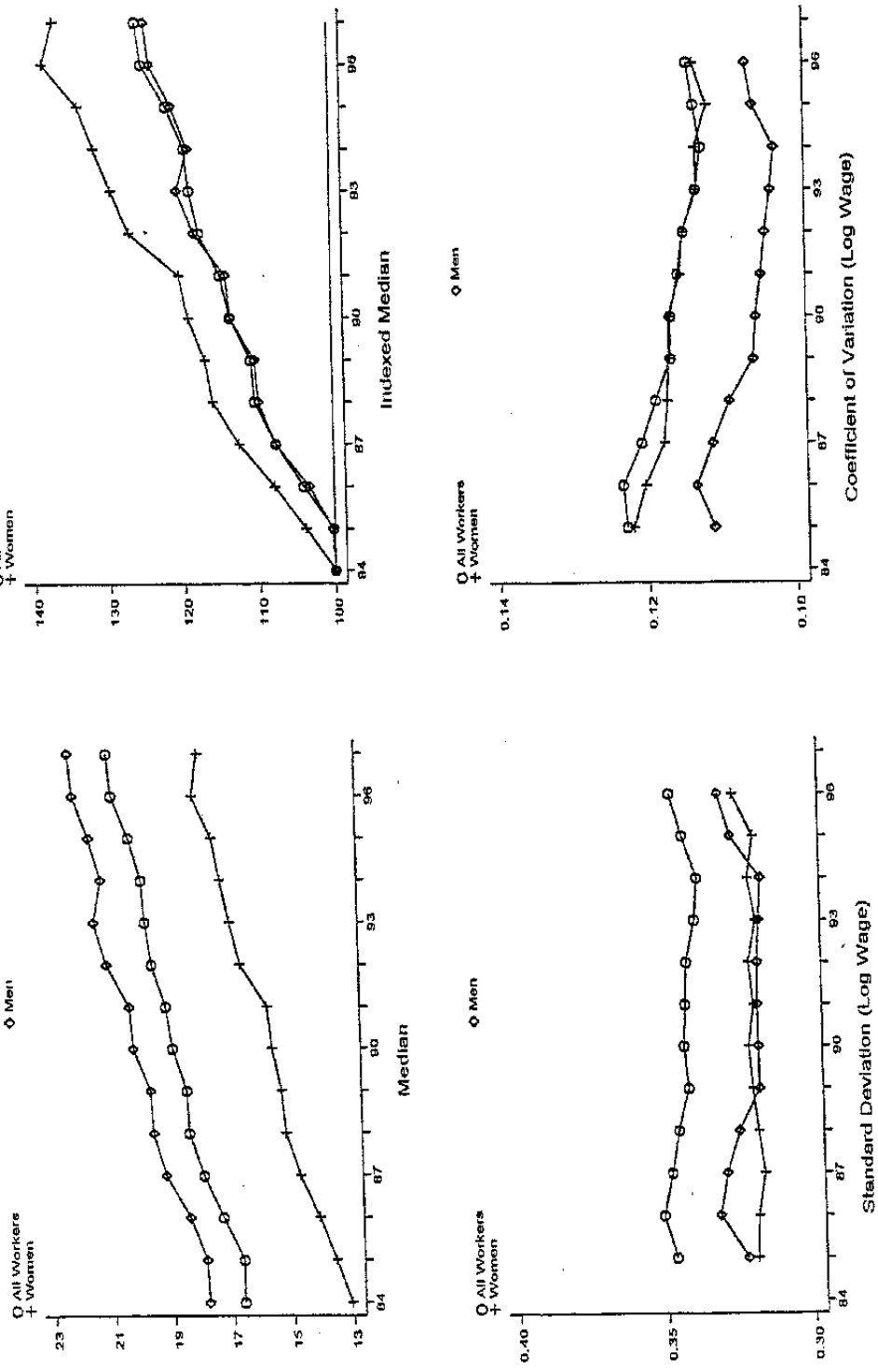
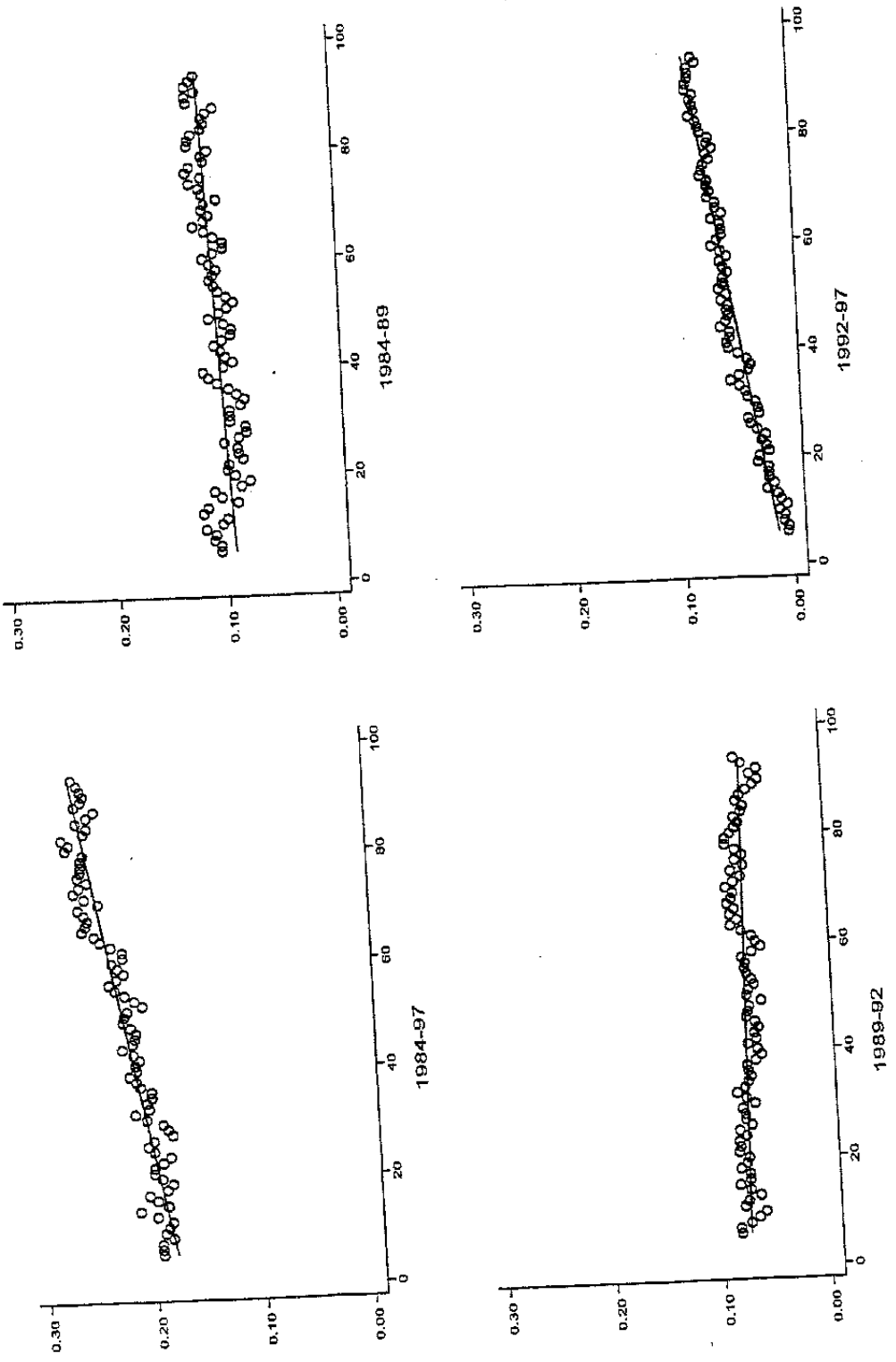


Figure 2. Changes in Log Wage Across Wage Distribution



the differences are relatively minor. Cumulative wage growth at the top part of the distribution appears to have been about 5 percentage points higher than at the bottom part of the distribution. This is in stark contrast to recent patterns of wage growth across the distribution in other industrialized countries that are viewed as having more "flexible" labor markets, such as the United Kingdom and the United States. In the United States, for example, a similar plot for the 1980s would have a steep positive slope, with cumulative *negative* real wage increases over this period at the low end of the distribution.

The remaining panels of this chart break down the total change over the period 1984-97 into three sub-periods. Wage growth across the distribution appears to have been flat during the 1980s, followed by a slight compression during 1989-92, and then by a slight widening of the wage structure in the 1990s.

Panel A of Table 2 shows a number of percentile differentials for hourly wages. The 90-10 percentile differential declined marginally during the 1980s, before returning to its earlier levels by the mid-1990s. Although the 75-25 percentile differential is essentially flat, it does show a small increase between 1992 and 1996. It is also interesting to note that the contribution of inequality above the median of the distribution to total wage inequality is greater than that of inequality below the median. In other words, the wage structure is more compressed below the median than above. However, the slight increase in wage inequality in the 1990s seems to have occurred both above and below the median of the distribution.

Overall, the analysis so far yields a picture of relative stability in the aggregate German wage structure over the last 15 years. There is little evidence of major increases in wage inequality, let alone increases in inequality of the magnitude seen in the United Kingdom and the United States.

C. Within-Group Inequality

It is interesting to examine the evolution of wage inequality within skill groups in order to understand the effects of within- and between-group wage dynamics on overall inequality. In the United States, for instance, JMP have documented that the rise in wage inequality in recent decades has been as dramatic within narrowly-defined skill groups as it has been in terms of increases in inequality between these groups.

Figure 3 plots cumulative wage changes at different ventiles for specific skill groups. Skill groups are defined on the basis of three skill attributes—education, labor market experience and tenure on the current job. The pattern of a mild increase in wage inequality across the distribution is consistent across most skill groups.

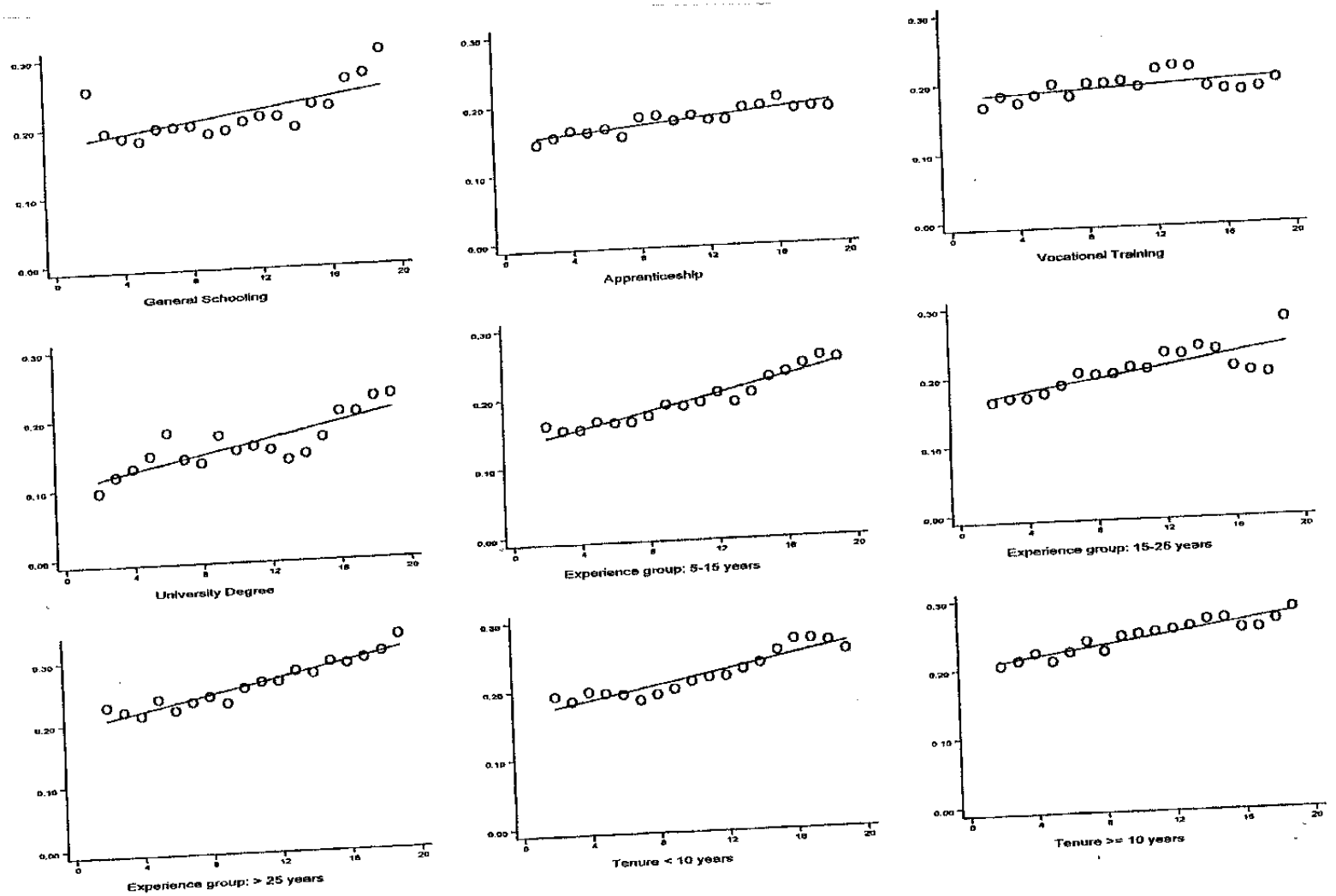
A more direct approach to control for between-group effects is to regress wages on observed skill attributes and to examine the dispersion of the wage residuals. Inequality measures based on wage residuals from human capital wage equations are reported in Panel

Table 2. Measures of Wage Inequality

Percentile Differential:	90-10	90-50	50-10	75-25	75-50	50-25
			A. Log Hourly Wage			
1985	0.79	0.43	0.36	0.37	0.19	0.18
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
1989	0.77	0.44	0.33	0.38	0.20	0.17
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
1992	0.76	0.42	0.34	0.37	0.20	0.17
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
1996	0.80	0.44	0.36	0.40	0.22	0.19
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)
			B. Wage Residuals			
1985	0.61	0.31	0.30	0.31	0.16	0.15
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
1989	0.61	0.32	0.29	0.31	0.16	0.15
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
1992	0.61	0.32	0.29	0.31	0.16	0.15
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
1996	0.63	0.32	0.30	0.32	0.16	0.16
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)

Notes: The reported differentials are three-year averages centered on the years shown above. Standard errors are in parentheses. The sample includes West German males with full-time jobs. Panel B reports differentials based on residuals from annual regressions of log hourly wages on a constant, education dummies, tenure, experience and its square, a dummy for German citizenship, and interactions of this dummy with the education dummies, tenure, experience and squared experience.

Figure 3. Within-Group Changes in Log Wage, 1984-97



B of Table 2.[8] The percentile differentials based on wage residuals are smaller than those based on actual wages but are still quite large, indicating that unobserved attributes constitute an important determinant of the wage distribution. The time profiles of the percentile differentials in this panel are, however, very similar to those in the top panel, indicating that within-group inequality has also been quite stable over the last 15 years. Figure 4, which shows cumulative wage changes at different percentiles of the residual wage distribution, confirms that inequality within narrowly defined skill groups has evolved in a manner similar to that of overall wage inequality.

D. Relative Prices of Skills

I turn next to an examination of changes in between-group inequality, based on changes in prices for observed skill attributes. The evolution of skill prices has important implications for labor market and, more generally, for macroeconomic outcomes. The incentives for acquisition of human capital are determined by the returns to that capital. The general equilibrium effects of inadequate wage differentiation, which typically implies smaller returns to skill attributes, could be quite large. Furthermore, the evolution of the wage structure could have implications for the demand for different types of labor.

Given the potential problems in using indicators such as job categories as measures of skill, I now examine the evolution of skill prices based on estimates of standard human capital wage regressions. The results reported below are based on annual ordinary least squares (OLS) regressions of log hourly wages on education dummies, labor market experience, the square of labor market experience, tenure, a dummy variable for German citizenship and interactions of this dummy with the other variables.[9] Labor market experience may be viewed as a component of general human capital while the tenure variable would be expected to pick up the returns to firm-specific human capital.

Figure 5 shows the evolutions of 3-year moving averages of the estimated (conditional) returns to education, experience and tenure. The regression coefficients for each year are reported in Table 3. General schooling is the excluded education category. Hence, the returns to the other three categories of education are expressed relative to that category. Since the experience variable enters the regressions as a quadratic, the returns to experience are evaluated at particular levels of experience.

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[8] Log hourly real wages were regressed separately for each year on a constant, education dummies, experience and its squared, tenure, a dummy for German citizenship and a full set of interactions of this dummy with the other independent variables. The choice of the specification for these regressions is discussed further below.

[9] I experimented with the inclusion of higher order polynomials of experience; the results were essentially unchanged. Coefficients on polynomials of the tenure variable were also small and statistically insignificant. I do not include industry or occupation dummies in these regressions. Since individuals typically self select into industries and occupational groups, inclusion of these dummies could induce substantial bias in estimated skill premia.

Figure 4. Changes Across Residual Wage Distribution

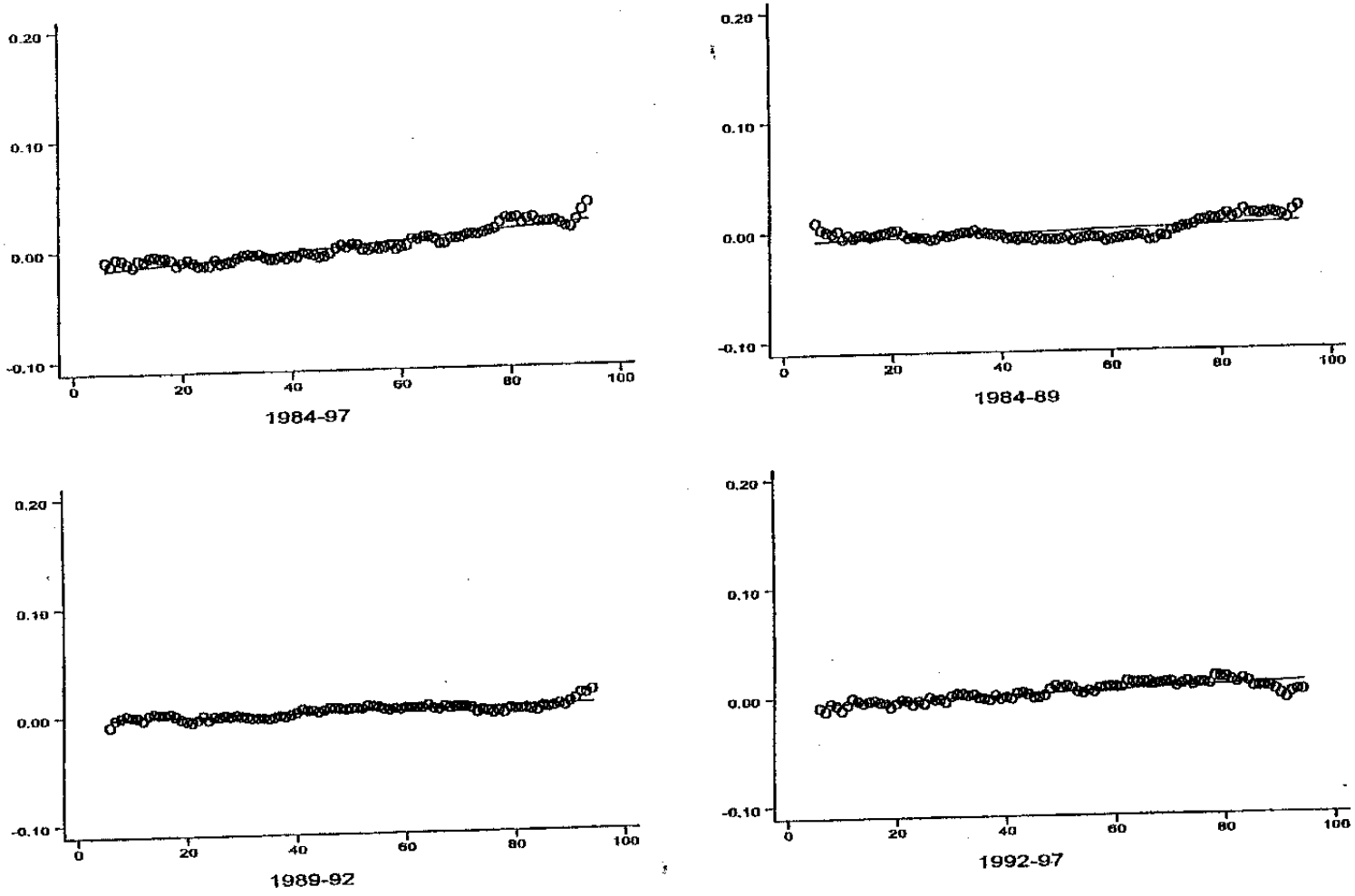
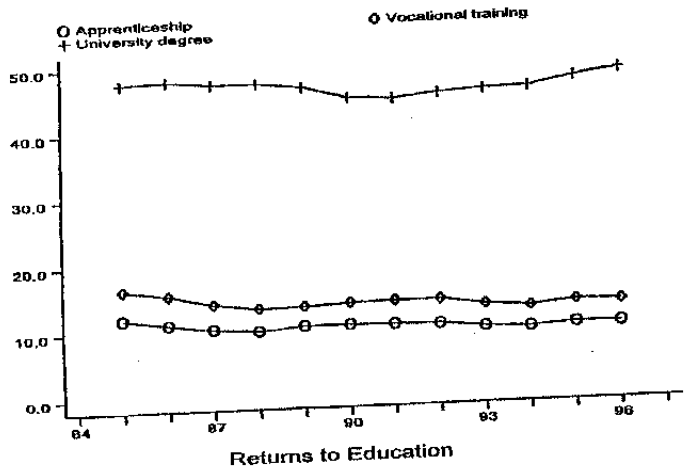
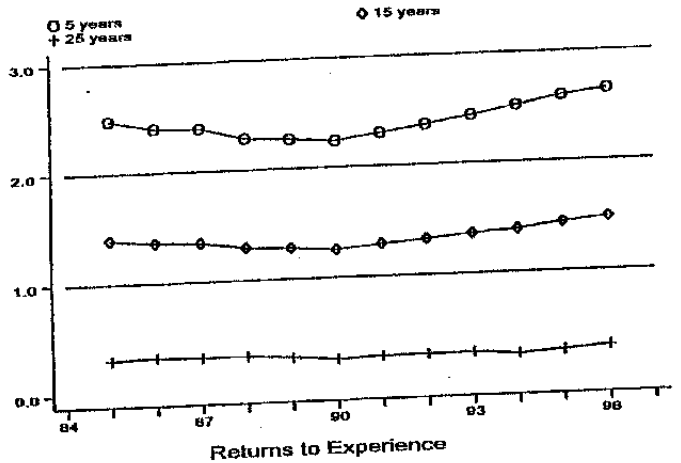


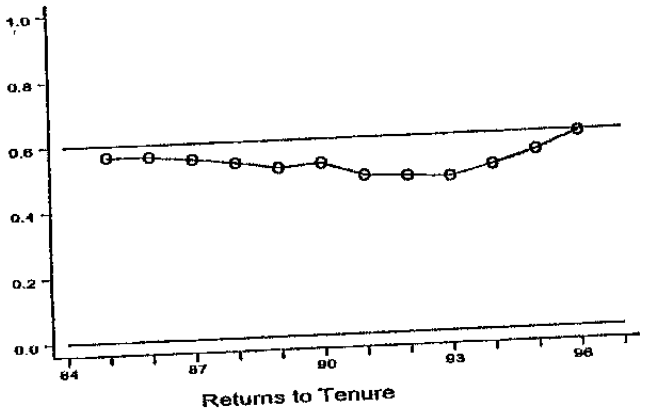
Figure 5. Returns to Education, Experience, and Tenure



Returns to Education



Returns to Experience



Returns to Tenure

Table 3. Skill Premia: OLS Results

	Education			Experience			Tenure		
	Apprenticeship	Vocnl. Trng.	Univ. Degree	5 years	15 years	25 years		Adjusted R-squared	Nobs.
1984	11.92	16.64	47.40	2.58	1.42	0.26	0.53	0.37	2865
	(1.38)	(1.49)	(3.20)	(0.15)	(0.08)	(0.05)	(0.07)		
1985	12.36	17.58	49.43	2.44	1.39	0.34	0.58	0.38	2550
	(1.72)	(1.84)	(3.47)	(0.18)	(0.10)	(0.06)	(0.08)		
1986	11.58	14.94	45.88	2.42	1.37	0.31	0.58	0.34	2521
	(1.77)	(1.86)	(3.59)	(0.18)	(0.10)	(0.07)	(0.08)		
1987	9.13	13.94	48.16	2.34	1.33	0.32)	0.52	0.35	2582
	(1.63)	(1.74)	(3.24)	(0.18)	(0.10)	(0.06)	(0.08)		
1988	9.87	13.04	47.77	2.41	1.36	0.31	0.55	0.36	2447
	(1.59)	(1.70)	(3.05)	(0.18)	(0.10)	0.06)	(0.08)		
1989	10.25	12.73	45.72	2.11	1.21	0.30	0.53	0.35	2476
	(1.62)	(1.74)	(3.06)	(0.17)	(0.10)	(0.06)	(0.08)		
1990	11.15	14.34	45.94	2.28	1.27	0.26	0.47	0.35	2398
	(1.61)	(1.73)	(2.92)	(1.18)	(0.10)	(0.06)	(0.08)		
1991	9.83	13.98	42.51	2.33	1.27	0.22	0.58	0.33	2332
	(1.76)	(1.87)	(2.87)	(0.19)	(0.11)	(0.07)	(0.08)		
1992	9.78	13.31	44.78	2.29	1.32	0.34	0.41	0.34	2225
	(1.78)	(1.88)	(2.88)	(0.20)	(0.11)	(0.07)	(0.80)		
1993	10.88	14.29	47.96	2.46	1.37	0.27	0.44	0.38	2213
	(1.68)	(1.84)	(3.18)	(0.19)	(0.11)	(0.06)	(0.08)		
1994	7.80	11.09	43.82	2.54	1.38	0.22	0.56	0.37	2132
	(1.88)	(2.00)	(3.03)	(0.21)	(0.12)	(0.07)	(0.08)		
1995	9.01	11.68	44.91	2.55	1.41	0.28	0.50	0.35	2056
	(1.85)	(1.97)	(3.23)	(0.21)	(0.12)	(0.07)	(0.08)		
1996	12.12	16.48	52.21	2.70	1.52	0.43	0.56	0.35	1985
	(2.17)	(2.30)	(3.76)	(0.23)	(0.13)	(0.08)	(0.10)		
1997	7.64	10.53	46.53	2.69	1.50	0.31	0.72	0.37	1931
	(2.10)	(2.23)	(2.80)	(0.22)	(0.12)	(0.08)	(0.09)		

Notes: The results reported in this table are from OLS regressions of log hourly wages on a constant, education dummies, experience and its square, tenure, a dummy for German citizenship and a full set of interactions with this dummy. The excluded education category is general schooling. Since experience enters the specification as a quadratic, the returns to experience are evaluated at specific experience levels. All coefficients were multiplied by 100. Robust standard errors are reported in parentheses.

As noted earlier, differences in definitions of the education variables make it difficult to compare the levels of education premia across countries. It is striking, however, that the education premia for all three categories are relatively flat over the entire sample. This is, again, in stark contrast to countries such as the United Kingdom and the United States where education premia have risen sharply during the 1980s and 1990s. In the United States, for instance, the college-high school differential more than doubled over a similar period, from 25 percent in 1980 to over 50 percent by 1995.[10] Although there are fluctuations in the estimated education premia from year to year, there are no discernible trends in these premia.

For workers with low and medium levels of experience (5 and 15 years of experience, respectively), the returns to an additional year of experience declined marginally during the 1980s, followed by a reversal of this decline during the 1990s. As in other industrial countries, the marginal returns to experience tend to be lower at higher levels of experience. One interesting finding is that, compared to other industrial countries for which good estimates from micro data are available, experience premia are lower in Germany at all experience levels. For the United States, for instance, Buchinsky (1994) reports average returns to experience of about 5 percent and 3 percent when evaluated at 5 and 15 years of experience, respectively, in the 1980s. Returns to experience appear to have been lower but also relatively more stable in Germany over the last 15 years.

The marginal returns to tenure, after controlling for attributes that would be expected to reflect general human capital, are quite small. An additional year of tenure adds about 0.6 percent to the hourly wage and, apart from a slight increase towards the end of the sample, this coefficient appears not to have changed much.

One interesting question that arises at this juncture is how recent labor inflows into West Germany have affected the wage distribution. To examine this issue, I extended the sample for 1991-97 to include migrants and commuters from East Germany. Starting in 1994, the GSOEP includes an additional sample of immigrants from other countries. For the period 1994-97, I also included full-time male workers from this sample and then recomputed the OLS wage regressions (using sample weights to correct for the consequent over-representation of immigrants). Given the small number of migrants and commuters in the sample for 1991-93, the results for these years hardly changed. For 1994-97, estimates of OLS wage regressions for this broader sample are reported in Table 3A. The results indicate that the slight increase in skill premia in the mid-1990s apparent in the West German sample is in fact slightly attenuated in this broader sample. Overall, the results remain unchanged. To maintain a homogeneous sample, the remainder of the analysis in this paper is limited to the

[10] As noted earlier, the *levels* of these premia must be interpreted with caution since the education variable might have different connotations in different countries.

Table 3A. Skill Premia: OLS Results, Extended Sample

	Education			Experience			Tenure	Adjusted R-squared	Nobs.
	Apprenticeship	Vocnl. Trng.	Univ. Degree	5 years	15 years	25 years			
1994	6.63	8.24	49.10	2.49	1.42	0.34	0.49	0.37	2181
	(4.59)	(4.70)	(5.17)	(0.36)	(0.20)	(0.12)	(0.12)		
1995	10.42	14.68	48.21	2.08	1.25	0.42	0.43	0.33	2275
	(2.71)	(3.44)	(3.36)	(0.29)	(0.15)	(0.12)	(0.12)		
1996	15.27	18.63	51.72	2.08	1.24	0.39	0.62	0.34	2237
	(2.78)	(3.16)	(3.55)	(0.29)	(0.16)	(0.12)	(0.13)		
1997	9.11	9.64	47.62	2.33	1.31	0.28	0.97	0.36	2203
	(2.68)	(3.31)	(3.32)	(0.30)	(0.15)	(0.12)	(0.13)		

Notes: See notes to Table 3. The sample is extended to include migrants and commuters from East Germany and also observations from the new immigrant sample. Sampling weights were used in the regressions.

West German sample but it should be kept in mind that the results are not sensitive to the addition of other workers in West Germany.[11]

E. Quantile Regressions

How have skill prices changed at different parts of the wage distribution? The OLS regressions provided estimates of the marginal returns to human capital attributes at the conditional mean of the data. It is also of interest to examine how these premia have evolved at other parts of the distribution.

Quantile regressions can be used to provide a parsimonious characterization of the entire conditional wage distribution. This technique can be used to estimate the marginal return to an observed skill attribute at any specific quantile point of the aggregate distribution. I estimated a set of quantile wage regressions, keeping the independent variable and the dependent variables the same as in the OLS regressions discussed above.

Figure 6 plots the estimated returns to education, experience and tenure at the 10^{th}, 25^{th}, 75^{th} and 90^{th} percentile points of the distribution. As in other industrial countries, the returns to education are higher at the upper quantiles of the distribution, although these differences are quantitatively significant only among workers with a university degree. Among workers with an apprenticeship or vocational training, the returns to the respective educational qualifications have actually declined at the top quantiles relative to the lower quantiles. Interestingly, the differences in returns to education between the lower and upper quantile points are quite small and appear to have fallen slightly over the sample. Thus, inequality both within and between educational groups appears to have fallen over time in Germany. The returns to experience at different quantile points are also clustered fairly close together for each set of experience levels examined here and appear quite stable over time.

Tables 4-6 provide more detailed results for each year on the returns to education, experience and tenure at different points of the wage distribution. Table 4 shows that, as in other countries, the returns to education tend to be higher at the upper quantiles of the distribution. For instance, in 1984, the marginal return to a university degree (relative to general schooling) was about 38 percent (exp(32.17/100)) at the 0.10 quantile compared to 72 percent at the 0.90 quantile. There is a fair amount of year-to-year variation in the estimated conditional returns to education at different quantile points. Overall, it is difficult to detect any systematic patterns of changes in wage inequality.

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[11] Another reason for limiting subsequent analysis to the West German sample is that some of the variables required for the analysis (e.g., years of education) were not available for East German and other migrants and had to be imputed. Further, it is unclear if human capital variables such as education and experience have similar connotations across these samples. Preliminary analysis indicated that there were some differences in the coefficients on the education and experience dummies across these samples. This problem is also apparent in the jump in standard errors on the estimated returns to education in Table 3A.

Figure 6. Condnl. Returns to Skill at Different Quantile Points

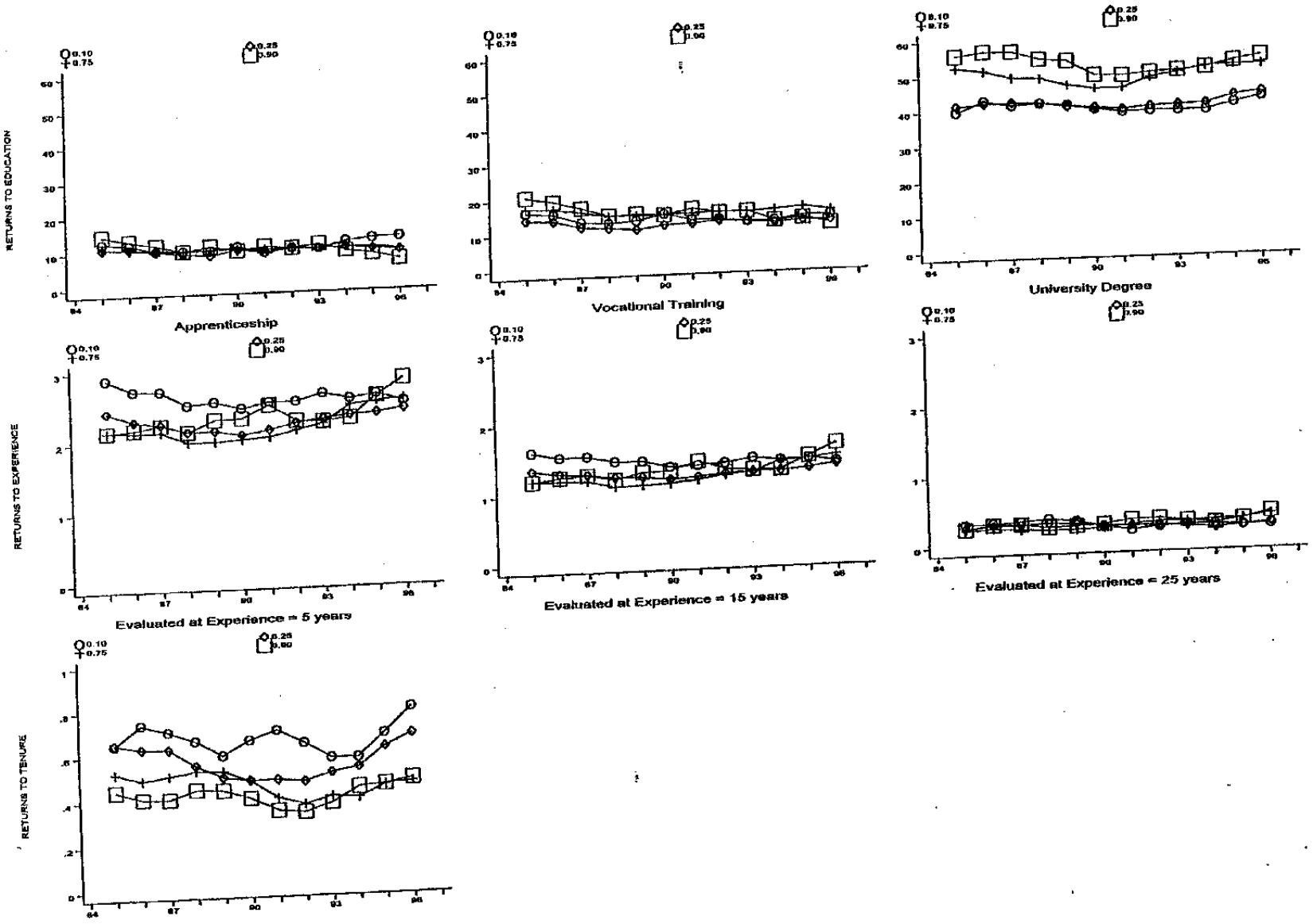

Table 4. Returns to Education: Quantile Regressions

Education level:	Apprenticeship					Vocational Training					University Degree				
Quantile Point:	0.10	0.25	0.50	0.75	0.90	0.10	0.25	0.50	0.75	0.90	0.10	0.25	0.50	0.75	0.90
1984	12.16	10.39	10.94	11.25	14.89	15.64	14.30	15.26	17.36	21.42	32.17	41.45	51.43	55.22	53.97
	(3.64)	(1.65)	(1.70)	(1.86)	(2.38)	(3.65)	(1.98)	(1.52)	(1.99)	(2.31)	(7.77)	(3.90)	(6.74)	(2.35)	(2.86)
1985	11.91	9.89	10.29	10.85	15.13	15.59	16.02	14.43	18.12	21.92	46.36	41.64	53.81	55.16	56.24
	(4.07)	(3.08)	(1.76)	(2.56)	(3.46)	(3.52)	(3.54)	(1.66)	(2.55)	(3.62)	(6.18)	(3.78)	(6.27)	(3.74)	(5.14)
1986	13.97	12.53	10.82	11.25	14.09	17.95	12.30	12.44	17.44	18.85	40.86	41.53	46.34	47.02	57.52
	(2.75)	(2.25)	(1.64)	(1.82)	(3.22)	(3.15)	(2.50)	(2.19)	(2.51)	(3.69)	(4.49)	(4.97)	(4.30)	(3.42)	(6.97)
1987	10.25	10.39	9.07	9.93	10.46	13.53	13.22	14.38	15.91	17.49	41.04	43.22	46.71	52.27	57.37
	(3.05)	(1.69)	(1.10)	(1.34)	(4.73)	(2.85)	(2.34)	(1.73)	(1.74)	(4.75)	(4.01)	(5.39)	(4.00)	(4.39)	(6.90)
1988	6.60	7.39	11.75	10.39	11.03	8.50	10.24	15.76	15.05	15.86	42.51	42.24	46.65	49.06	55.83
	(2.34)	(1.94)	(2.25)	(2.23)	(3.31)	(3.19)	(2.01)	(2.04)	(2.33)	(4.90)	(3.21)	(2.65)	(4.88)	(4.88)	(3.52)
1989	13.14	10.03	8.81	9.66	8.51	16.42	10.65	11.95	13.55	11.69	41.92	40.71	43.73	45.81	50.58
	(3.80)	(1.43)	(1.90)	(2.87)	(4.64)	(3.53)	(1.62)	(1.96)	(2.93)	(4.21)	(7.20)	(3.97)	(3.07)	(3.90)	(6.98)
1990	10.44	8.67	10.47	11.01	14.09	14.98	11.68	13.34	15.80	18.05	39.54	39.47	47.11	46.23	55.47
	(3.45)	(2.70)	(1.61)	(1.97)	(3.21)	(3.63)	(3.00)	(2.13)	(2.22)	(3.80)	(6.39)	(6.32)	(3.15)	(2.90)	(6.97)
1991	9.69	11.26	9.86	10.14	7.07	13.66	13.40	14.72	15.36	14.63	38.16	41.19	41.29	45.87	43.37
	(1.93)	(2.24)	(1.80)	(1.55)	(5.63)	(2.58)	(2.32)	(2.25)	(2.70)	(5.54)	(4.50)	(3.34)	(3.75)	(4.75)	(6.12)
1992	7.62	7.29	9.44	9.14	11.62	10.87	11.07	13.64	13.83	16.12	39.44	38.38	46.66	45.60	49.38
	(3.77)	(1.42)	(2.15)	(2.38)	(2.84)	(3.64)	(2.20)	(2.54)	(2.79)	(3.92)	(6.36)	(3.55)	(3.65)	(3.87)	(6.43)
1993	13.38	11.56	10.74	11.21	12.17	14.78	13.44	15.59	16.33	14.30	39.88	41.64	48.04	54.81	57.43
	(2.97)	(1.70)	(2.63)	(2.44)	(3.11)	(3.99)	(2.16)	(2.54)	(3.18)	(4.37)	(5.68)	(3.75)	(4.79)	(3.28)	(7.33)
1994	8.68	10.74	8.64	9.56	9.71	11.06	12.1	10.82	14.55	15.09	37.86	41.69	44.46	49.68	44.81
	(3.99)	(2.38)	(2.27)	(2.41)	(4.32)	(3.23)	(2.87)	(2.11)	(3.04)	(4.94)	(3.76)	(4.30)	(4.96)	(2.73)	(7.98)
1995	13.09	8.05	8.13	9.74	5.44	10.94	9.40	11.79	14.68	7.64	39.36	39.09	47.40	50.22	51.08
	(3.36)	(2.20)	(1.69)	(2.65)	(3.65)	(3.59)	(2.66)	(1.75)	(2.58)	(3.26)	(5.57)	(4.44)	(2.93)	(4.65)	(6.44)
1996	15.38	9.44	11.27	11.10	8.74	18.63	14.54	16.85	18.49	15.58	45.32	48.02	54.72	55.04	62.66
	(5.51)	(2.77)	(1.97)	(3.08)	(4.04)	(5.9)	(2.22)	(1.80)	(2.46)	(4.06)	(6.86)	(4.27)	(3.98)	(2.97)	(8.69)
1997	9.45	9.24	6.84	6.63	4.83	10.65	11.76	10.20	11.25	9.81	42.57	44.47	47.15	49.77	48.81
	(4.64)	(1.80)	(2.80)	(3.37)	(3.24)	(4.77)	(2.36)	(2.29)	(3.67)	(3.68)	(5.51)	(3.39)	(2.31)	(4.26)	(3.73)

Notes: All coefficients were multiplied by 100. See notes to Table 3 for list of regressors. Bootstrapped standard errors are reported in parentheses.

Table 5. Returns to Experience: Quantile Regressions

Experience level:	5 years					15 years					25 years				
Quantile Point:	0.10	0.25	0.50	0.75	0.90	0.10	0.25	0.50	0.75	0.90	0.10	0.25	0.50	0.75	0.90
1984	2.96	2.50	2.37	2.17	2.23	1.63	1.37	1.31	1.17	1.18	0.30	0.24	0.24	0.18	0.14
	(0.25)	(0.20)	(0.23)	(0.18)	(0.30)	(0.14)	(0.10)	(0.13)	(0.11)	(0.17)	(0.10)	(0.06)	(0.06)	(0.07)	(0.08)
1985	2.98	2.47	2.32	2.00	1.84	1.67	1.37	1.32	1.13	1.07	0.36	0.26	0.33	0.26	0.31
	(0.29)	(0.31)	(0.19)	(0.17)	(0.26)	(0.15)	(0.17)	(0.11)	(0.09)	(0.13)	(0.10)	(0.10)	(0.07)	(0.07)	(0.14)
1986	2.77	2.33	2.33	2.29	2.39	1.55	1.32	1.28	1.28	1.36	0.33	0.31	0.23	0.27	0.33
	(0.30)	(0.23)	(0.14)	(0.33)	(0.44)	(0.17)	(0.12)	(0.08)	(0.19)	(0.24)	(0.12)	(0.07)	(0.06)	(0.09)	(0.14)
1987	2.46	2.10	2.11	2.13	2.32	1.38	1.21	1.18	1.18	1.31	0.31	0.32	0.26	0.24	0.30
	(0.31)	(0.26)	(0.20)	(0.25)	(0.29)	(0.18)	(0.15)	(0.11)	(0.14)	(0.15)	(0.12)	(0.06)	(0.05)	(0.07)	(0.10)
1988	2.94	2.33	2.13	1.99	2.01	1.68	1.30	1.21	1.10	1.15	0.42	0.27	0.29	0.20	0.30
	(0.28)	(0.29)	(0.18)	(0.26)	(0.38)	(0.16)	(0.15)	(0.10)	(0.16)	(0.20)	(0.09)	(0.07)	(0.07)	(0.09)	(0.11)
1989	2.16	2.00	1.92	1.85	2.09	1.29	1.18	1.10	1.03	1.13	0.43	0.37	0.28	0.22	0.18
	(0.23)	(0.22)	(0.23)	(0.25)	(0.37)	(0.13)	(0.13)	(0.13)	(0.14)	(0.21)	(0.08)	(0.10)	(0.07)	(0.08)	(0.12)
1990	2.56	2.11	1.93	2.13	2.81	1.37	1.19	1.08	1.19	1.58	0.18	0.27	0.23	0.24	0.34
	(0.44)	(0.21)	(0.20)	(0.20)	(0.27)	(0.23)	(0.12)	(0.11)	(0.12)	(0.18)	(0.15)	(0.07)	(0.08)	(0.08)	(0.13)
1991	2.65	2.15	2.03	2.06	2.05	1.41	1.17	1.10	1.16	1.20	0.16	0.19	0.17	0.26	0.35
	(0.45)	(0.29)	(0.16)	(0.22)	(0.32)	(0.26)	(0.18)	(0.09)	(0.12)	(0.19)	(0.14)	(0.12)	(0.08)	(0.09)	(0.13)
1992	2.39	2.18	2.11	1.91	2.63	1.32	1.26	1.21	1.12	1.49	0.24	0.34	0.31	0.34	0.35
	(0.33)	(0.27)	(0.16)	(0.26)	(0.32)	(0.16)	(0.16)	(0.10)	(0.15)	(0.19)	(0.15)	(0.07)	(0.08)	(0.10)	(0.18)
1993	2.57	2.37	2.12	2.41	2.11	1.44	1.31	1.19	1.38	1.24	0.31	0.24	0.26	0.34	0.37
	(0.35)	(0.20)	(0.21)	(0.34)	(0.32)	(0.18)	(0.12)	(0.12)	(0.16)	(0.18)	(0.08)	(0.08)	(0.07)	(0.07)	(0.12)
1994	2.95	2.28	2.12	2.31	1.99	1.59	1.20	1.16	1.28	1.11	0.23	0.12	0.20	0.24	0.24
	(0.42)	(0.30)	(0.17)	(0.29)	(0.36)	(0.25)	(0.18)	(0.09)	(0.17)	(0.22)	(0.13)	(0.08)	(0.08)	(0.12)	(0.15)
1995	2.14	2.30	2.29	2.66	2.74	1.17	1.26	1.26	1.52	1.47	0.21	0.22	0.22	0.38	0.20
	(0.36)	(0.26)	(0.21)	(0.27)	(0.34)	(0.20)	(0.17)	(0.14)	(0.17)	(0.19)	(0.09)	(0.12)	(0.10)	(0.09)	(0.12)
1996	2.75	2.46	2.21	2.55	3.01	1.49	1.39	1.22	1.45	1.77	0.24	0.32	0.24	0.36	0.53
	(0.36)	(0.23)	(0.28)	(0.37)	(0.31)	(0.22)	(0.12)	(0.16)	(0.22)	(0.23)	(0.12)	(0.07)	(0.08)	(0.18)	(0.25)
1997	2.61	2.43	2.65	2.40	2.70	1.43	1.34	1.48	1.40	1.62	0.25	0.25	0.31	0.41	0.53
	(0.39)	(0.24)	(0.22)	(0.32)	(0.35)	(0.23)	(0.13)	(0.13)	(0.19)	(0.23)	(0.14)	(0.06)	(0.10)	(0.08)	(0.20)

Notes: Returns to experience are evaluated at specific experience levels. All coefficients were multiplied by 100. See notes to Table 3 for list of regressors. Bootstrapped standard errors are reported in parentheses.

Table 6. Returns to Tenure: Quantile Regressions

Quantile point:	0.10	0.25	0.50	0.75	0.90
1984	0.55	0.64	0.54	0.55	0.50
	(0.14)	(0.11)	(0.11)	(0.10)	(0.14)
1985	0.70	0.64	0.54	0.51	0.50
	(0.12)	(0.11)	(0.08)	(0.09)	(0.15)
1986	0.69	0.67	0.56	0.51	0.34
	(0.14)	(0.06)	(0.09)	(0.15)	(0.11)
1987	0.82	0.58	0.58	0.45	0.39
	(0.14)	(0.10)	(0.10)	(0.08)	(0.12)
1988	0.60	0.63	0.51	0.57	0.48
	(0.11)	(0.11)	(0.08)	(0.11)	(0.17)
1989	0.56	0.45	0.54	0.57	0.47
	(0.14)	(0.11)	0.10	(0.13)	(0.17)
1990	0.62	0.42	0.45	0.44	0.37
	(0.16)	(0.09)	(0.08)	0.10	(0.15)
1991	0.81	0.58	0.48	0.43	0.37
	(0.13)	(0.12)	(0.09)	(0.11)	(0.19)
1992	0.68	0.45	0.31	0.33	0.29
	(0.13)	(0.09)	(0.09)	(0.12)	(0.21)
1993	0.44	0.39	0.39	0.34	0.35
	(0.14)	(0.11)	(0.11)	(0.11)	(0.14)
1994	0.60	0.69	0.53	0.53	0.48
	(0.10)	(0.10)	(0.09)	(0.13)	(0.13)
1995	0.68	0.51	0.50	0.31	0.50
	(0.12)	(0.11)	(0.10)	(0.09)	(0.08)
1996	0.76	0.65	0.53	0.50	0.37
	(0.17)	(0.10)	(0.06)	(0.16)	(0.23)
1997	0.94	0.86	0.57	0.57	0.55
	(0.09)	(0.06)	(0.09)	(0.13)	(0.23)

Notes: All coefficients were multiplied by 100. See notes to Table 3 for list of regressors. Bootstrapped standard errors are reported in parentheses.

Table 5 shows that the returns to an additional year of experience are higher at lower experience levels, i.e., among younger workers. The returns to experience at different experience levels estimated from the quantile regressions are, however, significantly lower than those estimated for the United States (see Buchinsky, 1994). Interestingly, during the 1980s, returns to experience were higher at the lower quantiles of the distribution than at the upper quantiles. Towards the end of the sample, however, this pattern changes and the returns to experience become consistently higher at the upper quantiles of the distribution. This is true at all experience levels, although the timing of this switch occurs at different years for different experience levels. Consistent with the aggregate results discussed earlier, returns to experience at all levels of experience and at most quantile points are slightly higher by 1997 than in 1989-1990.

Table 6 indicates that, after declining somewhat in the latter half of the 1980s, the returns to tenure at all quantile points began to rise by the latter half of the 1990s. Further, the returns to tenure appear to have strengthened more at the lower quantiles of the distribution.

Although these results indicate some differences in the evolution of skill prices at different parts of the distribution, the overall picture is one of a relatively stable wage structure over the last 15 years, especially compared to the changes in wage structures that have been documented for other countries. For instance, Buchinsky (1994) estimates average returns to a year of education of about 7 percent in the early 1980s in the United States, rising to about 10 percent by the mid-1980s. He finds a much larger return to education at upper quantiles of the wage distribution than at the lower quantiles and also finds that this disparity has widened significantly during the 1970s and 1980s. This echoes JMP's findings that both between- and within-group wage inequality have risen in the United States in recent decades. For Germany, abstracting from year-to-year variation, both between- and within-group inequality have changed only very modestly over the last 15 years.[12]

F. Effects of Changes in Observed and Unobserved Prices and Quantities

For a more complete description of the effects of changes in skill quantities and prices, I now employ a technique developed by JMP that permits a decomposition of changes in inequality into the components attributable to changes in observed skill quantities, observed skill prices, and unobserved quantities and prices of skills. The main advantage of this framework, compared to a more traditional variance decomposition, is that it facilitates an analysis of how composition and price changes have affected the entire wage distribution, rather than just a summary measure such as the variance.

Consider a wage regression of the form:

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[12] Using CPS data for the United States, Buchinsky (1994) also finds a large amount of year-to-year variation in the returns to education and experience at different quantile points. It is also worth noting that, as in Buchinsky's results, the standard errors for the estimated coefficients in Tables 4-6 are much larger at the extreme quantiles than at the middle quantiles.

$$w_{it} = X_{it}\beta_t + u_{it} \quad (1)$$

where w_{it} is the log wage, X_{it} is a vector of observed individual-specific characteristics, u_{it} is the regression residual, and i and t are individual and time subscripts, respectively. The residual can be viewed as being comprised of two components: an individual's percentile in the wage distribution, θ_{it}, and the distribution function of the wage residuals, $F_t(.)$. It follows that

$$u_{it} = F_t^{-1}(\theta_{it} | X_{it}) \quad (2)$$

where $F_t^{-1}(.|X_{it})$ is the inverse cumulative residual distribution for workers with characteristics X_{it} in year t. Defining $\overline{\beta}$ to be the set of average prices for observed skill attributes and $\overline{F}(.|X_{it})$ to be the average cumulative distribution, equation (2) can be rewritten as follows:

$$\begin{aligned} w_{it} = {} & X_{it}\overline{\beta} + X_{it}(\beta_t - \overline{\beta}) + \overline{F}^{-1}(\theta_{it} | X_{it}) \\ & + [F_t^{-1}(\theta_{it} | X_{it}) - \overline{F}^{-1}(\theta_{it} | X_{it})] \end{aligned} \quad (3)$$

Using this formulation, it is straightforward to construct conditional wage distributions that allow one component to vary while keeping the other components fixed. For instance, with fixed observable prices and a fixed residual distribution, equation (3) collapses to:

$$w_{it} = X_{it}\overline{\beta} + \overline{F}^{-1}(\theta_{it} | X_{it}) \quad (4)$$

It is then possible to construct wage distributions where the changes over time are attributable solely to changes in observable quantities. Similarly, holding the other components fixed in turn, one can construct wage distributions where the changes in the distributions over time are attributable to changes in observed prices and to changes in unobserved prices and quantities (i.e., the residual), respectively.

Table 7 reports results from this decomposition to examine the changes in wage inequality, based on various percentile differentials, that can be attributed to these three components. The first column indicates that the total increase in the 90-10 differential over the period 1984-97, small as this increase is, is entirely attributable to changes above the median of the distribution. The compression of the wage distribution below the median in 1985-89 is almost exactly offset by a slight widening of the dispersion in the remaining years of the sample, leaving the dispersion in the lower part of the wage distribution essentially unchanged over the full sample.

The relative importance of changes in the residual distribution for changes in overall inequality is similar above and below the median in the 1985-89 and 1992-96 periods. During 1989-92, changes in observed quantities result in some compression (relative to the

Table 7. Decomposition of Inequality Changes into Components Attributable to Observed and Unobserved Quantity and Price Changes

Percentile Differential	Total Change	Observed Quantities	Observed Prices	Residual
1985-96				
9010	0.014	0.001	0.001	0.013
9050	0.015	0.007	0.001	0.007
5010	-0.001	-0.006	0.000	0.005
1985-89				
9010	-0.019	-0.016	0.000	-0.003
9050	0.010	0.009	0.000	0.001
5010	-0.029	-0.024	-0.001	-0.004
1989-92				
9010	-0.008	-0.016	-0.002	0.009
9050	-0.018	-0.022	0.000	0.004
5010	0.010	0.006	-0.002	0.006
1992-96				
9010	0.041	0.032	0.003	0.006
9050	0.023	0.020	0.000	0.003
5010	0.018	0.012	0.003	0.004

Notes: The numbers reported above are changes in 3-year averages centered on the years shown. See text for details of the decomposition technique.

1980s) above the median and a slight widening below the median. It is interesting to interpret this result in the context of German unification. Even though the associated influx of workers into West Germany included workers with relatively high formal educational attainment, the qualifications of these workers may have been valued relatively less than equivalent qualifications obtained in West Germany. It is also likely that migrants from the East were viewed as having less favorable work habits (and other unobserved attributes). Thus, although these migrants are not in the sample, the increase in the supply of low-skill workers might account for the slight widening of the wage structure below the median. However, note that even in this period there is no perceptible change in the contribution of observed prices to changes in inequality.

During 1992-96, the wage compression that occurred over the previous decade was largely reversed, with changes in the distribution of skills and increases in within-group inequality (the residual) accounting for much of the increase in overall inequality. This increase was spread in a roughly equal manner above and below the median. In none of the sub-periods examined here do changes in the prices of observed skill attributes affect overall inequality significantly.

Thus, the main story in this table is that most of the changes in inequality appear to be attributable to changes in the residual, which captures changes in unobserved prices and quantities, and, to a lesser extent, to changes in observed quantities. In other words, changes in the relative prices of observed skill attributes play only a small role in the evolution of wage inequality. It should also be kept in mind that the changes in overall inequality discussed here are quite small by international standards.

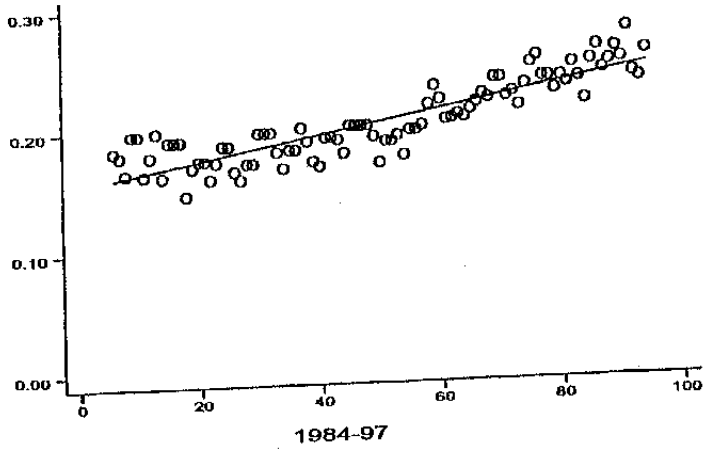
G. The Structure of Earnings

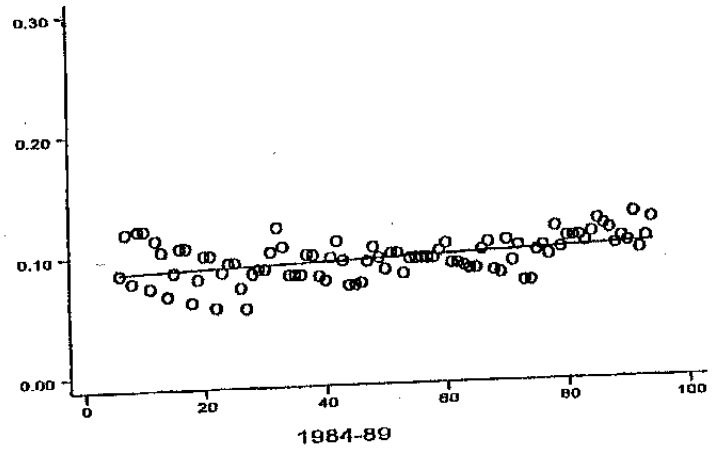
The discussion thus far has focused on the distribution of hourly wages. The cross-sectional dispersion of hourly wages could differ from monthly (or annual) earnings, depending on the covariance between monthly hours and the hourly wage. For instance, it is possible that high-wage workers tend to work (and get paid for) more hours per month than low-wage workers. This would imply that wage inequality is a downward-biased measure of earnings inequality.[13] Furthermore, measurement error in the hours variable is a potential problem, especially for salaried workers. Thus, although the hourly wage is indeed the appropriate variable for measuring skill prices, it is nevertheless useful to examine the evolution of earnings inequality as well.

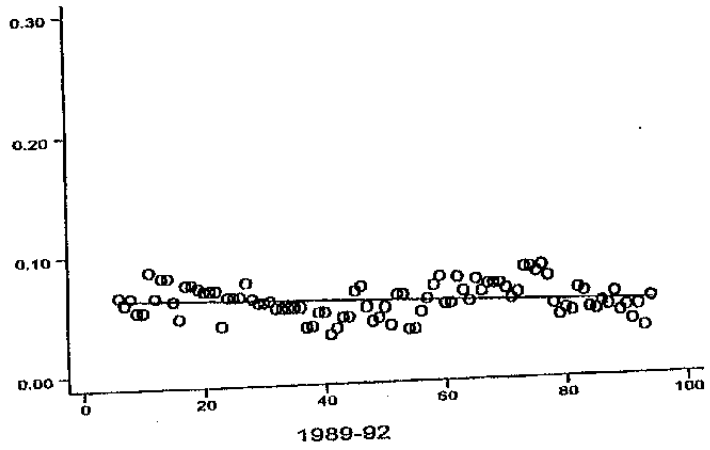
Figure 7 shows cumulative changes in log gross monthly earnings at different percentiles of the distribution. Similar to the pattern observed for changes in wage inequality, there appears to have been a slight increase in earnings inequality over the period 1984-97, with much of this increase occurring after 1992. A variance decomposition of earnings

[13] In addition, the dispersion of annual earnings could differ from that of monthly earnings. However, the GSOEP data set does not contain a variable indicating the number of months that a worker is employed during the survey year.

Figure 7. Changes in Log Monthly Earnings Across Distribution







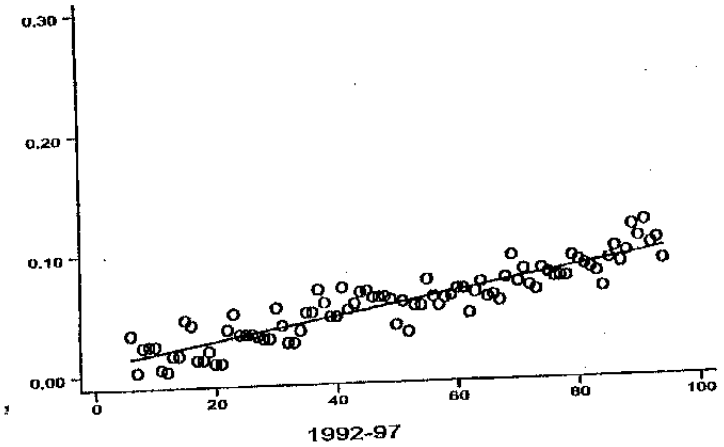
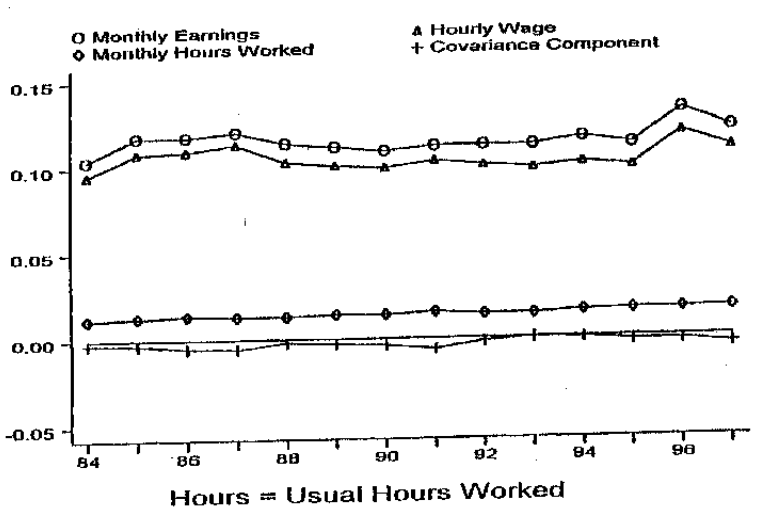
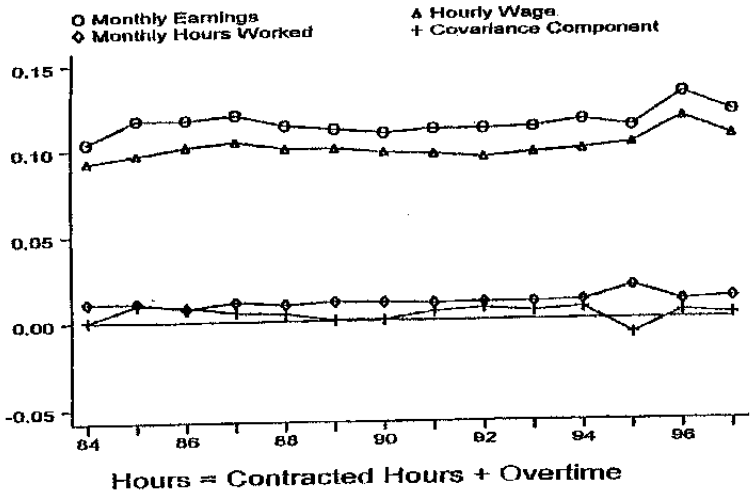


Figure 8. Variance Decomposition for Earnings





inequality indicated that the variances of hourly wages and monthly earnings look quite similar, while the variance of hours worked is small and is roughly offset by the covariance component (Figure 8). The data reveal only a small cross-sectional covariance between hourly wages and hours worked. Using an alternative measure of hours, the sum of contracted monthly hours plus overtime, yields similar results.

Overall, the basic picture of stability in the wage structure is reinforced by the stability of the structure of earnings.[14] The results in this section also indicate that measurement error in the weekly hours variable used to construct the hourly wage measure is unlikely to be driving any of the earlier results.

III. The Role of Market Forces in the Stability of the German Wage Structure

The empirical results in the previous section have clearly demonstrated the relative stability of the West German wage structure over the last 15 years. In this section, I explore a number of possible explanations for this remarkable stability during a period when all major industrial economies appear to have been going through massive shifts in the relative demand for skills resulting from skill-biased technological change, increased openness to external trade, and shifts in employment and output shares from manufacturing towards services (de-industrialization). In what follows, particular attention is given to the roles of market factors, including the effects of shifts in relative supplies of skilled and unskilled workers and in the sectoral composition of employment. I also exploit certain unique features of the GSOEP dataset to examine the possibility that measurement issues could affect the patterns of wage variation described in this paper.

A. Relative Supply Shifts

Changes in wage inequality that are attributable to changes in skill prices can be analyzed in terms of a supply and demand framework for different skill attributes. For instance, Katz and Murphy (1992) note that, despite an increase in the relative demand for skilled workers, wage inequality did not increase substantially in the United States in the 1970s since the relative supply of workers with high education levels rose substantially and offset much of the shift in demand. Despite continuing increases in the relative supply of highly educated workers, however, enormous shifts in the relative demand for skilled labor in the 1980s resulted in sharp increases in observed skill premia.[15]

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[14] Using GSOEP data, Abraham and Houseman (1995) and Steiner and Wagner (1998) report similar findings of a stable dispersion of gross monthly earnings during the 1980s.

[15] Katz and Murphy (1992) construct proxies for relative demand shifts using shifts in the mix of industry-occupation classifications and the relative proportions of skilled and unskilled workers within these industry-occupation cells. Unfortunately, preliminary calculations indicated that the GSOEP does not have enough data available (as reflected in the cell sizes) for such an exercise to yield reliable results.

Is there evidence that shifts in relative skill supplies may have resulted in the stable wage structure observed in Germany? Average education levels in West Germany have indeed been rising over the last two decades and the relative supply of college graduates, in particular, has increased significantly. In the GSOEP sample used here (the wage analysis sample), for instance, the cross-sectional average of the education variable increases from 10.9 years in 1984 to 11.7 years by 1997. Figure A1 shows that this increase was largely due to a small increase in the proportion of workers with university degrees and a corresponding decline in the proportion of workers with only general schooling. The relative sizes of the other two groups—those with an apprenticeship and with other vocational training—remained fairly stable. In the full GSOEP sample for West Germany that includes employed and nonemployed men and women, the relative proportion of workers with general schooling fell by about 6 percentage points, while the other three groups had increases of 2-3 percentage points each (Figure A2). Could this supply effect explain the absence, in Germany, of the marked increase in the returns to education in the 1980s and 1990s that was witnessed in other industrial countries with more "flexible" labor markets? A cross-country perspective suggests an answer in the negative. The relative supply of more educated and, especially, college-educated workers has been rising at roughly similar, and often higher, rates in most other major industrial countries as well.

Although cross-country comparisons of educational levels are notoriously difficult, I used ostensibly comparable data from the *OECD Education Statistics* to obtain some suggestive evidence. The tabulation below shows the ratio of (a) graduates of higher education (university and non-university) to the total of (a) plus (b) graduates of upper secondary education (general and vocational/technical) in the population.[16] Although the increase in this ratio over the period 1985-97 was 5.4 percentage points in Germany compared to 3.8 percentage points in the United States, this difference seems hardly sufficient to explain the huge disparities in the evolutions of premia for higher education in these two countries. Examinations of other such ratios revealed a very similar picture.

Ratio of Workers with High Relative to Medium Levels of Education

	1985	1990	1992
Germany	0.175	0.216	0.229
United States	0.406	0.428	0.444

A more direct approach, following Gottschalk and Joyce (1998), is to examine labor market quantities, i.e. unemployment and employment of workers of different skill levels. If

[16] Source: *OECD Education Statistics, 1985-92*, Table IV.3. These ratios can also be calculated (1985,1992) for certain other countries including Canada (0.623,0.702), Italy (0.191,0.182), Japan (0.349,0.348) and the Netherlands (0.280,0.260). Unfortunately, the relevant data are not available for France and the United Kingdom.

there were indeed relative shifts in the supplies of workers with different skill levels, this would be reflected in quantities rather than just prices. The first panel of Figure 9 plots unemployment rates for workers with different skill levels.[17] Clearly, unemployment rates for workers of different skill levels in West Germany have diverged markedly during the 1980s and 1990s. More strikingly, unemployment rates for unskilled workers have risen sharply during the 1990s while the increases in unemployment rates have been much smaller for medium-skilled workers and have in fact fallen for highly skilled workers during the recent cyclical recovery that began around 1993.

One cautionary note about interpreting these unemployment rates is that they could reflect the effects of German unification. From the West German perspective, unification was essentially a labor supply shock that was accentuated in the lower portions of the skill distribution and that may have resulted in the observed increases in unemployment rates for low-skill workers. However, in conjunction with the earlier results on the stability of skill premia, this outcome—persistent increases in absolute and relative unemployment rates for low-skill workers—is precisely what one would expect if a rigid wage structure prevented labor market adjustment through the adjustment of relative prices.

Stronger evidence for this interpretation comes an examination of employment levels. As shown in the second panel of Figure 9, employment levels for workers of different skill levels in West Germany have diverged steadily since the mid-1970s. During the 1990s, employment levels of high skill workers have risen sharply even as employment for unskilled workers has actually declined.[18] This evidence is difficult to reconcile with a story that relies on changes in the supplies of different skill categories to explain the stability of the wage structure as an equilibrium outcome.

In short, there is little evidence that shifts in relative supplies of workers with different skill levels can explain observed relative wage developments. Furthermore, the evolutions of relative unemployment rates and employment levels are strongly suggestive of the notion that, in the presence of institutional constraints that inhibit relative price adjustment, relative shifts in the demand for skills have resulted in quantity adjustments.

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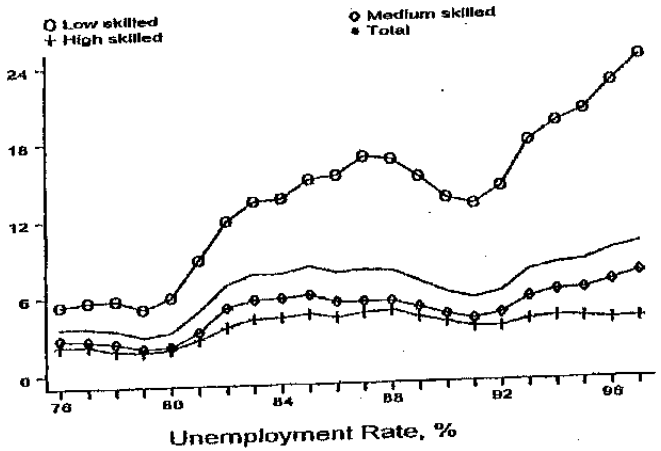
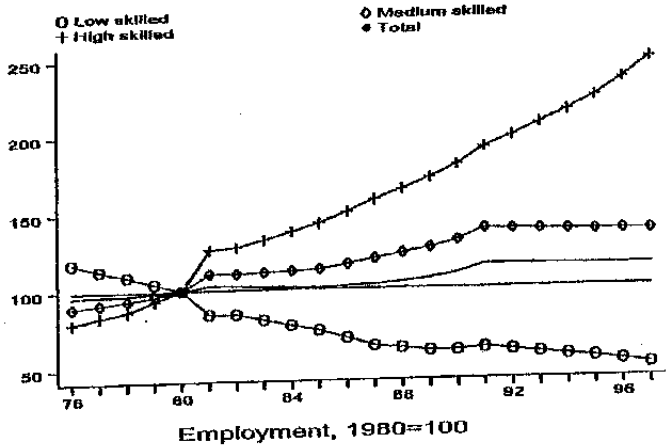
[17] The data for both panels of this figure, which are limited to West Germany, are taken from Reinberg and Rauch (1998) and are based on the Mikrozensus, a more comprehensive survey of the German labor force than the GSOEP. Skill levels are defined on the basis of a number of observed characteristics including education levels and occupational categories. The raw data from this survey are not publicly available. GSOEP data revealed very similar patterns.

[18] To examine the evolution of group-specific employment *rates*, I used the GSOEP data to estimate annual probit employment equations for men (extending the sample to include men without a job). The estimated coefficients (not shown here) confirm the sharp increase in the employment probabilities of workers with higher levels of education during the 1990s.

Figure 9. Unemployment Rates and Employment by Skill Level





B. Shifts in Sectoral Employment Shares

As in other industrial economies, in recent decades there has been a secular decline in the employment share of manufacturing and a corresponding increase in the employment share of the service sector in Germany. This and other cyclical shifts in sectoral employment could influence the overall wage structure since average wages and the dispersion of wages are likely to be quite different across sectors. These two channels through which changes in the structure of sectoral employment could affect the wage structure are also likely to be influenced by the effects of changing skill compositions of the workforce in these sectors.

One way to analyze the effects of sectoral shifts on the wage structure is to use a simple variance decomposition. The total variance of wages in a year can be decomposed into within- and between-industry components as follows:

$$\sigma_t^2 = \sum_j s_{jt}\,\sigma_{jt}^2 + \sum_j s_{jt}\,(w_{jt} - \overline{w}_t)^2 \qquad (5)$$

where σ_t^2 is the cross-sectional variance of log hourly wages, s_{jt} is the employment share of sector j, σ_{jt}^2 is the within-industry variance of wages, w_{jt} is the mean sectoral wage, $\overline{w}_t$ is the mean wage in the sample and the subscript t is a time index. Using this formula, the change in variance over time can be decomposed into changes attributable to within- and between-industry variance as well as composition effects within and between industries. The results of this decomposition are shown in Table 8.[19]

The total increase of 0.0046 in overall wage variance from 1984 to 1997 is the result of a marginal decline in variance over the period 1989 to 1992, more than offset by an increase in the variance from 1992 through 1997.[20] The key result from this table is that a substantial fraction of the developments in overall wage variance is attributable to changes in wage variation within industries, rather than between-industry wage variation. Composition effects, both within and between industries, account for only a small fraction of the changes in variance. The contribution of the between-industry component to the total change in wage variance is also quite small.

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[19] These results are based on a classification that corresponds roughly to the 1-digit SITC sectoral classification. The ten sectors are agriculture, forestry and fishing; utilities; manufacturing; construction; trade; transport and communications; finance and insurance; business and personal services; other basic services; and public administration. Using the full set of GSOEP industry codes, which would be similar to using a 2-digit classification, revealed quite similar results.

[20] Note that the numbers in the table are multiplied by 100; the absolute increase in variance over the full sample is actually quite small.

Table 8. Effects of Sectoral Shifts on Changes in Wage Inequality
(Variance Decomposition)

Period	Total Change in Variance	Within Industry		Between Industry	
		Change in Variance	Composition Effect	Change in Variance	Composition Effect
1985-96	0.46	0.35	0.05	0.02	0.05
1985-89	-0.01	-0.03	0.06	-0.01	-0.02
1989-92	-0.15	-0.14	0.01	-0.01	-0.01
1992-96	0.62	0.52	-0.02	0.03	0.09

Notes: Workers are classified into ten broadly defined sectors (agriculture, forestry and fishing; utilities and mining; manufacturing; construction; trade; transport and communications; finance and insurance; business and personal services; other basic services; public administration). The numbers reported in this table are changes in three-year averages, centered on the years shown, of total wage variance and its components. All numbers in this table were multiplied by 100.

Thus, shifts in sectoral employment do not seem to have played much of a role in influencing patterns of overall wage dispersion. Within-industry wage variation appears to dominate overall wage variation and both appear to have evolved in a smaller pattern.

C. Cohort Effects

The cross-sectional measures of inequality analyzed in this paper could be affected by changes over time in the observed and unobserved attributes of cohorts that enter the labor market at different periods. For instance, changes in inequality could be dampened by the increasing equalization of educational opportunities for workers in cohorts that have recently entered the labor force. Further, inequality changes over time within cohorts (as employers gain more information about workers based on job histories) could influence measures of overall inequality, especially if relative cohort sizes change over time.

It is difficult to disentangle cohort, experience and time effects. Nevertheless, by examining changes in inequality over time for different cohorts and different experience groups, it is possible to get an indication of whether cohort and age effects are important for understanding the evolution of overall wage inequality.

For this part of the analysis, I constructed synthetic cohort groups based on the imputed year of market entry for each worker.[21] Table 9 shows 3-year averages of the 90-10 and 75-25 percentile differentials for each cohort, centered on the years 1985, 1991 and 1996. For instance, the cohort with year of market entry between 1977 and 1981 had a 90-10 differential of 0.81 in 1985, which declined to 0.72 in 1991 and then went up to 0.76 by 1996. These results should be interpreted with caution since the samples are relatively small (typical cell size: 250-400; minimum cell size: 100). Nevertheless, although there are some small changes over time in inequality within cohorts, there is little evidence that these changes, or the differences in inequality across cohorts, are an important factor in explaining the apparent stability of the wage structure.

Note that the evolution of inequality within specific (synthetic) experience groups can be tracked by reading diagonally across this table. For instance, the experience group corresponding to the 1977-81 entry cohort, which has about 4 to 8 years of experience in 1985, has a 90-10 differential of 0.81 in 1986, 0.74 in 1991 and 0.81 in 1996. Within experience groups, there is a pattern of a small dip in the 90-10 differential in 1991, followed by an uptick in 1996. This is consistent with the pattern detected earlier of marginal wage compression in the 1980s, followed by a slight widening of wage dispersion after 1992.

The main conclusion from Table 9 is that changes in inequality within age and cohort groups are largely consistent with the patterns of overall wage variation. In other words, time effects appear to be more important than age or cohort effects per se in explaining changes in the wage structure.

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[21] Cohorts defined on the basis of birth year yielded similar results.

Table 9. Wage Inequality Across Cohorts and Experience Groups

Year of Market Entry	90-10 differential			75-25 differential		
	1985	1991	1996	1985	1991	1996
1987-91	...	...	0.81	...	...	0.41
1982-86	...	0.74	0.78	...	0.37	0.39
1977-81	0.81	0.72	0.76	0.41	0.39	0.40
1972-76	0.69	0.75	0.83	0.36	0.37	0.41
1967-71	0.74	0.73	0.71	0.36	0.36	0.36
1962-66	0.76	0.80	0.84	0.36	0.41	0.44
1957-61	0.76	0.79	0.80	0.41	0.45	0.44
1952-56	0.70	0.59	0.66	0.33	0.32	0.32
1947-51	0.79	0.75	...	0.37	0.36	...
1942-46	0.70	...	...	0.35	...	...

Notes: The percentile differentials reported above are 3-year averages centered on years shown.

D. Supplementary Earnings

Various forms of monetary compensation other than basic wages and salaries constitute an important element of compensation packages in Germany. These include 13th and 14th month salaries; Christmas and vacation bonuses; and profit-sharing and gratuities. These are usually provided as lump-sum payments once a year. Such payments could play an important role in differentiating total compensation across workers of different skill levels but would not be picked up in data on monthly wages and salaries.

The GSOEP does not provide data on these elements of compensation for the year of the survey. However, individuals are asked about the gross amounts of different categories of nonstandard compensation that they received in the previous year. Using these data, I constructed for each individual a wage adjustment factor in order to incorporate supplementary earnings, using the following formula:

Adjustment Factor = Total gross supplementary income in previous year /
(Average monthly gross wage in previous year *
Number of months worked in previous year)

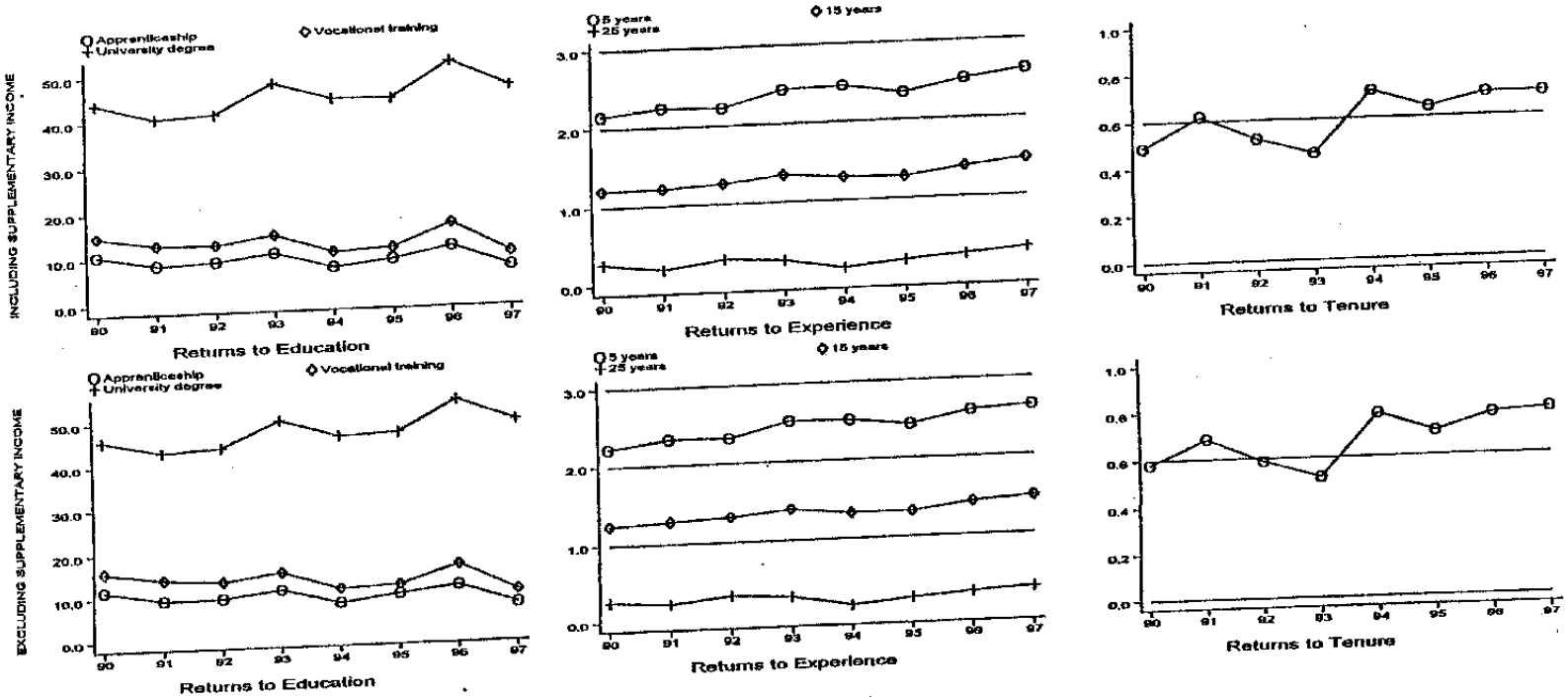
The adjustment factor turns out to be quantitatively quite important. Its distribution over the period 1990-97, shown in the tabulation below, indicates that the median supplementary income amounted to about 8.3 percent of the basic wage. There was no discernible trend over time in this adjustment factor. However, regressions of this factor on skill attributes did indicate a statistically significant positive relationship between the size of this factor and skill level, suggesting that total compensation could be more differentiated than basic wages.

Distribution of Adjustment Factor for Supplementary Income, 1990-97

Percentile point:	5	10	25	50	75	90	95
Adjustment factor:	0.000	0.016	0.046	0.083	0.097	0.129	0.167

For each worker for whom the relevant data were available, I constructed a new wage variable, where the current year wage was multiplied by (one plus) this adjustment factor. OLS estimates of the returns to experience and education were generally marginally higher while returns to tenure were generally marginally lower using (logarithms of) this wage measure compared to the estimates based on the basic wage. However, as shown in Figure 10, the differences are quite small in economic terms. More importantly, the time profiles of the returns to skill attributes are not altered when the adjusted wage variable is used. Plots of wage changes at different percentiles over the period 1990-97 (not shown here) were also

Figure 10. Supplementary Earnings and Skill Premia



essentially unaffected by the use of this alternative wage measure.[22]

Thus, although there is some evidence that total compensation is more differentiated by skill level than basic wages, the differences are not large. Over the period 1990-97, the structure of total compensation is essentially as stable as the structure of basic wages.

E. Selection Effects

Finally, I examine the sensitivity of the results to sample selection bias. Since wages are observed only for those workers who are employed, wage regressions could be subject to bias induced by systematic differences in unobserved characteristics (unobserved by the econometrician, that is) of employed versus nonemployed persons. In other words, the observed wage distribution may be a biased measure of the offer wage distribution. Further, the magnitude of selection bias could vary systematically across skill levels, thereby biasing estimated wage differentials and changes over time in these differentials across skill levels.[23]

Although sample selection effects are likely to be less important for men than for women, I estimated selection-corrected wage equations for the sample of males.[24] To conserve space, the results are only summarized briefly here; detailed results are available from the author. The selection-corrected coefficient estimates for the education and

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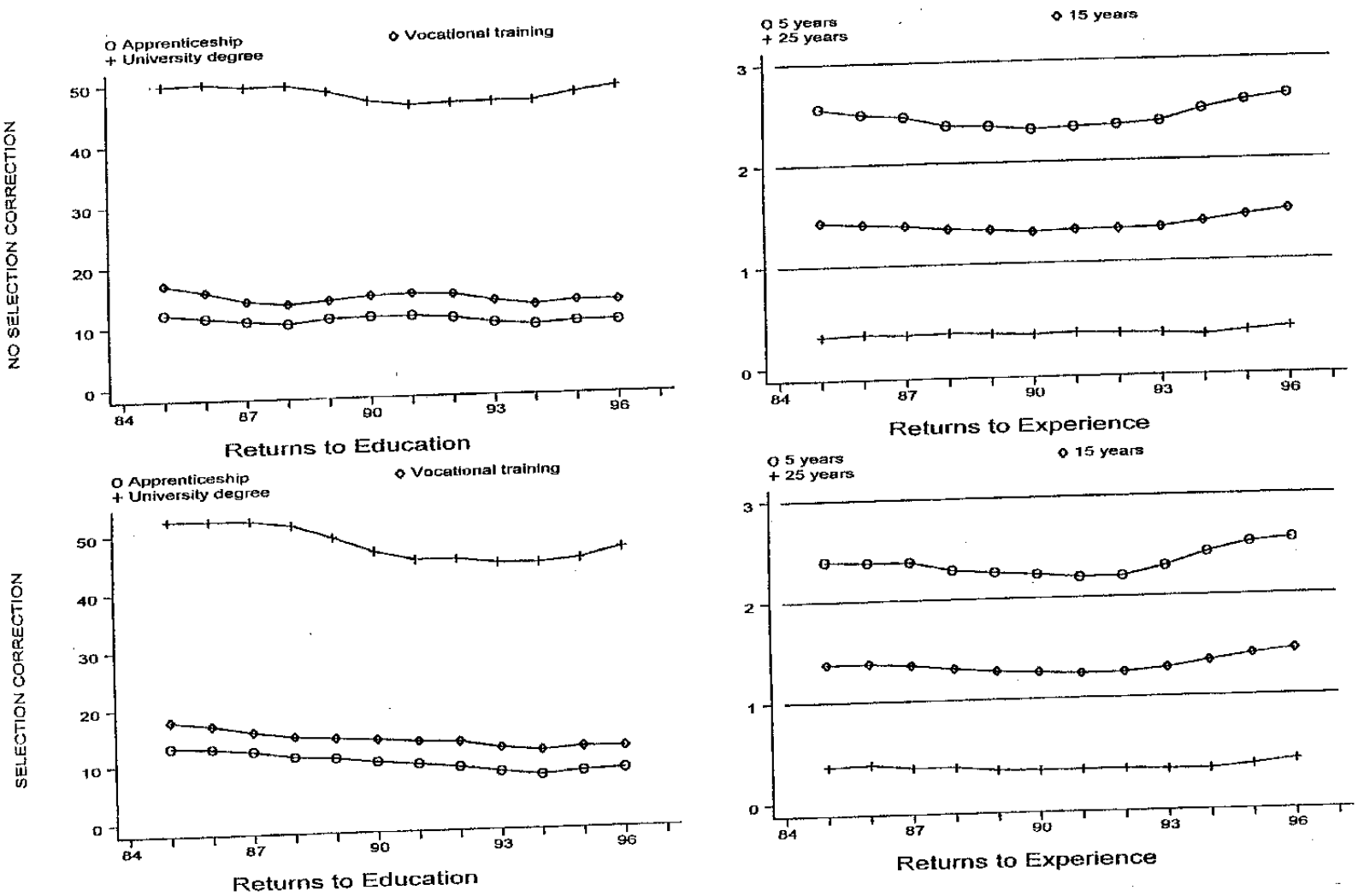
[22] The results reported in this paragraph, including the comparisons of skill premia with and without supplementary earnings, are limited to those observations for which the data needed for constructing the adjustment factor are available. This amounts to about 96 percent of the sample for the years 1990-97. Data on average gross monthly pay in the year prior to the survey were not available for 1984-89. For these years, I constructed the adjustment factors using current year gross income (assuming full-year employment) in the denominator. I do not show the results for 1984-89 here since the adjusted data would not strictly be comparable with those for 1990-97, but those results were also very similar in each year to the corresponding results for wages excluding supplementary income.

[23] Keane and Prasad (1996) provide an example of the importance of accounting for selection bias in estimating skill differentials.

[24] The selection model involves two equations: (i) the basic OLS wage equation and (ii) a probit employment choice equation. The employment equation includes the right hand side variables in equation (i) (except tenure) and a set of additional variables that could influence self-selection into employment but would not be expected to affect the wage. This set of additional variables included dummies for marital status and presence of kids. Additional dummies for status as head of household and home ownership were also tried, but did not add much. The sample for equation (i) conforms to that of the results reported in earlier sections (full-time employed males, excluding self-employed etc.); all other male labor force participants were included in the estimation of the second equation. The parameters of equations (i) and (ii) were jointly estimated by maximum likelihood techniques.

Figure 11. Selection Effects and Skill Premia



experience variables were very similar to those from the basic OLS regressions. As shown in Figure 11, the estimated education premia are slightly higher in the 1980s in the selection-corrected models compared to the basic OLS results. By the mid-1990s, however, the effects of this correction are close to zero. The returns to experience are also only marginally affected by the selection correction. The basic story of stable skill premia is thus confirmed by these results.

IV. Discussion

The results presented thus far provide fairly strong evidence that the stability of the German wage structure is attributable to constraints imposed by institutional factors rather than to market forces. As discussed earlier, it appears that the wage bargaining system and the role of unions have resulted in an inflexible wage structure that does not allow prices for skills to respond to shifts in the demand for and supply of different skills.

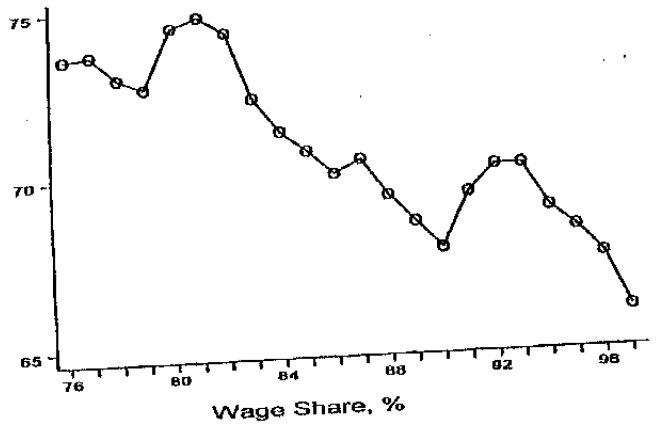
As noted by Fortin and Lemieux (1997) among others, it may generally not be appropriate to attribute the behavior of residuals from such an empirical analysis to "institutional factors." They argue that direct measures of institutional factors and empirical analysis using such measures are required in order to make such statements. Such an approach is vitiated in this context since there have been few significant institutional changes over the sample period that could help identify the direct effects of these factors. The approach in this paper has instead been to take seriously and analyze the effects of all observable "market forces" that could potentially explain the evolution of the wage structure. Given the results in this paper, the observed price and quantity outcomes in the labor market, and the wealth of anecdotal evidence about the rigidities induced by labor market institutions in Germany, the case for institutional factors playing a dominant role appears quite strong.

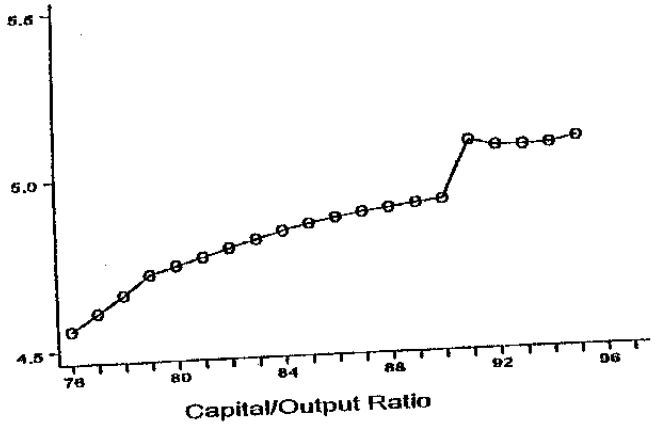
Some authors have argued that the relatively narrow dispersion of wages is attributable to the tighter distribution of skills in Germany compared to countries like the United Kingdom or the United States (e.g., Nickell and Bell, 1996). The German wage structure is also viewed by some as providing incentives for firms to provide optimal levels of training to their low-skill workers (e.g., Acemoglu and Pischke, 1999). Nevertheless, the rigidity of the wage structure during a period of massive shifts in demand towards the upper end of the skill distribution has had obvious deleterious consequences, as evident from the rising nonemployment rates and declining employment levels for unskilled workers, concomitant with declining nonemployment rates and rising employment levels for skilled workers. As discussed earlier, these divergent trends have been further accentuated in the mid 1990s. It should also be borne in mind that the central argument in this paper is based not so much on the levels of wage differentials as it is on the inability of the wage structure to adjust to demand shifts over time.

A. A Synthesis of Microeconomic and Macroeconomic Evidence

In this sub-section, I discuss the relationship between the microeconomic evidence presented in this paper and macroeconomic data related to the labor market. As in other continental European economies, the wage share in Germany has declined markedly since

Figure 12. Aggregate Data





the mid-1970s (Figure 12).[25] By contrast, in the United Kingdom and the United States, the wage share has remained largely unchanged over the last three decades, abstracting from some year-to-year variation in the data. Also, direct evidence of the substitution of capital for labor can be gleaned from an examination of the capital-output ratio in Figure 12. This ratio trended upward during the 1980s and, after a unification-related spike in 1991, continued to rise, although much more gradually, in the 1990s.[26]

Blanchard (1997) has argued that the pattern of declining wage shares--which he documents for France, Germany and Italy--can be explained by institutional rigidities that have perpetuated the effects of adverse macroeconomic shocks and that have resulted in the substitution of capital for labor and, consequently, rising aggregate unemployment rates. Blanchard and Wolfers (1999) take this argument further by trying to demonstrate that the interactions of shocks and institutions can explain differences in the evolutions of unemployment rates across industrial countries.

In Germany, the widening disparities in employment outcomes for skilled and unskilled workers indicate an important additional dimension to this story. A crucial ingredient for a comprehensive explanation is that of capital-skill complementarity.[27] Given a rigid wage structure that prevents relative skill prices from adjusting to demand shifts, capital-labor substitution, as has been observed in Germany, is indeed the likely outcome. But, particularly given capital-skill complementarity, this could imply an increase in the demand for skilled relative to unskilled labor and a concomitant net decline in the total demand for labor. Since low-skill labor accounts for a much greater fraction of the total labor force than high-skill labor, the net effect could be to raise aggregate unemployment.

More generally, skill-biased technological change would tend to shift out the relative demand for skilled labor. If the skill premium was constrained to remain unchanged, however, the net effect would be to lead to a substitution of both capital and skilled labor for unskilled labor in the aggregate production function. Capital-skill complementarity would

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[25] These data are taken from *Statistiches Taschenbuch 1998: Arbeits und Sozialstatistik* (Bundesministerium für Arbeit und Sozialordnung). Note that the numbers refer to United Germany starting in 1991 and to West Germany before that. Assuming plausible elasticities of substitution between capital and labor, the labor-supply shift caused by unification can not by itself explain anything close to the observed trend decline in the wage share.

[26] These data were obtained from the German Ministry of Finance. Since aggregate employment has grown by much less than output growth in the 1980s and 1990s, the increase in the capital-output ratio is probably a downward-biased measure of the increase in the capital-labor ratio. Recent developments in investment and output suggest that the capital-output ratio shown through 1995 in Figure 12 has risen further since then.

[27] See Griliches (1969) and Goldin and Katz (1998) for some evidence on capital-skill complementarity. Krusell et al. (2000) argue that capital-skill complementarity is important for understanding changes in wage inequality in the United States.

accentuate this effect. A production structure that formalizes this discussion, and shows analytically how capital-skill complementarity can interact with a rigid wage structure to produce these differences in employment effects for skilled and unskilled labor, is presented in the Appendix.

Making the reasonable assumption that industrial economies have been subject to similar shifts in the relative demand for skills in recent decades (see, e.g., Machin and Reenen, 1998; Manacorda and Petrongolo, 1999), this discussion suggests that the price and quantity outcomes across different countries can be viewed in part as being influenced by labor market institutions that affect the evolution of skill prices (Blau and Kahn, 1996, reach a similar conclusion). In the United States, where there are few constraints on wage differentials, relative skill prices have adjusted in response to the asymmetric demand shifts for skills, as evidenced by rising wage inequality and increasing skill premia. In Germany, by contrast, quantities have had to bear the brunt of adjustment, reflected in the rising and persistent disparities in employment and unemployment rates between high-skill and low-skill workers.

Thus, the microeconomic evidence presented in this paper is helpful in understanding the rising disparities in labor market outcomes for workers of different skill levels as well as patterns in macroeconomic data, including developments in the wage share, capital-labor ratios and aggregate unemployment.

V. Conclusions

This paper has produced two main empirical results. One is that the West German wage structure has been quite stable over the last 15 years, especially in comparison to countries with more "flexible" labor markets such as the United Kingdom and the United States. Inequality both within and between different skill groups declined slightly in the 1980s and increased marginally during the mid 1990s. Returns to skill attributes such as education, experience and tenure show a similar pattern. The second result is that this stability of the wage structure is not attributable to shifts in the relative supply of skills or other "market" forces such as shifts in the sectoral distribution of employment, or cohort and selection effects.

Taken together, these results suggest that institutional factors, including the wage bargaining system, appear to have fostered a relatively rigid wage structure that has not responded to shifts in the relative demand for skills. As evidenced by patterns of employment growth and evolutions of unemployment rates for different skill groups, unskilled workers essentially appear to have been priced out of their jobs because of the inflexible wage structure that has not accommodated shifts in labor demand towards the upper end of the skill distribution. Further, skill price rigidities appear to have encouraged capital-labor substitution, with detrimental effects on the employment probabilities of unskilled workers.

The paper has also argued that the micro evidence presented here is important for understanding and interpreting patterns in macroeconomic data, including the evolutions of the aggregate unemployment rate, the wage share and the capital-labor ratio.

Appendix

This appendix describes a production structure that formalizes the statements made in the text about the effects of relative demand shifts (for different types of skill) and capital-skill complementarity on the equilibrium skill premium. The potential employment effects of rigidities that prevent adjustment in the skill premium in response to different shocks are also discussed.

Krusell et al. (2000) propose the following production function with four inputs—capital structures, capital equipment, skilled labor and unskilled labor. The production function is Cobb-Douglas over capital structures (K_s) and a constant elasticity of substitution (CES) aggregate of the three remaining inputs. The specification they find to be consistent with U.S. data is as follows:

$$F(K_{st}, K_{et}, U_t, S_t) = K_{st}^{\alpha}\left[\mu U_t^{\sigma} + (1-\mu)\left(\lambda K_{et}^{\rho} + (1-\lambda) S_t^{\rho}\right)^{\frac{\sigma}{\rho}}\right]^{\frac{1-\alpha}{\sigma}} \qquad \text{(A1)}$$

The parameters σ and ρ determine the elasticities of substitution among capital equipment (K_e), skilled labor (S) and unskilled labor (U). Inputs of skilled and unskilled labor may be considered as the products of aggregate hours (h_i) and an efficiency index (ψ_i), where *i* is an index for skill type.

There are a couple of reasons for splitting capital into two types. First, the phenomenon of capital deepening in many industrial economies in recent years is largely attributable to equipment investment (including computers) rather than investment in structures. Second, it is not obvious that skilled and unskilled labor would have different degrees of substitutability with structures, while differences in substitutability with capital equipment are more plausible.

Note that this production function specification implies that the elasticity of substitution between equipment and unskilled labor is the same as that between skilled and unskilled labor. This restriction follows from the symmetry property of the CES aggregation and is consistent with empirical estimates of these elasticities. The elasticity of substitution between capital equipment and unskilled labor is $1/(1-\sigma)$ and that between capital and skilled labor is $1/(1-\rho)$. Hence, setting $\sigma > \rho$ implies capital-skill complementarity.

Under the assumption that factor prices are equal to marginal products (per unit of raw input), the skill premium is as follows:

$$\pi_t = \frac{(1-\mu)(1-\lambda)}{\mu}\left[\lambda\left(\frac{K_{et}}{S_t}\right)^{\rho} + (1-\lambda)\right]^{\frac{\sigma-\rho}{\rho}}\left(\frac{h_{ut}}{h_{st}}\right)^{1-\sigma}\left(\frac{\psi_{st}}{\psi_{ut}}\right)^{\sigma} \qquad \text{(A2)}$$

The key point to note here is that capital equipment is a determinant of the skill premium. In the absence of capital-skill complementarity, $\sigma = \rho$ and equation (A2) simplifies to:

$$\pi_t = \frac{(1-\mu)(1-\lambda)}{\mu}\left(\frac{h_{ut}}{h_{st}}\right)^{1-\sigma}\left(\frac{\psi_{st}}{\psi_{ut}}\right)^{\sigma} \tag{A3}$$

In this case, the skill premium is determined solely by the relative labor inputs, which in turn are a function of raw inputs (i.e., hours) and the respective efficiency indexes. To see the implications of capital-skill complementarity for the skill premium in the event of capital deepening, the skill premium can be differentiated with respect to K_e:

$$\frac{d\pi_t}{dK_{et}} = \frac{(1-\mu)(1-\lambda)\lambda}{\mu}(\sigma-\rho)\left[\lambda\left(\frac{K_{et}}{S_t}\right)^{\rho} + (1-\lambda)\right]^{\frac{\sigma-2\rho}{\rho}} \quad X \tag{A4}$$

$$K_{et}^{p-1}\ \frac{h_{ut}^{1-\sigma}}{h_{st}^{1+\rho-\sigma}}\quad \frac{\psi_{st}^{\sigma-e}}{\psi_{ut}^{\sigma}}$$

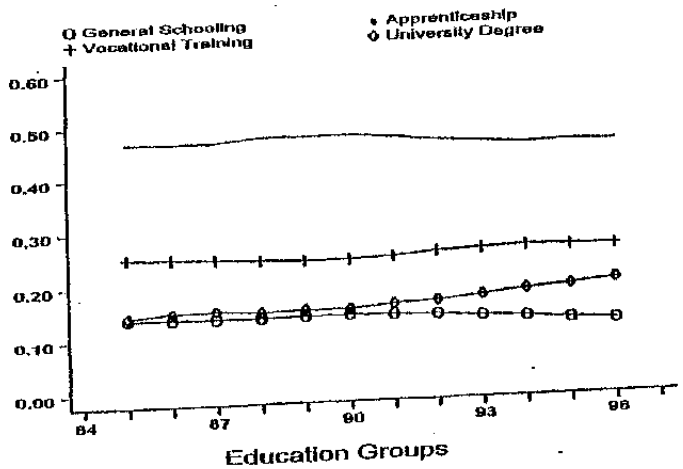
It is apparent that if $\sigma = \rho$ the RHS of equation (A4) is zero and, hence, capital deepening has no implications for the skill premium. For the case where $\sigma > \rho$, however, the equilibrium skill premium is increasing in K_e.

If K_e were to increase, the equilibrium skill premium rises to π^*. If $\pi^* > \pi$ but π were constrained to remain unchanged, however, the requirement for equation (A2) to hold would be for S to rise and U to fall (in relative terms), with the relative shifts for the demands of the two types of labor depending upon the model parameters. In either case, there would be an increase in the relative demand for skilled workers at given skill prices.

The phenomenon of skill-biased technological change may also imply an increase in ψ_{st} relative to ψ_{ut}.[28] Even in the absence of capital-skill complementarity, as can be seen from equation (A3), this would imply an increase in the equilibrium skill premium. Again, if the skill premium was constrained to remain unchanged, equation (A3) would be satisfied by reducing h_{ut} and/or increasing h_{st}, implying an increase in the relative demand for skilled labor.

[28] This is, again, a dynamic phenomenon but, for expositional convenience, is discussed here as a static concept. Steiner and Wagner (1997) present some evidence of relative labor demand shifts in West German manufacturing in response to skill-biased technological change as well as intensified international competition.

Figure A1. Means of Skill Proxies: Males With Full-Time Jobs



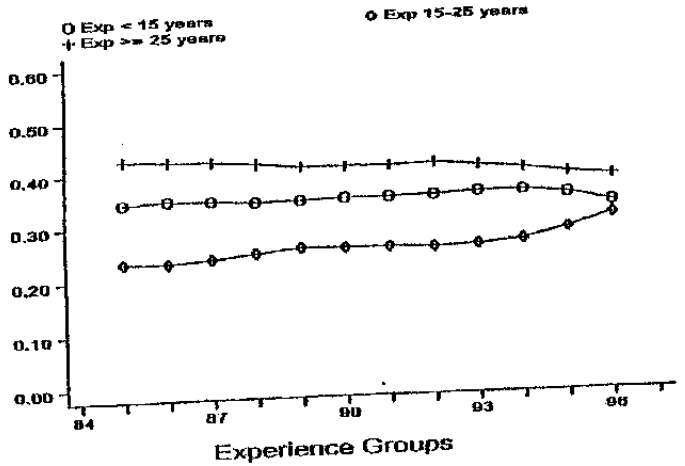
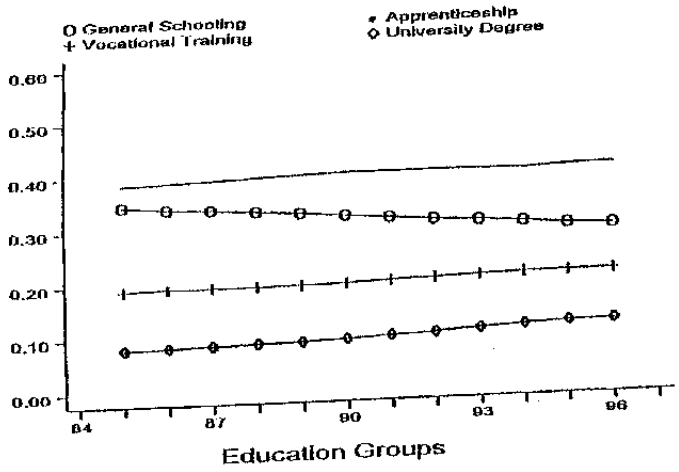
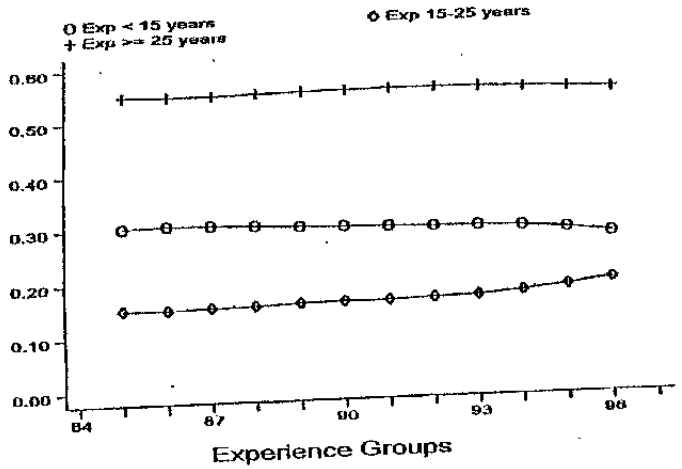


Figure A2. Means of Skill Proxies: Full GSOEP Sample





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