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DON'T BLAME THE ROBOTS

Assessing the Job Polarization Explanation of Growing Wage Inequality

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Executive summary

Many economists contend that technology is the primary driver of the increase in wage inequality since the late 1970s, as technology-induced job skill requirements have outpaced the growing education levels of the workforce. The influential "skill-biased technological change" (SBTC) explanation claims that technology raises demand for educated workers, thus allowing them to command higher wages—which in turn increases wage inequality. A more recent SBTC explanation focuses on computerization's role in increasing employment in both higher-wage and lower-wage occupations, resulting in "job polarization." This paper contends that current SBTC models—such as the education-focused "canonical model" and the more recent "tasks framework" or "job polarization" approach mentioned above—do not adequately account for key wage patterns (namely, rising wage inequality) over the last three decades. Principal findings include:

1. Technological and skill deficiency explanations of wage inequality have failed to explain key wage patterns over the last three decades, including the 2000s.

The early version of the "skill-biased technological change" (SBTC) explanation of wage inequality posited a race between technology and education where education levels failed to keep up with technology-driven increases in skill requirements, resulting in relatively higher wages for more educated groups, which in turn fueled wage inequality (Katz and Murphy 1992; Autor, Katz, and Krueger 1998; and Goldin and Katz 2010). However, the scholars associated with this early, and still widely discussed, explanation highlight that it has *failed* to explain wage trends in the 1990s and 2000s, particularly the stability of the 50/10 wage gap (the wage gap between low- and middle-wage earners) and the deceleration of the growth of the college wage premium since the early 1990s (Autor, Katz, and Kearney 2006; Acemoglu and Autor 2012). This motivated a new technology-based explanation (formally called the "tasks framework") focused on computerization's impact on occupational employment trends and the resulting "job polarization": the claim that occupational employment grew relatively strongly at the top and bottom of the wage scale but eroded in the middle (Autor, Levy, and Murnane 2003; Autor, Katz, and Kearney 2006; Acemoglu and Autor 2012; Autor 2010). We demonstrate that this newer version—the task framework, or job polarization analysis—fails to explain the key wage patterns in the 1990s it intended to explain, and provides no insights into wage patterns in the 2000s. We conclude that there is no currently available technology-based story that can adequately explain the wage trends of the last three decades.

2. History shows that middle-wage occupations have shrunk and higher-wage occupations have expanded since the 1950s. This has not driven any changed pattern of wage trends.

We demonstrate that key aspects of "job polarization" have been taking place since at least 1950. We label this "occupational upgrading" since it primarily consists of shrinkage in relative employment in middle-wage occupations and a corresponding expansion of employment in higher-wage occupations. Lower-wage occupations have remained a small (less than 15 percent) and relatively stable share of total employment since the 1950s, though they have grown in importance in the 2000s. Occupational upgrading has occurred in decades with both rising and falling wage inequality and in decades with both rising and falling median wages, indicating that occupational employment patterns, by themselves, cannot explain the salient wage trends.

3. Evidence for job polarization is weak.

We use the Current Population Survey to replicate existing findings on job polarization, which are all based on decennial census data. Job polarization is said to exist when there is a U-shaped plot in changes in occupational employment against the initial occupational wage level, indicating employment expansion among high- and low-wage occupations relative to middle-wage occupations. As shown in **Figure E** (explained later in the paper but introduced here), in important cases, these plots do not take the posited U-shape. More importantly, in all cases the lines traced out fit the data very poorly, obscuring large variations in employment growth across occupational wage levels.

4. There was no occupational job polarization in the 2000s.

In the 2000s, relative employment expanded in lower-wage occupations, but was flat at both the middle *and the top* of the occupational wage distribution. The lack of overall job polarization in the 2000s is a phenomenon visible in both the analyses of decennial census/American Community Survey data provided by proponents of the tasks framework/job polarization perspective (Autor 2010; Acemoglu and Autor 2012) and in our analysis of the Current Population Survey. Thus, the standard techniques applied to the data for the 2000s do not establish even a *prima facie* case for the existence of overall job polarization in the most recent decade. This leaves the job polarization story, at best, as an account of wage inequality in the 1990s. It certainly calls into question whether it should be a description of current labor market trends and the basis of current policy decisions.

5. Occupational employment trends do not drive wage patterns or wage inequality.

We demonstrate that the evidence does not support the key causal links between technology-driven changes in tasks and occupational employment patterns and wage inequality that are at the core of the tasks framework and job polarization story. Proponents of job polarization as a determinant of wage polarization have, for the most part, only provided circumstantial evidence: both trends occurred at the same time. The causal story of the tasks framework is that technology (i.e., computerization) drives changes in the demand for tasks (increasing demand at the top and bottom relative to the middle), producing corresponding changes in occupational employment (increasing relative employment in high- and low-wage occupations relative to middle-wage occupations). These changes in occupational employment patterns are said to drive changes in overall wage patterns, raising wages at the top and bottom relative to the middle. However, the intermediate step in this story must be that occupational employment trends change the occupational wage structure, raising relative wages for occupations with expanding employment shares and vice-versa. We demonstrate that there is little or no connection between decadal changes in *occupational employment* shares and *occupational wage* growth, and little or no connection between decadal changes in *occupational wages* and *overall wages*. Changes within occupations greatly dominate changes across occupations so that the much-focused-on occupational trends, by themselves, provide few insights.

6. Occupations have become less, not more, important determinants of wage patterns.

The tasks framework suggests that differences in returns to occupations are an increasingly important determinant of wage dispersion. Using the CPS, we do not find this to be the case. We find that a large and increasing share of the rise in wage inequality in recent decades (as measured by the increase in the variance of wages) occurred within detailed occupations. Furthermore, using DiNardo, Fortin, and Lemieux's reweighting procedure, we do not find that occupations consistently explain a rising share of the change in upper tail and lower tail inequality for either men or women.

7. An expanded demand for low-wage service occupations is not a key driver of wage trends.

We are skeptical of the recent efforts of Autor and Dorn (2013) that ask the low-wage "service occupations" to carry much or all of the weight of the tasks framework. First, the small size and the slow, relatively steady growth of the service occupations suggest significant limitations of a technology-driven expansion of service occupations to be able to explain the large and contradictory changes in wage growth at the bottom of the distribution (i.e., between middle and low wages, the 50/10 wage differential), let alone movements at the middle or higher up the wage distribution. The service occupations remain a relatively small share of total employment; in 2007, they accounted for less than 13 percent of total employment, and just over half of employment in the bottom quintile of occupations ranked by wages. Moreover, these occupations have expanded only modestly in recent decades, increasing their employment share by 2.1 percentage points between 1979 and 2007, with most of the gain in the 2000s. Relative employment in all low-wage occupations, taken together, has been *stable* for the last three decades, representing a 21.1 percent share of total employment in 1979, 19.7 percent in 1999, and 20.0 percent in 2007.

Second, the expansion of service occupation employment has not driven their wage levels and therefore has not driven overall wage patterns. The timing of the most important changes in employment shares and wage levels in the service occupations is not compatible with conventional interpretations of the tasks framework. Essentially all of the wage growth in the service occupations over the last few decades occurred in the second half of the 1990s, when the employment share in these occupations was flat. The observed wage increases *preceded* almost all of the total growth in service occupations over the 1979–2007 period, which took place in the 2000s, when service occupation wages were falling (another trend that contradicts the overall claim of the explanatory power of service occupation employment trends).

8. Occupational employment trends provide only limited insights into the main dynamics of the labor market, particularly wage trends.

A more general point can and should be drawn from our findings: Occupational employment trends do not, by themselves, provide much of a read into key labor market trends because changes within occupations are dominant. Recent research and journalistic treatment of the labor market has highlighted the pattern of occupational employment growth to assess the extent of structural unemployment, the disproportionate increase in low-wage jobs, and the "coming of robots"—changes in workplace technology and the consequent impact on wage inequality. The recent academic literature on wage inequality has highlighted the role of changes in the occupational distribution of employment as the key factor. In particular, occupational employment trends have become increasingly used as indicators of job skill requirement changes, reflecting the outcome of changes in the nature of jobs and the way we produce goods and services. Our findings indicate, however, that occupational employment trends give only limited insight and leave little imprint on the evolution of the occupational wage structure, and certainly do not drive changes in the overall wage structure. We therefore urge extreme caution in drawing strong conclusions about overall labor market trends based on occupational employment trends by themselves.

I. Introduction

Skill-biased technological change (SBTC) has been a leading explanation for the rise in wage inequality almost since economists first noticed the increase in wage inequality that began at the end of the 1970s. A recent wave of research, however, has questioned important aspects of the standard version of SBTC models of wage inequality (Autor, Levy, and Murnane 2003; Autor, Katz, and Kearney 2006, 2008; Acemoglu and Autor 2011, 2012; and others), frequently

invoking arguments made in an earlier round of criticism of SBTC-based explanations (Mishel and Bernstein 1994, 1998; Howell 1994, 1999; Mishel, Bernstein, and Schmitt 1997; Galbraith 1998; Howell and Wieler 1998; Card and DiNardo 2002, 2006). The new research rejects key features of the long-standing SBTC models, but is itself closely tied to an alternative, technology-based explanation of rising wage inequality. This new "tasks framework" grows out of important insights about the role of technology in production that were first discussed by Autor, Levy, and Murnane (2003) and has had its most formal presentation in a model developed by Acemoglu and Autor (2011, 2012).

This paper seeks to assess the usefulness of the "tasks framework" as implemented in a growing body of empirically oriented papers. Elsewhere, we have offered an alternative explanation of widening wage inequality since the late 1970s, which does not appeal to technology as an important explanatory factor.[1] Here, however, we make a narrower argument that current models of SBTC —either what Acemoglu and Autor call the "canonical model" or the more recent tasks framework offered to replace it— do not adequately account for key wage trends over the last three decades. We largely concur with Acemoglu and Autor's critique of the "canonical model" (we have been making similar arguments since at least the mid-1990s). As a theoretical exercise, we also find Acemoglu and Autor's formal modeling of the tasks framework elegant and much richer than the "canonical model" it seeks to supplant. But, we argue here that, its insights and elegance notwithstanding, the tasks framework fails to explain the most important developments in wage trends observed since the end of the 1970s.

A central empirical feature of the tasks framework is the concept of "job polarization," usually defined as stronger employment growth in jobs at the top and bottom of the wage distribution than in the middle. Job polarization is closely linked to the argument that the last several decades have seen a "hollowing out" of the middle of the wage distribution. To be clear from the outset, we have no strong views about whether or not computerization caused job polarization over the last three decades. In what follows, we comment extensively on the timing, direction, and magnitude of changes in occupational employment patterns, but our purpose is not to suggest that job polarization did or did not take place. Instead, our interest lies in whether any employment polarization that did take place is consistent with predictions made by the tasks framework and, more importantly, whether and to what degree any observed changes in *occupational employment* can contribute to our understanding of changes in the *overall* wage distribution, which is the focus of the canonical SBTC model, the tasks framework, and other competing models.

To preview our main findings, we believe that the tasks framework fails as an explanation of rising wage inequality. Technological forces may be behind observed changes in the wage distribution, but, if so, current versions of the tasks framework do not adequately represent those forces.

Our critique of the tasks framework has several elements. We begin by demonstrating that key aspects of job polarization have been taking place since at least 1950. We label this "occupational upgrading" since it primarily consists of a shrinkage of middle-wage occupations and a corresponding expansion of higher-wage occupations. This enduring decline in middle-wage jobs—most typically in manufacturing and administrative and clerical work—makes job polarization a weak candidate for explaining the rise in wage inequality that only began at the end of the 1970s. Focusing on just the period since the late 1970s, the continued smooth decline in employment in middle-wage occupations, combined with the continued smooth rise in employment in higher-wage occupations and the relative stability of lower-wage occupations (until the 2000s) makes these employment changes an unlikely driver of the sharp rise (from about 1979) and the subsequent *fall* (beginning in about 1986–1987) in the size of the earnings differential between workers at the 50th

percentile and the 10th percentile of the wage distribution. The inability of the tasks framework to provide an empirical accounting of the decline in the 50/10 differential after 1986–87 is particularly problematic because the need to explain differences in the divergent paths of the 90/50 and 50/10 differentials after the late 1980s was an important motivation for the theoretical innovations first proposed by Autor, Levy, Murnane (2003) and Autor, Katz, and Kearney (2006, 2008), and later formalized in Acemoglu and Autor (2011, 2012).

We also demonstrate significant problems with the evidence that is most commonly used to establish the existence of job polarization—the U-shaped plots of changes in occupational employment against the initial occupational wage level. In important cases, these plots do not take the posited U-shape and in all cases the lines traced out fit the data poorly, obscuring large variations in employment growth across occupational wage levels.[2]

When, as is often done, these same plots lump together the experience of the last two or three decades, they also mask substantial differences in occupational employment patterns for the 1980s, 1990s, and 2000s. Most importantly, the now-standard plots show *no signs of overall job polarization in the 2000s.* In the 2000s, relative employment expanded at the bottom, but was flat at both the middle *and the top* of the occupational wage distribution. The lack of job polarization in the 2000s is a phenomenon visible in both the decennial census / American Community Survey data and in our analysis here of data from the Current Population Survey (CPS). Thus, the standard techniques applied to the data for the 2000s do not establish even a *prima facie* case for the existence of job overall polarization in the most recent decade. This leaves the job polarization story, at best, as an account of wage inequality in the 1990s and clearly not a description of current economic trends on which one should base policy.

We also document that data from the CPS—unexpectedly—reveal occupational employment polarization the 1980s. In earlier empirical work using the decennial census, occupational employment rises monotonically with initial occupational wages, which is consistent with the monotonic rise in overall wages by initial position in the wage distribution. But, using the CPS data, occupational employment shows almost as much of a tendency toward job polarization in the 1980s as it did in the 1990s. As a result, and contrary to the conventional interpretation of the tasks framework, we have two cases (the 1980s and the 2000s) in which rising occupational employment shares at the bottom were associated with *falling* wages at the bottom; and only one case—the 1990s—when rising occupational employment shares at the bottom were associated with rising relative wages.

More generally, we find little evidence consistent with the causal story of the tasks framework. In the most commonly told version of the story, technology drives changes in the demand for tasks (increasing demand at the top and bottom relative to the middle) and this change in demand for tasks drives changes in occupational employment (increasing employment at the top and the bottom relative to the middle). The change in occupational employment is then supposed to drive changes in overall wages by operating through occupational wages. The literature, however, has neglected to carefully examine the intervening dynamic of changing the occupational wage structure (raising wages more at the top and the bottom than at the middle).We demonstrate that there is little or no connection between decadal changes in *occupational employment* shares and *occupational wage* growth, and little or no connection between decadal changes in *occupational wages* and *overall wages*. The only evidence presented by proponents of the tasks framework for the shifting pattern of the 50/10 wage gap between the 1980s and 1990s, for instance, has been circumstantial evidence: Job polarization and wage polarization both occurred in the 1990s.

We also question the view that differences in returns to occupations are an increasingly important determinant of wage dispersion, possibly even exceeding in statistical importance differences in the returns to education. Informally, we show that the goodness-of-fit of the standard plots of occupational-employment changes against initial occupational-wage-levels declines steadily and sharply between the 1980s, 1990s, and 2000s, suggesting that occupations have substantially *less* explanatory power in recent years. A more formal regression analysis of the contribution of occupation categories using the CPS finds, contrary to the findings in Acemoglu and Autor (2011), that occupations do not explain an increasing share of wage variation over time. We find a large and increasing share of the rise in wage inequality in recent decades (as measured by the increase in the variance of wages) occurred within detailed occupations. Furthermore, using DiNardo, Fortin, and Lemieux's reweighting procedure, we do not find occupations consistently explain a rising share of the change in upper tail and lower tail inequality for either men or women.

We are also skeptical of the recent research of Autor and Dorn (2013) that asks the typically low-wage "service occupations" to carry much or all of the weight of the tasks framework. First, the magnitude of employment changes in the service occupations (excluding public safety occupations, which generally pay much better than other service occupations) make them poor candidates for explaining overall wage trends. The service occupations remain a relatively small share of total employment. In 2007, for example, these occupations (excluding workers in public safety occupations, which generally pay much better) accounted for less than 13 percent of total employment, and just over half of employment in the bottom quintile of the occupations ranked by wages. Moreover, these occupations have expanded only modestly in recent decades, increasing their employment share by 2.1 percentage points between 1979 and 2007, with most of the gain in the 2000s. The small size and the slow, relatively steady, growth of the service occupations suggest significant limitations on the ability of a technology-driven expansion of service occupations to explain the large and contradictory changes in wage growth at the bottom of the distribution (i.e., the 50/10 wage differential) let alone movements at the middle or higher up the wage distribution.

Second, the timing of the most important changes in employment shares and wage levels in the service occupations is not compatible with conventional interpretations of the tasks framework. Seen over a long period—say, 1980 to 2005, as in Autor and Dorn (2012)—both employment and wages in the service occupations increased, which Autor and Dorn interpret as suggesting that increasing demand for service occupations drove up, first, employment and, then, wages in these occupations. Essentially all of the wage growth in the service occupations over this period, however, occurred in the second half of the 1990s, when the employment share in these occupations was flat. The observed wage increases *preceded* almost all of the total growth in service occupations over the period, which took place in the 2000s, when wages in service occupations were falling, in clear contradiction to the usual interpretation of the tasks framework.

A much more general point can and should be drawn from our findings: occupational employment trends, by themselves, provide only limited insights into the main dynamics of the labor market, particularly wage trends. Recent research has used occupational employment trends to discern the extent of structural unemployment and changes in workplace technology and the consequent impact on wage inequality. The recent wage inequality literature has highlighted the role of changes in occupational distribution of employment as drivers, and key indicators, of labor market trends. In particular, occupational employment trends have become increasingly used as indicators of changes in job skill requirements, reflecting the outcome of changes in the nature of jobs and the way we produce goods and services. Our findings indicate, however, that occupational employment trends give only limited insight and leave little imprint

on the evolution of the occupational wage structure, let alone the overall wage structure. We therefore urge caution in drawing strong conclusions about the labor market based on occupational employment trends alone.

What economists mean by 'technology' when they say technological change causes wage inequality

When economists talk about technological change and its role in generating wage inequality, they sometimes are talking past the general public who may not understand what is being discussed. In their analysis economists are referring exclusively to technology in its role in shaping how goods and services are produced and the consequent implications for what types of workforce skills are required. Autor, Katz, and Kearney (2008, footnote 17) say this clearly: "Skill-biased technological change refers to any introduction of a new technology, change in production methods, or change in the organization of work that increases the demand for more-skilled labor relative to less-skilled labor at fixed relative wages."

"Technology" in this usage does not include technology's impact on communication or transportation costs and the consequent implications for where production takes place. (This dynamic falls under offshoring and globalization as a driver of wage inequality.) Nor does "technology" in this usage include changes in the products or services themselves, such as new gadgets that improve our well-being. (These affect the relative demand for various goods and services but not how things are produced.)

As Mishel et al. (2012, p. 295) note:

> We are often told that the pace of change in the workplace is accelerating, and technological advances in communications, entertainment, Internet, and other technologies are widely visible. Thus it is not surprising that many people believe that technology is transforming the wage structure. But technological advances in consumer products do not in and of themselves change labor market outcomes. Rather, changes in the way goods and services are produced influence relative demand for different types of workers, and it is *this* that affects wage trends. Since many high-tech products are made with low-tech methods, there is no close correspondence between advanced consumer products and an increased need for skilled workers. Similarly, ordering a book online rather than at a bookstore may change the type of jobs in an industry—we might have fewer retail workers in bookselling and more truckers and warehouse workers—but it does not necessarily change the skill mix.

Structure of the paper

The next section of the paper reviews key elements of the tasks framework, including the basis for its compelling critique of the "canonical" SBTC model. Section 3 provides an overview of long-term trends in occupational employment and wage inequality, showing that job polarization, broadly defined, is a long-standing feature of the U.S. labor market, while rising wage inequality is strictly a phenomenon of the last three decades or so. Section 4 takes a closer look at changing patterns of occupational employment, occupational wages, and overall wages. We use the CPS data both to provide an independent test of earlier results based primarily on the decennial census and the American Community Survey and to take advantage of the annual nature of the CPS in order to examine more closely the timing and mag-

nitude of relative occupational employment changes across occupations ranked by their 1979 level of wages. Section 5 continues the analysis in the preceding section, focusing on the chain of causality that runs from changes in occupational employment, through changes in occupational wages, and finally to changes in the overall wage distribution. Section 6 focuses on the role of service occupations and low-wage occupations in job polarization and wage trends. Section 7 concludes.

II. Theory, claims, and data

In two recent important papers, Acemoglu and Autor (2011, 2012) raise significant concerns about the ability of the "canonical model" of skill-biased technical change (SBTC) to explain rising wage inequality. The "canonical model" argues that the main cause of the increase in wage dispersion since the late 1970s is the rise in skill-biased production technologies that place a premium on the skills of more-educated and better-paid workers at the expense of less-educated and lower-paid workers. Acemoglu and Autor propose a "tasks framework" that subsumes the "canonical model" as a special case and claims to explain key wage patterns and rising wage inequality over the last three decades. This section reviews their critique of the "canonical model," and lays out the basics and key empirical claims of their tasks framework.

A. The 'canonical model'

For the last two decades, the standard explanation for rising wage inequality has relied heavily on a fairly simple model of the interplay of supply and demand. Daron Acemoglu and David Autor (2012) have succinctly summarized the main workings of the "canonical model" as follows: "In this model, technological progress raises the demand for skill and human capital investments slake that demand. When demand moves outward faster than does the supply of human capital, inequality rises, and vice versa when supply outpaces demand" (p. 428).

Claudia Goldin and Lawrence Katz build on the prior literature and offer a comprehensive theoretical and empirical description of the "canonical model" in *The Race between Education and Technology* (2010). In the "canonical model," the primary driver of labor demand is skill-biased technological change (SBTC) in the production of goods and services, which leads employers to hire more high-skilled workers whose skills complement new production technologies (including, especially, computers). In most empirical implementations of the model, the key indicator of the supply of skills is the share of college-educated workers in the labor force. As Acemoglu and Autor (2011, 2012) stress, the "canonical model" features two types of workers: college graduates—or, more precisely "college equivalents," which includes all those with a college degree or further degree and half of those with "some college"—and non-college graduates (not-college equivalents). The level of computerization is the most common empirical measure on the demand side, but SBTC is often simply inferred from a time trend or the pattern of employment and wages (a key figure is in Acemoglu and Autor (2011), reproduced here as **Figure A**, see also Katz and Murphy, 1992).[3]

Almost since its inception, the "canonical model" has been subject to two distinct critiques. The first, in chronological terms, questioned the connection between technological change and inequality. As Lawrence Mishel and Jared Bernstein (1994, 1998) argued, technological change has been a constant feature of the economy throughout the entire 20th century, with no obvious associated increase in wage or income inequality for much of that period. David Howell (1994) noted that the timing of the microcomputer revolution, which was widely believed to be a key source of the skill bias, was also off: the largest increase in wage inequality took place in the few years between 1979 and 1982, well before per-

sonal computers, let alone the Internet, had transformed workplaces. Consistent with this critique, the pace of growth in inequality declined even as computerization spread steadily in the late 1980s and 1990s (Mishel, Bernstein, and Schmitt 1997; Card and DiNardo 2002). Card and DiNardo (2002) expanded the critique, noting "puzzles and problems for the [SBTC] theory in nearly every dimension of the wage structure" including the failure to explain important dimensions of wage inequality by gender, race, and age.

One common feature of the Mishel, Bernstein and Schmitt (1997) and the Card and DiNardo (2002) critiques was the failure of the 50/10 wage differential to expand after the late 1980s, and the subsequent fall of the 50/10 differential in the 1990s. These movements in the bottom half of the wage distribution were inconsistent with the canonical claim that the rising price of skills (reflected in wage levels) in all its dimensions was driving wage inequality, since it was clear that low-wage workers were seeing wage gains as large or larger than middle-wage workers.

The second, and later, critique of the "canonical model" (Autor, Levy, and Murnane 2003; Autor, Katz, and Kearney 2006; Acemoglu and Autor 2011, 2012) did not seek to replace the "canonical model" so much as to use it as the foundation for a more general skill-biased technological change framework, which essentially subsumed the canonical approach.[4] Acemoglu and Autor (2011, 2012), who provide the most articulate and comprehensive discussion, identify three key shortcomings of the standard account and offer a formal, task-based, rather than skills-based, model that is explicitly an extension of the "canonical model."[5]

The first shortcoming identified by Autor, Katz, and Kearney (2006),[6] and later by Acemoglu and Autor, is that even though the simple supply-and-demand framework can account well, in their view, for the rising wage differential between college-educated and high school–educated workers from the 1970s through the early 1990s, the same model substantially overstates the rise in the college premium thereafter (as shown by **Figure B**, reproduced from Acemoglu and Autor 2012).The deceleration in the college premium, they note, would suggest that the relative demand for high-skilled workers decelerated after about 1992 which, in their judgment "does not accord with common intuitions regarding the nature or pace of technological changes occurring in this era" (p. 437).

The second shortcoming noted by Acemoglu and Autor is the "canonical model's" inability to explain the divergence in the pattern of wage behavior of inequality between the top and bottom halves of the wage distribution in the early 1990s relative to the pattern of the 1980s.[7] In the 1980s, wage growth was a smoothly increasing function of the initial wage level. From the early 1990s (or slightly earlier) onward, however, inequality continued to grow in the top half of the distribution (the 90/50 differential widened), but inequality was flat or falling in the bottom of the distribution (the 50/10 differential declined somewhat).[8] Since the "canonical model" is usually framed around two kinds of workers—more- and less-skilled workers, often operationalized as college- and non-college-educated workers—these non-monotonic movements in the wage distribution in the 1990s are difficult to explain in that framework.

The final shortcoming noted by Acemoglu and Autor is the "canonical model's" inability to explain how technological progress could produce stagnant and, especially, declining real wages for middle- and less-skilled workers over long periods, even as technology was increasing average productivity.[9]

All three of these critiques were made by Mishel, Bernstein, and Schmitt (1997) 10 years earlier:

> …the experience since the mid- to late- 1980s does not accord with a technology explanation, whose imagery is of computer-driven technology bidding up the wages of "more-skilled" and "more-educated" workers, leaving behind a small group of "unskilled" workers with inadequate skills. The facts are hard to reconcile with the notion that technological change grew as fast or faster in the 1990s than in earlier periods. If technology were adverse for "unskilled" or "less-educated" workers, then we would expect a continued expansion of the wage differential between middle-wage and low-wage workers (the 50/10 differential).
>
> Yet, the 50/10 differential has been stable or declining among both men and women since 1986 or 1987. Instead, we are seeing the top earners pulling away from nearly all other earners. Therefore, there seem to be factors driving a wedge between the top 10 percent and everyone else, rather than a single factor aiding the vast majority but leaving a small group of unskilled workers behind. Further confirmation of the breadth of those left behind is that wages have been stable or in decline for the bottom 80 percent of men and the bottom 70 percent of women over the 1989–95 period, with wages falling for the entire non-college-educated workforce (roughly 75 percent of the workforce). Of course, even high-wage, white-collar, or college-graduate men have failed to see real wage growth in 10 years.
>
> The flattening of the growth of education differentials in the late 1980s and 1990s among men also does not easily fit a technology story. Since the wages of college-graduate men are not being "bid up" relative to others at the same pace as in the early and mid-1980s, one can only conclude that there has been a deceleration of the relative demand for education (given that the supply of college workers did not accelerate).

We also note that Autor and Acemoglu do not consider several additional critiques of the "canonical model," particularly: (1) the failure of education wage differentials to capture much, if not the majority, of the growth of wage inequality, which happened among workers with similar education and experience (so called "within-group" wage inequality); (2) the failure to explain the extraordinary rise of wages among the top 1 percent of earners; and (3) the possibility that observed education wage gaps could be driven by factors other than changes in the price of skills, including changes in the minimum wage and unionization, industry deregulation, and globalization, all of which could affect relative wages by education but have nothing to do with technological change.

B. The tasks framework

To address these three shortcomings,[10] Acemoglu and Autor (2012, Section 4) construct a formal model, which builds on the framework originally developed by Autor, Levy, and Murnane (2003), where the fundamental units of the production process are job "tasks," rather than workers' skills. Probably the most important feature of the model is that it defines three kinds of tasks: non-routine cognitive tasks (high-skilled), non-routine manual tasks (low-skilled), and routine tasks (middle-skilled, some of which are cognitive and some of which are manual). The second important feature of their model is that it separates tasks from skills. Workers of different skill levels (and different mixes of workers of different skill levels) can perform any of the tasks.[11]

In this framework the driving force is computerization. Computers have the capacity to compete directly with workers who perform routine tasks, such as those performed by clerical and administrative workers or production workers in manufacturing. Computers, however, are poor substitutes for workers performing non-routine cognitive jobs, such as managers, lawyers, or doctors. In fact, in practice, computers are likely to be strong complements to such workers. Nor

are computers effective substitutes for workers performing non-routine manual tasks, including many personal services, such as food preparation and cleaning.

The introduction of tasks and of three kinds of labor (low-, middle-, and high-skilled), however, allows the new model to overcome the main shortcomings of the standard approach identified earlier. Most prominently, by allowing for three types of tasks, their model can potentially explain the divergent inequality trends after the 1980s between the top and middle, on the one hand, and the middle and the bottom, on the other hand—something that the "canonical model," with only two types of labor, cannot.

1. Key empirical claims

Economists working in this framework have made several empirical claims, which are the focus of the empirical work in the remainder of this paper.

Claim 1: In the 1990s, employment growth was polarized, with the employment share of high-skilled and low-skilled occupations expanding and the employment share of middle-skilled occupations contracting. This pattern marked a stark change relative to the 1980s when, across occupational skill levels, employment grew least at the bottom, more in the middle, and most at the top.

Autor and various co-authors argue that sometime after the late 1980s, employment growth became polarized, with a simultaneous increase in the employment shares of high-skilled and less-skilled occupations coinciding with declining employments shares for middle-skill occupations.[12] This pattern was in stark contrast to the 1980s, when employment fell at the bottom of the skills distribution, whether skill was measured by education level or using the occupational wage rankings used in the tasks model. Simply put, the first claim is that job polarization occurred in the 1990s but not in the 1980s, when occupational employment at the bottom contracted, rather than expanded.

For the 1990s, Acemoglu and Autor (2012, Figure 5), Autor, Katz, and Kearney (2008, Figure 11) covering 1990–2000, Autor (2010, Figure 1) covering 1989–1999, and Acemoglu and Autor (2011, Figure 10) covering 1989-1999 find an increase in the employment share for low-skill occupations up to roughly the 10th percentile of the occupational skill distribution.[13] These same estimates show contemporaneous increases in the employment share of high-skilled occupations from about the 75th percentile of the occupational skill distribution (though, perhaps about as low as the 65th percentile in the case of Acemoglu and Autor (2011)). Since employment shares must add to 100 percent, increases in employment shares at the bottom and the top imply declining employment shares for occupations in the middle.

Most discussions of job polarization have emphasized the change in employment patterns between the 1980s and the 1990s. Researchers, however, have paid almost no attention to a similarly stark break in employment patterns between the 1990s and the 2000s. For the period 2000–2007, Autor (2010, Figure 1) and Acemoglu and Autor (2011, Figure 10) show employment gains for the bottom 30 percent or so of the occupational skill distribution, but no increase in relative employment for workers above that level in the distribution. These results suggest that by the 2000s, job polarization had ceased to be a factor in the U.S. labor market. This is acknowledged only indirectly, unfortunately, in the literature, but this finding undercuts the claim that occupational employment patterns correspond to key wage patterns, a topic explored below.

Claim 2: This switch in occupational employment patterns in the 1990s caused corresponding shifts in wage patterns. Specifically, occupational employment polarization in the 1990s can explain the shift in the 50/10 wage differential that the "canonical model" fails to explain: after wage inequality at the top and the bottom of the distribution grew symmetrically in the 1980s, wage inequality in the 1990s was distinctly asymmetric, with growing inequality in the top half (90/50 wage gap) of the distribution and declining inequality in the bottom half (50/10 wage gap).[14]

If the first claim is essentially "job polarization occurred in the 1990s but not in the 1980s" then the second claim is that "the arrival of job polarization in the 1990s explains changes in wage inequality at the bottom of the wage scale."

The most recent tasks framework theoretical work by Autor and Dorn (2012) indicates that job polarization's impact on wages is ambiguous though the empirical claim is that job polarization generates wage inequality, in this instance at the bottom of the wage distribution.[15]

Claim 3: Autor and Dorn (2012) argue that a "key fact" is that "rising employment and wages in service occupations account for a substantial share of aggregate polarization and growth of the lower tail of the U.S. employment and earnings distributions between 1980 and 2005."

The most recent research in the tasks framework has focused strongly on the role that low-wage "service occupations" have played in the process of both employment polarization and wage polarization and ignores the wage and employment patterns in the top half of the occupational and wage structure. The service occupations (excluding public safety workers, as Autor and Dorn do) are usually low-wage, non-routine manual jobs that accounted for less than 13 percent of total employment in 2007. Typical occupations in this category include food preparation, security guards, and janitorial services, but unless explicitly excluded from the analysis, the formal "service occupations" category also includes police and firefighters, who earn substantially more and are on average much better educated than other service occupations. The emphasis on the service occupations represents a methodological break with much of the earlier research in this area, which focused on much finer occupational categories (typically three-digit occupations) where the skill ordering was determined by the initial average wage in the narrow occupation group.

III. An introductory look at wage inequality and occupational employment trends

The "tasks framework" attempts to explain the patterns of wage inequality over the last 30 years by examining changes in the occupational employment mix. This section provides an introductory look at occupational employment and wage trends with two key goals. The first is to put the post-1979 occupational trends in a longer historical context. The second is to examine the correspondence of occupational shifts since 1979 to the evolution of key wage gaps—particularly the 50/10 and 90/50 wage gaps using the annual data available from the CPS.

A. The long view of occupational employment trends

We begin with a review of occupational employment trends over the postwar period in order to provide historical context. The focus is on the expansion and contraction of high-, middle-, and low-wage occupations (categories defined by Acemoglu and Autor (2011) and used in other papers). Acemoglu and Autor (2011) provide a long look back at the occupational composition of 10 occupations since 1959, which is reproduced in **Table 1** and supplemented with:

(1) changes in the aggregate categories of low-, middle-, and high- wage occupations; and (2) the percentage-point change in occupational employment shares for each decade and the most recent time period (for the 2000s, we show the period 2000–2007, adjusted to a 10-year rate of change). The Acemoglu and Autor data are derived from the decennial census data except for the latest year, which is based on the American Community Survey. The trend in these aggregate occupational shares are shown in **Figures C-A and C-B.** These figures also include comparable annual trends for the 1979–2007 period based on our tabulations of the Current Population Survey.[16]

Acemoglu (2010), in a newspaper column, summarized his and his co-author's view of the historical record:

> U.S. employment and demand for labour have been undergoing profound changes over the last 30 years. While the demand for high skill workers, who can perform complex, often non-production tasks, has increased, manufacturing jobs and other "middling occupations" have been in decline. Also noteworthy is that over the last 10-15 years, many relatively low-skill, low-pay service occupations have been expanding rapidly.

Table 1 and Figure C-A show that middle-wage occupations declined at a comparable pace in each of the last three periods dating back to 1979, eroding by roughly 4.5 percentage points per decade. *A critically important observation, however, is that such "middling occupations" have been declining throughout the entire period covered by their data, 1959–2007, which includes periods when wage inequality was stable as well as ones when wage inequality was growing. The decline in the "middle" that is highlighted in the discussion of job polarization is not unique at all to the 1990s.* Moreover, the blue-collar occupations, "Production, craft and repair" and "Operators, fabricators and laborers," eroded more quickly in the 1960s, 1970s, and 1980s than in the 1990s or 2000s, so any notion that job polarization represents some new technological turn against blue-collar middle-wage jobs is not accurate.

We also note that discussions of occupational employment trends in the job polarization literature consistently assume that these observed occupational shifts are solely a reflection of technological change. In fact, this assumption is clearly false since globalization trends and, in particular, the rise of trade deficits over the last three decades, has also changed the occupational composition of employment. We flag the likely important contribution of trade to the occupational employment mix. We hope to address the impact of trade on these occupational employment trends in future work.

Table 1 and Figure C-B also show that high- wage occupations have expanded over the entire 1959–2007 period, though faster in the 1980s and 1990s. An important development is that the growth of high-wage occupational employment in the 2000s was slower than it had been in the 1990s and grew comparably to the slow trend in the 1960s. Analysis of occupational employment growth by wage percentile, presented by Autor (2010), shows that employment in high-wage occupations grew no faster than employment in middle-wage occupations in the 2000s. This dramatic slowdown in demand for workers in high-wage occupations in the 2000s relative to demand in the 1980s and 1990s has important implications for the analysis of wage trends. The slowdown in the growth in top occupations in the 2000s was due to the failure of "technician" employment to expand (which also occurred in the 1990s), a remarkable slowdown in management occupations (up only 0.4 percentage points, about a fifth as fast as in the 1980s and 1990s), and a deceleration in the growth of professional employment. This overall slowdown in high-wage occupations in the 2000s is consistent with the slower growth of the 90/50 wage gap. The slower expansion of high-wage employment is consistent with recent technological change generating more modest growth in the demand for college graduates and could help explain the flattening of the growth of college wages and the college wage premium.

Given the continuing trends in both the middle- and high-wage occupations, an explanation of a changed pattern in the 50/10 wage gap rests heavily on the expansion of low-wage occupations in the 1990s, relative to the 1980s: Such an expansion can explain the differing pattern of low-wage (10th percentile) and 50/10 trends in each decade as demand for low-wage workers expanded in the 1990s relative to the 1980s, with the result that low-wage workers fared better and the 50/10 wage gap stopped expanding and even fell in the 1990s. As noted, low-wage occupations are equated to the aggregate of the three service occupations. However, service occupations represent only about half of the occupational employment of the bottom fifth (in terms of the lowest-paying occupations) of occupational employment. Section 6 provides a more in depth analysis of employment trends in service occupations and in low-wage occupations. For our purposes here our analysis focuses only on the aggregate of service occupations.

As shown in Table 1 and Figure C-B, service occupations were relatively stable in size over the 1970s and 1980s, then expanded modestly in the 1990s (up 1.0 percentage point over the full decade), and then grew far faster in the 2000s (up 3.0 percentage points at a 10-year rate).

Acemoglu and Autor (2011), citing Autor and Dorn (2010), suggest a sharper increase in the 1990s than seen in Table 1, indicating "the employment share of service occupations was essentially flat between 1959 and 1979. Thus, their *rapid* growth since 1980, marks a sharp trend reversal [emphasis added]." More importantly, they note:

> Indeed, Autor and Dorn (2010) show that rising service occupation employment accounts almost entirely for the upward twist of the lower tail … during the 1990s and 2000s. All three broad categories of service occupations, protective service, food preparation and cleaning services, and personal care, expanded by double digits in the both the 1990s and the pre-recession years of the past decade (1999-2007). Protective service and food preparation and cleaning occupations expanded even more rapidly during the 1980s.

Our reading of these initial data suggests that the scale and timing of the changes in service occupations does not correspond to Acemoglu and Autor's interpretation. The key empirical issue is whether trends in service occupations are consistent with the view that there was a substantial expansion of demand for low-wage workers in the 1990s relative to the 1980s as indicated by trends in service occupations. Such an expansion would need to have occurred in the late 1980s (the specific timing depends on whether the analysis is of all workers, men, or women).

The appropriate metric, in our view, is the change in employment shares rather than (percent) growth in employment because the issue is change in relative demand. In our reading of Acemoglu and Autor's data, displayed in **Table 1**, there was growth in service occupations in the 1990s (up 1.0 percentage point) that exceeded that of the 1980s (up just 0.3 percentage points). On first glance, however, this 1990s expansion does not seem sufficient to explain why a major increase of the 50/10 wage gap in the 1980s failed to continue in the 1990s. This is especially the case since measurement issues—the occupation coding change that occurs between the 1990 and 2000 decennial censuses— artificially expands service occupation employment in the 1990s in the Acemoglu and Autor series. This is examined in greater detail in a later section and in the data appendix.

The largest change in employment in service occupations appears to have taken place in the 2000s, when the service-occupation employment share increased at a 3.0-percentage-point 10-year rate. These observed employment (share) trends in the service occupations raise some important questions. One is whether a modest expansion of the low-wage occupation expansion in the 1990s relative to the 1980s is sufficient to explain a sharp change in wage patterns at the

bottom. A second question is whether the timing of the change in service occupation employment occurred coincident with the change in wage patterns, i.e., in the late 1980s or early 1990s. An even bigger question: If one believes the modest 1990s change in service occupation employment was sufficient to dramatically alter wage patterns in the 1990s, then why didn't a doubling of that rate of expansion in low-wage occupations in the 2000s lead to an acceleration of wage growth at the bottom and a sharp contraction in the 50/10 wage gap from 2000 to 2007? This is the first of many instances where the story which is said to explain the 1990s is clearly inconsistent with the trends in the 2000s (which is not adequately acknowledged, in our view, in the tasks framework/job polarization literature).

We have also examined the historical pattern of occupational employment shifts presented in two other papers. Autor and Dorn (2012, Table 1) present data for 1950, 1970, 1980, 1990, 2000, and 2005 based on shares of total hours worked and including farming (excluded from the Acemoglu and Autor (2011) data). The Autor and Dorn data use the same grouping of occupations into high-, middle- and low-wage as Acemoglu and Autor and confirm that the shrinkage of middle-wage occupational employment and the expansion of high-wage occupational employment also occurred in the 1950-70 period, though at a slower pace than in later periods.

Katz and Margo (2013) provide an even longer series, going back to 1920, and include agricultural occupations since they were very significant up through 1960. Katz and Margo, however, categorize occupations differently, expanding the "low" category beyond service occupations to also include blue-collar operatives and laborers. This more than doubles the size of the low-wage group even near the end of the period: In 2000, low-wage occupations comprised 27.5 percent of total non-agriculture employment while service occupations alone (the Acemoglu and Autor grouping for low-wage) were just 13.0 percent. Katz and Margo do not explain the basis for their categorization and it does seem odd to us to put more highly paid blue-collar workers (operatives and laborers) into the low-skill category while leaving lower-paid clerical/administrative workers in the middle-skill group. Katz and Margo's share of non-agriculture employment in the low-skill group declined in the 1950s, 1960s, 1970s, 1980s, and 1990s and increased in the 2000s. Middle-skill occupational employment declined and high-skill occupational employment expanded in every decade starting with the 1950s. Thus, the Katz and Margo data show that occupational upgrading was a constant feature of the postwar economy up through 2000, with low- and middle-skill occupational employment shrinking and high-skill occupational employment expanding. Moreover, Katz and Margo's data show no job polarization in the 1990s as low-skill occupational employment shrank absolutely and more than middle-skill occupational employment shrank.[17]

This ongoing shrinking of middle-wage occupations and expansion of high-wage occupations over the last 60 years represents the occupational upgrading associated with technological change (but also the impact of trade impact in the last few decades). This upgrading process should not be surprising to labor economists and has long been noted (Spenner 1988; Mishel and Bernstein 1994, Mishel, Bernstein, and Schmitt 1997; Handel 2005; and Howell and Wolff 1991).

Having now analyzed the postwar historical trajectory of occupational employment changes we can now characterize ways in which technology *has* affected the labor market (shaping the occupational employment structure) and ways it *has not* affected the labor market (causing wage inequality). Some analysts have mistakenly asserted that if an analysis suggests that technological change has not greatly affected wage inequality that this is equivalent to saying that technology has had no impact on the labor market. We have just documented a longstanding trend of occupational upgrading—more white-collar and less blue- and pink-collar work—for many decades. These changes in the occupational structure are primarily technology-driven and have increased the skills and education employers seek in the labor mar-

ket which, in turn, necessitates an educational upgrading of the workforce. This is what Claudia Goldin and Lawrence Katz refer to as the "race between technology and skills." We believe there has been such a race, that technology has had a major effect, *but also that the education and skills have greatly improved and satisfied that increased demand.*

There has also been an increase in so-called "skill premiums," such as the college wage premium. We view that increase as reflecting other factors such as deregulation of industries, globalization, an eroded minimum wage, excessive unemployment, and declining unionization rather than the product of technology-driven skill shortages. That is, in the race between skills and technology since 1979 there has been roughly a tie. This has especially been the case since 1995, after which the college premium has barely grown. Moreover, as shown in Mishel et al. (2012), over the last 10 years, real wages have been flat or falling for a majority of college graduates, including those in nearly every occupational group (e.g., business occupations). In these circumstances, where technology and skills have run neck and neck, technology has had a large impact on the labor market but it has not generated wage inequality. We have faced a "wage deficit" rather than a "skills deficit," meaning that jobs at every education and skill level have not seen appropriate wage growth. This is evident in the failure of wages of both high school– and college-educated workers to keep pace with productivity, and in the extraordinary share of profits in the economy, especially in the 2000s.

B. Occupational employment shifts and wage gap shifts

This section continues the analysis of occupational employment shifts and focuses on their correspondence over time with key wage gap trends. The starkest shift in wage patterns was for the 50/10 wage gap, which substantially expanded in the 1980s, stopped expanding in the late 1980s and then stabilized and contracted somewhat in the 1990s. This pattern indicates that in the 1990s, wage growth for low-wage workers was as good or better than it was for middle-wage workers in the same period—exactly the reverse of what occurred in the 1980s. The shift in wage patterns was most stark among women: The 50/10 wage gap grew from 1.47 in 1979 to 1.91 in 1988, a gap generated by a 17 percent decline at the 10th percentile and an 8 percent gain at the median. The 50/10 wage gap grew far less among men (from 2.04 in 1979 to 2.28 in 1986) because wages fell less at the 10th percentile and wages also fell at the median. The second wage gap, the 90/50 gap, continued to grow throughout the 1980s and the 1990s but rose more slowly among men after 1993 and among women after 1994.

Tables 2-A through 2-C and **Figures D-A through D-C** employ annual data from the CPS to portray the timing of occupational employment and wage-gap shifts. The 1973–2010 annual trend in the key occupational employment shares (hours-weighted) and the corresponding wage gap are presented in Figure D-A for all workers, and separately for men and women (Figures D-B and D-C). These figures allow us to see whether the shifts in occupational employment (e.g., changes in the size of service occupations) correspond to the shifting pattern of wages (e.g., the flattening in the 50/10 wage gap after the late 1980s). The 50/10 wage gap is displayed along with the employment shares in middle- and low- wage occupations and, likewise, the 90/50 wage gap is displayed alongside the employment shares in high- and middle- wage occupations. Table 2A through 2C use the same data to present the trends in particular time periods: business cycle periods such as 1979–1989, 1989–2000 and 2000–2007 plus the two distinct subperiods of the 1990s; 1989–1995 and 1995–2000.

Two metrics for assessing the occupational shifts are used. The first is the simplest, the annual percentage-point change in an occupation's employment share in each period. The percentage-point change, however, is not scaled at all to the size of the occupation group and since the occupation groups vary tremendously in size—the middle group represented

roughly 60 percent of employment in 1979 while service occupation represented only about 14 percent in the same year. Given differing sizes, the same percentage-point change means a larger expansion or contraction for service occupations than it would for middle-wage occupations. The second metric, therefore, divides the percentage-point change in a period by the starting share and thereby reflects the degree to which that occupation expanded or contracted.

Using the CPS-ORG for both the occupational employment trends and the wage trends has several advantages. One is that the CPS occupational employment trends have not yet been used in an analysis of job polarization, so they provide new information and an additional test of the robustness of the finding of job polarization.[18] Second, using the CPS allows us to examine annual trends and to test whether shifts in employment patterns are coincident with shifts in the 50/10 and 90/50 wage gaps. A third reason to use annual CPS data is that we can make an adjustment for the coding changes that occurred in 1983 and 2003. The annual data series we employ eliminates the change in occupational shares in the year of the coding changes, 1982–1983 and 2002–2003 by substituting the average of the change in share in the preceding and subsequent two years.[19] Last, the CPS-ORG is the acknowledged best data source for examining hourly wages.

Figures D-A through D-C also display the trends in low-, middle-, and high- wage occupational employment shares. Employment shares for all three groups move smoothly over the entire 1973–2010 period. Meanwhile, wage patterns show abrupt changes, particularly the sharp growth in the 1980s in the 50/10 wage gap and the subsequent shrinkage (among all and men) or flattening (among women) thereafter.

The *prima facie* evidence, therefore, does not support the claim that occupational employment polarization emerged in the late 1980s and early 1990s and caused a change in wage patterns. For instance, the trend in the employment share of service occupations, which Autor and Dorn (2010) and Acemoglu and Autor (2011) claim drives the 50/10 wage gap, has been smoothly changing over nearly 40 years. Similarly, the shrinkage of middle-wage occupations has been steady as well. *Steady trends in occupational employment composition cannot cause discontinuous shifts in key wage gaps.*

Tables 2A through 2C provide the detailed data that confirm the lack of correspondence between low-wage (service) occupation share trends and trends in the 50/10 wage gap. Our reading of the tasks framework literature is that it postulates that the expansion of service occupations should lead to a falling 50/10 wage gap as the demand for low-wage workers expands relative to workers in the middle. In the 1980s, service occupations expanded employment overall and among men, but, contrary to the expectations built into the tasks framework literature, the 50/10 wage gap expanded. Nor was there any shift to a faster expansion of service occupations overall or among men in the early 1990s (1989–1995), when the 50/10 wage gap flattened among men and declined overall. *Thus, shifts in occupational employment shares for service occupations do not appear to have any influence on the development of the 50/10 wage differential, raising doubts about a key claim of the task s framework literature.* Our analysis of the broader low-wage occupational group presented below affirms this finding.

The corresponding data for women are also inconsistent with the standard tasks framework. In the 1980s, service occupation employment shares for women fell modestly (-.03 percentage points per year), which does not tightly correspond to a stark widening of the 50/10 wage gap. Service occupation employment shares fell at a faster pace in the first half of the 1990s (-0.09 percentage points per year) but the 50/10 gap declined (0.56 log points per year). The abrupt change in the trend of the 50/10 differential for women was the largest change in wage patterns between the 1980s

and 1990s. Yet, low-wage service occupation employment trends among women cannot explain this key shift in wage patterns among women, a major failure of the tasks framework.

The trends in the wage gap at the top, the 90/50 wage gap, are not tightly linked to shifts in occupational employment shares either. Among men, the 90/50 wage gap grew more strongly in the early 1990s than in the 1980s even though the high-wage occupation growth slowed. The 90/50 wage gap grew far more slowly in the late 1990s (0.67 log points per year) though the growth of high-wage occupations did not slow at all. In the 2000s the growth of high-wage occupations among men was minimal (0.05 percentage points per year) but the 90/50 wage gap continued to grow (0.51 log points per year) though at a reduced pace compared with the 1980s or 1990s.

Among women, there was a clear deceleration in the growth of the 90/50 wage gap in the late 1990s and 2000s, but it is difficult to see how the trajectory of high-wage occupations could explain this pattern. The growth of high-wage occupations was slowed somewhat between the first and second halves of the 1990s (falling from 0.68 to 0.59 percentage points per year) while the 90/50 wage gap grew only a third as fast in the second half of the 1990s as it had in the first half of the decade. In the 2000s, the 90/50 wage gap grew a bit faster than in the second half of the 1990s, but high-wage occupations grew more slowly. The decline in middle-wage occupations among women was similar in the 1980s and the entire 1990s, which does not help resolve this puzzle. The faster shrinkage of middle-wage occupations in the 2000s, however, can help explain the pickup in 90/50 wag gap growth.

IV. What does the CPS tell us about occupational employment trends?

In this section, we first use data from the Current Population Survey Outgoing Rotations Group (CPS-ORG) to replicate a key figure in the job polarization literature—a figure that was created using data from the decennial census and the American Community Survey— Figure 10 in Acemoglu and Autor (2011) (which is also Figure 1 in Autor (2010)). Though the CPS-ORG has smaller sample sizes, its key advantages are that it has a better hourly wage measure, and data are available for each year. This exercise is also useful simply to see how robust this key finding in the job polarization literature is to changing the data source. Our treatment of the CPS-ORG data is described in the Appendix.

In this discussion, we find it helpful to distinguish between what we call "absolute" job polarization and "relative" job polarization. Absolute polarization is both what the job polarization literature conveys and what is most commonly referred to in popular discussions of this topic: employment share *growth* at both the top and bottom of the occupational distribution, with losses in the middle. Relative polarization refers to growth across the occupational distribution that has a U-shape, whether or not both ends see absolute growth in shares. So, for example, employment share growth across the occupational distribution where the middle loses substantial employment share, the bottom loses employment share but not as much as the middle, and the top gains employment share would represent relative but not absolute polarization. Of course, relative polarization of employment growth, even without absolute polarization of employment growth, would be expected to generate a polarization of relative wage trends.

Another important issue is the impact of changes in occupation coding over time. As described in the Appendix, we employ the same occupation crosswalk used in, among other papers on this topic, Acemoglu and Autor (2011), to attempt to obtain a consistent series across several coding changes in the CPS over the 1979–2007 period. As shown in Appendix Figure A, using this crosswalk, we are able to almost exactly replicate the underlying major occupational employment shares in each year used in Figure 12 of Acemoglu and Autor (2011).[20] There are 10 occupations and this

graph shows trends for each of these 10 occupations from both our tabulations and Acemoglu and Autor's. The fact that only 10 lines are observable means that the lines based on our tabulations almost exactly duplicate their tabulations. An examination of Figure A reveals that the major changes in occupation coding between 1982 and 1983 and between 2002 and 2003 are difficult to bridge. Even with the careful crosswalk used in Acemoglu and Autor (2011), there are large, visible discontinuities in employment shares between 1982 and 1983 and between 2002 and 2003.[21] The impact of the coding breaks is nontrivial. We find that the coding break between 1982 and 1983 masks the decline in middle-wage jobs in the 1980s, which is a key reason that, as discussed below, we find job polarization in the 1980s while Acemoglu and Autor (2011) do not (since we remove the effect of the coding break and they do not). We also find that the coding break between 2002 and 2003 leads to a substantial overstatement of low-wage job growth in the 2000–2007 period, and that when we remove the effect of the 2002/2003 coding break there is much more modest growth in low-wage jobs (when occupations are ranked according to their 1979 mean wage) in the 2000–2007 period. Our method for removing the effect of the coding breaks is to simply replace the change in employment share over the break years (1982–1983 or 2002–2003) with the average change of the two years on either side of each break. For more detailed information about the impact of the coding break, see the Appendix.

Figure E shows our replication of Figure 10 in Acemoglu and Autor (2011) (which is also Figure 1 in Autor (2010)), using data that are adjusted for the coding breaks using the simple adjustment procedure described above and in the Appendix. Figure E fairly closely replicates the Acemoglu and Autor (2011) figure, with some notable differences. While Acemoglu and Autor (2011) find monotonic increases in employment across occupational wage percentiles in the 1980s, we find relative (though not absolute) job polarization, with *less* job loss for the bottom of the occupational ranking than the middle during this period. The finding of relative job polarization in the 1980s is inconsistent with the Acemoglu and Autor claim that there was a stark shift in occupational employment patterns between the 1980s and the 1990s that can explain the shift in the 50/10 wage gap at the end of the 1980s (specifically, the observation that the 50/10 wage differential substantially expanded in the 1980s, stopped expanding in the late 1980s, and then contracted in the 1990s). For the 1990s, we replicate the Acemoglu and Autor (2011) job polarization finding, though here too we find no absolute job polarization, only relative polarization, with less job loss for the bottom of the occupational ranking than the middle during this period.[22] Between 2000 and 2007, Acemoglu and Autor (2011) find much more employment growth at the bottom of the occupational employment distribution than we do using CPS data; of the bottom half of the distribution we find that only the first five percentiles saw any employment share growth.

Most discussions of job polarization have emphasized the change in employment patterns between the 1980s and the 1990s. Researchers, however, have paid almost no attention to the stark break in employment patterns between the 1990s and the 2000s. For the period 2000–2007, Autor (2010, Figure 1) and Acemoglu and Autor (2011, Figure 10) show employment gains for the bottom 30 percent or so of the occupational skill distribution, but no increase in relative employment for workers above that level in the distribution. Our CPS results confirm that there was little or no employment expansion of occupations in the upper half of the wage scale. These results suggest that by the 2000s, job polarization had ceased to be a factor in the U.S. labor market. This is acknowledged only indirectly, unfortunately, in the literature.[23]

These descriptions fail to acknowledge how different the trends in the 2000s are from those of the 1990s and how those differences are at variance with the tasks framework interpretation of wage inequality trends. First, the failure to find a sizeable difference in the employment share growth of middle- and high- wage occupations in the 2000s means

that one key dimension of job polarization that was present in the 1990s (and 1980s) is absent in the 2000s. This has the important implication that occupational employment trends in the 2000s cannot explain continued growth in the 90/50 wage gap. Second, the faster (than in the 1990s) expansion of low-wage occupational employment share in the 2000s generates an additional puzzle for the job polarization interpretation of wage inequality: a smaller expansion of low-wage occupational employment in the early 1990s is said to have narrowed the 50/10 wage gap over that decade, yet, a larger expansion of low-wage occupations in the 2000s generates no contraction in the 50/10 differential in the 2000s.

An important and unspoken implication is that "job polarization," which features in many popular and policy discussions of the contemporary economy, is in fact, at best, only a theory of developments through the 1990s and does not contribute to our understanding of more recent trends.

A. The smoothing typically used in this context masks substantial variation

The key data presented to demonstrate occupational employment trends across wage percentiles (i.e., such as job polarization in the 1990s) rely on a locally weighted smoothing regression. Such analyses are useful, but unfortunately are not typically presented with an assessment of goodness of fit. In fact, the smoothed lines in the standard presentations of employment polarization mask substantial variation of occupational employment growth across the entire distribution of occupations. What is presented as a reliable picture of employment patterns obscures substantial variation in the underlying data (Lefter and Sand, 2011).

The smoothed lines in **Figures F-A through F-C** are the *exact* lines from Figure E, now displayed on a y-axis with a scale wide enough to incorporate the unsmoothed log employment share changes at each occupational percentile. We also report the "lowess" R-squared of the smoothed line to provide a measure of goodness-of-fit.[24] In every decade, the smoothed lines mask a great deal of underlying variability in the data. The lowess R-squared from the 1979–1989 period is the largest of the three periods, at 0.213. The lowess R-squares declines with each subsequent period, to 0.174 in the 1989–2000 period, and to 0.039 in the 2000–2007 period. In other words, for any of the three time periods, but most pronounced in the 2000s, the variation of employment shifts across detailed occupations is not well captured by the smoothed lines presented in the job polarization literature.[25] Knowing an occupation's initial wage level does not provide much information about employment growth in that occupation or about employment changes in nearby occupations. Much of the literature focuses on how the shapes of these smoothed lines shift from period to period, most prominently from "monotonic" in the 1980s to "polarized" in the 1990s. Such analyses are implicitly differencing lines which are not well estimated, suggesting that any claims about differences are subject to a substantial margin of error.

As mentioned, our preferred use of the data in this context is to adjust for the major occupational coding breaks in 1982/1983 and 2002/2003. However, since the empirical work in this literature typically does not make these adjustments, here we also present the lowess R-squared for the unadjusted data. The lowess R-squared for the unadjusted 1979–1989 data, at .043, is substantially lower than for the adjusted data (which was 0.213). The lowess R-squared for the unadjusted 2000–2007 data, also at .043, is slightly higher than for the adjusted data (which was 0.039). There was no major coding break (and therefore no adjustments) in the 1990s; the lowess R-squared for the 1989–2000 period is 0.174. We also note that whether we use the adjusted or the unadjusted data, the ability of initial occupational wage levels to predict employment changes declines substantially from the 1990s to the 2000s. This appears to contradict the claim in Acemoglu and Autor (2011) that the explanatory power of occupations has increased since the 1980s.[26]

V. Occupational employment shifts and wage determination

We now leave behind issues regarding the shape of occupational employment patterns and ask how occupational employment trends have affected wages, assessing Claim #2 above. As noted earlier, the literature has not offered direct evidence of how occupational shifts shape wage patterns: rather, the only evidence presented has been circumstantial, merely showing that when job polarization occurred in the 1990s there was also a polarization of wages (with the 90/50 gap expanding and the 50/10 gap closing).

We examine the relationship between occupational employment shifts and wages by first examining the main channel through which occupational shifts can be expected to affect wages: occupational employment shifts affect the wage patterns across occupations which, in turn, drive overall wage patterns. We find only weak empirical links between *occupational employment* changes, *occupational wage* changes, and changes in the *overall wage distribution*. We then move from observing the weak underlying relationship between wage changes at various parts of the wage distribution and changes in employment in occupations at different "skill" percentiles to an assessment in a regression framework of how much the variance of wages can be explained by occupations. We find that the importance of occupations in explaining wage variance slowed in the 1990s and reversed somewhat in the 2000s, and that a large and increasing share of the increase in wage inequality in recent decades is occurring *within* occupations, a phenomenon for which the tasks framework has no explanation.

A. Occupational employment shifts, occupational wage differentials and overall wage differentials and wage determination

In the tasks framework, first, technology changes occupational employment shares by changing demand for workers by occupation, which in turn drives changes in occupational wages, and finally, changes in occupational wages drive changes in the overall wage distribution. The poor fit of the smoothed occupational employment lines already seen in Figures F-A through F-C suggest a weak link between technology and the occupational employment structure. **Figures G-A through G-C**, however, take those occupational employment changes as real and examine their possible impact on *occupational wages* and then take the changes in occupational wages as given, and examine their possible impact on *overall wages*.

The poor links between changes in occupational employment, occupational wages, and overall wages are evident in **Figure G-B**, which presents data for the 1990s, the period when the occupational employment patterns best fit the tasks framework predictions. The blue, roughly U-shaped, line is the same as the fitted occupational employment line in Figure E and Figure F-B. The black line shows the corresponding (smoothed) change in occupational wages—using the same occupations in each percentile as the employment share line but portraying the percent change in mean log real hourly wages for those occupations. Occupational wages grew fastest at the bottom (through about the 30th percentile) and grew at the same—slower—rate through the rest of the occupational wage distribution. Rising occupational employment at the bottom could plausibly have driven rising occupational wages at the bottom, but rapidly rising occupational employment shares did not lead to higher occupational wage growth among higher-skilled occupations. The red line in the figure traces the (smoothed) wage change at the percentiles of the *overall* wage distribution. Again, the rise in occupational wages at the bottom of the occupational skill distribution could plausibly explain the more rapid rise at the bottom of the overall wage distribution. But, for the top half, growth in the occupational wage distribution was inconsistent with growth in the overall wage distribution. Wage growth rose steadily from about the median of

the overall wage distribution, but was basically flat over the corresponding range of the occupational wage distribution. In fact, the biggest increases in overall wages were at the very top of the distribution, while the very top of the occupational wage distribution experienced among the smallest wage increases across all occupations.[27] Based on the data for the 1990s, then, occupational employment changes in the upper half appear to be poor predictors of the corresponding occupational wage changes, which are, in turn, poor predictors of the corresponding changes in the upper half of the overall wage distribution. (It should be noted that one way stronger employment growth in high-wage occupations could be contributing to stronger wage growth at the top of the overall wage distribution is through composition changes. However, in the tasks framework, shifts in the overall wage distribution are due to changing *demand* for workers in different occupations, which would have to operate through occupational wages.)

The empirical links are also weak for the 1980s and the 2000s. **Figure G-A** shows the same set of lines for the 1979–1989 period. As we saw in Figure E and Figure F-A, the occupational employment growth shows a slight U-shaped relationship for the 1980s (in contrast with Autor's work, using the decennial census, which shows a monotonic rise in employment growth by occupational skill level). Occupational *wage* changes in the CPS, however, increase monotonically. The increase in the occupational employment shares of lower-waged occupations did not translate into more rapid wage growth for these occupations. The overall wage distribution also increases monotonically in the initial wage percentile, though much more steeply than the relationship followed by occupational wages.[28] For the 1980s then, we find that the corresponding changes in occupational employment, occupational wages and overall wages in the bottom half to be poorly aligned.

Figure G-C repeats the analysis using CPS data covering 2000–2007. Again, the occupational employment line is the same as the one in Figure E and Figure F-C. In the bottom occupational quintile, occupational employment and occupational wages move in opposite directions, with occupational employment growth declining through the bottom quintile, while occupational wage growth increases through the bottom quintile. As noted in earlier sections, the expansion of employment among low-wage occupations was greater in the 2000s than in prior decades but this does not appear to have translated into faster wage growth at the bottom. Occupational wages grew at essentially the same rate over the rest of the distribution. The overall wage distribution increased monotonically, with somewhat larger increases in the top quintile, inconsistent with the occupational wage patterns. As with the prior two plots, we find here that occupational employment changes, occupational wage changes, and changes in the overall wage distribution do not generally follow similar trends.

The tasks framework attempts to move from changes in production technologies to changes in occupational employment to changes in the overall wage distribution without pausing to examine the intervening changes in occupational wages. The initial, and still most common, empirical implementation of this framework operationalizes tasks as (roughly three-digit) occupations and then groups these tasks into "skill" percentiles based on the mean occupational wage. A review of the published evidence and our own analysis of the CPS data, however, demonstrate that the relationship between tasks and employment changes is fragile (as suggested by the poor fit between employment changes and occupational skill levels), inconsistent over time, and does not appear to hold at all in the 2000s. More importantly, occupational employment changes are not tightly linked to changes in the wage structure and the channel through which occupational employment shifts affect the wage structure—changes in the occupational wage structure—doesn't match up. Occupational employment changes are poor predictors of occupational wage changes and occupational wage changes are poor predictors of changes in overall wages.

Figures H-A through H-C highlight just how little occupational employment changes have to do with occupational wage changes in the tasks framework.[29] Figure H-A is a scatterplot of the log wage changes versus the log employment share changes at each occupational percentile for the 1979–1989 period. The slope of the least-squares regression line through the data is positive but insignificant, with an R-squared of 0.0102. In other words, roughly 1 percent of the variation in occupational wage changes is explained by occupational employment changes in the 1980s. Figures H-B and H-C present the same exercise for the 1990s and 2000. Between 1989 and 2000, the relationship between occupational wage changes and occupational employment changes is positive but insignificant, with less than 1 percent of the variation in occupational wage changes explained by occupational employment changes. Between 2000 and 2007, the relationship between occupational wage changes and occupational employment changes is actually negative, though insignificant. In other words, *changes in occupational employment shares explain virtually none of the variation in occupational wage changes in any of the last three decades*. If occupational employment changes do not drive occupational wage structure changes, as these figures show, then they surely do not drive overall wage structure changes.

As mentioned, in the tasks framework, first, technology moves occupational employment shares, then, changes in occupational employment drive changes in occupational wages, and finally, changes in occupational wages drive changes in the overall wage distribution. However, these links turn out to be extremely weak empirically. **Table 3** summarizes the empirical links between occupational employment, occupational wages, and the overall wage structure. The first column of Table 3 gives the R-squares from the simple linear regressions of the change in the log occupational wage on the change in log employment share discussed in the previous paragraph. As mentioned, almost none of the variation of log occupational wages can be explained by changes in occupational employment share. The second column looks at the second link, the link between occupational wages and the overall wage distribution, and also finds it to be very weak, particularly in the 1990s and 2000s. In the 1980s, changes in wages by occupation percentile explained 11.7 percent of the changes in the overall wage distribution, and that figure drops below 3 percent for the 1990s and 2000s. In other words, very little of the variation of the changes in the overall wage structure can be explained by changes in wages by occupation. These two weak links means that *occupational employment shifts explain virtually none of the shifts in the overall wage distribution.*

The last column shows that even if we do what is generally done in this literature and ignore the channel through which occupational employment shifts affect the wage structure (i.e., through changes in the occupational wage structure), the relationship between occupational employment shifts and the overall wage structure is still very weak. In the 1980s and 1990s, the R-squared of the OLS regression of log wage changes by percentile on log employment share change by occupational percentile is less than 0.1, and it drops to less than 0.03 in the 2000s. These results tell us that analyses of occupational employment trends do not provide much leverage for understanding shifts in the wage distribution, and make us skeptical that occupational employment trends by themselves are useful in explaining key labor market dynamics.

B. Role of occupations in explaining wage variation

In the tasks framework, differences in changes in demand for different tasks are posited to be driving relative wage trends. Empirically, detailed occupations are used as a proxy for tasks. We have shown above that changes in the relative wages across occupations (as ranked by their 1979 mean wage) depart from changes in the overall wage distribution in critical ways. This casts doubt on whether occupational employment shifts are driving changes in the wage distribution

since this would happen through changes in the wage distribution across occupations, rather than changes within occupations. Further, we have shown that there is in fact almost no relationship between occupational employment shifts and changes in the occupational wage structure. Here, we look at the direct link between occupations and wages using a regression analysis. A key result in this section is that we do not find that occupations explain an increasing share of wage variation over time, contradicting the claim in Acemoglu and Autor (2011) that occupations are becoming more important in wage determination. A related result is that a large and increasing amount of the rise in wage inequality in recent decades (as measured by the increase in the variance of wages) occurred *within* detailed occupations, even after accounting for the fact that a rising share of the workforce is in demographic groups—e.g., older workers—with higher residual wage inequality.

Tables 4A and 4B present, by gender, R-squares from cross-sectional OLS regressions of log hourly wages on the set of 250+ detailed occupation dummies along with a quartic in age, and dummies for region of the country (using the four major census regions), marital status, and race/ethnicity (using mutually exclusive categories of white non-Hispanic, black non-Hispanic, Hispanic any race, and other). We also calculate the partial R-squares of the set of detailed occupation dummies net of the remaining controls (i.e., net of the quartic in age and the dummies for region, marital status, and race/ethnicity).[30] The partial R-squares are equivalent to the explanatory power of the set of detailed occupation dummies in the log hourly wage regressions. The partial R-squares are also plotted in **Figures I-A and I-B.**[31]

Columns (2) and (4) of Table 4, along with Figures I-A and I-B**,** show how the importance of occupations in wage determination has evolved over time for women and men. Column (4) shows that for men, the increase in the share of wage variation explained by detailed occupations slowed dramatically from the 1980s to the 1990s and then *declined* in the 2000s. Between 1979 and 1989, the share of wage variation explained by detailed occupations increased by 6.3 percentage points, whereas it increased by just 0.5 percentage points between 1989 and 2000. Between 2000 and 2007, the share of wage variation explained by detailed occupations dropped by 0.8 percentage points. Column (2) shows that for women, the importance of occupations in wage determination dropped in both the 1990s and the 2000s; the share of wage variation explained by detailed occupations dropped by 2.8 percentage points between 1989 and 2000, and dropped 2.7 percentage points further between 2000 and 2007. Table 4 and Figures I-A and I-B show that, contrary to findings in Acemoglu and Autor (2011), we find that differences across occupations accounted for a *smaller* share of rising wage inequality in the 1990s and 2000s than they did in the 1980s.[32]

One implication of the results in Figures I-A and I-B and Table 4 is that a small share of the total increase in wage inequality between 1989 and 2007 can be explained by even detailed occupations. **Figures I-C and I-D** and **Table 4B** investigate how much of rising wage variance can be explained by detailed occupations. They show the variance of log wages over time by gender, plus the variance explained by detailed occupations, which is simply the wage variance multiplied by the partial R-squared values given in Figures I-A and I-B and Tables 4A and 4B. It is striking how little of the increase in wage inequality can be accounted for by occupations, particularly in the 1990s and 2000s. Between 1989 and 2000, just 32.7 percent of the increase in male wage variance can be explained by detailed occupation dummies, and that drops to 17.0 percent between 2000 and 2007. For women, just 6.0 percent and 9.9 percent of the increase in wage variance can be explained by detailed occupation dummies in the 1990s and 2000s, respectively. In other words, the vast majority of the increase in wage inequality is occurring *within* occupations. By themselves, occupations provide very little leverage for understanding shifts in the wage distribution.

One drawback of the analysis presented in Figures I-A through I-D and Tables 4A and 4B is that using wage variance as a measure of wage inequality does not allow for an investigation of the impact of occupations on trends in inequality at different parts of the wage distribution, which is such a crucial component of the job polarization explanation of rising wage inequality. We turn now to the reweighting approach developed in Dinardo, Fortin, and Lemieux (1996) to examine how much of the changes in upper-tail and lower-tail inequality—as measured by the 50/10 and the 90/50 wage gaps—can be explained by detailed occupations.

Table 4C presents the results. Column (1) shows the 50/10 wage gap, column (2) shows the 50/10 wage gap holding the demographic composition constant across years, and column (3) shows the 50/10 wage gap holding the demographic and occupational composition constant across years. Column (4) gives the difference between (3) and (2), providing a measure of the contribution of the composition of occupations to changes in the 50/10 gap over various periods. Columns (5)–(8) are analogous to columns (1)–(4), but for the 90/50 wage gap. The demographic characteristics held constant in this table are the same ones used in Table 4A, (a quartic in age, and region, marital status, and race/ethnicity dummies), and the occupations are the 250+ detailed occupations described above.[33]

The only decade when the 50/10 wage gap for men changed substantially was in the 1980s, when it increased by 4.4 log points. This increase was not due to occupational shifts—occupations *decreased* the 50/10 wage gap for men by 3.1 log points in the 1980s.

The major changes in the 50/10 wage gap were among women. In the 1980s, the female 50/10 wage gap increased by 25.5 log points, but occupations were responsible for only 2.0 log points of this increase. In the 1990s, the female 50/10 wage-gap decreased by 5.5 log points, while occupations slightly *increased* the 50/10 wage gap for women over this period (by 0.7 log points). In the 2000s, occupations mattered for women's wage shifts at the low-end of the wage distribution; the female 50/10 wage gap increased by 4.9 log points and 4.4 log points of that was due to occupations.

Occupational composition played a relatively small role in changes in the 90/50 wage gap. For men, occupations explained only 0.8 log points of a 10.7 log point increase in the 90/50 wage gap in the 1980s, and for women over this period occupations explained only 0.2 log points of a 10.4 log point increase in the 90/50 wage gap. For men in the 1990s, occupational composition explained only 1.0 log points of an 8.4 log point increase in the 90/50 wage gap. However, for women occupational composition did in fact explain a substantial share of the increase in the 90/50 wage gap in the 1990s, 3.4 log points out of an 8.0 log point increase.

In the 2000s, given the lack of job growth in high-wage occupations relative to middle-wage occupations (see Figure E), the job polarization explanation of wage inequality would not predict occupations having much of an effect on the 90/50 wage gap in the 2000s. This was largely true for women; occupational composition decreased the female 90/50 wage gap by a small amount, 0.5 log points. For men, however, the increase in the 90/50 wage gap due to occupations was *larger* in the 2000s than in the 1990s (1.2 log points versus 1.0 log points), which runs counter to the idea that job polarization was driving wage trends in the 2000s.

In short, for both men and women, occupational composition explains little of the changes in upper-tail and lower-tail inequality in most time periods examined.

To further investigate rising *within-occupation* wage inequality, we turn to an analysis of residual wage variance.[34] **Tables 5A and 5B** and **Figures J-A and J-B** show the variance of log hourly wages and the residual wage variance from cross-sectional OLS regressions of log hourly wages on the 250+ detailed occupation dummies along with a quartic in age and dummies for region of the country (using the four major census regions), marital status, and race/ethnicity (using mutually exclusive categories of white non-Hispanic, black non-Hispanic, Hispanic any race, and other). (This is the same model used to generate the R-squares in Table 4.) In order to account for changes in residual wage inequality that are due to composition effects linked to the secular increase in groups with higher within-group wage variance—for example the aging of the workforce over this period—we also calculate the composition-adjusted residual wage variance according to the reweighting approach developed in Dinardo, Fortin, and Lemieux (1996) and described in the previous section. [35]

The last two columns of Tables 5-A and 5-B show how much of the increase in the wage variance is due to an increase in residual (within-group) variance, both unadjusted and adjusted for composition changes. A key result from this table is that even after accounting for composition changes, a large and increasing share of the wage variance since 1989 is occurring *within* detailed occupations and demographic controls. For men, 25.5 percent of the increase in wage variance occurred within groups between 1989 and 2000, and that rose to 55.9 percent between 2000 and 2007. For women, 55.2 percent of the increase in wage variance occurred within groups between 1989 and 2000, and that rose slightly to 56.1 percent between 2000 and 2007. It is notable that less than half of the increase in wage variance for both men and women can be accounted for by detailed occupation and demographic controls between 2000 and 2007. These results reinforce the view that analysis of occupational changes provides only a limited assessment of changes in wage inequality, particularly in the 2000s.

VI. Service and low-wage occupations

In the latest iteration of the polarization literature, Autor and Dorn (2012) focus on the role of service occupation employment, offering "an integrated explanation and empirical analysis of the polarization of U.S. employment and wages between 1980 and 2005, and the concurrent growth of low-skill service occupations." Autor and Dorn claim that the "rapid rise of employment and wages in service occupations" (page 4) is tightly linked to the overall polarization of employment and wages from 1980 to 2005. Specifically, they conclude that:

> Between 1980 and 2005, the share of hours worked in service occupations among non-college workers rose by more than 50 percent. Simultaneously, real hourly wages of non-college workers in service occupations increased by 11 log points, considerably exceeding wage growth in other low-skill occupations. This phenomenon is broadly important because it offers insight into the polarization of employment and earnings in the U.S. and, potentially, other industrialized countries. Indeed, a key fact documented by this paper is that rising employment and wages in service occupations account for a substantial share of aggregate polarization and growth of the lower tail of the U.S. employment and earnings distributions between 1980 and 2005.

And, their bottom line is: "Our results suggest a critical role for changes in labor specialization, spurred by automation of routine task activities, as a driver of rising employment and wage polarization in the U.S. and potentially in other countries."

The key claim then is that workplace technological change eroded middle-class routinized jobs and simultaneously increased demand for tasks done in service occupations, and this higher relative demand for service occupation work boosted wage growth in these occupations. This increase in service occupation employment and wages, in turn, boosted low-wage occupational employment and wages at the bottom, and largely explains wage and employment polarization at the bottom end.

This new line of research suffers from many of the weaknesses of the earlier research. First, and most fundamentally, over the period Autor and Dorn study, there was no wage polarization between service occupations and the middle of the overall wage distribution. As shown in **Table 9**, between 1979 and 2007, the median hourly wage grew faster (7.8 percent in real terms) than wages in service occupations (3.9 percent). The median family wage also grew faster than the 10th-percentile wage in the overall wage distribution (down 0.9 percent).[36] These wage trends make it difficult to use the pattern of growth in service occupations to explain a compression between the bottom and the middle of the overall wage distribution that did not occur. Second, all of the data and the regression analyses presented focus on decadal periods (1980s, 1990s, and sometimes the 2000s) and the key analysis of the wage impact of employment changes is examined for changes over the entire 1979–2005 period, thus ignoring annual patterns and failing to examine the issue of the precise timing of trends.[37] The timing is important because the increase in real wages of service occupations (primarily a late 1990s trend) *preceded* the expanded employment share of service occupations (primarily a 2000s trend). Third, by focusing on changes over the long period 1980–2005, Autor and Dorn paper over the earlier finding in the literature that wage and employment polarization did not occur in either the 1980s or the 2000s. That is, the discussion presumes that the research is explaining job polarization over the entire 1980–2005 period, a phenomenon that did not occur throughout that time period and was notably absent in the most recent period (2000–2005 or 2000–2007). Fourth, job polarization over the 1980–2005 period is not well rooted in the data. When, following Autor and Dorn (their Figure 1), we estimate the smoothed changes in employment shares across occupations ranked by wages we find evidence of polarization but the Lowess R-squared for our fitted line is just 0.111.[38] Using the smoothed or unsmoothed data for the entire period, there is only a small absolute employment share expansion for low-wage occupations and only for those in the bottom decile—occupations in the second decile of the 1979 occupational wage distribution actually saw their employment share decline. Finally, although Autor and Dorn attempt to provide insights into the growth of wage inequality due to technological change, they never present any metric for assessing technology's impact on wages nor compare any such estimates to changes in the overall growth of wage inequality. Therefore, it is not possible to assess the quantitative significance of the findings.

The Autor and Dorn research on the role of service occupations shifts the focus of attention in three important ways. First, the emphasis is now almost exclusively on the bottom of the occupational ladder, the low-wage service occupations. It therefore avoids the topic of why high-wage occupations expanded relative to middle-wage occupations in the 1980s and 1990s but not in the 2000s. Second, the focus is no longer on explaining the change in the trend of the 50/10 wage gap between the 1980s (when it grew) and the 1990s (when it stabilized and fell). In fact, nothing in their analysis helps to explain trends in the 50/10 wage gap, even though doing so was the key motivator for the tasks framework (Autor, Katz, and Kearney 2006, 2008; Acemoglu and Autor 2011, 2012). Last, research focuses on the share of *non-college educated* workers (specifically, those with a high school degree or less) in service occupations rather than on the share of *all* workers in service occupations. This appears to muddy the water in our view because, as shown below, the share of workers with a high school degree or less education working in service occupations has not been primarily

driven by technological (and other) trends affecting the share of total employment in these occupations, but rather by the educational upgrading that has depleted the share of workers with such education (from 58.4 percent in 1979 to just 38.9 percent in 2007).

The service occupation intensity among workers with a "high school or less education" is:

$$\frac{N_S^{HS}}{N_T^{HS}} = \left[\frac{N_S^{HS}}{N_S^T} \times \frac{N_S^T}{N_T^T}\right] \div \frac{N_T^{HS}}{N_T^T}$$

where N refers to employment, subscripts refers to occupation and superscripts refers to the education category of the workforce: HS indicates workers with a high school degree or less; T stands for the all workers, and S stands for service occupations.

Thus, this ratio, on which Autor and Dorn focus, is determined by three distinguishable factors:

1. the share of "high school or less" workers among all workers;
2. service occupation employment's share of total employment; and
3. the share of "high school or less" workers among those working in service occupations.

Although Autor and Dorn treat the share of those with a "high school or less" education in service occupations as being driven by technological change, this ratio clearly depends upon the relative importance of these three factors above. The first factor reflects labor supply and has declined in recent decades because of the "educational upgrading" of the workforce as more workers attend at least some college. The second factor, the share of employment in service occupations, is most clearly the result of technology.[39] The third factor is ambiguous, potentially reflecting the decreased use of "less educated" workers in the production process (a result of technology), but also possibly reflecting underemployment of those with more education who are forced to work in lower-paying service occupations.

We present a decomposition of the role of these three factors in driving changes in the share of those with a "high school or less" education in service occupations below. Before doing so, we explore trends in the first two factors.

We have shown earlier that the main technological driver in the Autor and Dorn framing, the service occupation share of employment, has remained low and relatively stable over the last three decades, with some expansion occurring in the 2000s. As such it would seem that technological change has played an inconsequential role in concentrating "high school or less" in service employment. **Table 6** gathers an array of measures of the service occupation employment to further assess trends in service occupations' employment share. We draw on several sources of information: our tabulations of the CPS-ORG data; published tabulations of decennial census and American Community Survey data from Acemoglu and Autor (2011), Autor and Dorn (2012), and Katz and Margo (2013); and published data from the BLS Occupational Employment Statistics (OES) program. Some of the data reflect shares of employment while other data reflect share of total hours worked. Last, Autor and Dorn present trends for service occupation employment that exclude public safety employment (i.e., police and firefighters) and the table presents comparable results from our tabulations of the CPS.

All of the CPS tabulations—service occupations' employment and work hours shares and the hours share of service occupations excluding public safety occupations—show that the importance of service occupations remained relatively

low (12 to 14 percent) and stable over the 1980s and 1990s, with some expansion in the 1980s but stability in the 1990s. A faster growth in the 1980s than the 1990s is inconsistent with a story of expanded service occupation employment shifting the 50/10 wage gap pattern in the 1990s.

In contrast, the decennial census data from Acemoglu and Autor (2011) and Autor and Dorn (2012) indicate a modest expansion of service occupations in the 1980s and a somewhat larger expansion in the 1990s. There is a measurement problem, however, in the decennial census comparisons for the 1990s. The coding change that occurs in the CPS data between 2002 and 2003 occurs between 1990 and 2000 in the decennial census data. The CPS annual data for 2002–2003 indicate that this coding change, using Autor and Dorn's occupational coding crosswalk, generates an artificial 1.0 percentage-point increase, equivalent to the entire expansion of service occupations in the 1990s.[40] If the effect of the coding changes between the censuses in 1990 and 2000 is similar to the impact of the same change in the CPS between 2002 and 2003, then it is possible that the entire service occupations expansion in the 1990s shown by census data reflects the coding change implemented between the two censuses.[41] Katz and Margo (2013), whose analysis relies on a different census crosswalk (one that puts all occupations into the 1950 occupation scheme), shows a slight decline in service occupation employment in the 1990s. The Katz and Margo data therefore lend support to our sense that the differences between the analysis by Acemoglu and Autor (2011) and Autor and Dorn (2012) and our own analysis of CPS data—we find stable service occupation employment while they find an expansion in the 1990s—is based on differing occupational coding schemes (with the one employed by Acemoglu and Autor overstating the expansion of service occupations in the 1990s by about 1.0 percentage point).

Data from BLS employment projections (Alpert and Auyer 2003) provide another estimate of the growth of service occupations in the 1990s, showing an expansion of 0.5 percentage points from 1988 to 2000. Other BLS employment projections provide reads on earlier periods, with expansion over 1983–1994, 1986–1996, and 1988–1998 of, respectively, 0.7, 0.5 and 0.5 percentage points.[42] In these various BLS series there appears to be little, if any, expansion of service occupation employment between 1994 and 2000 and the fastest expansion shown is from 1983 to 1994.

None of the available data series available show any sizeable expansion of service occupation employment or hours, including or excluding public safety workers, in the 1980s and 1990s, and no evidence of any sizeable acceleration of service occupation growth in the 1990s. This is true even for the census data, which show the greatest expansion in the 1990s (Autor and Dorn 2012; Acemoglu and Autor 2011). This relative stability of the share of service occupation *employment* goes back to 1959 and of service occupation *hours* share goes back to 1949. Given this stability, it is difficult to explain how any technology-driven change in service occupations could have materially affected wage patterns and wage inequality in the 1980s or 1990s. By contrast, all of these same data series (including data from the establishment survey based Occupational Employment Statistics) show a sizeable expansion in service occupations in the short period from 1999 to 2005, or during the 2000s more generally.

The last line in Table 6 presents Autor and Dorn's tabulation of the service employment share among those with a "high school or less" education, rising from 12.9 percent in 1979 to 19.8 percent in 2005. This is the only indicator to show a substantial expansion of service occupations. Given the relative stability of the more inclusive measures, it follows that the expansion highlighted in the table reflects the focus on a limited subset of the workforce. This previews our results below, which show that it is *educational upgrading* that is driving this trend, not a technology-driven change in the importance of service occupations in the economy. Last, we would note that Autor and Dorn characterize the

roughly 7 percentage-point expansion (12.9 to 19.8) over the 26 years from 1979 to 2005 as a "50 percent" increase. That description, in our view, exaggerates the roughly 2.8 percentage-points per-decade expansion and is not the best description of these trends.

In the literature, service occupations are frequently equated with "low-wage occupations." However, service occupations comprise about half the employment in the bottom fifth of occupational employment ranked by wage level. Autor and Dorn (2012, footnote 7) report that service occupations' share of employment in the bottom fifth rose from 47 to 55 percent between 1979 and 2005, suggesting this indicates their rising importance. In fact, these same data indicate that service occupations (in the bottom fifth) rose from 9.4 to 11.0 percent of total employment between 1979 and 2005, another confirmation of the low and relatively stable role of low-wage service occupation employment—a rise of only 1.6 percentage points over 26 years.

We use the CPS data to examine the Autor and Dorn claim that service occupations are responsible for the expansion of employment in low-wage occupations. The CPS data suggest the opposite conclusion, showing that low-wage occupational employment actually contracted both in the 1980s and the 1990s before expanding modestly in the 2000s: the modest expansion of service occupation employment was offset by a larger contraction among other low-wage occupations.

Table 7 provides CPS tabulations of the breakdown of the hours-weighted employment shares of the lowest-wage occupations, separating service (excluding public safety occupations) and other occupations, in key years over the 1979–2007 period. This analysis uses the Autor and Dorn occupational coding crosswalk but adjusts for the coding breaks in 1983 and 2003. These "decile" breakdowns are "lumpy"—not being exact deciles—because the analysis relies on the actual cumulative shares of detailed occupations.[43] The data in Table 7 are, in other terms, displaying growth in the unsmoothed occupational employment share for the bottom two deciles of occupations (defined by wage level); the numbers in Table 7 directly correspond to the growth in the smoothed occupation shares portrayed in the graphical analysis used by Autor and Dorn to examine job polarization trends.[44]

These data indicate that service occupations comprise the vast majority of the bottom decile of occupations and roughly half of the bottom fifth of occupational employment. Service occupation employment in each of the lowest two deciles was relatively stable in the 1980s and 1990s and expanded in the 2000s in the lowest decile but remained stable in the second decile. The lowest-wage occupations in the first decile (as determined by 1979 wage levels) expanded modestly over the entire 1979–2007 period in the first decile (rising to 10.8 from 10.2 percent). In the second decile, however, the lowest-wage occupations shrank over the same period (from 10.9 to 9.3 percent). As a consequence, on net, among the lowest-paying fifth of occupations there was no employment expansion over the last three decades. A direct implication of this result is that there was no employment polarization at the bottom to speak of over this period. The service occupations at the low end did expand modestly (from 9.6 to 11.0 percent) but this was offset by employment shrinkage in other (meaning "non-service") low-paying occupations. This analysis of CPS employment data, therefore, contradicts the Autor and Dorn claim that service occupation trends have generated employment polarization at the bottom end of the occupation wage scale since 1979.

As noted earlier, Autor and Dorn focus much of their discussion on service occupation employment among a subset of the workforce, those with no more than a high school education. This metric is partially driven by the eroded share of

the workforce in this education category, what we refer to as educational upgrading. **Figure K** displays the educational upgrading of the workforce over the 1973 to 2007 period, showing the share of employment represented by those with less than a high school degree, those with a high school degree (or GED) and those with some college but not a four-year college degree (including those with associate degrees). In contrast to the stability of the service occupations' share of employment and hours, Figure K shows a rapidly declining share of those in each of these educational categories.

Autor and Dorn do not explain their selection of "high school or less" as their focus rather than those lacking a four-year college degree when analyzing "non-college" employment. They label their category as "non-college" which invites confusion because it excludes those who have no degree past a high school credential, the fifth of the workforce that has "some college" but no further degree (including not having an associate's degree). The "some college" group's wage levels and wage behavior mirror those of high school graduates much more than it does those with college degrees. We choose to label the Autor and Dorn category as "high school or less" rather than "non-college" to avoid any confusion about the category. The share of the non-college when defined as those lacking a four-year college degree comprised 69 percent of all workers in 2007 (down from 85.4 percent in 1973), a large share of the workforce. In contrast, the share of workers that have "high school or less" educations in 2007 was just 39.4 percent (down from 66.9 percent in 1973).

Table 8 presents a formal decomposition of the changes in the share of "high school or less" workers employed in service occupations. This is done by using the equation shown above, taking logs in each relevant year and differencing across time periods. Our focus is on the role of the increased share of employment in service occupations since that is the factor clearly identifiable as being driven by technological change. The decomposition shows that only about 30 percent (29.8) of the growth of the service occupation employment intensity among workers with a "high school or less education" from 1979 to 1999 was due to a growth of service occupation employment in the economy. In contrast, the growing importance of service occupation employment among "high school or less" workers in the 1980s and 1990s was heavily driven by educational upgrading. This group comprised 58.4 percent of all workers in 1979 but just 42.4 percent 20 years later. Consequently, movement in the share of "high school or less" workers employed in service occupations, at least over the 1980s and 1990s, hardly seem to reflect technological developments regarding routinization of middle-wage occupations or the expansion of low-wage service occupation employment. The 2000s, on the other hand, is the only period when service occupation employment's expansion drove its importance among "high school or less" workers.

What role has service occupation employment played in wage patterns? We have already seen that service occupations did not expand at a notably different pace in the 1990s than in the 1980s (in the CPS there was no expansion). Even among workers with a "high school or less" education there was not a greater expansion of service employment in the 1990s relative to the 1980s.[45] In our view, the similar expansion of service occupation employment in both the 1980s and 1990s should have produced similar wage trends for workers at the bottom of the wage distribution in the two decades. That the same employment patterns were associated with workers at the bottom of the wage distribution losing relative to the middle of the 1980s, but gaining relative to the middle in the 1990s, suggests that forces other than occupational employment patterns are the main drivers of shifting wage inequality.

What of the Autor and Dorn claim that "real hourly wages of non-college workers in service occupations increased by 11 log points, considerably exceeding wage growth in other low- skill occupations"? This phenomenon is broadly important because it offers insight into the polarization of employment and earnings in the United States. First, the

wage polarization between 1979 and 2005 evident in their Figure 1 shows that wage growth for each of the percentiles in the bottom third of occupations were greater than that of *each* percentile in the middle third of occupations, something that probably cannot be explained by service occupation employment which comprised less than 13 percent of employment in 2005. Second, Autor and Dorn's empirical analysis examines differences between 1979 and 2005 across local labor markets in order to identify the role of service occupation employment on wages. Their key finding is that, "7 percentage point higher routine share in 1980, equal to the gap between the 80th and 20th percentile commuting zones, predicts approximately 3 log points greater wage growth in service occupations between 1980 and 2005." So, the technological process on which Autor and Dorn focus yields at most a modest change—3 log points—in wages over 26 years, which does not get us that far in explaining wage polarization.

Last, and most importantly, an examination of the timing of trends within the 1979–2005 period indicates that rising service occupation employment occurred *after* the notable real wage growth. The key data are presented in **Table 9** and in **Figure L** for the 1979–2007 period.[46] The median hourly wage grew faster than wages in service occupations between 1979 and 2007, 7.8 versus 3.9 percent, indicating that there was *not* any polarization between the middle and bottom wages over the period of interest to Autor and Dorn. The premise of that research is incorrect since there isn't any wage polarization over the longer 1979–2007 period to explain. Most damaging to this framework, however, is that wage growth in service occupations only occurred in the late 1990s (up 15.2 percent), a period when service occupation employment did *not* expand relative to other occupations.

Moreover, the during the period from 2000 to 2007, when service occupation employment did expand, real wages for service occupations fell 6.2 percent. This pattern of stable employment shares with rising wages followed by rising employment shares with falling wages runs completely counter to the idea that the demand for service occupation work has been lifting wages at the bottom of the wage distribution relative to the middle and that such a dynamic provides insight into the evolution of overall wage inequality. Put in other terms, service occupation wages rose relative to the median wage in the late 1990s (see the column on the ratio) when service occupation employment wasn't expanding and fell relative to the median wage over 2000–2007 when service occupation employment expanded more in seven years than it had over the preceding 21 years. The timing just does not work for the service occupation variation of the tasks framework analysis. (See Figure L**,** which shows the annual data.)

The trend in service occupation wages is certainly disappointing, rising only 3.9 percent over 28 years. Productivity in the economy as a whole rose 59 percent over that same period, so service occupation workers clearly have not gained correspondingly. Note also that Table 9 demonstrated that workers in service occupations had substantially more education in 2007 than in 1979 (the share with more than a high school education grew from 30 to 43 percent from 1979 to 2007). It seems at least as plausible to attribute the wage gains for service occupations in the second half of the 1990s to persistently low unemployment and 20 percent boost in the minimum wage enacted in 1996 and 1997.

VII. Conclusion

As Acemoglu and Autor (2011, 2012) and others before them have argued, the "canonical model" of SBTC fails to explain important developments in the U.S. wage distribution. The most notable of these gaps are the inability to explain the following: the reversal of the 50/10 differential after 1986–1987; the deceleration in the college premium after the mid-1990s; and the stagnation or decline over long periods in the real wage for important segments of the wage

distribution. The tasks framework that Acemoglu and Autor developed to replace the "canonical model" is a distinct improvement over the "canonical model," not simply because it can, in principle, account for these three key developments, but also because it provides a richer description of the labor market and the production process.

The tasks framework, however, suffers from its own empirical failings. Central among these are: the relatively smooth, long-standing nature of job polarization, which appears poorly suited to explaining the abrupt rise in inequality at the end of the 1970s or, more importantly, the sharp change in the path of the 50/10 wage differential after 1986–1987; the failure of the most conventional measure of job polarization (plots of occupational employment change against occupational wage level) to show any signs of occupational employment polarization in the 2000s, even as wage inequality continued to grow; and, the consistent lack of correspondence across the 1980s, 1990s, and 2000s between changes in occupational employment, occupational wages, and the overall wage distribution.

Recent research that has focused on the role of typically low-wage service occupations has not rescued the tasks framework from these shortcomings. Over the last three decades, service occupations comprised only about one-tenth of the workforce and increased their total employment share by less than two percentage points. A group of occupations that is small to begin with and that grows only slightly over the course of three decades seems unlikely to be a major driver of the overall wage distribution and almost by definition can tell us nothing about developments at the middle and the top of the occupational or overall wage distributions. More importantly, the timing of employment and wage changes in this sector is the exact opposite of what is suggested by the tasks framework. Service occupation wages grew first (in the boom of the late 1990s), at a time when employment in the sector was basically flat; when service occupation employment finally grew (after the 1990s boom went bust), wages in the sector actually fell.

The tasks framework offers a theoretical model that can, in principle, account for wage and employment trends that the "canonical model" cannot. In practice, however, the tasks framework suffers from its own empirical failings. Technology may be a factor in widening wage inequality, but, if so, the tasks framework is not the model that captures those dynamics.

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Data appendix

By Heidi Shierholz and Hilary Wething

Unless otherwise noted, data used throughout this analysis are from the Outgoing Rotation Groups of the Current Population Survey (CPS-ORG) and the May CPS files 1973–1978. Our sample includes all public or private sector (unincorporated self-employed excluded) wage and salary workers who are age 18–64 and have valid wage and hour data. A detailed description of our treatment of the data, including calculation of hourly wages and treatment of top-coded earnings, is available in Appendix B of Mishel et al. (2012) (http://stateofworkingamerica.org/files/book/Appendices.pdf). Throughout this paper, unless otherwise noted, data are weighted by hours, in particular using CPS person weights multiplied by usual hours worked. It should be noted that we do *not* exclude from any analysis in this paper observations where wages are imputed, (unless the observations is being excluded for other reasons, for example if unincorporated self-employed). Future work will test whether our findings are affected by removing observations with imputed wages.

To obtain a consistent series across several occupation coding changes in the CPS over the 1973-2007 period, we employ the same occupation crosswalk as was used to create Figure 12 in Acemoglu and Autor (2011) (which is also Figure 3 in Autor, 2010). In particular, we use the programs generously available for download on David Autor's MIT website under Acemoglu and Autor (2010), *May/ORG Wage Prep*, http://economics.mit.edu/~dautor/hole-vol4/morg/morg-wage-prep.zip. We document that we are able to implement this occupation crosswalk successfully by replicating the underlying occupation employment shares over time used to make Figure 12 in Acemoglu and Autor (2011), the programs and data for which are also available for download under Acemoglu and Autor (2011), *Figure 12 – Percent Change in Employment by Occupation, 1979-2009*, http://economics.mit.edu/~dautor/hole-vol4/figs/fig-12-rev.zip.

Appendix Figure A shows these occupation employment shares over time. There are 10 major occupations and this graph shows trends for each of these 10 occupations from both our tabulations (in light grey) and Acemoglu and Autor's tabulations (in dashed dark blue). The fact that only 10 lines are observable means that the lines based on our tabulations exactly duplicate their tabulations. It should be noted that in order to replicate the Acemoglu and Autor employment shares, the sample we used is slightly different that the sample we use for the rest of this paper. In particular, it includes workers age 16 and 17, includes all non-agriculture, non-military workers who report having worked and report an occupation, not just those with valid wage and hour data, and the data are person-weighted instead of hours-weighted.

One finding from looking at the year-by-year data is that there are discontinuities in 1983 and 2003, when major occupation coding changes were implemented. That is, despite "consistent" occupation coding schemes used by Acemoglu and Autor (2011) and Autor and Dorn (2012) there are substantial inconsistencies remaining. These discontinuities do not surface in the job polarization literature because all of the analysis covers changes across multiple years and no data are presented on an annual basis. We now turn to assessing the quantitative impact of the discontinuities in the occupation employment data due to coding changes. In **Appendix Table 1** we compare the changes in employment shares for each of the 10 major occupation groups using both our CPS data with the occupation crosswalk described above,

and an "adjusted series" (which substitutes the average of the trends in 1980–1982 and 1983–1985 for the 1982–1983 change and the average of the trends in 2000–2002 and 2003–2005 for the 2002–2003 change). **Appendix Table 2** compares the changes in the unadjusted and adjusted series for 1982–1983 and 2002–2003 and presents the changes in the adjusted series over the business cycles, 1979–1989 or 2000–2007. We consider the difference between the two series a measure of the error introduced by the coding changes. The last column measures the scale of that error relative to the longer period trend—the periods for which occupation employment trends are presented in the literature. It turns out that the distortions due to the coding changes are large relative to the trends presented in the literature. Most prominent is that the increase in the employment share for low-wage service occupations between 2000 and 2007 in the unadjusted series was 2.3 percentage points, substantially higher than the 1.3 percentage-point growth in the adjusted series. This implies that the coding change was responsible for 42 percent (1.0 percentage point of the observed 2.3 percentage-point change) of the observed expansion of low-wage service occupations in the unadjusted CPS series employed in the job polarization literature. Also, the unadjusted data series seriously understates the erosion of middle-wage occupational employment in the 1980s. The unadjusted series shows a decline of just 3.9 percentage points, whereas the adjusted series shows a decline of 5.6 percentage points. This implies the coding change was responsible for a 45 percent understatement (1.7 percentage points on the observed 3.9 percentage-point drop) of the erosion of middle-wage occupations. Correspondingly, the unadjusted series understates the expansion of high-wage occupations in the 1980s. (It should be noted that the employment shares in these tables are calculated from the subsample described in the first paragraph of this data appendix and used throughout this paper, not the somewhat expanded subsample used in Appendix Figure A that matches the data used in Acemoglu and Autor (2011, Figure 12.)

Appendix Table 3 explores the extent to which the effect of the coding change for key annual changes (1982–1983 and 2002–2003) varies depending on whether the data are person-weighted or hours-weighted. We find that the 1982/83 coding change leads to an understatement of the erosion of middle-wage occupations (and an overstatement of the growth of high-wage occupations) using both employment and hours weights, but the under/overstatements are more pronounced using employment weights. We find that there is little difference on the impact of the 2002/2003 coding change using employment-weighted versus hours-weighted occupational shares.

An important issue with the 1982/1983 coding break is that there are many occupations in 1983 and later that do not exist in the earlier data. In particular, of the 318 occupations that have workers in them with valid CPS wage data in 1983, 63 do not exist in 1982. They are relatively small occupations on average, but altogether 9.1 percent of workers in 1983 are in occupations that do not exist in the 1982 coding. This is a concern because in Acemoglu and Autor (2010), occupations are ranked by 1979 wages prior to this coding break, and any occupations that don't exist in the year occupations are ranked, are, for obvious reasons, dropped from the analysis. This means that a nontrivial chunk of the post-1982 data are dropped. **Appendix Table 4** shows the distribution across the major occupations of employment in 1983 by whether or not the worker is classified into an occupation that existed in 1982. Workers that are in occupations that did not exist in prior to 1983 are necessarily dropped from any analyses in which occupations are ranked prior to 1983. Dropping these occupations meaningfully increases the share of personal care and personal service workers, operators, fabricators, and laborers, and professionals, and meaningfully decreases the share of workers in sales, management, and production, craft and repair.

Finally, **Appendix Tables 5A through 5C** provide our complete annual data of our aggregate occupations shares, with the adjustments made for the 1982/1983 and 2002/2003 coding breaks, between the years 1973 and 2010 for all workers and by gender.

Means vs. Medians: In most of the job polarization research, occupations are ranked by their mean wage in 1979. However, since the idea of the ranking is to capture wages paid for the typical set of tasks associated with each occupation, arguably one would want to rank occupations by their *median* wage to ensure that the occupational rankings are not distorted by atypical wages within occupations. In any event, ideally the results would be robust to ranking by either means or medians. We find that the broad contours of Figure E—which, consistent to what is typically done in this literature, is generated with occupations ranked using means—are indeed quite similar when ranking occupations by either their means or median wage.

Endnotes

1. See Mishel et al. (2012).

2. Our findings using the Current Population Survey (CPS) corroborate similar results first described by Lefter and Sand (2011) using decennial census and ACS data.

3. The "canonical model's" supply-and-demand framework has sometimes been augmented by a consideration of labor-market institutions (most typically, the minimum wage and unions), but as Goldin and Katz (2009) have argued: "The rise and decline of unions plays a supporting role in the story [of wage inequality], as do immigration and outsourcing. But not much of a role. Stripped to essentials, the ebb and flow of wage inequality is all about education and technology." (p. 28)

4. The tasks model "…nests the canonical model as one parametric case; thus, this model builds upon rather than dispenses with the many strengths of the canonical model." (Acemoglu and Autor 2012, 445)

5. As we note below, all three of these shortcomings were identified by Mishel, Bernstein, and Schmitt (1997). Acemoglu and Autor (2011, 2012) build on task-based models proposed by Autor, Levy, and Murnane (2003).

6. The abstract of the article (Autor, Katz, and Kearney 2008) that grew from the initial job polarization paper (Autor, Katz, and Kearney 2006) presented at the 2006 AEA meetings says, "The slowing of the growth of overall wage inequality in the 1990s hides a divergence in the paths of upper-tail (90/50) inequality—which has increased steadily since 1980, even adjusting for changes in labor force composition—and lower-tail (50/10) inequality, which rose sharply in the first half of the 1980s and plateaued or contracted thereafter…. Models emphasizing rapid secular growth in the relative demand for skills—attributable to skill-biased technical change—and a sharp deceleration in the relative supply of college workers in the 1980s do an excellent job of capturing the evolution of the college/high school wage premium over four decades. But these models also imply a puzzling deceleration in relative demand growth for college workers in the early 1990s…"

7. Our reading of the data is that the key inflection point occurred somewhat earlier in 1987 or 1988.

8. Acemoglu and Autor, characterizing the difference in wage patterns between the 1980s and 1990s, focus on the shift in the 50/10 wage gap differential: "During the initial period of 1974 through 1988, the monotonicity of wage changes by percentile is evident. Equally visible is the U-shaped (or 'polarized') growth of wages by percentile in the 1988 through 2008 period. Interestingly, the steep gradient of wage changes above the median is nearly parallel for these two time intervals. *Thus, the key difference between these periods turns on the evolution of the lower tail, which fell steeply in the 1980s and then regained ground relative to the median thereafter"* (Acemoglu and Autor 2012, 440-1, emphasis added).

9. As they observe, "The canonical model of factor-augmenting technical change robustly predicts that demand shifts favoring skilled workers will raise the skill premium and *boost the real earnings of all skill groups (e.g., college and high school workers)*... This prediction appears strikingly at odds with the data…" (2012, 439, emphasis added).

10. Acemoglu and Autor (2012, 444) are very explicit that the motivation for developing the tasks framework is to overcome the deficiencies of the "canonical model": "We believe that these discrepancies between the data and the predictions of the canonical model— specifically, the heterogeneous behavior of the top, middle and bottom of the earnings distribution, falling real wages of some skill groups, polarization of earnings growth, and polarization of occupational growth are sufficiently important to warrant enriching the canonical model to gain leverage on these trends." And they note: "We do not wish to suggest that this model *resolves* the puzzles posed above; to some degree, it was purpose-built to interpret them. Our claim — or at least our hope — is that this framework is a productive conceptual tool for confronting key facts that currently lie beyond the canonical model's scope" (448).

11. Acemoglu and Autor (2012) write: "Many of the shortcomings of the canonical model can, we believe, be overcome by relaxing the implicit equivalence between workers' skills and their job tasks in the model. In our terminology, a task is a unit of work activity that produces output. A skill is a worker's stock of capabilities for performing various tasks. Workers apply their skills to tasks in exchange for wages. Thus, the task-based approaches emphasize that skills are applied to tasks to produce output—skills do not directly produce output. The distinction between skills and tasks is irrelevant if workers of a given skill always perform the same set of tasks. The distinction becomes important, however, when the assignment of skills to tasks is evolving with time, either because shifts in market prices mandate reallocation of skills to tasks or because the set of tasks demanded in the economy is altered by technological developments, trade, or offshoring" (444-45).

12. See, most recently, Acemoglu and Autor (2012, Figure 5) covering 1990–2007, as well as Autor, Katz, and Kearney (2008, Figure 11) covering 1990–2000; Autor (2010, Figure 1) covering 1989–1999; and Acemoglu and Autor (2011, Figure 10) covering 1989–1999. In all cases, occupational skill level is measured by the mean occupational wage in 1980, except Autor, Katz, and Kearney, who use the median occupational wage in 1980.

13. There is *relative* polarization (a term further elaborated below) further up the distribution to the 20th percentile, meaning employment shares among low-wage occupations were expanding greater (falling less) than those in middle-wage occupations.

14. The tasks framework also is said to address two other shifts in wage patterns: (1) from the early 1990s, education wage differentials stabilized among the non-college educated (that is, those with some college, a high school degree, or no high school degree); and (2) from the mid-1990s, the college premium decelerated sharply and grew at a rate well below what would have been predicted by the "canonical model." This paper does not examine these empirical claims. Our research, not included here, does lend support to the second claim—occupational employment-driven changes in educational requirements do correspond to the deceleration of the college wage premium. Thus, the tasks framework and the data contradict "common intuitions regarding the nature or pace of technological changes occurring in this era," meaning that SBTC actually did slow in the late 1990s, just like the "canonical model" suggests.

15. The authors note, "This result is of signal importance to our analysis because it underscores that despite ongoing, skilled labor augmenting technological progress and a fixed skill endowment, wage inequality need not rise indefinitely. If goods and services are at least weakly complementary, inequality between high- and low-skill labor either asymptotes to a constant or reverses course. Thus, consumer preferences determine whether the rising marginal physical product of high-skill workers translates into a corresponding rise in their marginal value product" (1566). Moreover, the tasks framework focuses on the demand-side and not the supply-side of the labor market.

16. These are hours-weighted employment trends "adjusted" to remove the inconsistencies generated by occupation coding changes in 1983 and 2003. We employ the consistent occupation coding developed by Autor and Dorn. The Appendix provides methodological detail.

17. The ratio of the employment shares of middle-skill and low-skill occupations grew from 1.233 in 1990 to 1.255 in 2000.

18. Acemoglu and Autor (2011) use CPS-ORG data for computing wage trends for the 10 broad occupational groups in Tables 2A through 2C based on their consistent occupation coding crosswalk, but do not use these data for annual employment trends.

19. That is, the change in 1982 to 1983 is the average of the changes from 1980 to 1982 and from 1983 to 1985. Comparably, the change in 2002–2003 is the average of the change from 2000–2002 and from 2003–2005. The changes from 1983 to 2002 are the 1983 occupation share obtained this way plus the change in each year's occupation share change in the CPS. Similarly, the changes from 2003 to 2010 are based on the actual percentage-point change in occupation shares in the CPS.

20. Acemoglu and Autor (2011) do not show annual data but do have them in their publicly available program.

21. The consistency problems associated with the Autor and Dorn occupational classification system are also discussed in Foote and Ryan (2012).

22. This difference may reflect the fact that the occupational coding change that occurs between 2002 and 2003 in the CPS occurs between 1990 and 2000 in the census data, used by Acemoglu and Autor (2011). We find, for instance, that the 2002–2003 coding change artificially inflated service occupation (excluding public safety) growth by 1.0 percentage point. This measurement issue is addressed in more detail in the section on service occupations.

23. Acemoglu and Autor (2011, 17):

"In contrast, during the most recent decade for which census/ACS data are available, 1999-2007, employment growth was heavily concentrated among the lowest three deciles of occupations. In deciles four through nine, the change in employment shares was negative, while in the highest decile, almost no change is evident. Thus, the disproportionate growth of low-education, low-wage occupations became evident in the 1990s and accelerated thereafter."

And Autor (2010, 3) describes the 1997–2007 trends in the upper 60 percent as "flat," which better accords with our read of the facts:

"Fast forward to the period 1999 to 2007. In this interval, the growth of low-skill jobs comes to dominate the figure. Employment growth in this period was heavily concentrated among the lowest three deciles of occupations. In deciles four through nine, growth in employment shares was negative. In the highest decile of occupations, employment shares were flat. Thus, the disproportionate growth of low-education, low-wage occupations becomes evident in the 1990s and accelerates thereafter."

24. The lowess R-squared is calculated in the same way an R-squared is calculated: the sum of the squared deviations of the lowess fitted values from the mean of the lowess fitted values divided by the total sum of squares of the dependent variable. Jacoby (2000) notes that a summary fit statistic of this type "cannot, strictly speaking, be interpreted as variance explained because the lowess fitting procedure does not partition the total sum of squares in Y neatly into additive components representing the sums of squares in the fitted values and the residuals, respectively. … Users should simply give the lowess R-squared value a more limited interpretation. It conveys the size of the fitted value variance, expressed as a ratio of the total variance in Y. While the latter is not really variance explained in the traditional sense, it does provide an effective summary of the degree to which the lowess fitted values track the empirical data points in the scatterplot."

25. We also fit a quadratic curve to these data in each period. For the 1979–1989 period, the R-squared associated with a quadratic curve is 0.232. The t-statistic on the linear term is -2.58, and the t-statistic on the quadratic term is 3.68. Thus, there is a statistically significant U-shape in the 1980s. For the 1989–2000 period, the R-squared is 0.1830. The t-statistic on the linear term is -1.35, and the t-statistic on the quadratic term is 2.42, so there is also a statistically significant U-shape in the 1990s. For the 2000–2007 period, the R-squared is 0.0306. The t-statistic on the linear term is 0.10, and the t-statistic on the quadratic term is 0.33. The two terms are not individually or jointly significant (F-statistic of 1.53).

26. Acemoglu and Autor (2011, 13) note: "The explanatory power of occupation reaches a nadir in 1979 and then, like the education measures, rises over the subsequent three decades. Distinct from the education measures, however, the explanatory power of the occupation variables rises less rapidly than education in the 1980s and *more rapidly* than education thereafter – overtaking education by 2007. Thus, as hypothesized, occupation appears to gain in importance over time. This is most pronounced starting in the 1990s, when the monotone growth of employment and earnings gives way to polarization."

27. An obvious implication of the divergence between the occupational wage distribution and the overall wage distribution is that an important part of the changes in the overall wage distribution is taking place *within* occupations, not between them.

28. Again, this suggests that much of what is happening to wages is happening within not between occupations.

29. Figures H-A through H-C are similar in spirit to figures 2.7 and 2.8 in Howell, Houston, and Milberg (2001), though we do not subdivide occupations by industry sector.

30. In particular, the log hourly wage and each occupation dummy is separately regressed on the remaining controls (the quartic in age and the dummies for region, marital status, and race/ethnicity), and using the residuals from each of these regressions, residual log hourly wages are regressed on the residuals from the occupation dummy regressions. The partial R-squares are the R-squares from these regressions.

31. Though the specifications differ slightly, Figures IA-B here are similar in spirit to Figures 17a and 17b in Acemoglu and Autor (2011). One key difference is that we calculate the partial R-squares using the 250+ detailed occupations. The Acemoglu and Autor figure shows rising partial R-squares of occupation dummies since 1989, while we do not.

32. It should be noted in Figures I-A and I-B that there is a visible drop between 1993 and 1994 in the partial R-squared values. This drop coincides with major changes in the CPS survey, however it does not coincide with occupational coding breaks (as can be seen in Appendix Figure A). This merits further investigation. There is also a noticeable rise in the partial R-squared values, particularly for women, between 1982 and 1983. This is unsurprising since, as noted in the Appendix, there are 63 *more* occupation dummies for 1983 than there are for 1982. To test whether these breaks may affect the finding in Table 4 of a slowdown in the importance of occupations between the 1980s and the 1990s, we simply subtract the changes associated with these two "break" years (1982/1983 and 1993/1994). We find the following: For men, the increase in the share of wage variation explained by detailed occupations drops from 5.6 percentage points between 1979 and 1989 to 3.0 percentage points between 1989 and 2000 (instead of dropping from 6.3 percentage points to 0.5 percentage points). For women, the increase in the share of wage variation explained by detailed occupations drops from 5.2 percentage points between 1979 and 1989 to 1.5 percentage points between 1989 and 2000 (instead of dropping from 7.5 percentage points to -2.8 percentage points). Thus, after removing the effect of these breaks, the slowdown in the importance of occupations between the 1980s and the 1990s is somewhat smaller, but it remains pronounced. Of course, the finding also remains that for both men and women the partial R-squared values associated with detailed occupations declines between 2000 and 2007.

33. It should be noted that in this reweighting approach any year can be selected as the "base" year, the composition of which is held constant; typically the base year is either the first or last year of the series. We select 2007 rather than 1979 as the base year because of the major expansion of occupations that occurs between 1982 and 1983; since we are composition-adjusting for

occupations, if we were to composition-adjust using the 1979 occupations, the data from the 60+ occupations that existed in 1983 and later but did not exist in 1979 would be dropped from the composition-adjusted series.

34. We abandon our investigation of 50/10 and 90/50 trends in this context since the residual wage distribution does not map on to the overall wage distribution and therefore the 90/50 in the residual wage distribution does not provide information about inequality in the upper-tail of the wage distribution and the 50/10 in the residual wage distribution does not provide information about inequality in the lower-tail of the wage distribution.

35. It should be noted that the break in the composition-adjusted residual wage variance between 1982 and 1983 that is visible in Figures J-A and J-B is likely due to the occupational coding break that happened at that time. As in Figures I-A and I-B, there is also a visible break between 1993 and 1994 in Figures J-A and J-B with major changes in the CPS survey (not occupational coding breaks). This merits further investigation.

36. Mishel et al. (2012, Table 4.4)

37. Though Autor and Dorn refer to the decennial census data in terms of the year the data were collected (1980, 1990, or 2000) we refer to the data for the year the data capture (1979, 1989, and 1999) since those are the years we use in our CPS analysis.

38. This follows the same procedures as the estimates explained in an earlier section. We did not adjust the employment shares to account for the inconsistencies resulting from coding changes in 1983 and 2003 since we are seeking to replicate Autor and Dorn's finding. Our analysis uses hours-weighted employment data from the CPS-ORG data for 1979 and 2005, the same years as the 1980–2005 period presented by Autor and Dorn.

39. Of course, globalization and consumer preferences also matter here.

40. The Appendix presents this analysis.

41. David Autor, in correspondence, has provided a more detailed breakdown of the 1.1 percentage-point growth in service occupations in the Autor and Dorn data analysis: "food occupations" (0.4 ppt.); health aides (0.4 ppt.); child care (0.3 ppt.); janitors (-0.2 ppt.) and recreation (0.2 ppt.). Our CPS analysis shows a 0.1 ppt. decline, a gap of 1.2 ppt. with the Autor and Dorn analysis. To gauge the correspondence of our CPS analysis and the impact of the coding change (judged by the 2002–2003 impact) we computed the detailed change of the sum of the CPS change plus the coding impact and find: "food occupations" (0.5 ppt.); health aides (0.4 ppt.); child care (0.1 ppt.); janitors (-0.3 ppt.) and recreation (0.3 ppt.) which sum to a 0.8 ppt. change. The relatively close correspondence by detailed service occupation subgroup indicates that the impact of the coding change represents most of the difference between the Autor and Dorn and our CPS computations of the growth of service occupations in the 1990s.

42. See Silvestri (1995, 1997) and Braddock (1999).

43. There are 18 occupations in the first decile with 1979 average wages of $4.04 or less and another 26 occupations in the second decile with 1979 average wages of greater than $4.04 but less than or equal to $4.84. The cutoffs for the first and second decile occupational employment groups in 2012 dollars are $11.91 and $14.27. These cutoffs are dramatically different than the first and second decile wage cutoffs for the overall wage distribution in 1979—$8.71 and $9.93, another indication of how different the occupational and actual wage structures are.

44. The data in Table 7 show changes in employment shares while the "polarization graphs" show log changes in employment shares.

45. This is true in the census data presented by Autor and Dorn and the CPS data show a much smaller expansion in the 1990s than in the 1980s.

46. Extending the analysis to 2007 from 2005 does not change any conclusions.

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Tables and figures

TABLE 1

Occupational Employment Trends, 1959–2007

	Shares of total employment						Changes in employment shares				
	1959	1969	1979	1989	1999	2007	1959–69	1969–79	1979–89	1989–99	1999–2007*
High wage	20.9%	22.4%	25.2%	29.3%	33.0%	34.0%	1.5(ppt.)	2.8(ppt.)	4.1(ppt.)	3.7(ppt.)	1.3(ppt.)
Managers	9.4	8.7	10.0	12.0	14.3	14.6	-0.7	1.3	2.0	2.3	0.4
Professionals	9.1	11.0	12.0	13.6	15.1	15.9	1.9	1.0	1.7	1.4	1.0
Technicians	2.3	2.7	3.2	3.7	3.6	3.5	0.3	0.5	0.5	0.0	-0.1
Middle wage	65.7	63.5	60.6	56.2	51.4	48.0	-2.2	-2.9	-4.4	-4.7	-4.3
Sales	8.8	8.5	10.2	12.1	11.4	11.5	-0.3	1.7	1.9	-0.7	0.1
Office and administration	16.0	18.6	17.7	16.9	15.5	14.2	2.6	-0.9	-0.8	-1.4	-1.6
Production, craft and repair	14.6	13.1	13.0	11.3	11.3	10.2	-1.6	-0.1	-1.7	0.0	-1.4
Operators, fabricators and laborers	26.2	23.3	19.7	15.9	13.2	12.0	-3.0	-3.6	-3.8	-2.7	-1.4
Low wage (service occupations)	13.4	14.1	14.2	14.5	15.6	18.0	0.7	0.1	0.3	1.0	3.0
Protective service	1.2	1.1	1.5	1.8	2.0	2.2	0.0	0.4	0.3	0.2	0.3
Food prep, buildings and grounds, cleaning	5.1	6.2	7.6	7.7	7.6	8.9	1.1	1.4	0.2	-0.1	1.6
Personal care and personal services	7.1	6.8	5.1	5.0	6.0	6.9	-0.3	-1.7	-0.1	1.0	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0					

* Computed at a decadal rate of change.

Source: Authors' analysis of Acemoglu and Autor (2011, Table 2) (Data are rescaled to sum to 100.0%)

TABLE 2A

Occupational shifts and wage gaps, all workers, 1973–2007

	Annualized					
	1973–79	1979–89	1989-00			2000–07
			1989–95	1995–00	Total	
Occupational shifts (annual percentage-point change)						
High	0.40	0.51	0.46	0.44	0.45	0.27
Middle	-0.34	-0.58	-0.45	-0.45	-0.45	-0.46
Low: service occupations	-0.06	0.07	-0.01	0.01	0.00	0.19
Annual change in log wage gap						
90/50	0.34	0.72	0.84	0.19	0.54	0.57
50/10	-1.18	1.52	-0.60	-0.61	-0.61	0.01

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata. See Appendix for details

TABLE 2B

Occupational shifts and wage gaps, men only, 1973–2007

	Annualized					
	1973–79	1979–89	1989-00			2000–07
			1989–95	1995–00	Total	
Occupational shifts (annual percentage-point change)						
High	0.38	0.35	0.29	0.30	0.29	0.05
Middle	-0.46	-0.46	-0.34	-0.33	-0.34	-0.22
Low: service occupations	0.08	0.11	0.05	0.03	0.04	0.17
Annual change in log wage gap						
90/50	-0.25	1.04	1.15	0.67	0.93	0.51
50/10	0.59	0.39	-0.01	-0.84	-0.39	0.20

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata. See Appendix for details

TABLE 2C

Occupational shifts and wage gaps, women only, 1973–2007

	Annualized					
	1973–79	1979–89	1989-00			2000–07
			1989–95	1995–00	Total	
Occupational shifts (annual percentage-point change)						
High	0.50	0.73	0.68	0.59	0.64	0.54
Middle	-0.10	-0.70	-0.59	-0.58	-0.58	-0.75
Low: service occupations	-0.40	-0.03	-0.09	-0.02	-0.06	0.21
Annual change in log wage gap						
90/50	0.24	0.99	1.01	0.34	0.70	0.44
50/10	-2.36	2.19	-0.56	-0.32	-0.45	0.42

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata. See Appendix for details

TABLE 3

Correlations between occupational employment changes, occupational wage changes, and changes in the overall wage distribution, 1979–2007

	R^2 from OLS regression of change in log occupation wage on change in log employment share	R^2 from OLS regression of change in log wage on change in log occupation wage	R^2 from OLS regression of change in log wage on change in log employment share
1979–1989	0.01	0.117	0.098
1989–2000	0.008	0.025	0.097
2000–2007	0.013	0.026	0.027

Note: In each regression, observations are percentiles. For log occupation wages and log employment shares, they are occupation percentiles. For log wages, they are percentiles in the overall wage distribution. For the first-column regressions, if occupations are used as observations instead of occupation percentiles, the R-squared values are the following: 0.029 for the 1979–1989 period with 260 observations, 0.041 for the 1989–2000 period with 326 observations, and 0.031 for the 2000–2007 period with 323 observations. (The number of observations varies across periods due to the occupation coding changes discussed in the text and in the appendix.) Thus, the result that very little of the variation in log occupation wages can be explained by changes in occupational employment shares is robust to using either occupations or occupation percentiles as observations.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 4A

Explanatory power of detailed occupation dummies, 1979–2007

	Women		Men	
	R-squared	Partial R-squared	R-squared	Partial R-squared
	(1)	(2)	(3)	(4)
1979	0.355	0.294	0.370	0.206
1989	0.446	0.368	0.444	0.269
2000	0.418	0.340	0.424	0.273
2007	0.405	0.313	0.415	0.265
Change				
1979–1989	0.092	0.075	0.075	0.063
1989–2000	-0.029	-0.028	-0.020	0.005
2000–2007	-0.012	-0.027	-0.009	-0.008

Note: The R-squares are from cross-sectional OLS regressions of log hourly wages on the 250+ detailed occupation dummies, along with (in all cases) a quartic in age, and dummies for region of the country (using the four major Census regions), marital status, and race/ethnicity (using mutually exclusive categories of white non-Hispanic, black non-Hispanic, Hispanic any race, and other). The partial R-squares are calculated in the following way: the log hourly wage and each detailed occupation dummies are separately regressed on the remaining controls (the quartic in age and the dummies for region, marital status, and race/ethnicity). Using the residuals from these regressions, residual log hourly wages are regressed separately on the residuals from the occupation dummies regressions. The partial R-squares are the R-squares from these regressions.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 4B

Share of wage variance explained by detailed occupations, 1979–2007

	Men			Women		
	Variance of log wages	Variance explained by detailed occupations	Share explained by detailed occupations	Variance of log wages	Variance explained by detailed occupations	Share explained by detailed occupations
1979	0.250	0.051	20.6%	0.188	0.055	29.4%
1989	0.327	0.088	26.9	0.273	0.101	36.8
2000	0.355	0.097	27.3	0.301	0.102	34.0
2007	0.384	0.102	26.5	0.338	0.106	31.3
Change						
1979–1989	0.077	0.036	47.3	0.085	0.045	53.4
1989–2000	0.028	0.009	32.7	0.028	0.002	6.0
2000–2007	0.029	0.005	17.0	0.037	0.004	9.9

Note: Variance explained by detailed occupations is found by multiplying the variance of log wages by the partial R-square values presented in Table 4a, which isolate the explanatory power of detailed occupations net of other controls in cross-sectional OLS wage regressions.

Source: Authors' analysis of Current Population Survey Outgoing Rotation group microdata

TABLE 4C

Overall and composition-adjusted changes in upper-tail and lower-tail inequality, 1979–2007

	(1)	(2)	(3)	(4)=(3)-(2)	(5)	(6)	(7)	(8)=(7)-(6)
	50/10	50/10 with constant demographic and occupational composition	50/10 with constant demographic composition	Change in 50/10 due to occupational composition	90/50	90/50 with constant demographic and occupational composition	90/50 with constant demographic composition	Change in 90/50 due to occupational composition
Men								
1979	67.0	72.9	71.8		58.3	61.8	58.8	
1989	71.4	74.9	70.7		69.0	74.3	72.1	
2000	72.2	72.3	71.3		77.4	79.4	78.3	
2007	71.1	71.1	71.1		82.3	82.3	82.3	
1979-2007	4.1	-1.8	-0.7	1.1	24.0	20.5	23.5	3.0
1979-1989	4.4	2.0	-1.2	-3.1	10.7	12.5	13.3	0.8
1989-2000	0.9	-2.6	0.6	3.3	8.4	5.2	6.2	1.0
2000-2007	-1.1	-1.2	-0.2	1.0	4.9	2.8	4.0	1.2
Women								
1979	39.1	48.3	41.1		57.3	62.1	59.0	
1989	64.5	69.3	64.2		67.7	70.9	68.0	
2000	59.0	63.2	58.8		75.7	75.4	75.9	
2007	63.9	63.9	63.9		77.7	77.7	77.7	
1979-2007	24.9	15.6	22.8	7.2	20.4	15.5	18.6	3.1
1979-1989	25.5	21.0	23.1	2.0	10.4	8.7	9.0	0.2
1989-2000	-5.5	-6.1	-5.4	0.7	8.0	4.6	7.9	3.4
2000-2007	4.9	0.7	5.1	4.4	2.0	2.3	1.7	-0.5

Note: Column (1) is 100*[ln(50th percentile wage)−ln(10th percentile wage)]. Similarly column (5) is 100*[ln(90th percentile wage)−ln(50th percentile wage)]. Composition adjustments are made using the Dinardo, Fortin, and Lemieux (1996) kernel reweighting approach. The demographic characteristics controlled for in the composition adjustments are a quartic in age, dummies for region of the country (using the four major census regions), marital status, and race/ethnicity (using mutually exclusive categories of white non-Hispanic, black non-Hispanic, Hispanic any race, and other). The occupations are the 250+ detailed occupations. The base year is 2007, which is further explained in the text.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 5A

Wage variance for men 1979–2007

	Wage variance	Residual wage variance	Composition-adjusted residual wage variance	Within-group share of wage variance	Composition-adjusted within-group share of wage variance
1979	0.250	0.158	0.160*	0.630	0.640*
1989	0.327	0.182	0.201	0.556	0.615
1995	0.348	0.197	0.217	0.567	0.624
2000	0.355	0.204	0.208	0.576	0.587
2007	0.384	0.225	0.225	0.585	0.585
Change					
1979–1989	0.077	0.024	0.041*	0.314	0.535*
1989–2000	0.028	0.023	0.007	0.810	0.255
2000–2007	0.029	0.020	0.016	0.690	0.559

*The 1979 composition-adjusted figures are not directly comparable to other figures because of the major expansion of occupations that occurred between 1982 and 1983.

Note: The residual wage variances are from cross-sectional OLS regressions of log hourly wages on the 250+ detailed occupation dummies along with a quartic in age and dummies for region of the country (using the four major Census regions), marital status, and race/ethnicity (using mutually exclusive categories of white non-Hispanic, black non-Hispanic, Hispanic any race, and other). The composition-adjusted residual wage variances are calculated according to the procedure described in Lemieux (2006), page 468, using the same set of explanatory variables in the logit as in the wage regressions described above and using 2007 as the base year.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 5B

Wage variance for women, 1979–2007

	Wage variance	Residual wage variance	Composition-adjusted residual wage variance	Within-group share of wage variance	Composition-adjusted within-group share of wage variance
1979	0.188	0.121	0.132*	0.645	0.699*
1989	0.273	0.151	0.165	0.554	0.604
1995	0.309	0.177	0.191	0.573	0.618
2000	0.301	0.175	0.180	0.582	0.599
2007	0.338	0.201	0.201	0.595	0.595
Change					
1979–1989	0.085	0.030	0.033*	0.351	0.393*
1989–2000	0.028	0.024	0.015	0.864	0.552
2000–2007	0.037	0.026	0.021	0.693	0.561

*The 1979 composition-adjusted figures are not directly comparable to other figures because of the major expansion of occupations that occurred between 1982 and 1983.

Note: The residual wage variances are from cross-sectional OLS regressions of log hourly wages on the 250+ detailed occupation dummies along with a quartic in age and dummies for region of the country (using the four major Census regions), marital status, and race/ethnicity (using mutually exclusive categories of white non-Hispanic, black non-Hispanic, Hispanic any race, and other). The composition-adjusted residual wage variances are calculated according to the procedure described in Lemieux (2006), page 468, using the same set of explanatory variables in the logit as in the wage regressions described above and using 2007 as the base year.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 6

Service occupation employment share, 1949–2007

	1949	1959	1969	1973	1979	1989	1999	2005	2007
Service occupations (employment shares)									
Current Population Survey				13.8%	13.5%	14.0%	14.0%	15.0%	15.1%
Decennial Census/ACS*		13.4%	14.1%	-	14.2%	14.5%	15.6%	-	18.0%
Occupation Employment Survey (OES)							17.6%	19.0%	19.2%
Decennial Census/ACS**		11.6%	12.6%		12.9%	13.2%	13.0%		
Service occupations (hours shares)									
Current Population Survey				11.8%	11.5%	12.3%	12.4%	13.5%	13.6%
Service occupations, excluding public safety (hours shares)									
All education groups									
Current Population Survey	-	-	-	10.8%	10.5%	11.3%	11.4%	12.4%	12.6%
Decennial Census/ACS	10.7%	-	10.7%	-	9.9%	10.5%	11.6%	12.9%	-
High school or less									
Current Population Survey	-	-	-	13.7%	13.7%	16.3%	17.9%	19.5%	19.8%
Decennial Census/ACS	12.2%	-	13.3%	-	12.9%	15.6%	17.9%	19.8%	-

* Acemoglu and Autor.

** Katz and Margo.

Source: Decennial Census/ACS employment is from Acemoglu and Autor 2011 Table 2, rescaled to sum to 100. CPS is our ORG data, employment and hours, adjusted for coding changes 1982–1983 and 2002–2003 Decennial Census/ACS hours shares is Autor and Dorn (2012). Decennial Census/ACS data is from Katz and Margo (2013, Table 6). OES data is from the Bureau of Labor Statistics

TABLE 7

Employment shares in low-paying occupations, 1979–2007

Occupation wage category*	Employment Shares			
	1979	1989	1999	2007
Lowest 'decile'	10.2%	10.4%	10.2%	10.8%
Service occupations	7.2	7.7	7.7	8.4
Other occupations	3.0	2.7	2.5	2.3
Second 'decile'	10.9	10.1	9.5	9.3
Service occupations	2.5	2.5	2.4	2.5
Other occupations	8.5	7.6	7.1	6.7
Lowest 'fifth'	21.1	20.5	19.7	20.0
Service occupations	9.6	10.2	10.1	11.0
Other occupations	11.5	10.3	9.6	9.1

* Sorted by mean wage in 1979. The lowest decile has 18 occupations. The second decile has 26 occupations.
These are CPS ORG tabulations using Autor-Dorn occupation coding crosswalk. Service occupations exclude public safety occupations. Employment is hours-weighted. Employment trends are adjusted to remove inconsistencies due to coding changes in 1983 and 2003. Agriculture is excluded.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 8

Determinants of the service occupation intensity of the high school workforce, 1979–2007

	A=	+ B	+ C	- D
Years	Service occupation employment intensity of high school* workforce	High school* intensity of service employment	Service intensity of employment	High school* intensity of overall workforce
1979	13.7%	69.5%	11.5%	58.4%
1989	16.6	67.1	12.4	50.2
1999	18.3	61.7	12.5	42.4
2007	20.3	56.6	13.9	38.9
Contribution to change, decades**				
1979-1989	100.0%	-75.1%	24.8%	150.3%
1989-1999	100.0	-84.7	11.1	173.6
1999-2007	100.0	-82.9	101.5	81.5
Contribution to change, longer periods**				
1979-1999	100.0%	-40.8%	29.8%	111.0%
1979-2007	100.0	-52.0	48.9	103.1

* Refers to workers with a high school credential or less education.

** Decomposition based on changes of logged values of A = B + C − D, where A, B, C, and D refer to variables with those column heads. These are CPS ORG tabulations using Autor-Dorn occupation coding crosswalk. Service occupations exclude public safety occupations. Employment is hours-weighted. Employment trends are adjusted to remove inconsistencies due to coding changes in 1983 and 2003. Agriculture is excluded.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

TABLE 9

Real hourly wages, 1979–2007 ($2011)

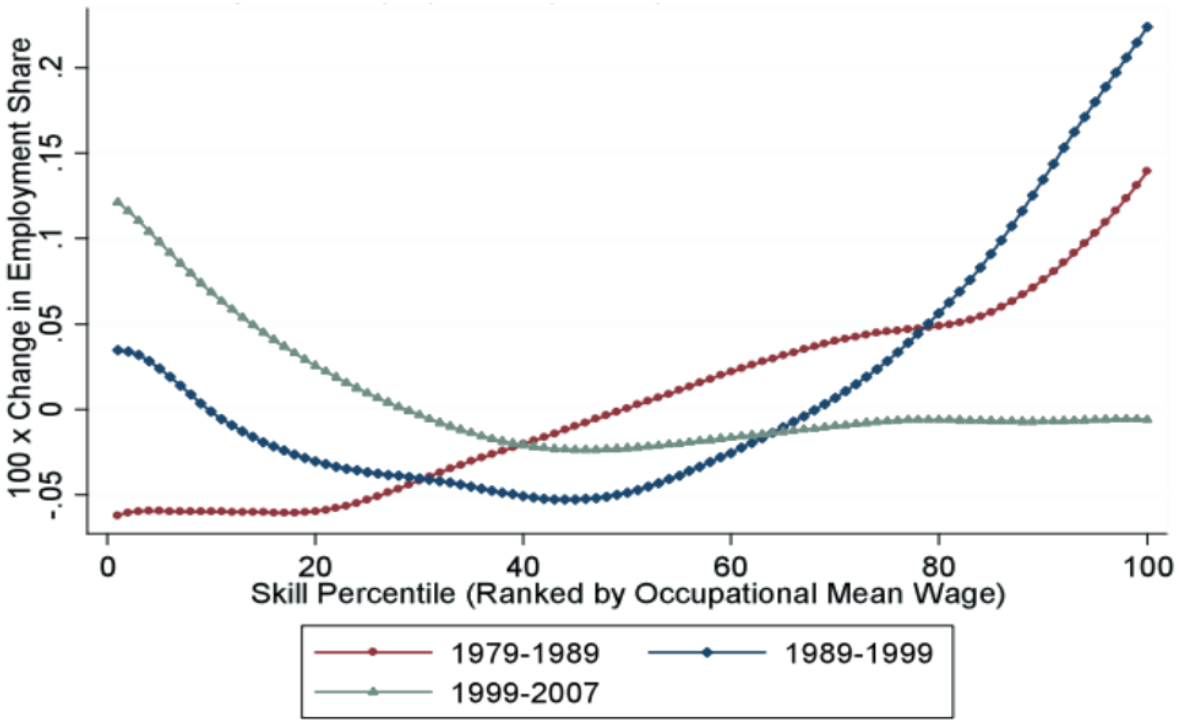
	Service occupations*	Median	Service share of median	Service occupations* hours share
1979	$7.28	$15.21	47.9%	10.6%
1989	6.74	15.12	47.3	11.4
1995	7.00	14.84	47.2	11.4
2000	8.06	15.99	50.4	11.5
2007	7.57	16.40	46.1	12.6
Percent change				
1979–1989	-1.8%	-0.6%	-0.6 (ppt.)	0.8 (ppt.)
1989–1995	-2.1	-1.8	-0.1	-0.1
1995–2000	15.2	7.7	3.3	0.1
2000–2007	-6.2	2.6	-4.3	1.2
1979–2007	3.9	7.8	-1.8	2.0

* Excluding public safety

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE A

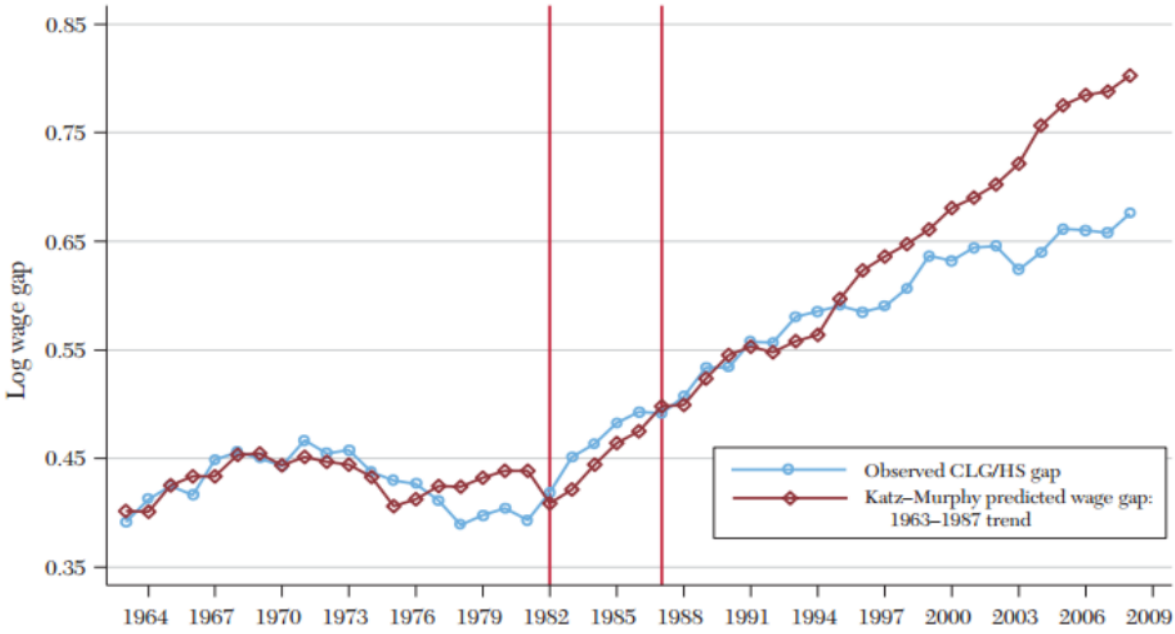
Changes in employment by occupational skill percentile, 1979–2007



Source: Reproduced from Acemoglu and Autor (2011); Census IPUM 5 percent samples for years 1980, 1990, and 2000, and Census American Community Survey for 2008. All occupation and earnings measures in these samples refer to prior year's employment. The figure plots log changes in employment shares by 1980 occupational skill percentile rank using a locally weighted smoothing regression (bandwidth 0.8 with 100 observations), where skill percentiles are measured as the employment-weighted percentile rank of an occupation's mean log wage in the Census IPUMS 1980 5 percent extract. Mean education in each occupation is calculated using workers' hours of annual labor supply times the Census sampling weights. Consistent occupation codes for Census years 1980, 1990, and 2000, and 2008 are from Autor and Dorn (2009)

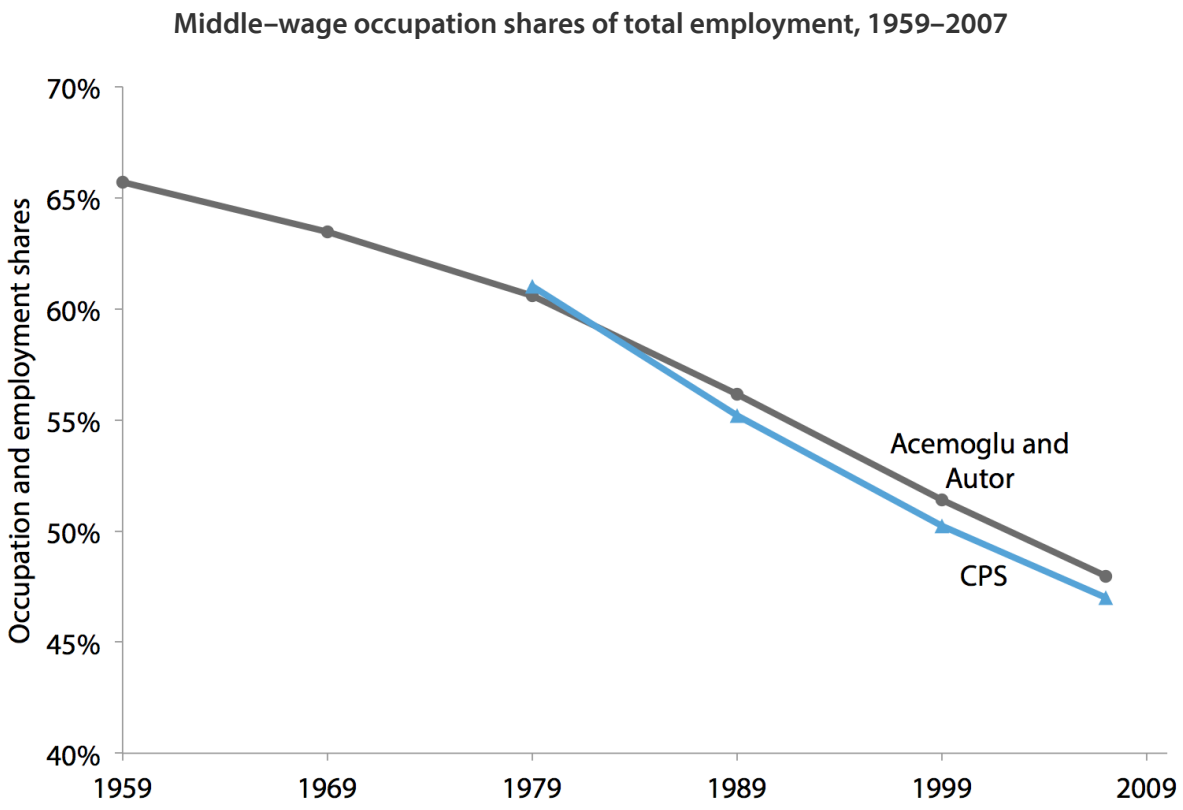
FIGURE B

Katz-Murphy prediction model for the college-high school wage gap



Source: Reproduced from Acemoglu and Autor (2012, Figure 1) March CPS data for earnings years 1963–2008. Log weekly wages for full-time, full-year workers are regressed in each year on four education dummies (high school dropout, some college, college graduate, greater than college), a quartic in experience, interactions of the education dummies and experience quartic and two race categories (black, nonwhite other). The composition-adjusted mean log wage is the predicted log wage evaluated for whites at the relevant experience level (5, 15, 25, 35, 45 years) and relevant education level (high school dropout, high school graduate, some college, college graduate, greater than college). The mean log wage for college and high school is the weighted average of the relevant composition adjusted cells using a fixed set of weights equal to the average employment share of each group. The ratio of mean log wages for college and high school graduates for each year is plotted. See Data Appendix for more details on treatment of March CPS data. The Katz-Murphy predicted wage gap are predicted values from a regression of the college/high-school wage gap on time trend term and log labor supply, as measured in efficiency units, for years 1963–1987

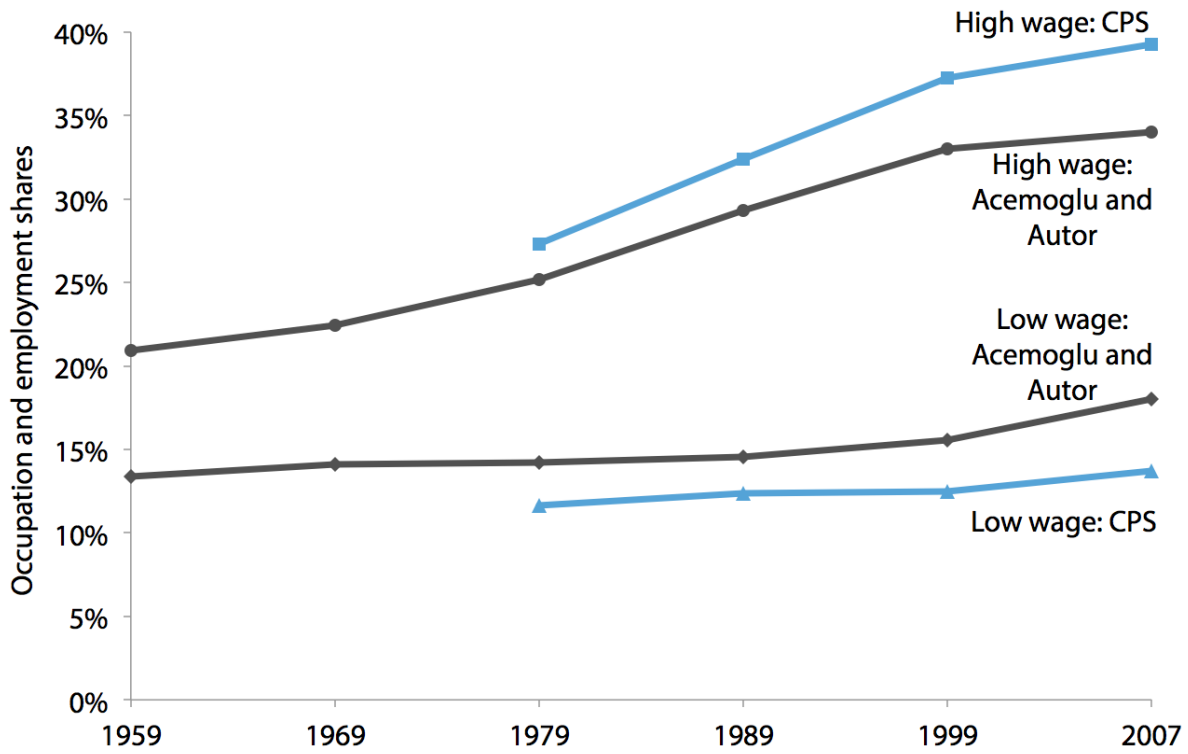
FIGURE CA



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata and Acemoglu and Autor (2011)

FIGURE CB

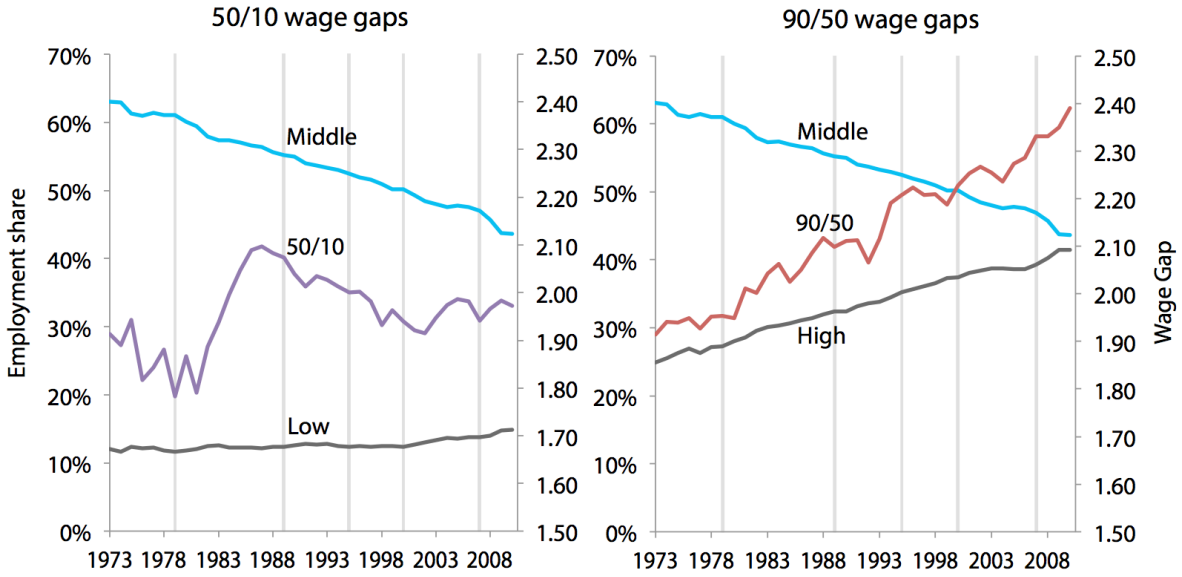
Low-wage and high-wage occupation shares of total employment, 1959–2007



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata and Acemoglu and Autor (2011)

FIGURE DA

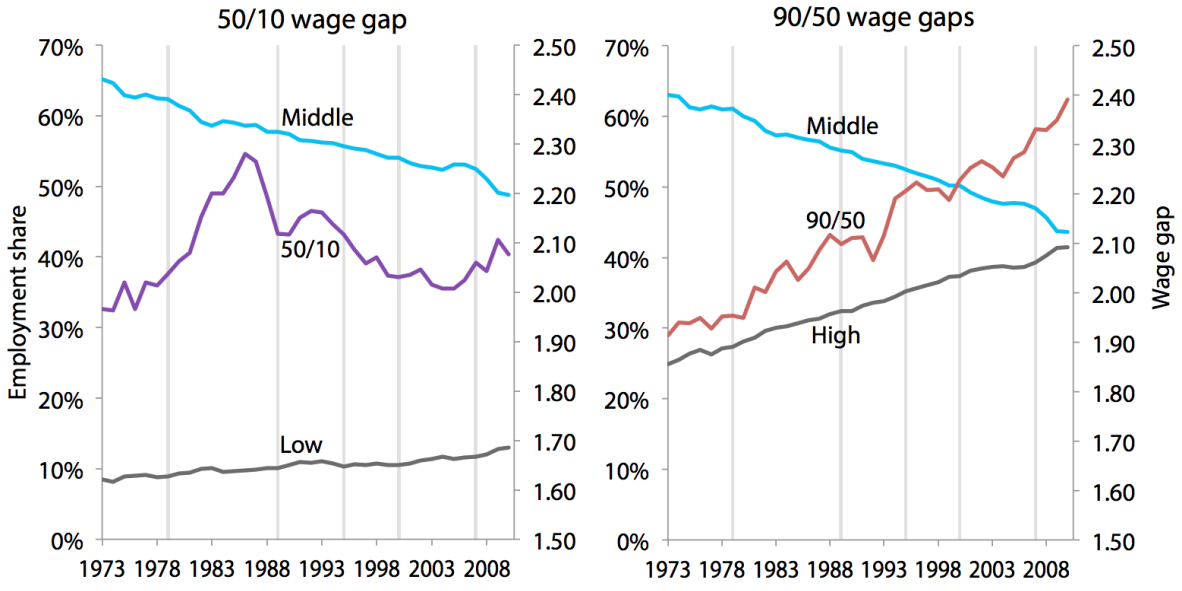
Occupational employment shares and wage gaps for all, 1973–2010



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE DB

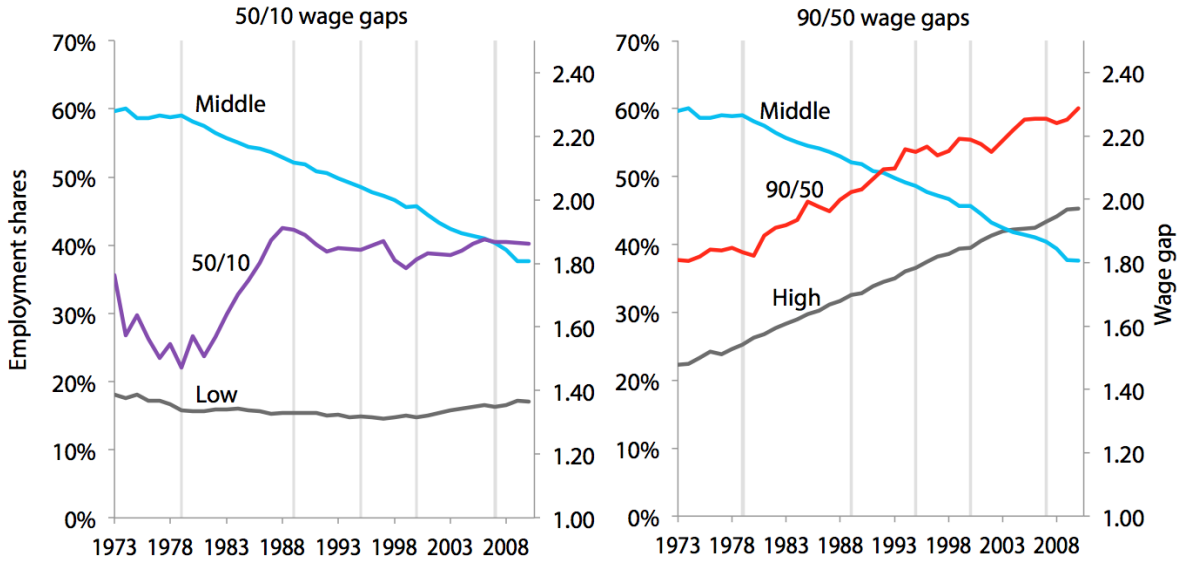
Occupational employment shares and wage gaps for men, 1973–2010



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE DC

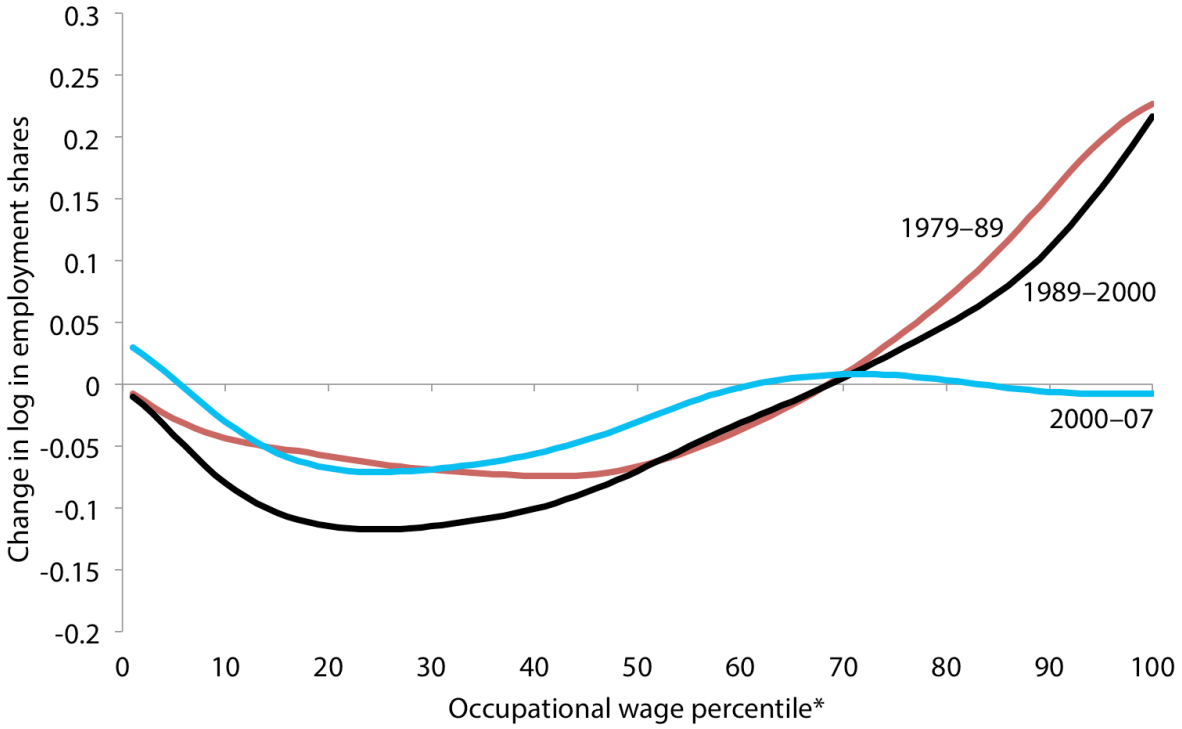
Occupational employment shares and wage gaps for women, 1973–2010



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE E

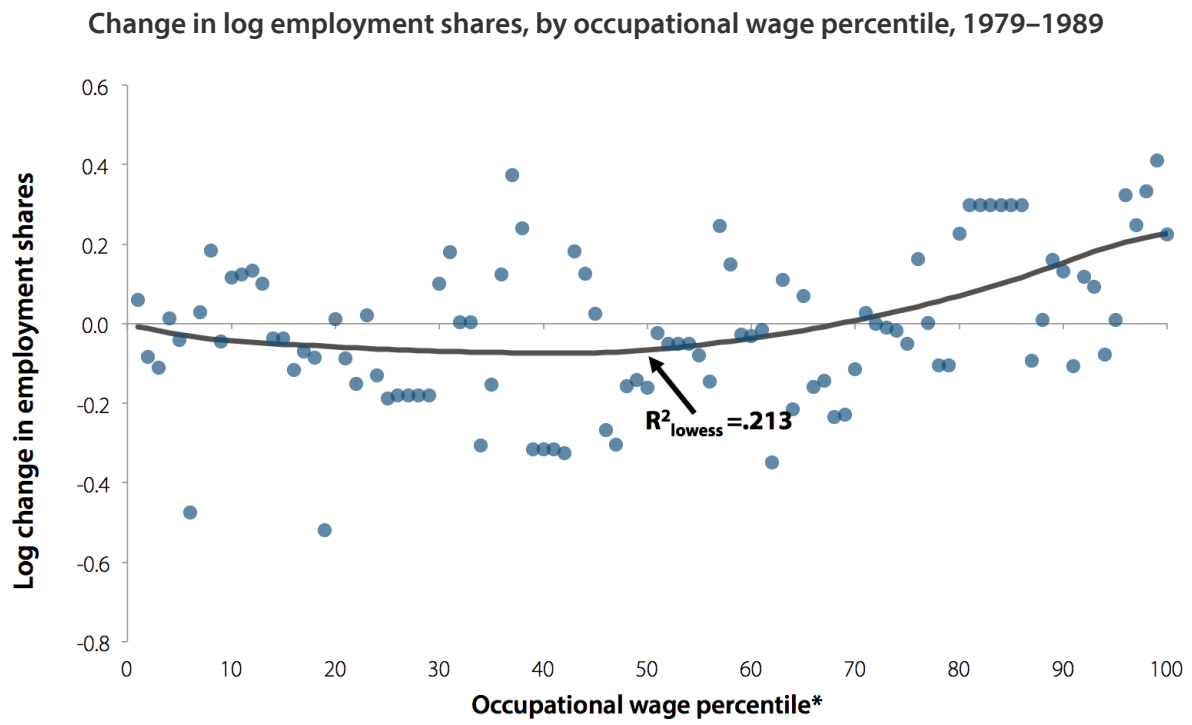
Replication of key job polarization figure using CPS-ORG data adjusted for occupation coding breaks in 1982/1983 and 2002/2003, 1979–89, 1989–2000, 2000–07



*Ranked by 1979 occupational mean wage.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE FA

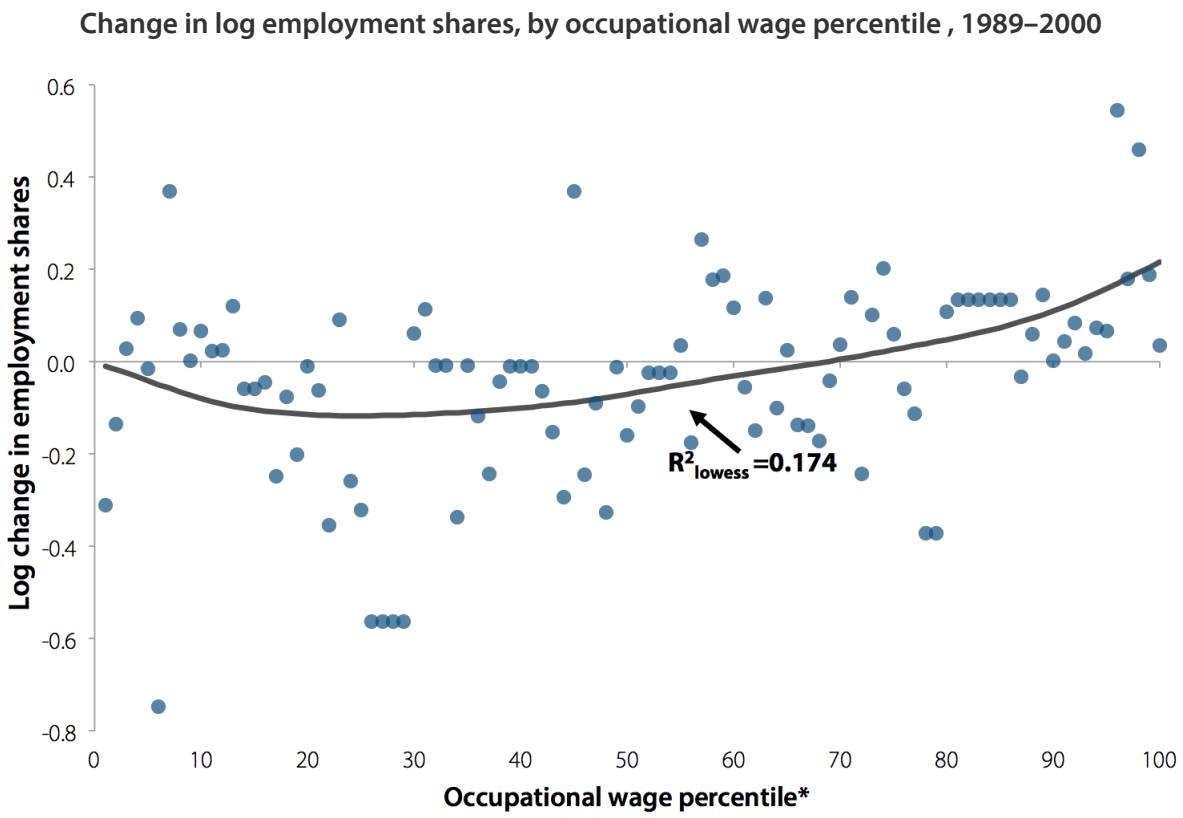


*Ranked by 1979 occupational mean wage.

Note: Due to discontinuities in employment shares caused by a major occupational coding change between 1982 and 1983, the change in log employment share between 1982 and 1983 was replaced by the average change of 1980–1981, 1981–1982, 1983–1984, and 1984–1985.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

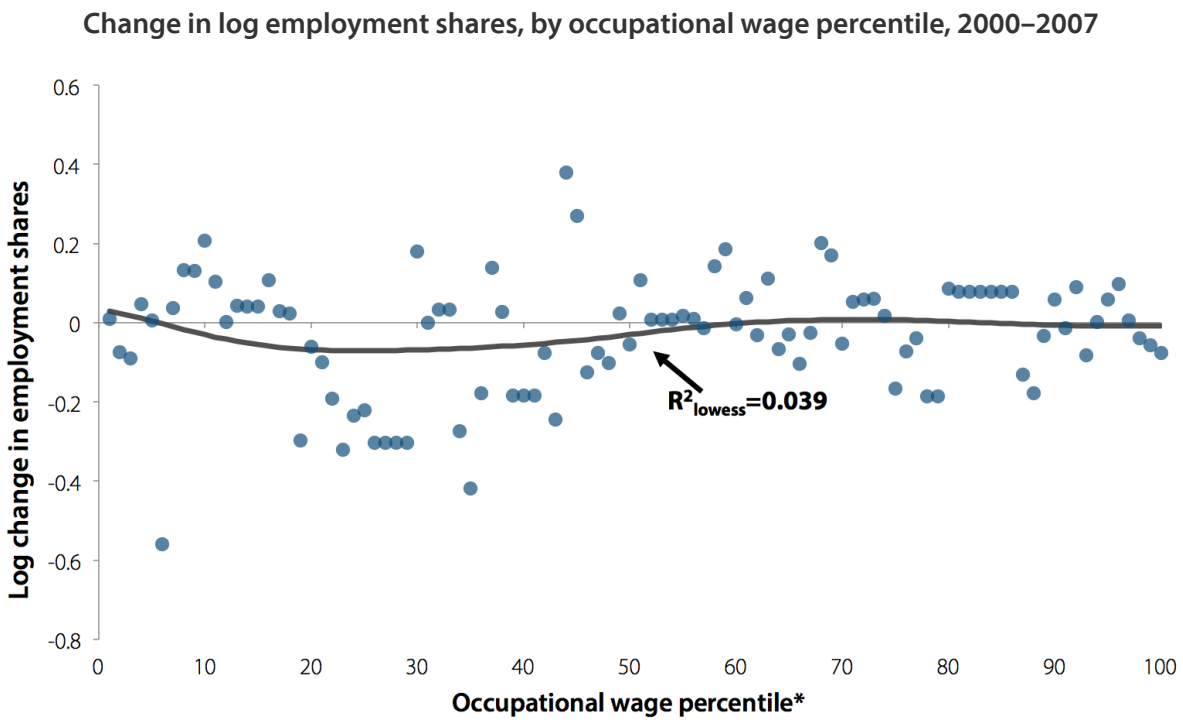
FIGURE FB



*Ranked by 1979 occupational mean wage.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE FC



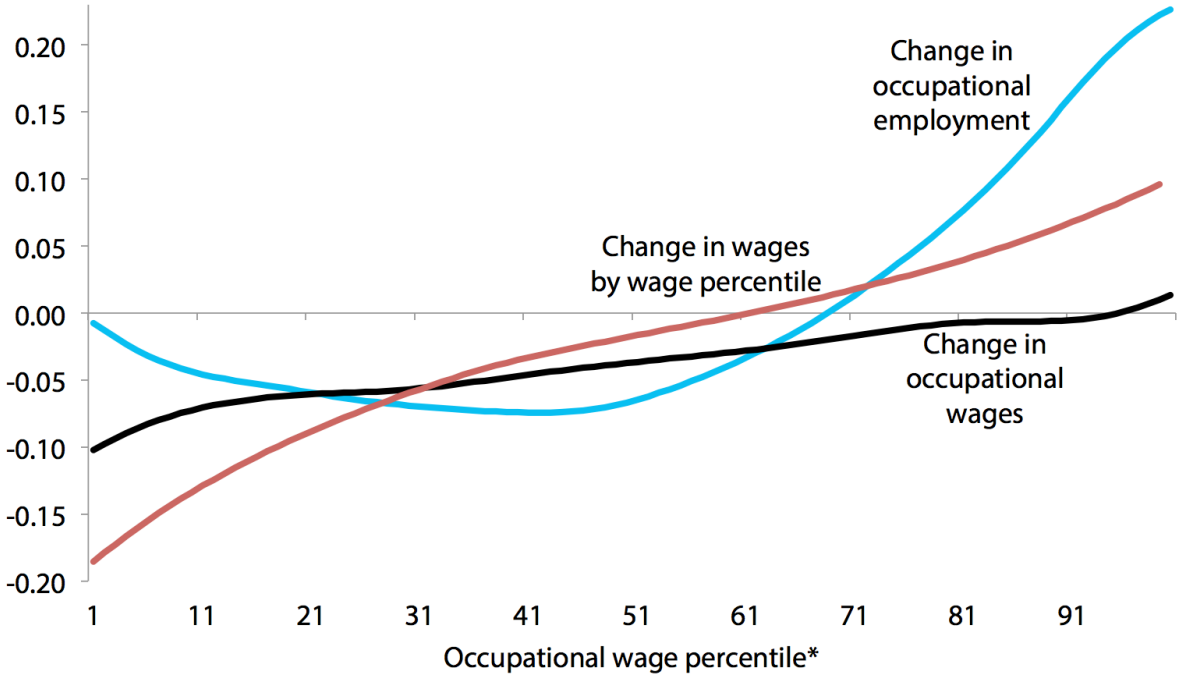
*Ranked by 1979 occupational mean wage.

Note: Due to discontinuities in employment shares caused by a major occupational coding change between 2002 and 2003, the change in log employment share between 2002 and 2003 was replaced by the average change of 2000–2001, 2001–2002, 2003–2004, and 2004–2005.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE GA

Smoothed changes in log employment share and log wage by occupational wage percentile, and smoothed changes in log wage by wage percentile, 1979–1989



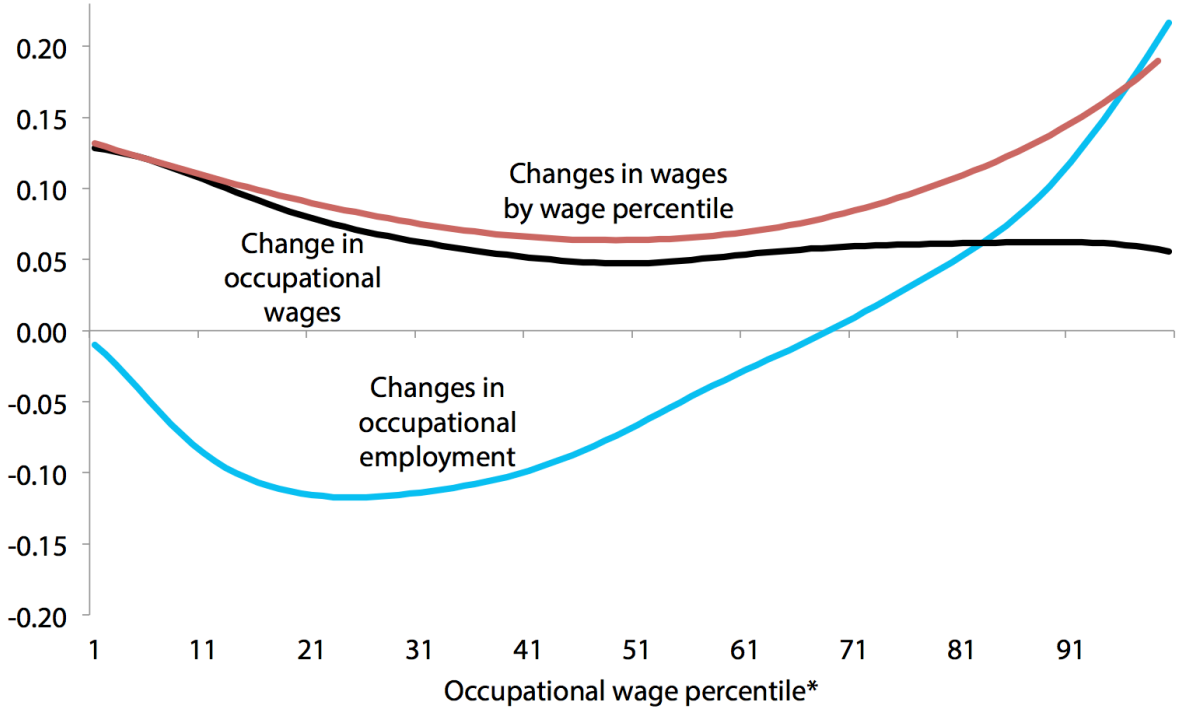
*Ranked by 1979 occupational mean wage.

Note: Due to discontinuities in employment shares caused by a major occupational coding change between 1982 and 1983, the change in log employment share and log occupational wage between 1982 and 1983 was replaced by the average change of 1980–1981, 1981–1982, 1983–1984, and 1984–1985.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE GB

Smoothed changes in log employment share and log wage by occupational wage percentile, and smoothed changes in log wage by wage percentile, 1989–2000

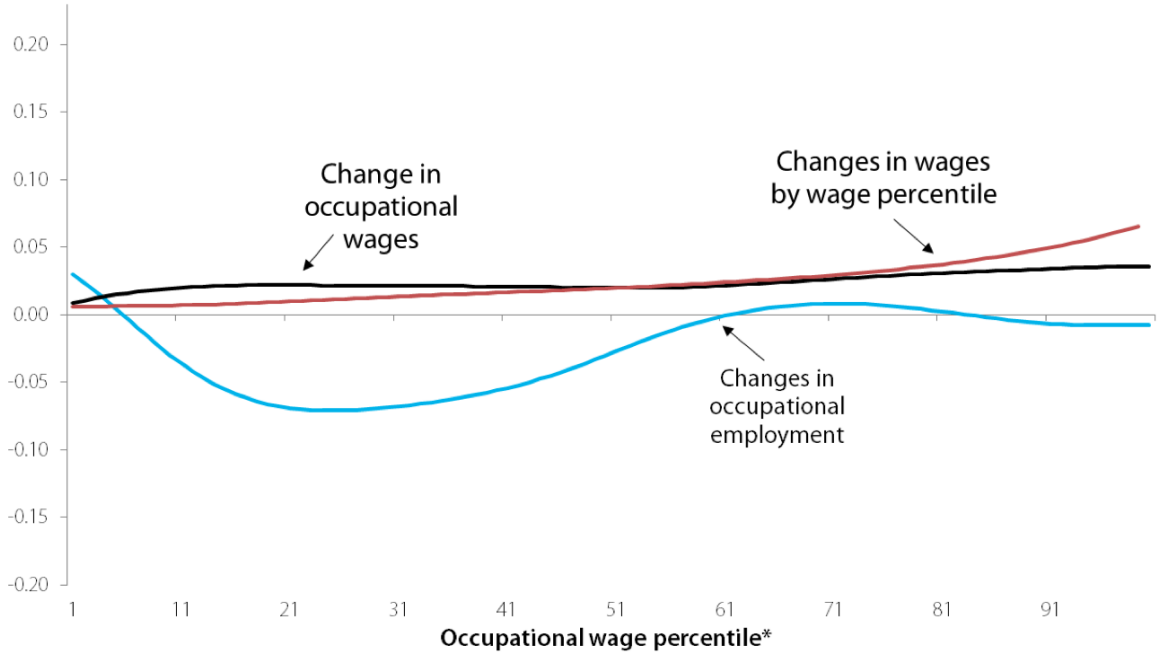


*Ranked by 1979 occupational mean wage.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group micrdata

FIGURE GC

Smoothed changes in log employment share and log wage by occupational wage percentile, and smoothed changes in log was by wage percentile, 2000–2007



*Ranked by 1979 occupational mean wage.

Note: Due to discontinuities in employment shares caused by a major occupational coding change between 2002 and 2003, the change in log employment share and log occupational wage between 2002 and 2003 was replaced by the average change of 2000–2001, 2001–2002, 2003–2004, and 2004–2005.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE HA

Note: The regression line is from a simple linear regression of change in log occupation wage on change in log employment share. Observations are the 100 occupation percentiles. Standard errors are in parentheses.

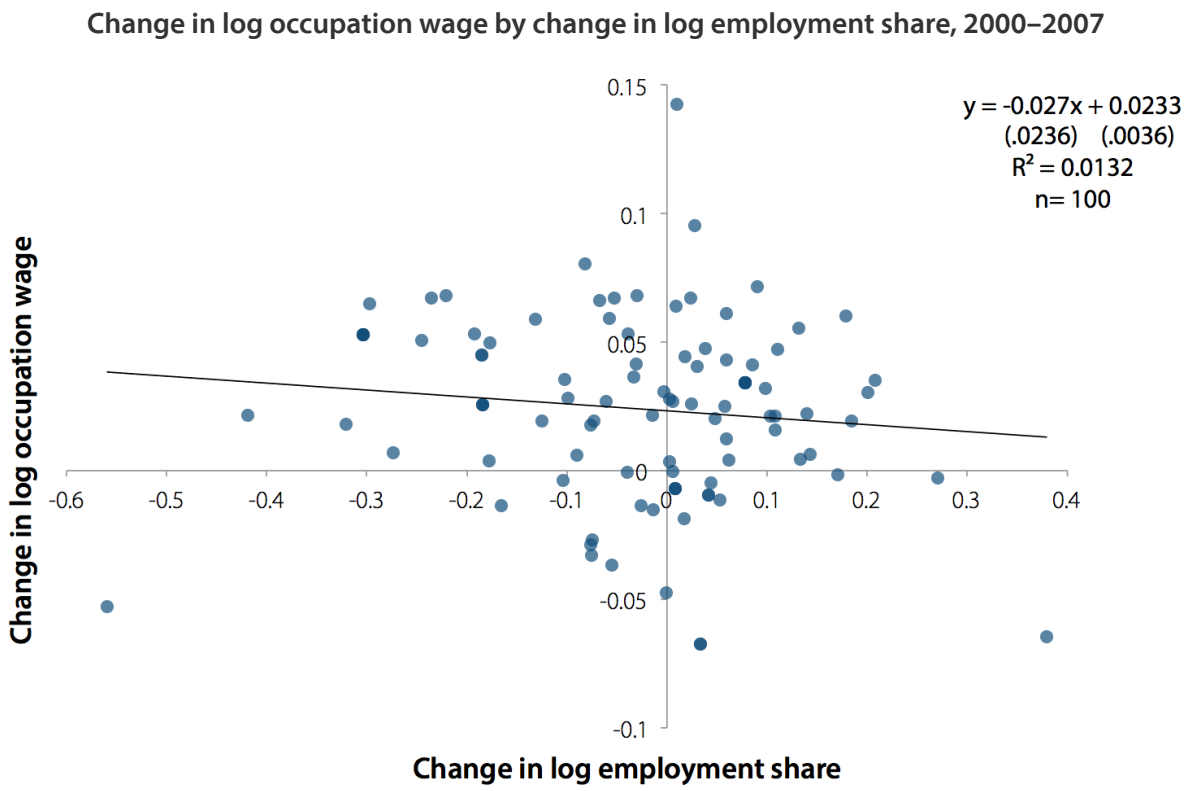
Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE HB

Note: The regression line is from a simple linear regression of change in log occupation wage on change in log employment share. Observations are the 100 occupation percentiles. Standard errors are in parentheses.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE HC

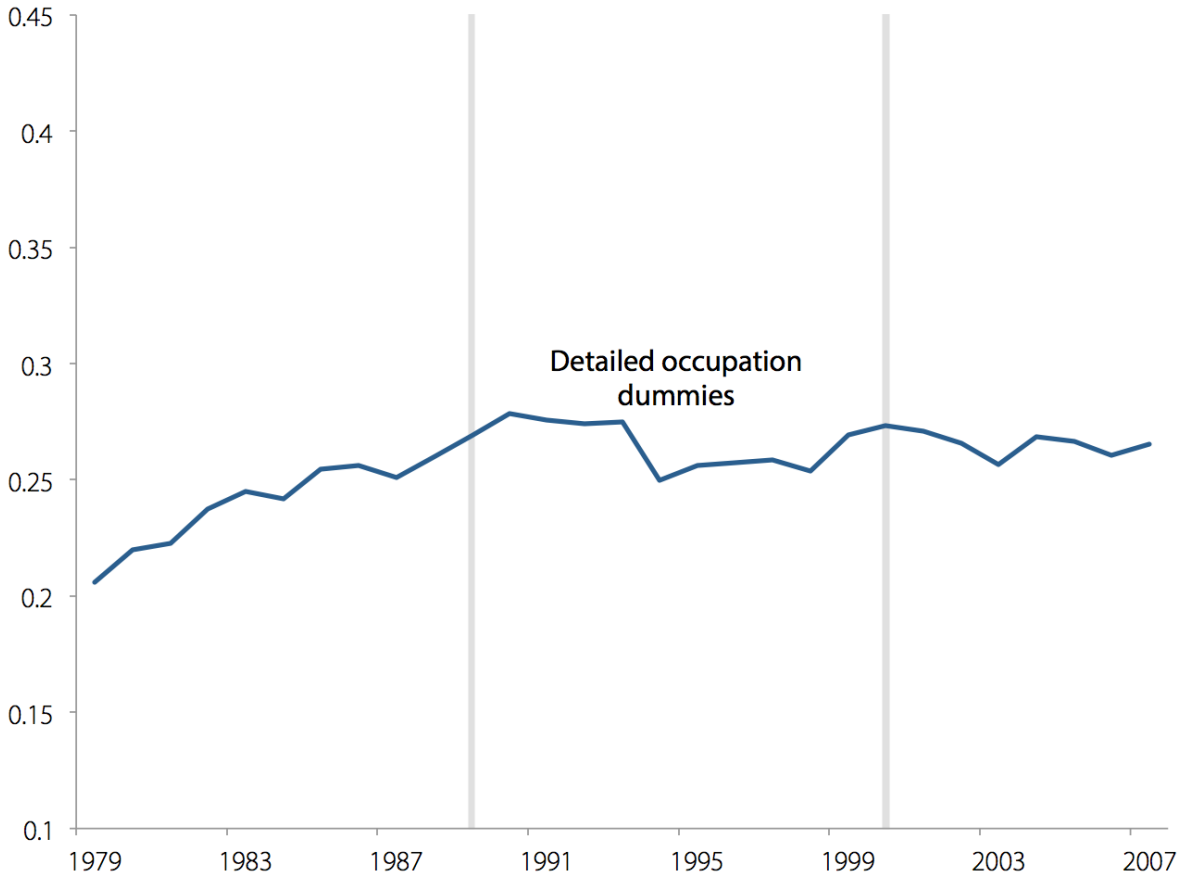


Note: The regression line is from a simple linear regression of change in log occupation wage on change in log employment share. Observations are the 100 occupation percentiles. Standard errors are in parentheses.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE IA

Partial R-squared of education and occupation dummies for men, 1979–2007

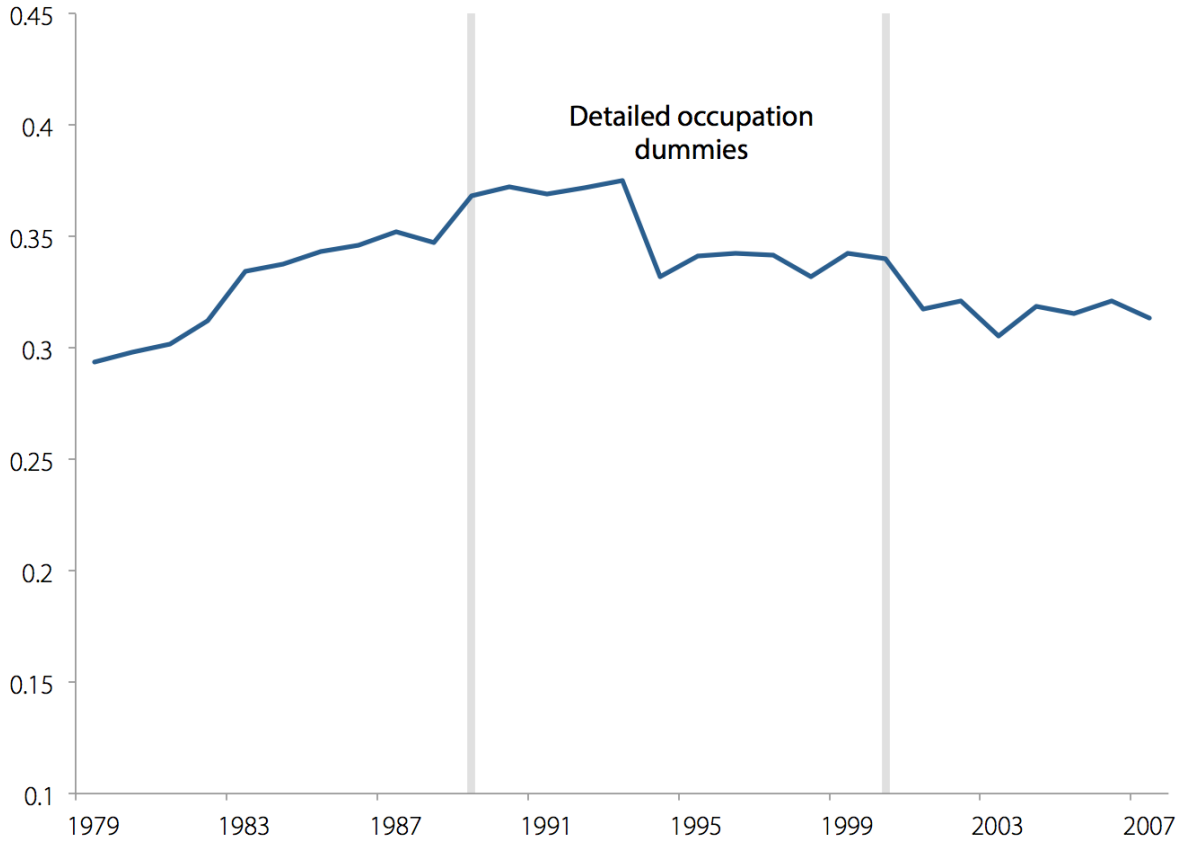


Note: See Table 4a note for further explanation.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE IB

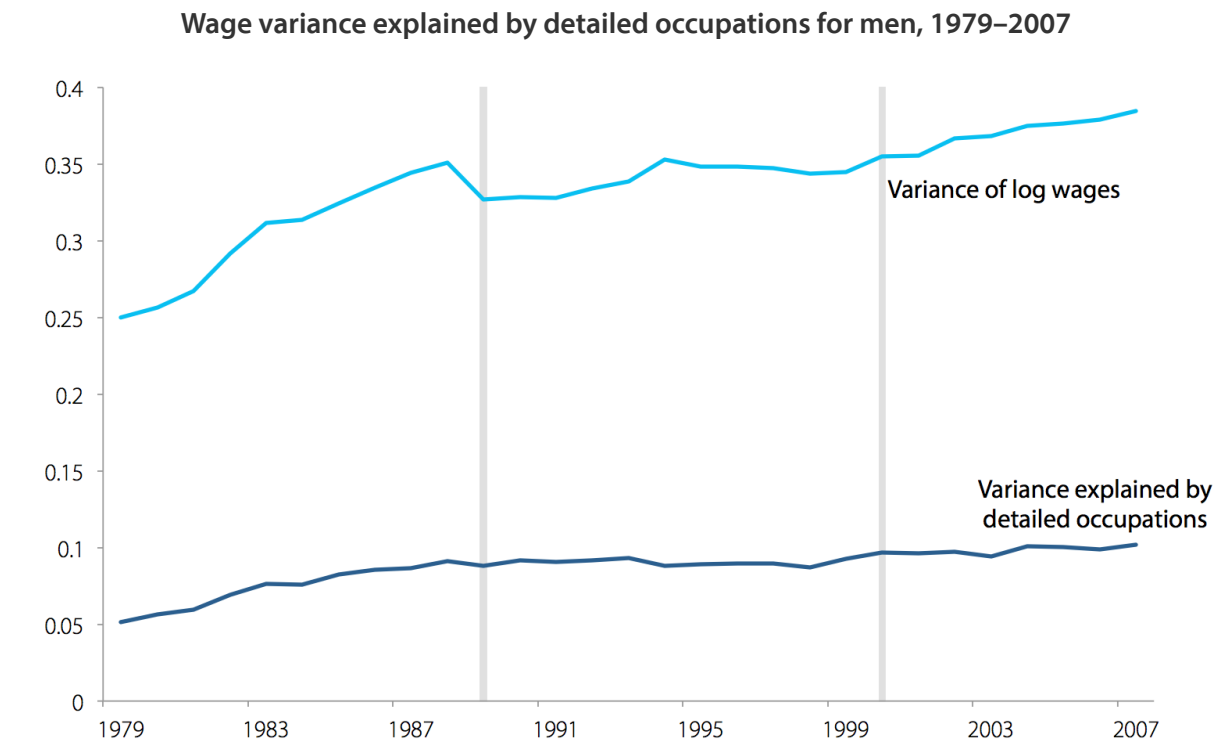
Partial R-squared of education and occupation dummies for women, 1979–2007



Note: See Table 4a note for further explanation.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group micrdata

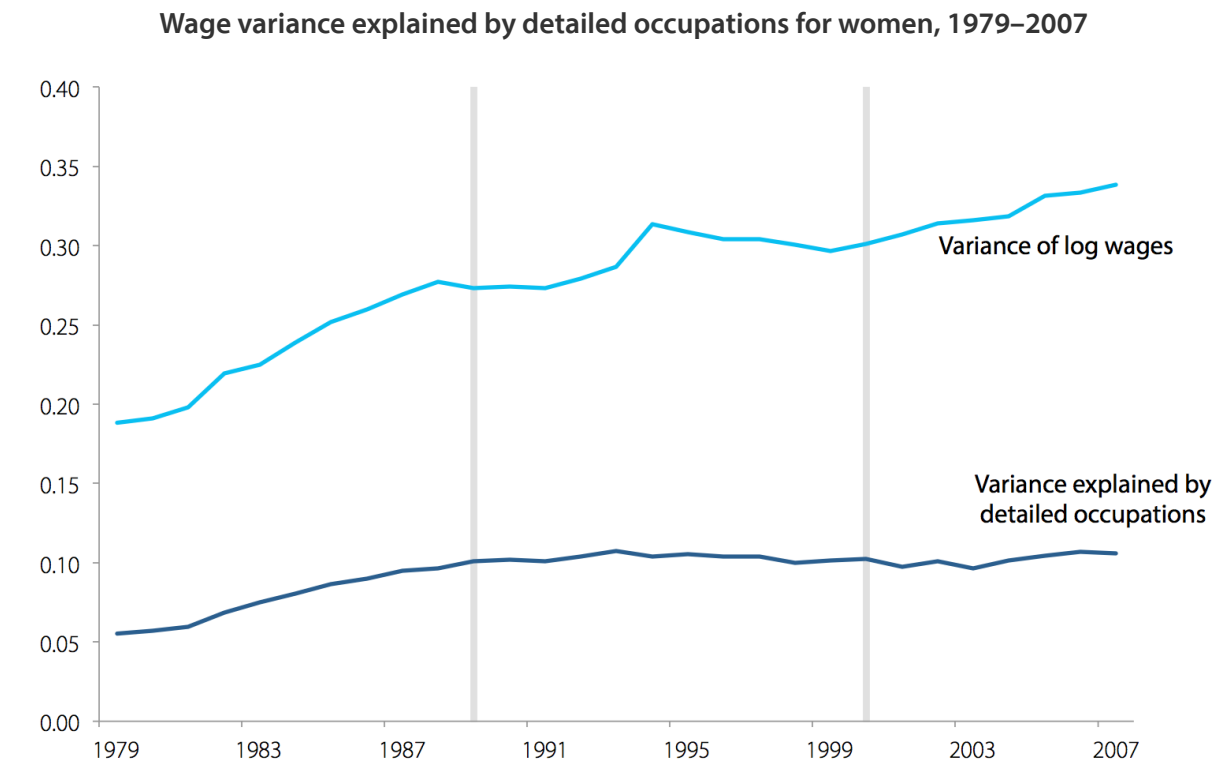
FIGURE IC



Note: See note to Table 4b.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE ID

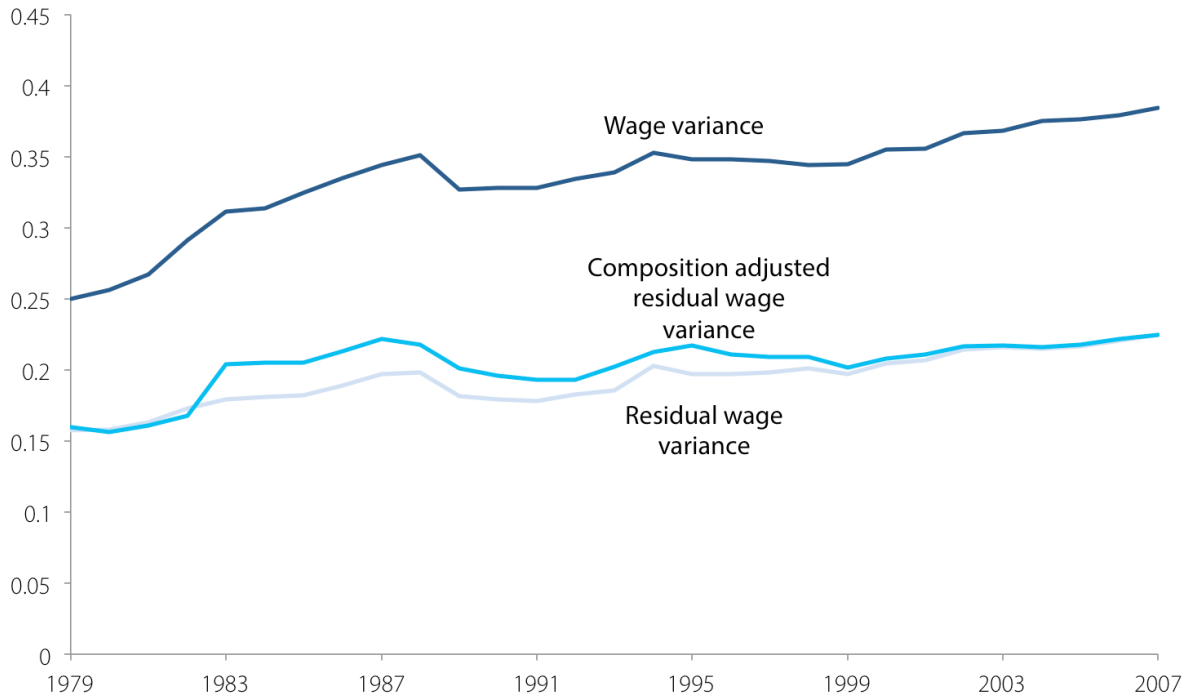


Note: See note to Table 4b.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE JA

Wage variance, residual wage variance, and composition-adjusted residual wage variance for men, 1979–2007

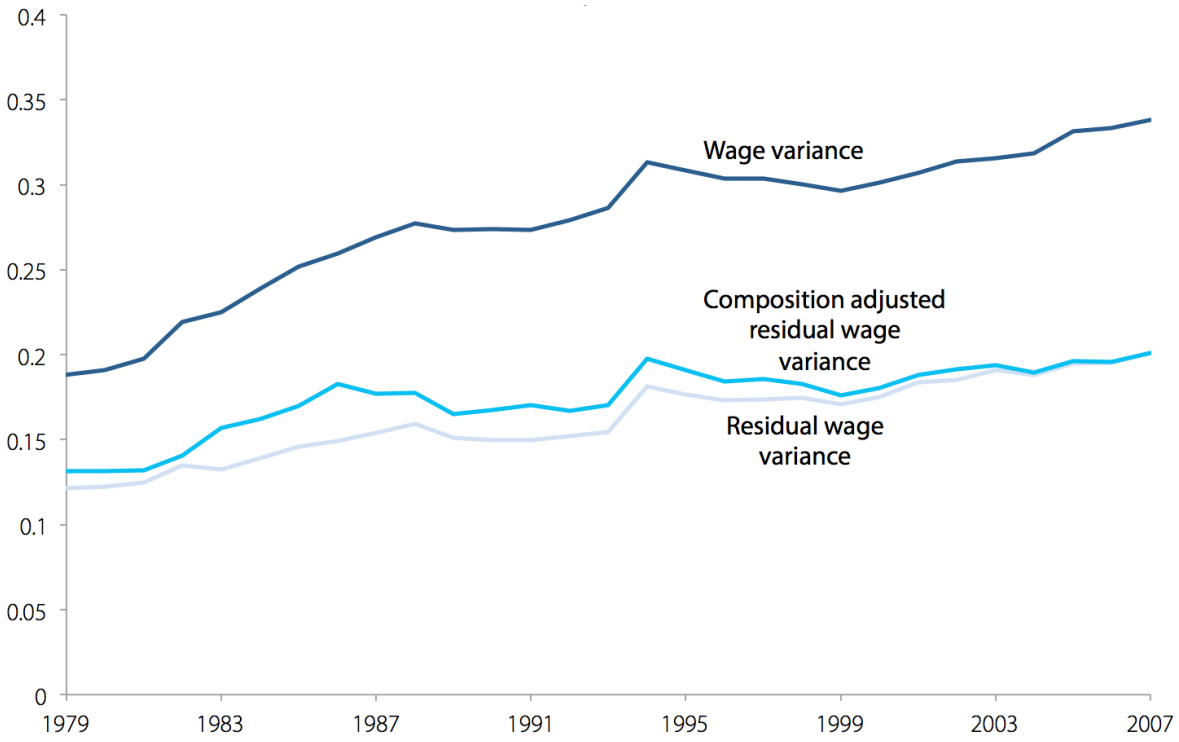


Note: The values in the composition-adjusted series from 1979–1982 are not directly comparable to the later years in this series because of the major expansion of occupations that occurred between 1982 and 1983. See Table 5A for further explanation.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE JB

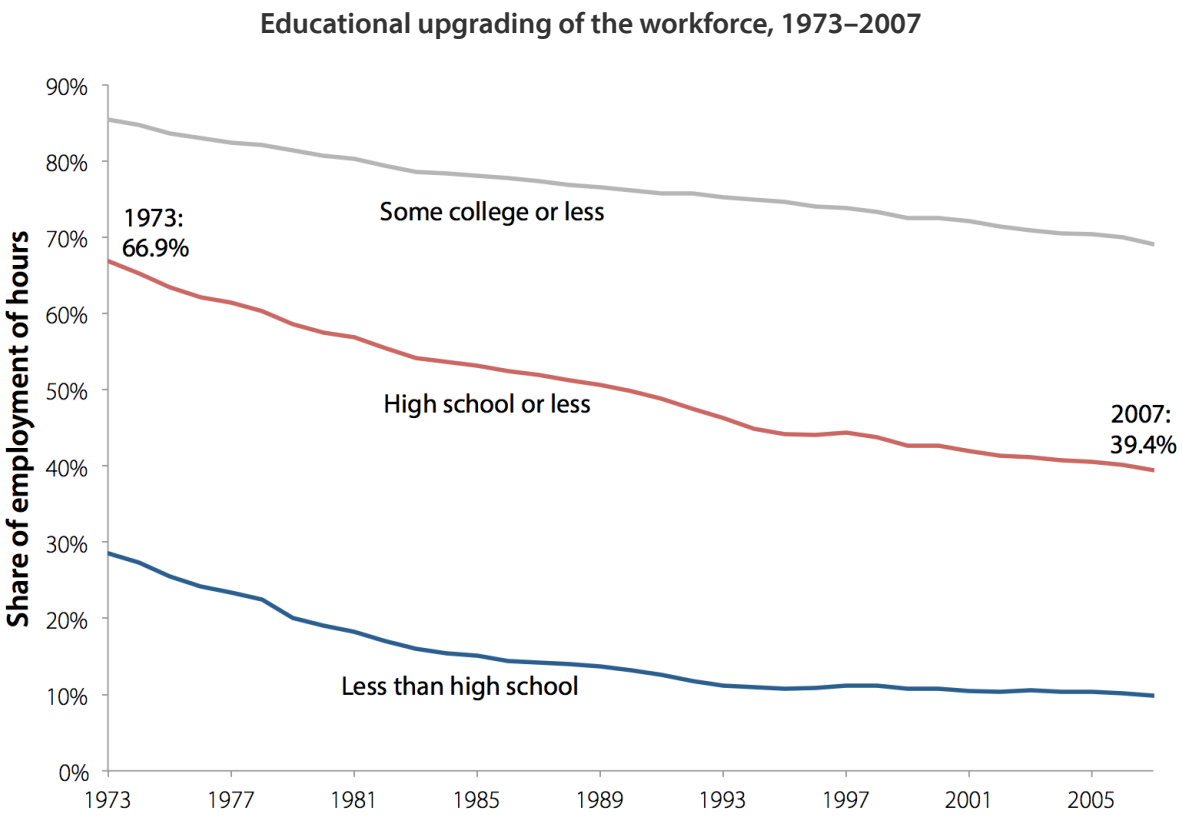
Wage variance, residual wage variance, and composition adjusted residual wage variance for women, 1979–2007



Note: The values in the composition-adjusted series from 1979–1982 are not directly comparable to the later years in this series because of the major expansion of occupations that occurred between 1982 and 1983. See Table 5B for further explanation.

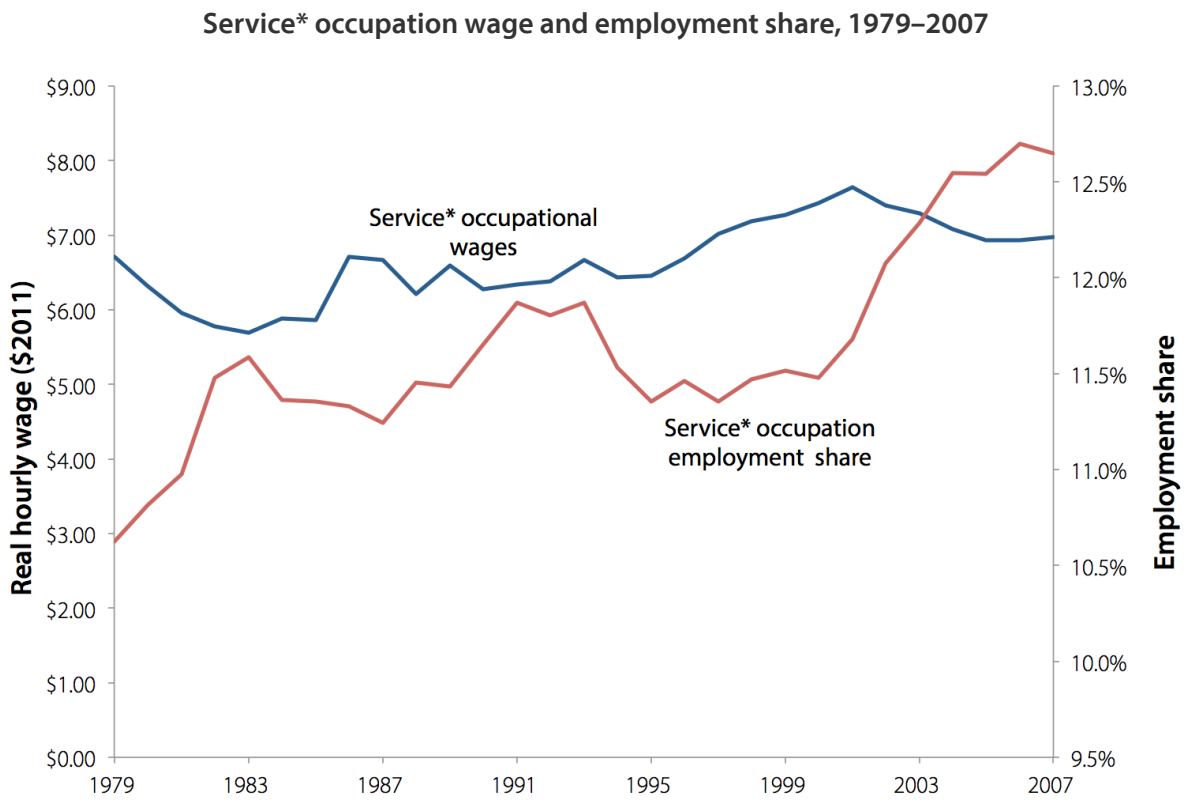
Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE K



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

FIGURE L



*Service occupations exclude firefighters and policemen.

Source: Authors' analysis of Current Population Survey Outgoing Rotation Survey microdata

APPENDIX TABLE 1

Changes of occupational employment shares in 1982–1983 and 2002–2003, adjusted and unadjusted series

	1982–83			2002–03		
Unadjusted data	1982	1983	Change	2002	2003	Change
Managers	12.6%	11.1%	-1.4%	16.0%	16.1%	0.1%
Professionals	13.3	13.0	-0.3	16.5	16.4	-0.1
Technicians	3.3	3.6	0.3	3.6	3.8	0.2
Sales	7.5	9.9	2.5	10.8	10.4	-0.4
Office and admin	18.1	17.3	-0.8	14.0	14.4	0.4
Production, craft and repair	12.8	12.9	0.1	10.7	11.0	0.2
Operators, fabricators and laborers	18.7	18.1	-0.6	14.3	12.6	-1.6
Protective service	1.9	2.1	0.2	2.3	2.3	0.0
Food prep, buildings and grounds, cleaning	5.7	6.4	0.8	6.5	6.9	0.4
Personal care and personal services	4.7	4.1	-0.6	4.3	5.1	0.8
Agriculture	1.4	1.4	0.0	0.9	1.0	0.0
High	29.1%	27.7%	-1.4%	36.1%	36.3%	0.2%
Middle	58.5	59.7	1.1	50.7	49.3	-1.4
Low: service occupations	12.3	12.6	0.3	13.2	14.4	1.2
	1982–83			**2002–03**		
Adjusted data	1982	1983	Change	2002	2003	Change
Managers	12.6%	12.9%	0.3%	17.8%	17.9%	0.1%
Professionals	13.3	13.5	0.2	17.0	17.0	0.1
Technicians	3.3	3.3	0.0	3.4	3.4	0.0
Sales	7.5	7.7	0.2	8.5	8.5	0.0
Office and admin	18.1	18.0	-0.1	14.7	14.5	-0.2
Production, craft and repair	12.8	12.7	-0.1	10.5	10.5	0.0
Operators, fabricators and laborers	18.7	18.2	-0.6	14.3	14.1	-0.2
Protective service	1.9	1.9	0.0	2.1	2.2	0.1
Food prep, buildings and grounds, cleaning	5.7	5.7	0.1	5.9	5.9	0.1
Personal care and personal services	4.7	4.8	0.0	5.0	5.1	0.1
Agriculture	1.4	1.4	0.0	0.9	0.9	0.0
High	29.1%	29.7%	0.5%	38.1%	38.3%	0.3%
Middle	58.5	57.9	-0.6	49.0	48.5	-0.5

APPENDIX TABLE 1 (CONTINUED)

	1982–83			2002–03		
Low: service occupations	12.3	12.4	0.1	13.0	13.2	0.2

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata. Data are hours weighted

APPENDIX TABLE 2

Impact of coding changes on period trends

	Change 1982-1983			Change 1979-1989		
	Unadjusted	**Adjusted**	**Coding change impact**	**Unadjusted**	**Adjusted**	**Coding change impact**
1982-83						
High	-1.4%	0.5%	-1.9 (ppt)	3.2%	5.1%	-1.9 (ppt)
Middle	1.1	-0.6	1.7	-3.9	-5.6	1.7
Low	0.3	0.1	0.2	1.0	0.8	0.2
	Change 2002-2003			**Change 2000-2007**		
	Unadjusted	**Adjusted**	**Coding change impact**	**Unadjusted**	**Adjusted**	**Coding change impact**
High	0.2%	0.3%	-0.1 (ppt)	1.9%	1.9%	-0.1 (ppt)
Middle	-1.4	-0.5	-0.9	-4.0	-3.1	-0.9
Low	1.2	0.2	1.0	2.3	1.3	1.0

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata; data are hours weighted

APPENDIX TABLE 3

Effect of coding change on 1982–1983 and 2002–2003 trends

Employment weighted

	Change 1982–1983			Change 2002–2003		
	Unadjusted	**Adjusted**	**Coding change impact**	**Unadjusted**	**Adjusted**	**Coding change impact**
High	-2.1%	0.5%	-2.6 (ppt)	0.1%	0.3%	-0.2 (ppt)
Middle	1.9	-0.5	-2.4	-1.5	-0.5	-1.0
Low	0.2	0.1	0.2	1.4	0.2	1.2

Hours weighted

	Change 1982–1983			Change 2002–2003		
	Unadjusted	**Adjusted**	**Coding change impact**	**Unadjusted**	**Adjusted**	**Coding change impact**
High	-1.4%	0.5%	-1.9 (ppt)	0.2%	0.3%	-0.1 (ppt)
Middle	1.1	-0.6	1.7	-1.4	-0.5	-0.9
Low	0.3	0.1	0.2	1.2	0.2	1.0

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata; data are hours weighted

APPENDIX TABLE 4

The impact on the occupational distribution of adding 60+ new occupations in the 1983 occupational recode

	Occupational distribution of employment in 1983		
	Distribution in occupations that do exist in 1982	Distribution in occupations that do not exist in 1982	Difference
Food prep, buildings and grounds, cleaning	7.8%	7.2%	0.6 (ppt.)
Personal care and personal services	5.2	0.9	4.3
Protective service	2.1	1.1	1.0
Office and administration	18.6	15.9	2.7
Operators, fabricators and laborers	18.6	9.9	8.7
Production	11.6	19.4	-7.8
Sales	9.0	23.1	-14.1
Managers	9.6	15.7	-6.1
Professionals	13.7	5.1	8.5
Technicians	3.8	1.6	2.2
Total	100%	100%	

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata

APPENDIX TABLE 5A

Occupational shares for all workers, 1973–2010

	High-wage			Middle-wage					Low-wage		
	Managers	Professionals	Technicians	Sales	Office and administration	Production, craft and repair	Operators, fabricators and laborers	Agriculture	Protective service	Food preparation, buildings and grounds, cleaning	Personal care and personal services
1973	10.8%	11.3%	2.4%	6.4%	16.3%	14.5%	24.9%	1.6%	1.8%	5.2%	4.8%
1974	11.0	11.5	2.6	6.5	16.5	14.2	24.5	1.6	1.8	5.0	4.7
1975	11.3	12.0	2.6	6.7	17.0	14.0	22.6	1.6	1.7	5.4	5.0
1976	11.5	12.3	2.6	6.4	17.3	13.8	22.7	1.5	1.8	5.4	4.7
1977	11.5	11.8	2.6	6.8	16.8	13.7	23.1	1.7	1.8	5.6	4.6
1978	11.6	12.2	3.0	6.5	17.1	13.9	22.5	1.7	1.7	5.4	4.5
1979	11.8	12.3	2.9	7.0	17.6	13.8	21.8	1.3	1.8	5.1	4.6
1980	12.1	12.6	3.1	7.0	18.2	13.3	20.7	1.3	1.8	5.3	4.7
1981	12.2	12.8	3.2	7.2	18.0	13.2	20.2	1.4	1.8	5.4	4.7
1982	12.6	13.3	3.3	7.5	18.1	12.8	18.7	1.4	1.9	5.7	4.7
1983	12.9	13.5	3.3	7.7	18.0	12.7	18.2	1.4	1.9	5.7	4.8
1984	13.3	13.3	3.2	7.9	17.6	12.8	18.4	1.3	1.8	5.6	4.7
1985	13.7	13.4	3.2	8.0	17.7	12.8	17.9	1.2	1.7	5.7	4.7
1986	14.0	13.5	3.3	8.1	17.7	12.4	17.8	1.1	1.8	5.6	4.7
1987	14.2	13.6	3.2	8.1	17.7	12.3	17.7	1.1	1.9	5.6	4.6
1988	14.5	13.8	3.3	8.0	17.4	12.2	17.4	1.1	1.9	5.5	4.8
1989	14.9	13.9	3.3	8.1	17.0	12.1	17.5	1.0	1.9	5.6	4.8
1990	14.6	14.1	3.5	8.3	17.1	11.8	17.2	1.1	1.9	5.8	4.8
1991	15.0	14.4	3.5	8.1	17.0	11.4	16.9	1.0	2.0	5.8	5.0
1992	14.9	14.5	3.9	8.1	17.6	11.1	16.4	1.0	1.9	5.8	4.8
1993	15.1	14.7	3.6%	8.1	17.4	10.9	16.3	1.0	2.0	5.8	4.9
1994	15.6	15.2	3.3	8.3	16.6	11.0	16.6	1.0	2.0	5.6	4.8
1995	16.1	15.4	3.3	8.4	16.1	10.9	16.5	1.0	2.0	5.5	4.7

APPENDIX TABLE 5A (CONTINUED)

	High-wage			Middle-wage					Low-wage		
	Managers	Professionals	Technicians	Sales	Office and administration	Production, craft and repair	Operators, fabricators and laborers	Agriculture	Protective service	Food preparation, buildings and grounds, cleaning	Personal care and personal services
1996	16.2	15.8	3.2	8.5	15.9	10.8	16.3	1.0	1.9	5.6	4.8
1997	16.6	15.8	3.4	8.5	15.5	11.0	16.1	1.0	1.9	5.6	4.7
1998	16.8	16.0	3.4	8.6	15.4	10.9	15.6	0.9	2.0	5.6	4.8
1999	17.1	16.5	3.3	8.4	15.2	10.9	15.4	0.8	2.0	5.6	4.8
2000	17.1	16.5	3.4	8.4	15.2	10.9	15.3	0.9	1.9	5.6	4.7
2001	17.5	16.8	3.5	8.5	14.9	10.9	14.6	0.8	2.0	5.7	4.9
2002	17.8	17.0	3.4	8.5	14.7	10.5	14.3	0.9	2.1	5.9	5.0
2003	17.9	17.0	3.4	8.5	14.5	10.5	14.1	0.9	2.2	5.9	5.1
2004	18.0	16.9	3.5	8.5	14.2	10.4	14.1	0.8	2.3	6.1	5.2
2005	17.8	17.0	3.6	8.4	14.1	10.8	14.2	0.8	2.2	6.0	5.3
2006	17.9	16.9	3.5	8.4	13.9	10.8	14.2	0.8	2.3	6.0	5.4
2007	18.1	17.4	3.5	8.4	13.6	10.6	14.0	0.7	2.3	5.9	5.4
2008	18.6	17.7	3.6	8.1	13.6	10.0	13.6	0.8	2.3	6.1	5.5
2009	19.0	18.3	3.8	8.3	13.4	9.2	12.6	0.8	2.5	6.3	5.9
2010	18.8	18.5	3.8	8.0	13.4	9.1	12.7	0.8	2.6	6.3	5.8

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata; data are hours weighted

APPENDIX TABLE 5B

Occupational shares for men, 1973–2010

	High-wage			Middle-wage					Low-wage		
	Managers	Professionals	Technicians	Sales	Office and administration	Production, craft and repair	Operators, fabricators and laborers	Agriculture	Protective service	Food preparation, buildings and grounds, cleaning	Personal care and personal services
1973	13.8%	9.7%	2.3%	5.5%	6.9%	21.9%	29.4%	2.2%	2.7%	4.1%	1.5%
1974	14.2	10.0	2.5	5.6	6.7	21.6	29.2	2.3	2.7	3.9	1.4
1975	14.7	10.4	2.5	5.8	7.1	21.2	27.4	2.3	2.6	4.4	1.7
1976	14.8	10.6	2.5	5.5	7.0	21.2	27.5	2.1	2.8	4.5	1.5
1977	14.5	10.3	2.4	5.9	6.5	21.2	27.8	2.4	2.8	4.4	1.7
1978	14.4	10.7	3.0	5.6	6.7	21.6	27.1	2.4	2.5	4.4	1.6
1979	14.5	10.8	2.9	6.0	6.7	21.6	26.8	1.9	2.7	4.3	1.7
1980	14.6	11.1	3.1	6.1	7.0	21.3	25.8	1.9	2.7	4.5	1.8
1981	14.6	11.5	3.1	6.3	6.7	21.1	25.3	2.0	2.8	4.7	1.8
1982	15.0	12.0	3.2	6.6	6.9	20.6	23.8	2.1	3.0	5.1	1.8
1983	15.2	12.2	3.3	6.7	6.8	20.5	23.3	2.1	3.0	5.2	1.7
1984	15.5	12.0	3.2	6.9	6.7	20.7	23.8	2.0	2.8	5.0	1.6
1985	15.5	11.9	3.3	6.9	6.7	20.7	23.5	1.8	2.7	5.2	1.6
1986	15.7	12.0	3.3	7.1	6.6	20.3	23.5	1.7	2.9	5.1	1.6
1987	15.8	12.0	3.2	7.4	6.7	20.3	23.4	1.6	3.0	5.2	1.6
1988	15.8	12.5	3.4	7.0	6.6	20.1	23.2	1.6	3.0	5.3	1.7
1989	16.1	12.3	3.3	7.0	6.5	20.0	23.4	1.5	2.9	5.3	1.6
1990	15.7	12.4	3.5	7.1	6.7	19.5	23.2	1.6	2.9	5.7	1.7
1991	16.0	12.6	3.5	7.2	6.6	19.0	22.9	1.6	3.1	5.8	1.8
1992	15.9	12.4	3.9	7.4	6.9	18.6	22.6	1.6	3.0	6.0	1.7
1993	16.2	12.5	3.5	7.3	7.1	18.4	22.6	1.5	3.1	5.9	1.9
1994	16.3	13.1	3.2	7.4	6.7	18.2	23.1	1.4	3.1	5.6	1.9
1995	16.9	13.4	3.2	7.4	6.4	18.2	22.9	1.4	3.0	5.4	1.7

APPENDIX TABLE 5B (CONTINUED)

	High-wage			Middle-wage					Low-wage		
	Managers	Professionals	Technicians	Sales	Office and administration	Production, craft and repair	Operators, fabricators and laborers	Agriculture	Protective service	Food preparation, buildings and grounds, cleaning	Personal care and personal services
1996	16.8	13.7	3.1	7.5	6.4	18.0	22.7	1.5	2.9	5.8	1.8
1997	17.0	13.6	3.3	7.3	6.4	18.4	22.3	1.5	2.9	5.7	1.8
1998	17.3	13.8	3.2	7.4	6.4	18.4	21.7	1.3	3.1	5.7	1.8
1999	17.5	14.3	3.2	7.4	6.2	18.3	21.6	1.2	3.0	5.6	1.8
2000	17.4	14.3	3.3	7.4	6.2	18.2	21.5	1.3	2.9	5.7	1.8
2001	17.7	14.6	3.3	7.5	6.1	18.4	20.7	1.2	3.0	5.8	1.8
2002	17.9	14.4	3.1	7.8	6.1	17.8	20.6	1.2	3.2	6.1	1.9
2003	18.0	14.4	3.1	7.8	6.0	17.7	20.5	1.2	3.2	6.1	1.9
2004	18.0	14.3	3.2	7.7	5.9	17.6	20.7	1.1	3.3	6.3	2.0
2005	17.5	14.3	3.3	7.5	6.0	18.1	21.0	1.0	3.2	6.1	2.0
2006	17.8	14.1	3.2	7.6	5.9	18.1	21.0	1.0	3.3	6.2	2.0
2007	17.8	14.5	3.2	7.5	5.8	17.9	20.8	0.9	3.4	6.1	2.1
2008	18.3	14.8	3.4	7.2	5.9	17.0	20.4	1.0	3.3	6.4	2.2
2009	18.9	15.3	3.5	7.5	5.9	16.0	19.2	1.1	3.7	6.7	2.3
2010	18.9	15.3	3.6	7.2	6.1	15.7	19.3	1.1	3.9	6.7	2.3

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata; data are hours weighted

APPENDIX TABLE 5C

Occupational shares for women, 1973–2010

	High-wage			Middle-wage					Low-wage		
	Managers	Professionals	Technicians	Sales	Office and administration	Production, craft and repair	Operators, fabricators and laborers	Agriculture	Protective service	Food preparation, buildings and grounds, cleaning	Personal care and personal services
1973	5.5%	13.9%	2.7%	8.0%	32.8%	1.5%	17.0%	0.5%	0.2%	7.2%	10.6%
1974	5.5	14.1	2.6	8.1	33.4	1.6	16.5	0.5	0.2	6.9	10.4
1975	5.7	14.7	2.7	8.2	33.7	1.7	14.7	0.5	0.2	7.2	10.5
1976	6.2	15.1	2.9	7.9	34.0	1.7	14.8	0.5	0.2	7.0	9.9
1977	6.6	14.2	2.9	8.2	33.3	1.6	15.5	0.6	0.3	7.5	9.3
1978	7.1	14.4	2.9	8.0	33.7	1.7	15.1	0.6	0.3	7.1	9.1
1979	7.7	14.5	2.9	8.6	34.4	1.7	14.1	0.4	0.3	6.4	9.0
1980	8.4	14.7	3.0	8.4	34.7	1.7	13.2	0.5	0.3	6.3	8.9
1981	8.8	14.6	3.2	8.6	34.2	1.7	12.7	0.4	0.4	6.4	8.8
1982	9.2	15.1	3.3	8.7	33.9	1.9	11.7	0.4	0.4	6.5	8.9
1983	9.7	15.2	3.3	8.9	33.5	1.9	11.2	0.4	0.4	6.5	8.9
1984	10.3	15.2	3.3	9.3	32.6	1.8	11.1	0.4	0.4	6.5	9.1
1985	11.1	15.4	3.2	9.4	32.6	2.0	10.3	0.4	0.4	6.3	9.0
1986	11.6	15.4	3.2	9.5	32.6	1.9	10.1	0.3	0.4	6.3	8.9
1987	12.2	15.7	3.2	9.2	32.3	1.8	10.1	0.4	0.5	6.1	8.7
1988	12.9	15.5	3.2	9.4	31.6	1.9	9.9	0.4	0.5	5.9	9.0
1989	13.3	15.8	3.2	9.5	30.7	1.9	9.8	0.4	0.5	5.9	8.9
1990	13.1	16.2	3.4	9.8	30.7	1.8	9.4	0.4	0.5	5.9	8.9
1991	13.6	16.6	3.4	9.4	30.4	1.7	9.1	0.4	0.5	5.7	9.1
1992	13.4	17.2	3.8	9.0	31.1	1.6	8.6	0.4	0.6	5.7	8.6
1993	13.7	17.5	3.7	9.2	30.3	1.6	8.4	0.4	0.7	5.7	8.7
1994	14.6	17.8	3.5	9.5	29.2	1.8	8.5	0.4	0.6	5.6	8.5
1995	15.0	18.1	3.4	9.8	28.4	1.7	8.4	0.4	0.6	5.6	8.6

APPENDIX TABLE 5C (CONTINUED)

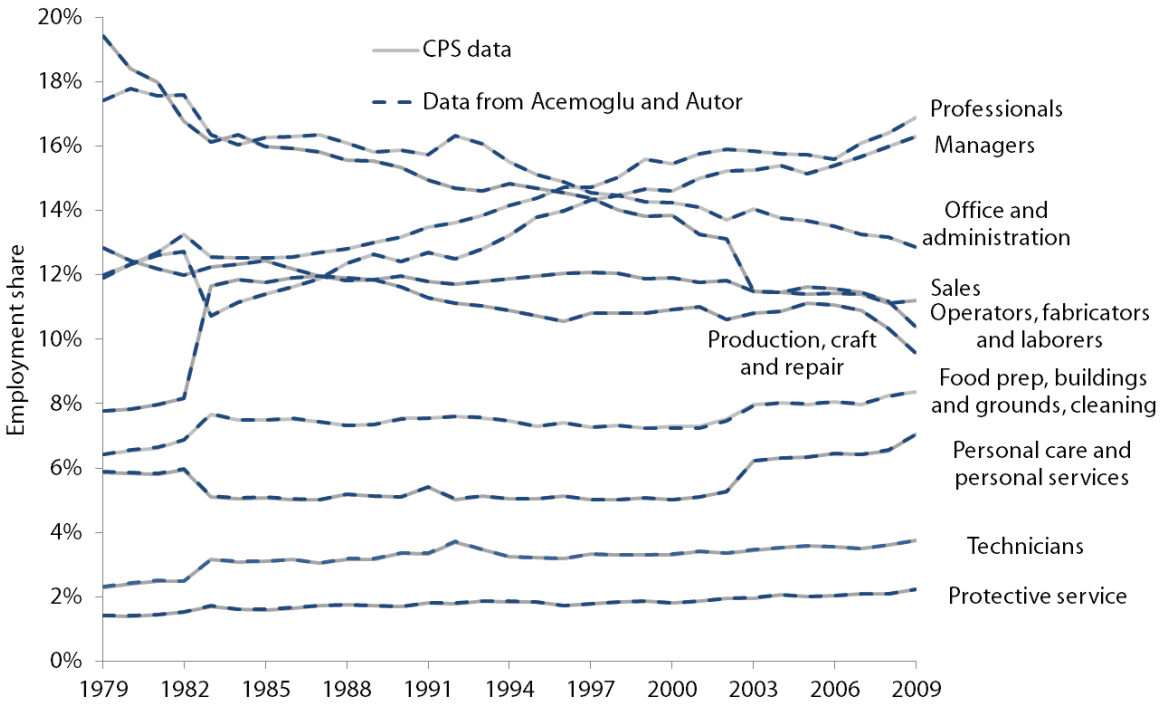
	High-wage			Middle-wage					Low-wage		
	Managers	Professionals	Technicians	Sales	Office and administration	Production, craft and repair	Operators, fabricators and laborers	Agriculture	Protective service	Food preparation, buildings and grounds, cleaning	Personal care and personal services
1996	15.4	18.5	3.4	9.8	27.9	1.7	8.2	0.4	0.6	5.4	8.6
1997	16.0	18.5	3.6	10.0	27.0	1.7	8.3	0.4	0.7	5.5	8.4
1998	16.2	18.6	3.6	10.1	26.8	1.6	8.0	0.4	0.7	5.5	8.5
1999	16.5	19.3	3.5	9.7	26.3	1.8	7.7	0.4	0.7	5.6	8.6
2000	16.6	19.3	3.5	9.7	26.3	1.8	7.7	0.4	0.7	5.6	8.4
2001	17.1	19.5	3.7	9.7	25.9	1.7	7.0	0.4	0.8	5.6	8.6
2002	17.4	20.1	3.6	9.5	25.3	1.6	6.6	0.5	0.8	5.6	8.9
2003	17.7	20.3	3.7	9.5	24.9	1.6	6.2	0.5	0.9	5.7	9.1
2004	17.9	20.2	3.8	9.6	24.5	1.6	6.0	0.5	1.0	5.8	9.3
2005	17.9	20.3	3.8	9.5	24.2	1.6	5.8	0.6	1.0	5.9	9.4
2006	17.9	20.4	3.9	9.5	23.9	1.7	5.7	0.5	1.0	5.9	9.6
2007	18.5	20.9	3.7	9.6	23.3	1.6	5.6	0.5	1.0	5.7	9.4
2008	18.8	21.3	3.8	9.3	23.1	1.4	5.3	0.5	1.0	5.8	9.6
2009	18.9	21.8	4.1	9.3	22.2	1.3	4.6	0.5	1.1	5.9	10.2
2010	18.6	22.3	4.1	9.2	22.2	1.4	4.7	0.5	1.1	5.9	10.0

Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata; data are hours weighted

APPENDIX FIGURE A

Replication of the occupation coding crosswalk

Occupation employment share comparison between Acemoglu and Autor (2011) and our data, 1979–2009



Source: Authors' analysis of Current Population Survey Outgoing Rotation Group microdata and Acemoglu/Autor data provided on David Autor's website among the files used to create Figure 12 for Acemoglu /Autor (2011), located here: http://economics.mit.edu/~dautor/hole-vol4/figs/fig-12-rev.zip