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Abstract: Based on detailed payroll data of blue collar male and female labor in Britain's engineering and metal working industrial sectors between the mid-1920s and mid-1960s, we provide empirical evidence in respect of several central themes in the piecework-timework wage literature. The period covers part of the heyday of pieceworking as well as the start of its post-war decline. We show the importance of relative piece rate flexibility during the Great Depression as well as during the build up to WWII and during the war itself. We account for the very significant decline in the differentials after the war. Labor market topics include piecework pay in respect of compensating differentials, labor heterogeneity, and the transaction costs of pricing piecework output.

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1 Introduction

From the late Nineteenth Century to the 1970s, incentive pay in the form of piece-rates comprised an essential part of core manufacturing production in Europe and North America (Pencavel, 1977). Focussing on British engineering and allied industries[1] between the 1920s and 1960s, this paper is concerned with cyclical and structural rises and falls of piecework-timework differentials. Over these five decades, two-thirds of skilled and semi-skilled blue-collar workers in engineering and metal working were paid piece rates.[2] The period covered part of the heyday of piece rates as a remuneration method as well as the start of the decline of the practice of piecework. It embraced three important sub-periods – the Great Depression, WWII, and post-war reconstruction - during which times economic forces acted significantly to raise or to depress the relative pay of pieceworkers compared to timeworkers. We attempt to account for the various ups and downs in the differentials.

It is well established in the literature that the hourly wages of pieceworkers are higher than those of timeworkers undertaking equivalent work. Through time, the differentials gap has varied considerably. It peaked in the early years of WWII for three primary reasons. First, favourable piece rates and other output-related bonuses were used by employers to incentivise productive war effort. Second, rewarding ability and work application helped firms retain their best workers in an intensly competitive wartime labor market for skilled labor. Third, a significant rise in the employment of more narrowly trained skilled female workers forced employers to break down traditional work practices into smaller component parts. The resulting clearer separation of skilled and semi-skilled

[1] Covering firms engaged in engineering, metal manufacturing, vehicle parts supply and assembly. Table 1 shows the range of industrial activities of member firms covered in our data.

[2] We know that this proportion of pieceworkers held also for Germany in these industrial sectors in the early 1930s (Hart and Roberts, 2013a).

job tasks enabled skilled workers to concentrate more intensively on high value added output. On either side of the war years, there were two distinctly different periods during which the differentials narrowed. Piece rates were cyclically more responsive than time rates to the Great Depression downturn due to their closer association with productive effort. In the immediate post-war decades employers systematically reduced the differentials as piece rates began to lose their comparative payments by results advantages. The main cause of this trend centred of the increasing costs of determining and negotiating piecework output prices and times.

Our British wages data are taken from detailed payroll statistics (wages and hours) of member firms of the industry's largest and most influential employers' association, the Engineering Employers' Federation (EEF). The EEF annual payroll statistics, collected in October of each year, offer an unrivalled insight over a considerable run of time into the pay and hours of pieceworkers and timeworkers by blue-collar occupations, geographical locations, and engineering sections. During our study period from 1926 to 1965, the EEF represented between 1800 and 5000 engineering and metal working firms employing between 260 thousand and 1120 thousand adult male manual workers and between 378 thousand and 1500 thousand workers when junior males and females are included (Wigham, 1973, Appendix J). The data include a unique coverage of skilled and semi-skilled female blue collar labor employed during the war years.[3]

[3] Table 1 contains details of the occupations, districts, and sections covered here. The data consist of cell means that differentiate employees by whether they are paid piece rates or time rates as well as by their occupation and their geographical work districts (largely travel-to-work areas). For a slightly shorter sub-period, 1930 to 1965, we also have wages and working hours by occupation within engineering sections. Section data are not available by district. A unique aspect of the data is that, for the years 1940-1942, we can separate female blue collar workers into their (official) categories of 'women doing men's work' (essentially skilled workers) and 'women doing women's work' (semi-skilled workers.

Section 2 contains background details of British engineering employment and wages over our study period. We present estimated piecework-timework hourly wage differentials in Section 3. The comparative cyclical behaviour of piecework and timework pay is examined in Section 4. We highlight in Section 5 the important associations between pieceworking and war production. Estimation is then carried out in Section 6 into the association between labor heterogeneity and wartime piecework-timework wage differentials. The significant post-war decline in the differentials is the subject of Section 7. Section 8 briefly concludes.

2 Employment, wages, and market conditions in British engineering, 1926 – 1965

For most of the Twentieth Century, engineering and metal goods formed the backbone of British manufacturing. Derived from various data sources, Figure 1 shows the total adult employment in the industry as a whole, including shipbuilding and repair[4]. From just over 2 million workers in 1933, there was an exponential increase in workforce size in the run-up to WW2 and during the early war years. Between 1939 and 1943, employment grew by 77%, reaching a peak of about 4.8 million workers. After the war, the industry had scaled down to 3.3 million workers by 1948 and then during the post war reconstruction period employment rose steadily, to reach 3.8 million in 1966.

In 1939 there was a serious labor shortage caused principally by a substantial increase in the demand for military-related products in the run-up to war combined with a loss of blue collar male workers who were volunteering for military service. In January 1939, skilled workers in the munitions factories were exempted from compulsory military call up but some had joined the services before this date while others voluntarily joined up

[4] Shipbuilding and repair is not a part of our EEF data. It is included here since it comprises an integral part of these more general source statistics.

(Inman, 1957, pp. 34/35). The solution was to recruit and train very large numbers of blue collar female workers. From Figure 2, we find that females accounted for 15% of total employment in 1938/9 and by 1943 they accounted for around 40%. At the end of the war there was a large-scale reduction in the female workforce. However, at about one-quarter of the total workforce in the post-war years, female employment in the industry remained considerably above its pre-war levels.

There were two types of blue-collar remuneration systems in the engineering industry, piece-rates and time-rates. This distinction was not completely clear-cut. Part of the earnings of pieceworkers consisted of flat rate payments while some supplementary pay elements of timeworkers' earnings were linked to output. In stark contrast to modern manufacturing pay practises, however, high proportions of male blue collar skilled and semi-skilled workers were paid piece rates. Figure 3 shows that between 1926 and 1965, the percentage of the EEF's total adult (over the age of 21) skilled and semi-skilled male pieceworkers remained above 55% of all workers, with a weighted average of 66%.

A typical timeworker's hourly earnings were comprised of an effective rate component, consisting of a basic hourly rate combined with a National Bonus, together with an overtime pay component and various supplementary payments. Supplementary payments comprised an increasingly important part of pay during the war and in the post-war years. There was an important national pay setting influence. Fitters and laborers basic time rates were agreed nationally and formed guidelines for pay relativities among other occupations. But engineering firms, sections, and districts were free to deviate from the occupational guidelines. Pieceworkers' hourly earnings also included a fixed basic element; they were guaranteed the equivalent timeworker's basic hourly rate and they were paid a slightly lower National Bonus. Additionally, pieceworkers were also paid overtime premium rates and special supplementary payments. Supplementary increments to pieceworkers' pay were especially high during the war period. However, in contrast to time work, a pieceworker's remuneration importantly depended on productive effort per unit of time, via agreed piece rates and time settings. Piece rates were determined in respect of a vast number of different products and processes. The EEF attempted to simplify matters through national agreements that established minimum percentage basic wage mark-ups above equivalent time rates that a pieceworker of average ability might be expected to attain. These were set at one-third of the appropriate basic time rate up to June, 1931 and one-quarter of this rate thereafter. Again, firms, sections, and districts were not bound to these agreed targets.

The market demand for British manufacturing products, and especially those of engineering and metal work products, was extremely volatile between 1926 and 1943. This contrasted with a 20 year immediate post-war period of relative stability, with steady growth in engineering and allied production. These wide differences in market experiences are exemplified in Figure 4 in terms of unemployment rates. The national unemployment rate is calculated as the numbers unemployed as a percentage of the civilian working population (Feinstein, 1972, Table 57). The mean district rate comprises an aggregation of local unemployment rates in the major engineering districts in our EEF data (see Table 1).[5] The Everest in the rates occurs in the early 1930s. They declined during the military build-up in the mid- to late 1930s, unemployment then plummeted virtually to zero during the war and only once exceeds 2% up to 1965. The fact that the Great Depression especially damaged manufacturing employment is illustrated in Figure 4 by the fact that the districts where the main engineering and related activity took place exhibited 1930s unemployment

[5] These district rates were originally extracted from the Local Unemployment index and from records provided by the Department of Employment and are made available in the data archive (see Acknowledgements). They cover all unemployed workers in the districts, not just engineering workers.

rates that were considerably higher than the national unemployment rates. In the post-war period, the EEF district rates and the national rates virtually coincided.

3 Piecework – timework hourly wage differentials, 1926-1965

We begin by investigating hourly wage differentials between pieceworkers and timeworkers over the period 1926 to 1965. Table 1 shows the EEF's blue collar occupations and their member firms' district locations.[6]

For occupation *j* in district *d* at time *t*, we have

$$(1)\ \ lnWP_{jdt} - lnWT_{jdt} \equiv lnRW_{jdt} = Z_{jdt}\theta_1 + e_{jdt}$$

$$(2)\ \ lnEP_{jdt} - lnET_{jdt} \equiv lnRE_{jdt} = Z_{jdt}\theta_2 + e_{jdt}$$

where *lnWP* (*lnWT*) denotes the log of the hourly basic wage of pieceworkers (timeworkers), *lnEP* (*lnET*) denotes the log of the hourly earnings of pieceworkers (timeworkers), *lnRW (lnRE)* is the log of the ratio of basic piece and time hourly wages *(earnings)*, and Z is a set of controls consisting of occupation, district and time dummies.

We are also able to estimate the wage differentials in respect of engineering sections as opposed to districts (see Table 1 for the list of sections). EEF section data cover the period 1930-1965.

Letting section be denoted by *s*, we have

$$(3)\ lnRW_{jst} = Z_{jst}\emptyset_1 + e_{jst}$$

$$(4)\ lnRE_{jst} = Z_{jst}\emptyset_2 + e_{jst}$$

[6] We do not have statistics for district-level data 1943-1947, 1949, 1950, 1957, and 1963; for section-level data we have no data for 1926-1929, 1943-47, 1949/50, 1957, 1963 and 1965.

where the Zs contain occupation, section, and time dummies.

Our district-based estimates are shown in Figure 5, based on the estimated time dummies in (1) and (2). They are plotted against the national unemployment rate. Reported estimates are weighted by the number of workers in each occupation/district/year cell. Equivalent section-based differentials from specifications (3) and (4), weighted by occupation/section/year numbers of workers, are shown in Figure 6. Between 1930 and 1965, both the shapes of the differentials through time and the closeness of the plots in respect of basic wages and earnings are very similar comparing district- and section- level outcomes. Over the entire period, from 1926 to 1965, the paths of the differentials display three distinctive features. First, the Great Depression cycle between 1927 and 1937 is marked by strong procyclicality in the differentials. Second, during the immediate run-up to war and the early war years the differentials display particularly steep rises. Third, the post-war period from 1948 to 1965 corresponds to a significant long-term narrowing of the differentials.

Over our entire periods, we see from Table 2 that the average piecework-timework differentials, for both basic hourly wages and hourly earnings, are about 14% based on our district-level data and 10% using the section-level data. In general, these estimates are in the ball park of those obtained in earlier studies. Pencavel (1977) finds a piecework premium of 7% based on 183 male punch press pieceworkers and timeworkers in Chicago. Seiler (1984) obtains a 14% premium for U.S. Footwear and Boys' suits and coats manufacture covering 100 thousand workers in 500 firms. In a study of 3000 workers in the Safelight Glass Corporation, Lazear (2000) estimates that a move to piece rates improves a worker's pay by about 10%.

The narrowing of the differentials in the post-war period is very marked. Between 1926 and 1942, the two data sets average differentials lay between 14% and 16% while in the latter period from 1948 to 1965 they average between 7% and 11%. Based on our district (section) hourly earnings data, the differential dropped from 19% (19%) in 1942 to 13% (10%) in 1948 to 8% (5%) in 1965/64.

We take a closer look at the relative wage differentials during Great Depression, war, and post-war phases in the following sections.

4 Wage differentials and market volatility

In the short run pieceworkers' pay is more dependent on hourly productive effort than timeworkers' pay. One argument supporting positive piecework-timework wage differentials is that a wage premium is paid to pieceworkers as a compensating differential for greater expected wage instability. This may result, for example, from exogenous fluctuations in the state of market demand. Exceptional falls in product demand as experienced in the Great Depression would have resulted in exogenously induced reductions in the levels of required work intensity for many pieceworkers and, hence, in greater falls in hourly wages relative to timeworkers. Reverse relative wage movements would be expected in the recovery period.

Using the national unemployment rate to represent the state of the business cycle, we investigate relative wage responses for the period 1926 to 1939.[7] Estimates are based on blue-collar occupations available up to 1942 together with our full set of districts (see Table 1). Estimating equations are given by

$$(5)\ \Delta lnRW_{jdt} = a_0 + a_1\Delta U_t + a_2 Year_t + Z_{jdt}\psi_1 + \Delta e_{jdt}$$

$$(6)\ \Delta lnRE_{jdt} = b_0 + b_1\Delta U_t + b_2 Year_t + Z_{jdt}\psi_2 + \Delta e_{jdt}$$

[7] Using data from the 1940s involves a significant reduction in occupational detail. Data availability is maximised for the periods covered in this section.

where annual changes in the wage and earnings differentials are regressed on the change in the unemployment rate (ΔU_t) an annual time trend ($Year_t$) and where Z contains occupation and district dummies. Estimates $\hat{a}_1$ and $\hat{b}_1$ are semi-elasticities and obtained after clustering at the year level. Reported estimates are weighted by (i) the number of total piecework and timeworkers in each occupation/district/year/cell (changes in differentials as dependent variable), and (ii) number of pieceworkers or timeworkers in each occupation/district/year cell (where respective chnages in real wages are incoporated as dependent variable).

For a sub-set of our engineering districts (shown in Table 1) we have matching unemployment rates for the period 1926-1938, constructed to match the travel to work district areas. These cover over 80% of the workforce in our full district samples. So, we are able to estimate semi-elasticities controlling for local labor market experience. These alternative estimating equations are given by

(7) $\Delta lnRW_{jdt} = c_0 + d_1 \Delta U_{dt} + Z_{jdt}\psi_1 + \Delta e_{jdt}$

(8) $\Delta lnRE_{jdt} = c_0 + d_1 \Delta U_{dt} + Z_{jdt}\psi_2 + \Delta e_{jdt}$

where ΔU_{dt} is the district-level unemployment rate and where, as well as occupation and district dummies, Z additionally includes time dummies. Since we have observations on up to 13 separate occupations per district over the period 1926 to 1939 (see Table 1), estimates $\hat{d}_1$ and $\hat{d}_1$ are obtained after clustering at the district/year level. We use the same regression weights as in equations (5) and (6).

Results in respect of national and district unemployment rates are reported in Table 3. The wage differentials vary procyclically. Estimated semi-elasticities indicate that a one point increase in the national (district) rate of unemployment is associated with a significant 0.5% (0.4%) narrowing of the hourly basic wage differential. Using hourly earnings, the respective reduction is 0.4% (0.3%). We also estimate equations (5) to (8) replacing the wages differentials with separate hourly real pay of pieceworkers and timeworkers. We find in Table 3 results that, especially in the case of real earnings, the pay of pieceworkers is significantly more procyclical than that of timeworkers. This finding is consistent with the compensating differentials explanation of positive wage differentials in favour of piecework (see also Hart and Roberts, 2013a and b).

5 Labor heterogeneity, monitoring costs, output pricing in wartime production

A rise in labor heterogeneity increases the incentive for employers to reward workers by ability. In particular, it reduces the probability of losing the most able workers to competing firms. It follows that, in tightening labor markets, a rising value of the alternative wage, increases the value of piece rates relative to time rates. However, switching from a time-rated to a piece-rated remuneration system involves an increased cost of monitoring productive performance per period of time. *Ceteris paribus,* the lower the value of monitoring cost then the more inclined is the firm to use piece rates (Brown, 1990). Paying piece rates also involves costs of pricing output. The lower the cost of pricing units of output the more inclined is the firm to use piece rates. The labor market in British engineering during WWII linked strongly to each of these contributory factors in favor of piece rate pay.

(a) Heterogeneous ability, deskilling, and monitoring costs

By 1940, there was an acute shortage of skilled labor in British engineering combined with an urgent need to supply wartime equipment.[8] The only solution was the recruitment and training of female employees on a massive scale (see Figure 2). As shown in Table 4, the proportion of females to total workers almost doubled between 1940 and

[8] The general aim was to produce equipment that could actively be used within 3 months.

1942, from 31% of total employment to 59%. In large sections especially geared to war production – like aircraft manufacture, heavy engineering, and light engineering – the rates of increase were higher still.

Starting with an agreement between the EEF and the Amalgamated Engineering Union in May 1940, employer-union so-called dilution agreements enabled women to undertake skilled job tasks that traditionally had been the sole preserve of men who had served 5 to 7 year craft apprenticeships. Such recruits were officially labeled 'women doing men's work'. Women allocated to skilled jobs were given 32-week training schedules.[9] From Table 4 we see that women doing men's work comprised about 12% of the EEF workforce by 1942, and about 20% of all women workers. They were an especially important part of large wartime-oriented sections of aircraft manufacture and heavy general engineering. Additionally, the agreements allowed for the employment of 'women doing women's work'. These consisted largely of semi-skilled women employed in work places for the first time but who were known to be undertaking tasks that were performed by women in other engineering workshops.

The large scale recruitment of women into the engineering industry represented the most important part of a general production and labor market process universally referred to as 'dilution'. Women became very adept and undertaking skilled work but many had to focus on narrower ranges of skilled tasks compared to fully- apprenticed male counterparts. As pointed out by Douie (1950), where a women was substituted for a skilled man, *"though she might be doing the whole of the skilled job required for the operation on which she was engaged, she might not have acquired the whole range of knowledge of different processes by the man she*

[9] Over the training period women were paid less than the equivalent male rates and then equal pay applied. The government played an important part in persuading engineering employers and unions to accept equal pay to men for women undertaking men's work. In practice, however, the attainment of equal pay proved to be difficult in many cases largely due the fact that the distinction between men's and women's work often proved difficult to establish (see Inman, 1957).

replaced". For this sort of reason, it became important to break down traditional pre-war skilled male job descriptions so into separate skilled and semi-skilled task requirements. This provided two advantages. First, it narrowed the task requirements of female workers who generally had less training and work experience than their male counterparts. Second, it provided better matches between skill levels and task requirements. The whole process was aided and abetted by a war-induced acceleration in mechanized production methods (Parker, 1981). Douie (1950) itemizes a comprehensive range of jobs undertaken by women in general engineering, munitions production, aircraft manufacture, and heavy iron and steel.[10] While these often involved highly skilled operations, most tasks were repeated over and over again.

Sheet metal working provided a prime example of the dilution process (Inman, 1957, pp.60/1). This was a vital wartime production activity involving the engineering of thinner varieties of metal plate. It had essential applications in aircraft and vehicle manufacture. A sheet metal worker cuts out, bends, and beats metal into shape (panel beating) and also laps, rivets and solders joints. These are skilled tasks requiring on the job experience and know-how. Both during and immediately before the war, technical changes facilitated elements of de-skilling. Traditional skilled manual processes involving hand and bench tools were increasingly replaced by power presses and automatic tools which could be operated by less skilled labor. Where traditional skilled work was retained – for example, in the use of free hand methods of shaping metals – associated operations, like drilling and riveting, could be carried out by semi-skilled operatives. Those engaged in pressing, drilling and riveting performed relatively narrow and repetitive tasks.

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[10] Including operating capstan lathes, turret lathes, and capstan milling machines, riveting, coil winding, tool making, oxy-acetylene and electric welding (general engineering); shell and cartridge production (munitions); steel smelting and iron puddling, crane operation, circular plate burning, performing tasks of skilled turners (iron and steel); assembling, riveting, fitting, metal cutting, reconditioning (aircraft).

(b) The alternative wage

The better are the opportunities in outside employment, the greater are the losses incurred by the firm in failing to sort and remunerate workers by value added. Acute skilled labor shortages in engineering during the war produced intense competition for scarce labor resources.

"In any district firms could attract labour from other factories by adjustments in piece rates, the offer of merit bonuses or of overtime. As skilled labour grew scarcer and the number of new factories increased, poaching became steadily worse…..Firms spent hundreds of pounds advertising for skilled workers while those already in their employment sometimes left as fast as new men were recruited. Labour costs increased out of all proportion to increases in output; indeed long hours, high labour turnover and high piece rates tended to bring individual output down." (Inman, 1957, p.26).

In other words, the value of the alternative wage grew relative to the value of output in the current firm. Therefore, firms perceived the advantage of offsetting higher job quit probabilities among their most productive workers by directly rewarding individual value added. [11]

(c) Output pricing

Higher costs involved with the pricing of individual output tend to reduce firms' propensities to adopt piece rates. In the case of the costs of output pricing, two countervailing forces acted on the use of piecework during the war years. Fama's 'menu of tasks scenario' provides useful background.

"The worker and the principal agree on a menu of generic tasks for the worker, but actual tasks are always somewhat novel. There is usually uncertainty about the mix of tasks for a given

[11] Another argument involving the outside wage concerns employee shirking and is, incidentally, also relevant to the high demand for engineering products during the war period. The effectiveness of the sanctions available in the case of timeworkers is inversely related to the degree of labor market tightness. Threat of dismissal in the event of shirking, for example, has potentially little impact if the alternative opportunities are large. Under these circumstances, Macleod and Malcomson (1989) show that the employer will tend to switch to piecework contracts as a means of worker motivation.

period, and the unit values of tasks to the principal change with changes in the demand for different tasks and with changes in the novel outputs from specific tasks. ….When the values of tasks change through time, piecework contracts are likely to be costly to write and enforce. Frequent renegotiation of piece rates will be needed to align the values of tasks to the worker with their values to the firm." (Fama, 1991, p. 35)

In two directions, labor dilution reduced the cost of valuing job tasks. First, the requirement that skilled workers concentrate on more narrowly defined sets of high skill job tasks facilitated less costly monitoring of worker performance. Further, fewer job tasks per job specification meant that there was less scope for mixing and varying task sequences. Second, increased mechanisation reduced the demand for traditional skills – like free hand methods in shaping metal by sheet metal workers – and thereby narrowed the scope for individual initiative in task executions.

However, in another important direction, engineering output expansion during the war increased the cost of valuing job tasks. The escalation in war production created increased pressures to re-assess piece rates and job execution times in order to achieve efficient pricing. In fact, the industry tended to offset the associated costs by adopting less efficient rate setting. Knowles and Robertson (1951a) use the term, 'tight' piece rates, to describe long periods of product price stability in which 'equilibrium' piece rates can be determined and administered. By contrast, these authors argue that 'loose' piece rates prevailed in wartime engineering because rapid price fluctuations brought about by war demand precluded full assessments of appropriate relative prices.

6 Wage differentials and labor heterogeneity

An overarching consideration in the distinction between piecework and timework is the degree of labor heterogeneity. If workers were equally productive then firms would have no incentive to introduce piece rate systems since, *ceteris paribus*, unit labor costs of pieceworkers would be higher than those of timeworkers due to higher monitoring costs (Lazear, 1986). The need in WWII to employ significant numbers of skilled female workers – officially referred to as women doing men's work - into jobs in which men had previously held a monopoly increased labor heterogeneity to a degree only previously experienced during WWI. By contrast, there was a long pre-war tradition of women undertaking semi-skilled engineering work and so increased numbers during WWII did not necessarily signify a major increase in labor heterogeneity.

For any given engineering section, let the variable *PFM* denote the proportion of women doing men's work to total adult workers (i.e. males and females). Sections in which *PFM* was high tended to identify narrower ranges of skilled job tasks and also to demarcate more carefully between skilled and unskilled task requirements. This would have allowed the more able skilled male workers to undertake piecework that was concentrated more intensively on high value output. Thus, we hypothesise that *PFM* would be expected to associate positively with male piecework-timework wage differentials.

Evidently, the rapid growth of skilled blue collar female workers, from almost zero to 12% of the entire workforce in the space of 3 years, constituted an impressive change in workforce composition. However, as apparent from Table 4, most sections employed considerably larger numbers of semi-skilled women, so-called women doing women's work. Did the general relative increase in female employment – from 31% of the EEF adult workforce in 1940 to 59% in 1942 - have implications for male piecework-timework wage differentials? The growing 'voice' of women in the engineering industry succeeded in improving the extremely low minimum time rates of semi-skilled women.[12] However, while

[12] Inman (1957, pp. 356/7) reports on the minimum basic time rates of women doing women's work from October 1939 to August 1944. In May 1940, the women's rate for a standard workweek was 61% of that for male laborer's time rate, 35 shillings compared to 57 shillings. By August 1944 the women's rate was 74% of the male laborers' rate (56 shillings compared to 75.5 shillings).

engineering unions supported women's claims at the outset of the dilution period, they also sought to protect male time rate differentials. So, the pressure by women to improve rates of pay also benefited the pay of less-skilled time-rated male workers. At section level, the proportion of females in total employment, *PF*, is a good proxy for the strength of women's voice and likely to correlate negatively with the male piecework-timework wage differentials.

Incorporating *PFM* to proxy the degree of labor heterogeneity and *PF* to proxy labor supply pressure on low skilled time rates, we estimate regressions based on the EEF's 1940-1942 section data that reports on numbers of women doing men's and women's work. The male occupations and sections for which we have complete information during these three years are reported in Table 5. We note from Table 4 that all the major sections employing high proportions of women skilled and semi-skilled workers – e.g. aircraft manufacture, heavy and light engineering, and electrical engineering – are included in this coverage. These sections were vital to war production.

Anticipating findings, there are virtually no differences in regression outcomes between male hourly wage rate or hourly wage earnings differentials and so we concentrate attention on the latter. Our section-level regression specification for adult males for occupation *j* in section *s* at time *t* for the period 1940 to 1942 is given by

$$(9)\quad lnRE_{jst} = c_0 + c_1 PFM_{st} + c_2 PF_{st} + Z_{jst}\phi + e_{jst}$$

where *Z* contains occupation dummies, section dummies, and time dummies. We also estimate equation (9) by replacing the differential hourly earnings expression with the separate real hourly earnings of male pieceworkers and male timeworkers. Since our female variables are measured at section level while the earnings differentials refer to males by occupations within sections, estimates $\hat{c}_1$ and $\hat{c}_2$ are obtained after clustering at the section/year level. Reported estimates are weighted by the number of workers in each section. Results are shown in Table 5.

Higher sectional proportions of women doing men's work, represented by the variable *PFM*, are found to be strongly associated with larger piecework-timework hourly wage differentials among male workers. Due to much shorter periods of training and a lack of relevant work experience, the employment of skilled female workers necessitated reorganizations of working practices. This in turn improved the returns to piecework because skilled men and women could concentrate their work effort on better demarcated high-value skilled tasks. When we separate piecework and timework real hourly earnings, we find that *PFM* is significantly negative in the two regressions, although significantly less so for pieceworkers. While nominal wage increases among pieceworkers greatly exceeded those of timeworkers, real wages of both groups declined due to high price inflation in the early war years. The resulting dip in average real earnings is shown in Figure 6. The annual percentage change in the consumer price index between 1938 and 1939 was 6.3%, rising to 16.6% between 1939 and 1940, before falling back to 10.8% in 1940-41, and 7.2% in 1941-42 (Feinstein, 1972, Table 61). The producer price index follows a very similar pattern.

The large majority of newly hired women in 1940 onwards were employed, in line with the existing blue-collar female workforce at the start of the war, in semi-skilled jobs. They were supported by both government and unions in their increasing demands for higher rates of pay. However, unions were also keen to preserve wage differentials among comparable lower-skilled males. From Table 5, we find that *PF*, the proportion of females within total sectional employment is significantly negatively associated with male piecework-timework hourly earnings differentials. Basic time rates of both males and females rose due largely to the increased pressure from the surge in female employment and their protest at the extremely low pre-war rates. Separating piecework and timework real hourly earnings reveals the *PF* had no impact on the former but were significantly positively related to the latter.

7 Piece rate pricing and the narrowing of the differentials

Why did the piecework-timework wage differentials narrow so appreciably in the post-war years? Two explanations involve issues highlighted in previous sections. In the first place, the market volatility that typified the period from 1929 to 1942 was succeeded by two post-war decades of relative stability coupled with strong growth in the real hourly earnings of both pieceworkers and timeworkers (see Figure 7). The national unemployment rate between 1946 and 1965 exceeded 2% in only 1 year (1963 = 2.1%, see Figure 4). The argument that pieceworkers require to be compensated for expected relatively high variations in wage income became less and less potent. Second, labor dilution reduced in the post-war period. From Figure 2 we see that, from a peak of around 40% 1942, the share of females in total employment had reduced to around 25% by 1965. To the extent that an increase in the proportion of male workers – aided and abetted by men returning from war service – reduced blue collar labor heterogeneity may have exerted a degree of downward pressure on the differentials. However, this probably had a limited impact. Labor dilution agreements between engineering employers and engineering unions lasted well beyond WWII (Inman, 1957, p. 367). Moreover, it is unlikely that production changes resulting from labor dilution – such as the breaking down of processes into smaller and more coherent task components – would have been discontinued if efficiency improvements had resulted.

Without doubt, other factors played important roles. These are usefully separated into short-term and long-term.

In the short run, the transition from wartime to peacetime production served to narrow the earnings differentials (Knowles and Robertson, 1951b). First, unlike timework, piecework pay is importantly determined by productive effort per unit of time. The scale and urgency of war production, combined with a patriotic zeal within the workforce, gave rise to exceptional piecework effort and this was almost certainly not sustained in the period of post-war reconstruction. Second, positive wartime earnings drift in piecework resulted from loose pricing of piece rates due to employers' inability to assess fully relative prices in the face of frenetic wartime demand. A tightening of price-setting during the relative calm of the post-war years would have served to rein back this rate inflation. Third, pieceworkers' productive efficiency is conditioned by the length of production runs of given products. The transition from wartime to peacetime production would have involved falls in returns to effort for many workers due to unfamiliarity with new products and their related job task re-specifications. As summarized by Knowles and Hill (1954, p 293):
"..skilled pieceworkers, who had been asked for maximum production at virtually any price and benefited disproportionately from the long wartime runs, suffered the most when the conversion to peacetime needs entailed extensive recalculations of piecework prices and times."

But, as is clear from Figures 5 and 6, the differentials continued to narrow well beyond the end-of-war transition phase. There were two key and interrelated drivers behind this trend: continual technological advances combined with employers' concerns that piece rates were rising too strongly relative to comparable time rates.[13] For given piece rates, technical improvements increase worker productivity and hence hourly earnings.[14]

[13] The collective bargaining need to avoid excessive drift of piece rates away from time rates was not only a concern within national negotiations but also at district and firm-levels. In the case of within-firm differentials, significant numbers of firms employed both pieceworkers and timeworkers within the same occupation. Based on EEF data in respect of 2555 EEF companies in 1952, Hill and Knowles (1956) find that 23% employed both piece- and time-rated fitters.

[14] A complicating factor is that technology improvements occured unevenly across engineering occupations and sections.

Evaluating piecework remuneration required constant changes in output pricing. The associated costs of evaluating and negotiating new rates involved issues similar to those considered by Coase (1937) concerning the implications of transaction costs of market exchange (Helper, Kleiner, and Wang, 2010). In Coase, an advantage of firm-level production is that entrepreneurs can organize internal factors of production so as to reduce transaction costs compared to those associated with a full recourse to market transactions. Engineering employers sought to limit the number of piece rate and time revisions thereby alleviating associated costs of rate determination and negotiation. For given improvements in technology, as the marginal costs associated with setting piece-rates exceeded the marginal productive returns, it became attractive to simplify remuneration decisions. With industrial relations concerns to the fore, this turned out to be the somewhat crude expediency of paying pieceworkers and timeworkers equal money wage increments (Knowles and Hill, 1954). This served considerably to narrow hourly earnings differentials because pieceworkers' percentage increases were smaller than their timeworker equivalents. Figure 7 illustrates the far tighter correspondence between average hourly wage differentials in the post-war years compared to the earlier periods.

By 1965, the wage differentials had reduced to one half or less of their 1926-1942 average (see Table 2). The increasing recourse by employers to equalise wage increases of pieceworkers and timeworkers was perhaps symptomatic of an increased blurring in the distinction between the two pay groups. One pointer to this was a very significant wartime and post-war growth of supplementary payments. This is illustrated in Table 6 in the case of EEF fitters' earnings between 1926 and 1953. Such payments were set outside of national agreements and consisted of various types of compensating differentials for adverse working conditions as well as incentive payments, bonuses, and merit awards. Unsurprisingly, pieceworkers gained relatively from these payments during the war when incentives to produce maximum output-related effort were to the fore. However, from a peak representing 47% of standard weekly earnings in 1942, pieceworkers' supplementary payments had fallen back to 39% in 1953. The timeworkers' equivalent 1942 figure was considerably lower, at 25%, but this had increased to 33% by 1953. Timeworkers' productive effort was increasingly incentivized. One supplementary payment, the compensatory bonus, only applied to timeworkers. This rewarded workers whose work was deemed to be worth more than typical time rates but who were not entitled to payments by results.

Merit rates, another type of supplementary payment, perhaps most clearly signalled the future trend not only of piecework-timework earnings differentials but also in the incidence of piece work itself. They were used to reward both individual and group performances (Knowles and Hill, 1954). At an individual level, merit awards were applied in recognition of the quality of work performance as it related to ability, special aptitudes, work experience, time keeping, and length of tenure. At group level, awards reflected levels of skill and work quality realised within departments or workshops of the firm. Combining improvements in technology with the special need to reward individual and team quality of output were not altogether conducive to piece work (Helper, Kleiner, and Wang, 2010). Advances in precision and automated technologies enhance potential product quality and product variety. Where the attainment of product quality involves both observable task execution combined with harder to observe initiatives for process innovations – such as suggestions for improved task executions - then advantages of piece rates relative to fixed wages are not so apparent (Holmstrom and Milgrom, 1991). Enhanced product variety involves associated increases in the costs of piece rate pricing and associated negotiation. Output depending on interactive inputs among work groups is difficult to monitor and reward on an individual basis.

8 Concluding remarks

Recent decades have witnessed a decline in piece rate remuneration in manufacturing industry in both Europe and North America. Contributory factors include changes in production techniques such as just-in-time systems, the increased cost of piece rate setting amid technologies that permit quite rapid changes in product varieties and designs, and a stronger emphasis on jobs involving both observable and non-observable work inputs. Our post-war observations of systematic declines in piecework-timework wage differentials in the British engineering industry during the first two post-war decades reflected several of these types of influence and signalled the eventual decline of piecework itself. Yet, the recent period of economic history covered here serves to remind us that piecework played two important roles during times of extreme economic crisis. First, and in contrast to the prevailing Keynesian view of downward real hourly wage stickiness, piecework offered a degree of short-run hourly procyclical pay adjustment. At the margin, this would have helped to preserve engineering jobs during the Great Depression. Such adjustment was especially noticeable in the modern manufacturing firms of the southern and midland districts of Britain, such as aircraft and vehicle manufacture (Hart and Roberts, 2013b). Second, a piece rate system that rewarded productive effort was best suited to meet the intense and urgent pressures of demand in war supply industries during the build up to, and execution of, a major military conflict.

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Table 1 EEF industries, occupations, sections, and districts

Industrial activities of EEF member firms (Ministry of Labour classifications)	Heating and Ventilation Apparatus; Scientific & Photography; Motor Vehicles, Cycles & Aircraft; Metal; Industries not separately specified; Constructional Engineering; Iron & Steel Tubes; Stove, Grate, Pipe etc. & general Iron Founding; Explosives; Hand Tools, Cutlery, Saws, Files; Marine Engineering; Brass, Copper, Zinc, Tin, Lead etc.; General Engineering; Brass and Allied Metal Wares; Watches, Clocks, Plate, Jewellery etc.; Wire, Wire Netting, Wire Ropes; Steel Melting & Iron Puddling, Iron & Steel Rolling and Forging; Bolts, Nuts, Screws, Rivets, Nails etc.; Tin Plate; Carriages , carts etc.
Occupations[1]	**Fitters (skilled)**; **Fitters (other than skilled)**; **Toolroom fitters**; **Turners**; **Patternmakers**; **Moulders(loose pattern)**; **Platers, riveters and caulkers**; **Sheet metal workers; Coppersmiths**; Turners and machinemen (at or above fitter's rates); Turners and machinemen (below fitter's rates); **Machinemen (at or above fitter's rates)**; **Machinemen (below fitter's rates)**; Machine moulders (at or above fitter's rates); Machine moulders (below fitter's rates);Moulding machine operators; **Fitters**; Fitters skilled (not toolroom or other);Toolroom fitters & turners; Skilled maintenance electricians; Skilled maintenance fitters; Other skilled maintenance; Maintenance men; **Moulders**
Engineering Sections	Agricultural engineers; Aircraft manufacturers; Allied trades; Boilermakers; Brassfounders; Construction engineers; Coppersmiths; Drop forgers; Electrical engineers; Founders; Gas meter makers; General engineers (Heavy); General engineers (Light); Instrument makers; Lamp manufacturers; Lift manufacturers; Locomotive manufacturers; Machine tool makers; Marine engineers; Motors: cars, cycles; Motors: commercial; Scale, beam etc. makers; Sheet metal workers; Tank and gasholder makers; Telephone manufacturers; Textile machinery makers; Vehicle builders; Miscellaneous; Plastic moulders; Iron castings; Non-ferrous castings; Other metal manufacturing; Engineers' small tools; Mechanical handling equipment; Industrial plant steel workings; Other mechanical engineering; Scientific etc./ watches; Radio & telephone apparatus; Domestic electrical appliances; Other electrical goods; Motor vehicle manufacturing; Motors & pedal cycles; Metal goods n.e.s.
Engineering Districts[2]	**Aberdeen**; **Bedford**; Belfast Marine; **Birmingham**; **Blackburn**; **Bolton**; Border Counties; Bradford; **Burnley**; **Burton**; Cambridge; Chester; **Coventry**; **Derby**; Doncaster; Dublin; **Dundee**; East Anglia; East Scotland; Grantham; **Halifax**; Heavy Woollen; Huddersfield; **Hull**; Keighley; Kilmarnock; Leeds; **Leicester**; **Lincoln**; **Liverpool; London; Manchester; North East Coast; Northern Ireland; North Staffs**; **North West Scotland; Nottingham; Oldham**; Otley; Outer London; Peterborough; **Preston; Rochdale; St Helens; Sheffield**; Shropshire; South Wales; **West of England**; Wakefield; **Wigan**.

Note: 1 **Bold** denotes occupations classified in the period up to 1942.

2 **Bold** denotes districts for which we have matching unemployment rates.

Table 2 Male piecework-timework hourly wage differentials, 1926 - 1965

Time period	Districts % differentials		Time period	Sections % differentials	
	Basic hourly wages	Hourly earnings		Basic hourly wages	Hourly earnings
1926-65	13.7	13.8	**1926-64**	9.9	10.3
1926-42	16.5	16.4	**1934-42**	14.4	14.4
1948-65	10.2	10.7	**1948-64**	6.7	7.2
1965	8.4	8.0	**1964**	4.3	5.1

Table 3 Piecework-timework hourly wages and district unemployment rates: adult males by occupations and districts

Dependent Variable	$\Delta lnRW$	$\Delta lnWP$	$\Delta lnWT$	$\Delta lnRE$	$\Delta lnEP$	$\Delta lnET$
	1927-1939 (national unemployment rate)					
Semi-elasticities (ΔU)	-0.5000** (0.1778)	-0.2265* (0.0942)	0.2492 (0.2589)	-0.4054* (0.2265)	-0.4453** (0.1020)	-0.0550 (0.3083)
Occupation dummies[a], district dummies[b], and time trend	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2506	2506	2506	2506	2506	2506
	1927-1938 (district unemployment rates)					
Semi-elasticities (ΔU_r)	-0.2027* (0.0949)	-0.2980* (0.0818)	-0.0430 (0.0355)	-0.1624* (0.0824)	-0.3248** (0.0746)	-0.0996** (0.0313)
Occupation dummies[a], district dummies[c], and time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1637	1637	1637	1637	1637	1637

OLS estimates are obtained after weighted by numbers of workers represented in each cell. Robust standard errors in brackets with ** (*) indicating 0.01(0.05) significance on two-tail test. Final output price deflator using national unemployment rate is obtained from Feinstein (1972, Table 61). Price deflation using district and unemployment dummies in second set of regressions. Standard errors are obtained after clustering at the year level (national unemployment) and at district/year level (district unemployment).

Table 4 Proportions of women workers in engineering sections, 1940-1942

		Proportion women doing men's work to all workers			Proportion women to all workers			Proportion women doing men's work to all women workers		
Sections	**Section weights, in 1942**	**1940**	**1941**	**1942**	**1940**	**1941**	**1942**	**1940**	**1941**	**1942**
Agricultural Engineering	0.01	0.0173	0.0599	0.2205	0.1034	0.2161	0.4396	0.1673	0.2773	0.5015
Aircraft Manufacture	0.25	0.0142	0.0982	0.1329	0.3064	0.5522	0.6803	0.0464	0.1778	0.1954
Motors (commercial)	0.03	0.0659	0.2317	0.3094	0.1032	0.2837	0.4744	0.6386	0.8165	0.6523
Construction Engineering	0.01	0.0217	0.1116	0.2978	0.0279	0.2089	0.4958	0.7778	0.5341	0.6007
Copper	0.003	0.0081	0.2543	0.3317	0.0121	0.3252	0.4880	0.6667	0.7820	0.6798
Electrical Engineering	0.12	0.0017	0.0112	0.0260	0.6050	0.6938	0.7428	0.0028	0.0161	0.0350
Founders	0.03	0.0044	0.0746	0.1380	0.1656	0.3608	0.4763	0.0268	0.2067	0.2896
General Engineering (heavy)	0.12	0.0140	0.0946	0.1981	0.1604	0.2991	0.4571	0.0870	0.3164	0.4333
General Engineering (light)	0.20	0.0159	0.0356	0.1088	0.2835	0.4055	0.5446	0.0563	0.0877	0.1998
Gas Meter Makers	0.005	0.0133	0.0293	0.1515	0.2869	0.4938	0.5827	0.0462	0.0594	0.2600
Instrument Makers	0.03	0.0001	0.0208	0.0168	0.5509	0.7063	0.7455	0.0003	0.0295	0.0225
Marine Engineering	0.03	0.0294	0.0715	0.1852	0.0322	0.0831	0.2041	0.9148	0.8613	0.9073
Motors, Cars, Cycles etc.	0.12	0.0007	0.0360	0.0407	0.4106	0.4954	0.6356	0.0018	0.0727	0.0640
Tank and Gasholder Makers	0.002	0.0000	0.0418	0.2758	0.0355	0.2965	0.4232	0.0000	0.1408	0.6518
Textile Machinery Makers	0.04	0.0086	0.0382	0.0711	0.1315	0.3003	0.5384	0.0653	0.1272	0.1320
Total (weighted averages)	1.00	0.0121	0.0622	0.1162	0.3100	0.4628	0.5944	0.0390	0.1344	0.1955

Table 5 Piecework-timework hourly wartime hourly earnings: adult males by occupations and sections

Dependent Variable	*lnRE*	*lnEP*	*lnET*
	1940-1942: occupations[a] and sections[b]		
Proportion of Women Doing Men's Work in Section Adult Employment (*PFM*)	0.3228** (0.1042)	-0.1877** (0.0543)	-0.5106** (0.0500)
Proportion of Women in Section Adult Employment (*PF*)	-0.2331** (0.0774)	0.0090 (0.0991)	0.2421** (0.0218)
Occupation dummies, section dummies, and time dummies	Yes	Yes	Yes
Observations	179	179	179

Robust standard errors in brackets with ** (*) indicating 0.01(0.05) significance on two-tail test. Final output price deflator is obtained from Feinstein (1972, Table 61).

a. Moulders (loose pattern); Sheet Metal Workers; Turners and Machinemen (at or above fitters' rates); Turners and Machinemen (below fitters' rates).

b. Agricultural engineering; Aircraft manufacture; Construction engineering; Copper; Electrical engineering; Founders; Gas meter makers; General engineering (heavy); General engineering (light); Instrument makers; Marine engineering; Motors: cars, cycles etc.; Motors (commercial); Tank and gasholder makers; Textile machinery makers.

Table 6 Supplementary payments as percentages of fitters' earnings for a standard workweek, 1926-1953

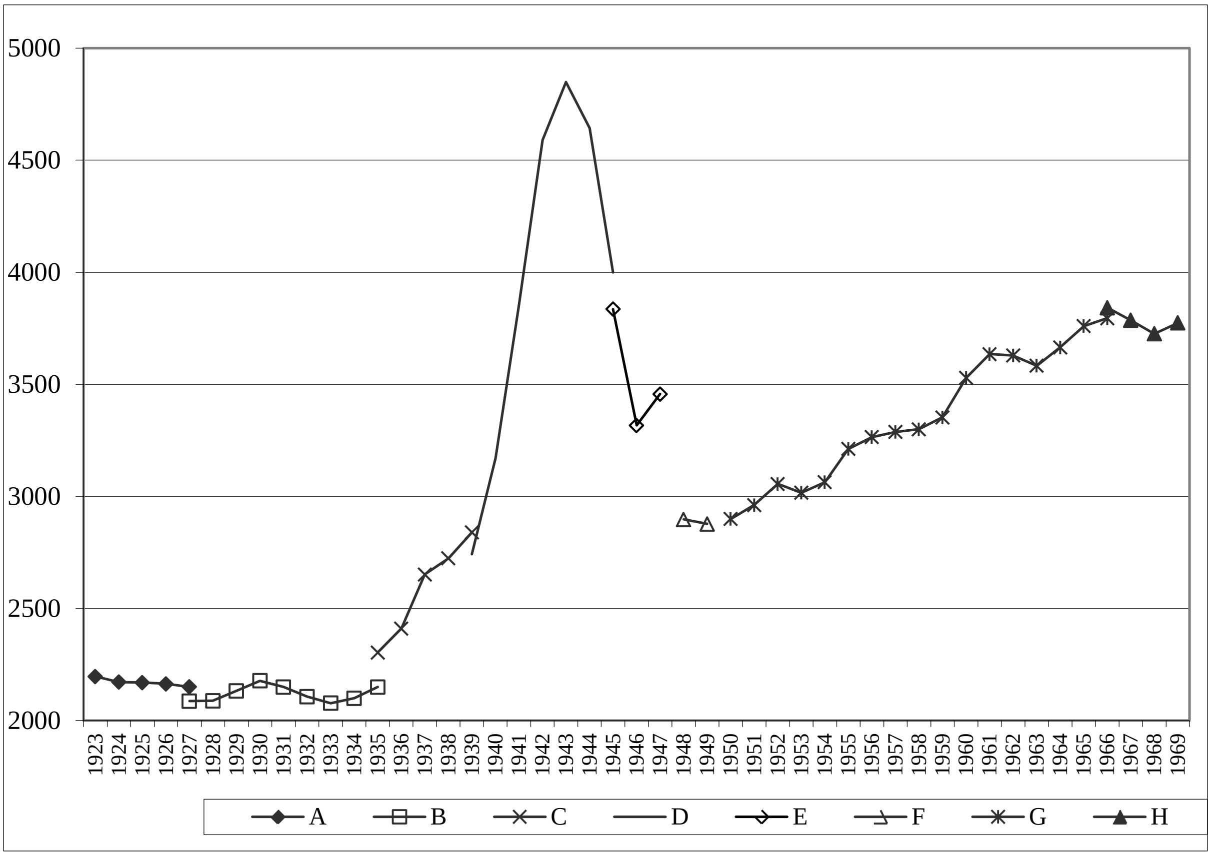
	Pieceworkers[a]	**Timeworkers**[b]
1926 October	4.8	7.3
1931 October	8.3	8.6
1938 July	15.5	11.8
1942 July	47.2	25.3
1948 January	41.2	27.4
1953 June	38.7	32.7

Source: Knowles and Hill (1954, Table VI)

a. Piecework fitters' basic earnings comprise the basic time rate plus the nationally agreed piecework percentage above the basic time rate plus the pieceworkers' National Bonus.

b. Timework fitters' basic earnings comprise the basic (district) time rate plus the timeworkers' National Bonus.

Figure 1 Adult employment (males and females) in engineering, metal manufacture, metal trades, ship building and repair in June/July, 1923 to 1969 (thousands)



Sources: A to C and E to J – Ministry of Labour Gazettes (data refer to UK); D – Ministry of Labour and National Service (data refer to Great Britain).

A – Data include unemployed workers attached to these industries.

B – Persons over 65 excluded.

C – Youths aged 14 and 15 included.

D – Men aged over 65 and women aged over 60 excluded but including non-manual workers earning from £250 to £420 per year.

E - Women aged over 60 excluded but including non-manual workers earning from £250 to £420 per year.

F – Civil servants stationed overseas excluded.

G – Figures for 1964 and 1965 were recalculated (for method see Ministry of Labour Gazettes, March and May, 1966) and totals for 1950 to 1965 were recalculated accordingly.

H – Industrial classification for many establishments was corrected.

Figure 2 Proportions of female workers to total workers in engineering, metal manufacture, shipbuilding and repair, 1923 - 1969

Figure 3 Percentage of pieceworkers in total workforce, 1926-1965

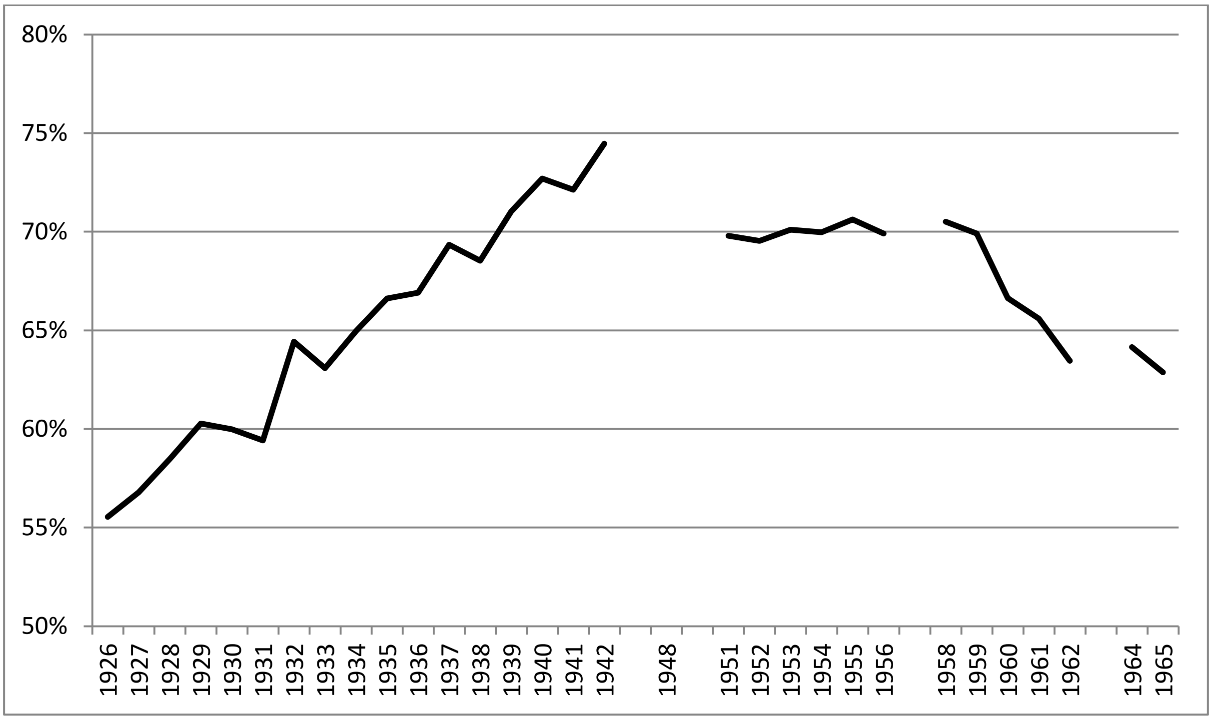


Figure 4 Unemployment rates, 1926 – 1965

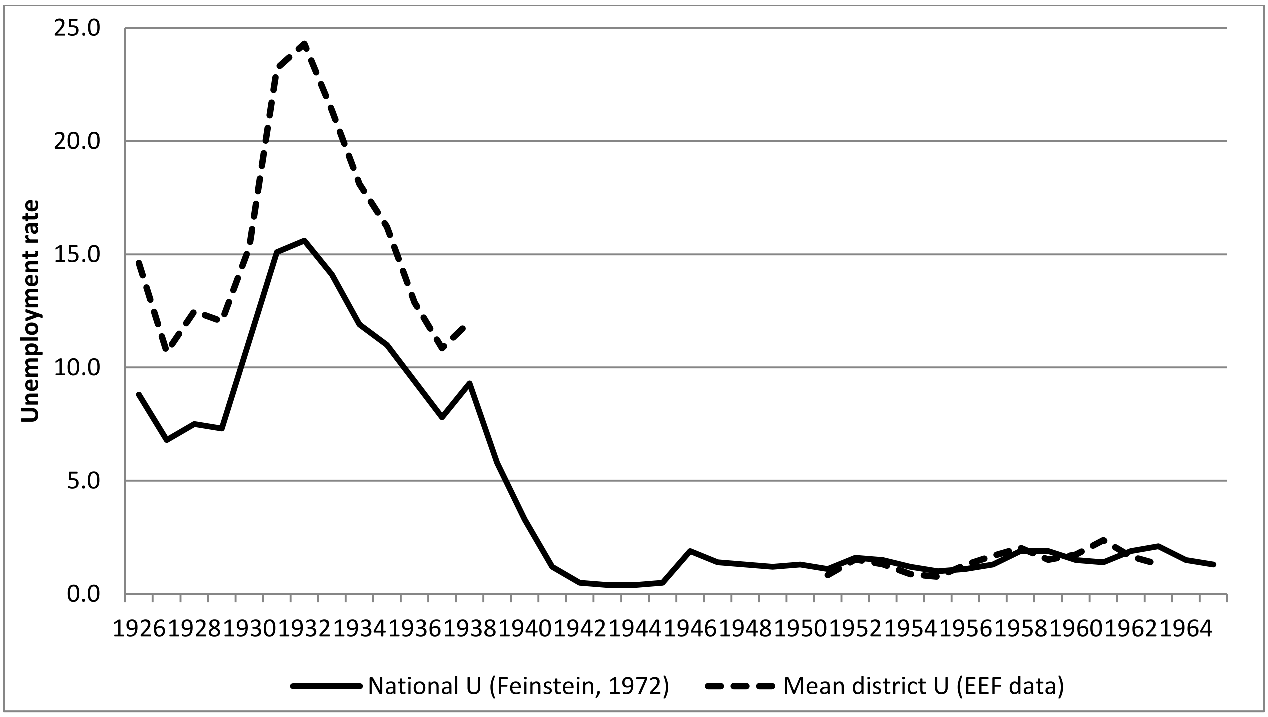


Figure 5 Male piecework–timework hourly earnings differentials, 1926-1965 (EEF district data)

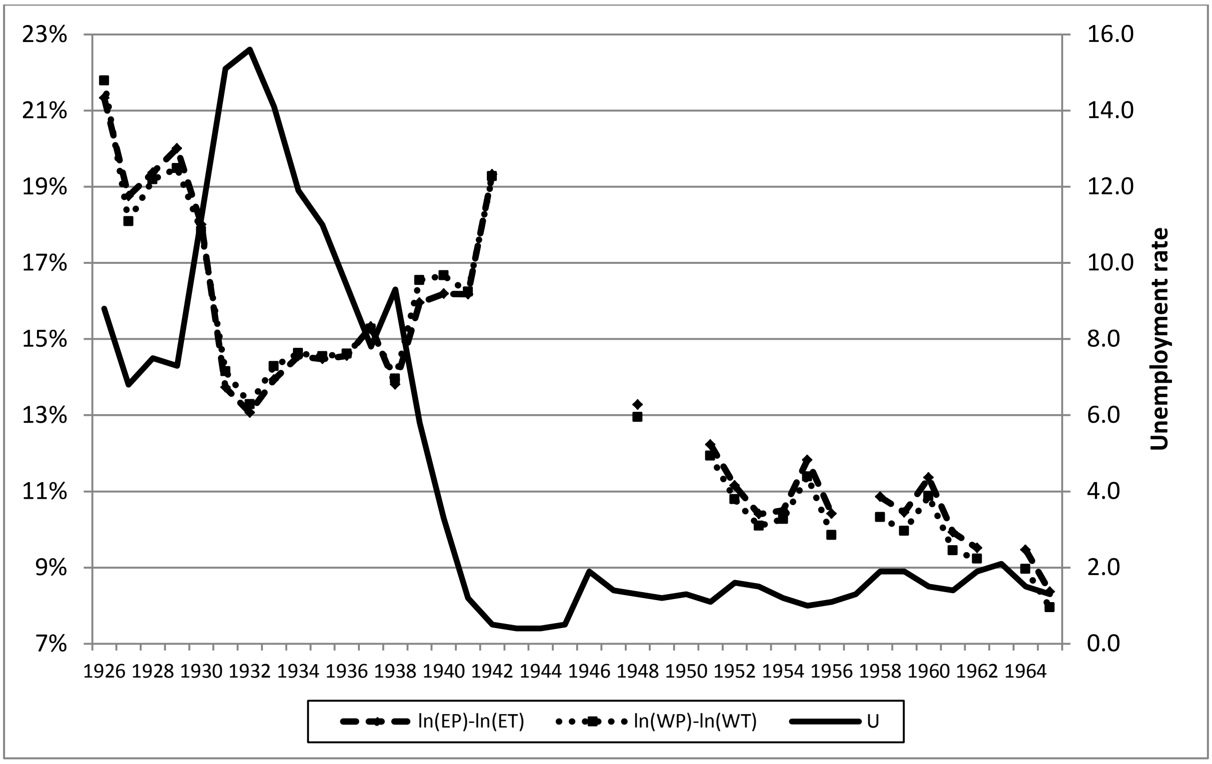


Figure 6 Male piecework–timework hourly earnings differentials, 1930-1965 (EEF section data)

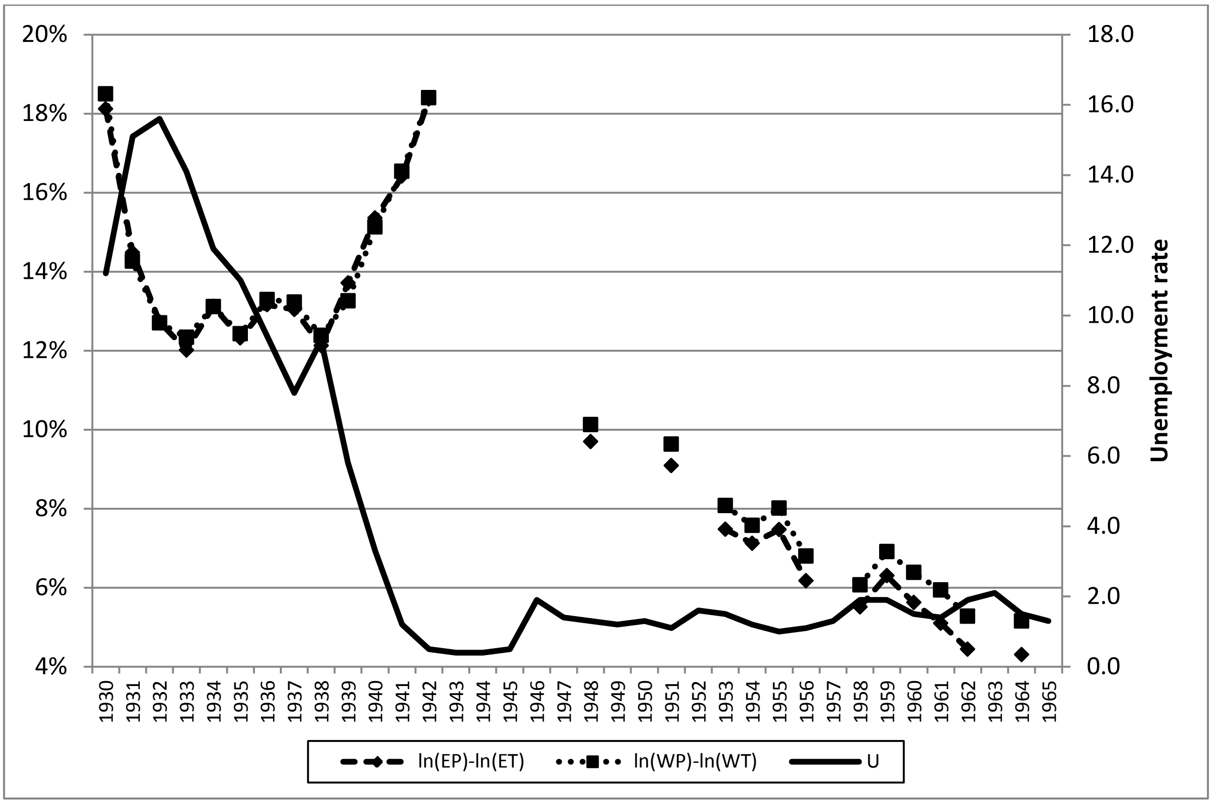


Figure 6 Real hourly earnings of pieceworkers and timeworkers, 1934-1942

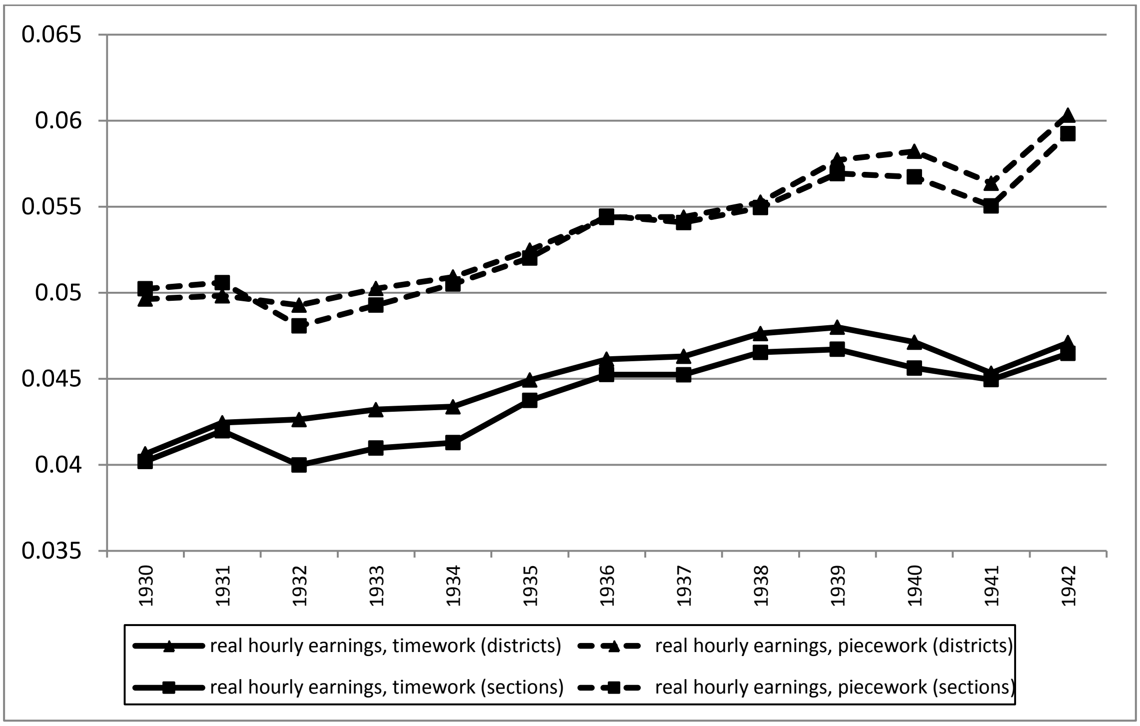


Figure 7 Mean real hourly earnings of pieceworkers and timeworkers, 1926-1942