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ABSTRACT

Women Workers in Essential British Metal and Chemical Industries during the Second World War and the Immediate Post-war Years

Group 1 metal and chemical industries formed the essential suppliers of British war materials during WW2. Their industrial sectors covered metal manufacture, general and electrical engineering, vehicle production, aircraft production, shipbuilding, metal goods, chemicals and explosives, and scientific instruments. Due mainly to almost 4 million men joining the armed forces, acute labour shortages necessitated women's recruited in large numbers. Women workers accounted for 16% of total Group 1 employment in 1939 rising to a peak of 37% in 1943. We use Ministry of Labour statistics on total annual numbers of female and male employees between 1937 and 1960. We examine in detail women's recruitment, training, skill growth as well as firms' radical changes to production methodologies to accommodate lower average women's skills. We compare female and male employment during the wartime transition period 1944 to 1947, followed by the period 1948 to 1960. Explanations are given for the decline and rise of female fortunes in the two periods. The employment data allow us to compare women's war-time and peace-time activities at industrial section-levels - e.g. repair of aircraft, iron and steel melting, explosives manufacture. The analysis includes wartime metal working data of the Engineering Employers' Federation (EEF). This allows us to widen our analysis. Among other features we use (1) female/male pay differentials to proxy the growth of women's skill attainments, and (2) differentiate between piecework and timework to compare employment advantages of incentivised payments contracts versus fixed short-run wage contracts.

JEL Classification: J16, J24, J31, N44

Keywords: women workers, Group 1 industries, skill acquisition, pay differentials

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1. Introduction

Almost 4 million British men joined the armed forces between mid-1939 and mid-1943. Additionally, 530,000 women joined the auxiliary services and civil defence. The resulting severe losses in civilian employment, together with a highly significant expansion of war-related manufacturing industry, created critical labour and skill shortages. There were two vital and pressing requirements. First, large numbers of women needed to be recruited into the essential war industries. Second, the skills' deficit needed to be eliminated in a short space of time. The principal source of the vast volume and range of war materials were the so-called essential Group 1 metal and chemical industries. Group 1 enterprises experienced by far the greatest wartime pressures both on recruitment and on skills' training.

Not only were Group 1 industries of vital importance to the war effort but also a core driver of post-war manufacturing growth in the post-war period. Our work on women's employment in both periods is based on Ministry of Labour statistics on total annual numbers of employees between 1937 and 1960. We also record equivalent data for males, especially in order to capture the annual shares of females within total employment. Apart from providing a comprehensive employment bedrock, these statistics allow us to break down employment by sections within the main industrial groups. This allows detailed Group 1 comparisons in sectional manufacturing activities in the war years and the subsequent post-war growth period to 1960.

Women's participation in metal and chemical factories constituted one of the most important contributions to the war effort. In mid-1939, 506,000 women were employed in Group 1 industries, comprising a 16.3% share of total employment. At the peak of war in mid-1943, 1,928,000 women employees comprised 36.8% of total employment. They were employed

across the whole range of manufacturing activities, including metal manufacture, general engineering, electrical engineering, motor and other vehicle production, aircraft and aircraft repair, shipbuilding and ship repair, metal goods manufacture, precision instruments, chemicals, and explosives.

We start by detailing women's wartime recruitment into Group 1 industries. At the start of the war, female employment growth was on a voluntary basis which was soon followed by a series of state interventions involving tightening legal controls. We deal with employment interactions among Group 1, Group 2 and, Group 3 industries in this process as well as the core age-structures of employment in essential industries. For the mid-1939 to mid-1943, we examine women's employment penetration across Group 1 industries, their ranges of job activities, and the narrowing of female/male pay differentials as an indicator of female skill improvements. Success in these three areas was importantly predicated on the systematic breakdowns of production into sub-processes in which women of various skill levels were matched with specific, and often quite narrow, job tasks.

From mid-1943 to mid-1947, we investigate women's employment experience during the war-to peace transition period between, giving reasons why these years marked a major decline in women's employment numbers compared to their male counterparts. For the following period from mid-1948 to mid-1960, we give reasons for women's significant pick-up in employment fortunes. We focus on similarities between women's war and post-war Group 1 activities, comparing the peak of war in mid-1943 with the years 1954 and 1960 as detailed examples.

An invaluable and detailed source of information on women workers in metal industries for the war years 1940, 1941 and 1942 was provided by the Engineering Employers' Federation (EEF). We integrate three aspects of these data to enrich our discussion of women's employment, pay and growth of skills during the war. First, the EEF differentiates between workers on time-rates and on piece-rates and we report on the relative wartime usefulness of these two work modes. Second, the EEF data are detailed down to sectional industrial levels. They allow measurement of female/male hourly and weekly pay differentials, thus providing a useful proxy for women's growth in skill attainments. Third, the data allow us to measure the effects on pay differentials of differences in overtime working between men and women.

2 Women's wartime recruitment in Group 1, 2, and 3 industries

A useful starting point is to consider the changes brought about by WW2 on the structures of the female and male civilian workforces. Table 1 shows the net changes in the British civilian adult workforce of insured male and female workers (i.e. excluding the armed forces and the auxiliary services) in the period 1942 to 1945 compared to 1937. Very large reductions occurred among males aged between 18 and 35. Given that we have adjusted the data for changes in the birth rates of these age cohorts, it is safe to conclude that the vast bulk of the reductions were due to military call-up. The reductions are mirrored by increases in the employment of females aged between 18 and 50. These net female employment increases

Table 1 Net changes in the British civilian adult workforce aged 18 to 51: 1942-45 compared to 1937 after adjusting for changes in the birth rates

Age-Group	1937	1942	1943	1944	1945
	Actual numbers insured (thousands)	Estimated net changes compared to 1937 (adjusted for birth rates)			
		Males			
18 to 20	757	-285	-391	-394	-376
21 to 25	1564	-902	-969	-993	-957
26 to 30	1525	-610	-659	-681	-711
31 to 35	1368	-260	-358	-402	-450
36 to 40	1118	31	-21	-63	-96
41 to 45	935	119	126	139	126
46 to 50	856	50	58	50	36
		Females			
18 to 20	567	159	123	143	154
21 to 25	828	330	217	180	136
26 to 30	556	255	234	179	115
31 to 35	378	236	276	230	168
36 to 40	286	222	266	236	195
41 to 45	211	184	241	241	212
46 to 50	154	114	164	172	158

Notes: Figures on insured employees are based on statistics in **Ministry of Labour and National Service** (MLNS 1947, p.260). The numbers in the 1942 to 1945 columns are adjusted to account for changes in the birth rates across the age cohorts. (Sources: for 1838 to 1983, birth statistics for England and Wales obtained from **Office for National Statistics, Birth Statistics 1937-1983**. Birth statistics for Scotland are obtained from General Register Office for Scotland, gro-scotland.gov.uk.) For example, there were 757,000 insured males aged 18 to 20 in 1937. These were born between 1917 and 1919. In 1942, there were 560,000 insured males, born between 1922 and 1924. The number of births between 1922 and 1924 was 1.1168 higher than those between 1917 and 1919. Therefore, assuming equivalent proportions of insured workers to total births through time, this translates to 845,000 insured workers in 1942, adjusted for the rise in the birth rate (i.e. $757,000 \times 1.1168$). The difference between actual insured numbers and those corrected for the birth rate (i.e. $560,000 - 845,000 = -285,000$) represents the estimated drop in the insured employed due to military call-up.

included (i) rises in married women's participation rates¹, (ii) rises in the numbers of older women's participation rates², (iii) reductions in women's unemployment from 257,000 to 14,000 between 1939 and 1944 (MLNS, 1947, p.53).

Table 2 presents male and female employment in the armed forces and civil defence etc. for females and males in Group 1, 2 and 3 industrial sectors. Group 2 were regarded as essential civilian industries while Group 3 were dominated by service-sector industries. As shown, employment statistics are calculated for mid-1939, mid-1943, mid-1945 and late-1946 and includes female shares of total employment. In Group 1 industries between mid-1939 and mid-1943 numbers of employed women in Group 1 industries grew from 506,000 to 1,938,000 and their percentage employment shares grew from 16.3 to 36.8. This accounted for the greatest war-time expansion of female employment. Additionally, growth in women's employment numbers and employment shares also featured strongly in Group 2 national and local government services as well as in transport and shipping. While women's shares increased in Group 3 industries their actual total numbers declined given that these industries contracted during the war.

For the first year of war, there was no major shortage of available female labour. From January to July 1940, insured female employment grew by 322,000 divided equally between

¹ Only 10.4% of married women were employed in 1931, a figure that by the end of the war, in 1947, had risen to 18% (Smith, 1984).

² This can be inferred from Table 1 for the 41 to 51 age groups. The expansion also occurred among the 51 to 60 age group (see Ministry of Labour and National Service (MLNS), 1947, p. 260).

Table 2 Male and female employment, 1939 – 1946 (thousands)

	Males aged 14 – 64				Females aged 14 - 59			
	June 1939	June 1943	June 1945	Dec. 1946	June 1939	June 1943	June 1945	Dec. 1946
Armed forces and auxiliary services	480	4296	4653	1361	-	461 (9.7)	437 (8.6)	78 (5.4)
Civil defence etc.	80	253	112	85	-	70 (21.7)	15 (11.8)	4 (4.5)
GROUP 1								
Metal industries	2379	3025	2643	2671	433 (15.4)	1635 (35.1)	1257 (32.2)	778 (22.6)
Chemical industries	221	280	248	236	73 (24.8)	293 (51.1)	198 (44.4)	117 (33.1)
GROUP 2								
Agriculture, horticulture, fishing etc.	884	879	883	959	66 (6.9)	168 (16.0)	158 (15.2)	122 (11.3)
Mining and quarrying	868	804	785	790	5 (0.6)	14 (1.7)	14 (1.8)	12 (1.5)
National government service	416	515	501	631	123 (22.8)	471 (47.8)	493 (49.6)	385 (37.9)
Local government service	520	342	390	540	326 (38.5)	458 (57.3)	519 (57.1)	485 (47.3)
Gas, water and electricity	225	167	165	234	17 (7.0)	33 (16.5)	31 (15.8)	24 (9.3)
Transport and shipping	1183	979	1038	1249	50 (4.1)	197 (16.8)	214 (17.1)	124 (9.0)
All Group 2	4096	3686	3762	4403	587 (12.5)	1341 (26.7)	1429 (27.5)	1152 (20.7)
GROUP 3								
Food, drink and tobacco	391	274	276	354	263 (40.2)	245 (47.2)	242 (46.7)	243 (40.7)
Textiles	401	233	222	317	601 (60.0)	436 (64.2)	412 (65.9)	442 (58.2)
Clothing	138	69	70	107	449 (76.5)	312 (81.9)	301 (81.1)	354 (76.8)
Boots and shoes	108	67	66	92	57 (34.5)	45 (40.2)	44 (40.0)	49 (34.8)
Other manufactures	917	496	498	807	384 (29.5)	336 (40.4)	343 (40.8)	391 (32.6)
Building and civil engineering	1294	700	698	1235	16 (1.2)	26 (3.6)	24 (3.3)	25 (2.0)
Distributive trades	1888	1016	978	1306	999 (34.6)	993 (49.4)	980 (50.1)	998 (43.3)
Other services	1250	576	560	922	975 (43.8)	1037 (64.3)	1038 (65.0)	1044 (53.1)
All Group 3	6387	3431	3368	5140	3744 (37.0)	3430 (50.0)	3384 (50.1)	3546 (40.8)

Source: Ministry of Labour and National Service (MLNS) 1947, p.351. Figures in brackets show percentage shares of female to total employment.

munitions production and other essential war industries. Up to this point, industrial recruitment was on a voluntary basis. However, by December 1940 it was realised that the supply of women was inadequate, especially given the continuing call-up of men to the armed forces. An estimated 2 million additional women workers were needed for the war effort. In March 1941, the Registration for Employment Order for women was issued with 11.8 million women born in the years 1893 to 1927 required to register for employment (see MLNS, 1947, pp. 42-44 and p. 337). The conscription of women into the auxiliary services and essential industries was introduced in the National Service (No.2) Act of December 1941. Those conscripted were given the choice between the auxiliary services or civil defence or certain specified industrial jobs.³

Despite substantial female labour supply growth during 1941, employment fell well short of labour requirements.⁴ The Control of Engagement Order of January 1942 ensured that women leaving their existing jobs or entering the labour market were directed to jobs that were essential to the national interest.⁵ By May 1942, women aged between 18 and 40 – other than those with children under the age of 14 living with them – were obliged to obtain their employment through an employment exchange or an agency approved by the Ministry of Labour and National Service

³ Where no preference was expressed then an eligible woman would be placed in industry. This form of conscription was suspended at the beginning of 1944.

⁴ A manpower survey undertaken in mid-1941 estimated that an additional 922,000 women would be required by industry and the services by mid-1942 (Smith, 1984).

⁵ The earlier Registration of Employment Order had no power to ensure that women who had been placed into essential jobs by a local employment office remained in those jobs. Also, it was possible for women themselves to find employment before the Ministry of Labour was able to interview them and place them into strategic vacancies (see Parker, 1957, p.287).

(MLNS) or a government approved employment agency. Added to this, if employers wished to recruit women covered by the Engagement Order they were required to do so only through an approved agency.

Table 3 Female Employment Changes by 18-40 and 41-59 Age Groups in the Auxiliary Services and in Group 1, Group 2 and Group 3 Industries. (Mid-1939 to Mid-1943) (Thousands)

Age Group	Auxiliary Services and Group 1 industries	Group 2 industries	Group 3 industries
18 – 40			
Mid-1939	344	565	2,175
Mid-1943	1,935	1,086	1,651
<i>Change</i>	+1,591	+521	-524
<hr/>			
Mid-1939	40	192	636
Mid – 1943	335	366	923
<i>Change</i>	+295	+174	+287

Source: Ministry of Labour Gazette (1944), p. 197.

Female wartime recruitment into the essential Group 1 and Group 2 industries as well as in the auxiliary services largely involved younger women. Table 3 compares employment growth rates of women aged 18–40 and those aged 41–59 between mid-1939 and mid-1943. There was a 460% growth among the younger age band in Group 1 industries and the auxiliary services over the four years. There was a 92% rise in younger female employment in Group 2 industries. By contrast, the younger age band displayed a 24% reduction in employment in the less essential Group 3 industries. There was also growth in employment among 41-59 year olds in the essential industries but on a much smaller absolute

scale than their younger counterparts. However, there was a 45% employment increase in the older age group within Group 3 industries. The contrast between negative younger and positive older female growth rates in Group 3 industries reflected an overt government policy of re-allocating younger women towards more pressing war supply jobs with older women filling the Group 3 employment gaps.⁶

How significant was Group 1 and Group 2 industrial employment among young females by 1943, the peak of wartime industrial activity? Table 4 provides estimates by 5 age bands for the period mid-1939 to mid-1943 within the 18 – 40 age range. We have estimated (a) the 18–40 age group employment totals in 1943 and (b) 1939 – 1943 employment changes in Group 1 and Group 2 industries. Weighting is based on each age range’s share of *total* insured employment in 1943. Almost certainly, however, this understates the weights of the 18 – 30 employment numbers and overstates the older 30 – 40 numbers because we know that employment in these industries was biased towards the youngest age groups.⁷

We estimate that, in 1943, at least 42% of ages 18 – 20 (women born between 1923 and 1925) worked in these essential industries and that at least 27% of this birth cohort band owed their employment to the wartime expansion of these industries. Respective figures for the ages 21 – 25 are

⁶ Younger women were directly withdrawn from less important jobs to work within the essential industries. Examples, including the movement of women from retail distribution, are given by the International Labour Office (ILO), 1946, pp. 18-20. Transfers from Group 3 industries to work in the munitions factories occurred ‘on a very large scale’ (Ministry of Labour Gazette, December 1947, p. 197).

⁷ Greater accuracy is dependent on dividing total insured employment by age into Group 1 and Group 2 industries on the one hand and Group 3 industries on the other. Requisite data are not available.

32% and 21%. Mainly due to the fact that young women were conscripted to work in the essential industries, these are lower bound estimates with ‘true’ percentages probably considerably higher.

Table 4 Estimated Percentages of Female Age Cohorts Working in British Group 1 and Group 2 Industries in mid- 1943 and in mid-1943 compared to mid-1939

Age group	Proportion of 1943 insured workforce aged 18 - 40 (1)	Estimated 1943 total Group 1 and 2 employment numbers (2)	Estimated Group 1 and 2 employment increase, mid-1939 to mid-1943 (3)	Numbers born by age group (4)	Total Group 1 and 2 employment as % of births [(3)/(5)] x 100 (5)	Group 1 and 2 increase in employment as % of births [(4)/(5)] x 100 (6)	% share women in Auxiliary Services (7)
18 to 20	0.202	521,806	338,188	1,232,175	42.3	27.5	52.0
21 to 25	0.271	700,047	453,708	2,204,032	31.8	20.6	42.5
26 to 30	0.199	514,057	333,166	2,251,122	22.8	14.8	25.1
31 to 35	0.176	454,643	294,659	2,517,446	18.1	11.7	19.0
36 to 40	0.152	392,646	254,478	2,617,362	15.0	9.7	15.4

Notes: Employment weights in column (2) are obtained from **MLNS (1947, p.260)**. The figures in column (3) are arrived at by applying the insured employment weights in column (2) to a total of 3,021,000 estimated total employment of 18 to 40 age groups in Group 1, Group 2 industries, and Auxiliary Services in Table 3. Auxiliary services numbers by age range are then subtracted out using data in **Howlett (1995, Table 3.5)**, leaving a total of 2,583,200 of 18 to 40 age groups in Group 1 and Group 2 industries. Similarly, the weights are applied to a total increased employment of 1,674,200 to obtain column (4). Sources of birth numbers obtained from **Office for National Statistics, birth statistics 1937-1983**. Birth statistics for Scotland are obtained from General Registrar Office for Scotland, gro-scotland.gov.uk.

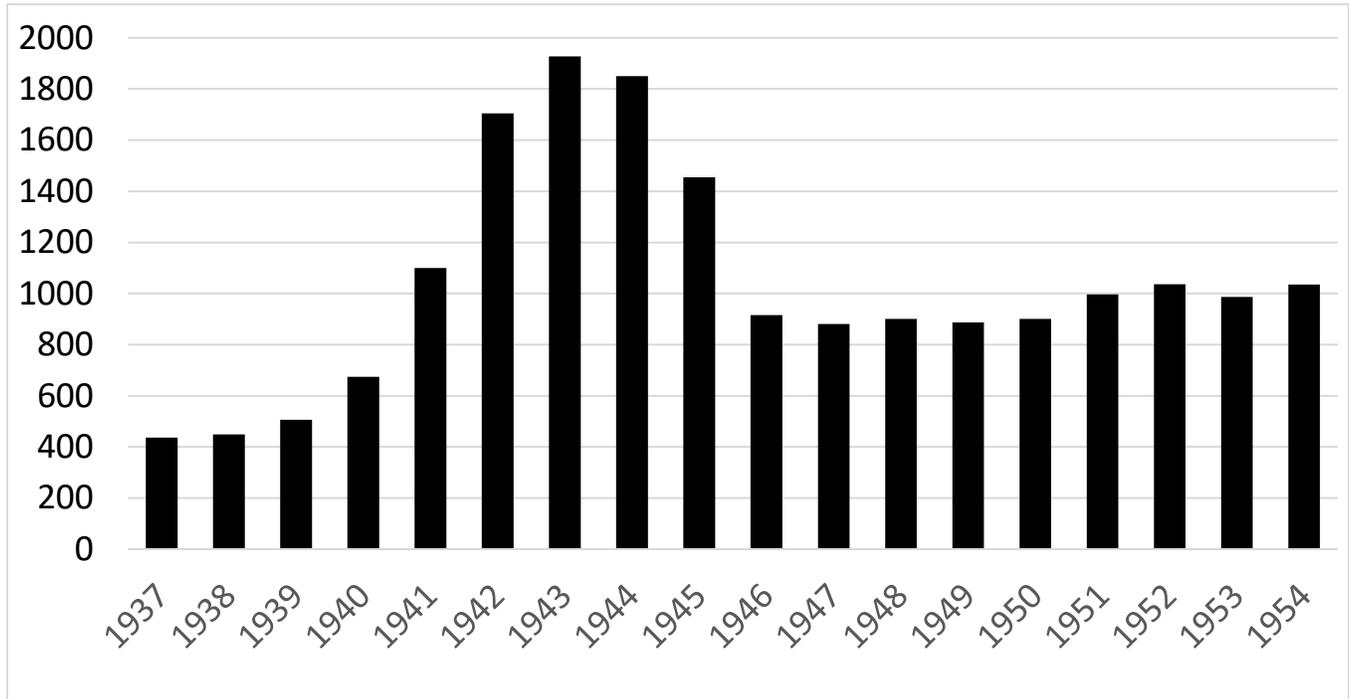
3 Women's employment and employment shares in Group 1 industries, 1937 -1960

In order to achieve a high level of employment accuracy, we produce comprehensive measures of the mid-year industrial totals of all females as well as their shares in total employment (i.e. females + males) in all Group 1 industries between mid-1937 mid-1960. These match the same construction as those shown in Table 2 for Group 1 metal and chemical industries.⁸ This level of detail enables us to compare at later stages numbers working at section levels: for example, explosives, iron and steel melting, manufacture and repair of aircraft.

Figure 1 shows an annual mid-year bar chart showing total counts of all women employees working in Group 1 metal and chemical industries from mid-1937 to mid-1954. From mid-1937 to mid-1939, women's employment was relatively small, ranging from 437,000 to 506,000. Their employment rose from 674,000 in mid-1940 to a pinnacle of 1,928,000 in mid-1943. In the last years of the war to the early post-war period, employment numbers fell from 1,831,000 in mid-1944 to 881,000 in mid-1947. Thereafter they rose from 901,000 in mid-1948 to 1,035,000 in mid-1954.

⁸ As in Table 2, we cover males aged 14 (the earliest school leaving age) to 64. For women the comparable age range is 14 to 59. These different employment spans have virtually no effect on the comparative compositions of male and female totals given very few employees in the 59-64 age range were employed in Group 1 industries. Later years update the school leaving age to 15.

Figure 1 Women in Group 1 metal and chemical industries, mid-years 1937 to 1954 (thousands)



Sources: Parker (1957, Appendix Table 1), Table 2, Ministry of Labour Gazettes between 1937 and 1954.

For the same years, together with the mid-1960, Table 5 shows women’s mid-year employment shares of total employment. Over the post-war years from 1946 to 1954, the average annual share was 22.1% while in the period 1937 to 1939, the average share is 16.3%. At the 1943 peak year of Group 1 their share was 36.8%. However, there is a missing detail. It is also important to consider the industrial employment totals to which the shares apply. For example, the 16.1% women’s share in 1937 was of the total workforce of 2,708,000 employees. The 21.7% share in 1954 was of a total workforce of 4,773,000. We will return to this important point in Section 7.

**Table 5 Women as a percentage of all Group 1 workers
Mid-years 1937 – 1960**

1937	16.1	1943	36.8	1949	20.8
1938	16.5	1944	36.5	1950	21.0
1939	16.3	1945	33.5	1951	21.9
1940	18.9	1946	25.5	1952	22.0
1941	25.9	1947	23.2	1953	21.2
1942	34.2	1948	21.2	1954	21.7
				1960	23.6

Sources: As in Figure 1, plus **Ministry of Labour Gazette, 1961**

4. Women at work in Group 1 industries, mid-1939 to mid-1943

The Group 1 metal and chemical industries embraced extensive ranges of products, production methodologies, and associated job task requirements. By 1942, women workers had achieved almost complete penetration of the wide diversity employment across manufacturing sections. Table 6 highlights sections together with several industrial aggregates that employed at least 15,000 women in mid-1943, the peak of women’s employment. Workforce allocations in two areas especially reflected vital areas of supply at the height of war. First, within chemical industries 180,000 women worked on the production of explosives, compared to 7,900 in 1939. Both the ILO (1946, p54) and Douie (1950, p101) paint pictures of women in chemical industries undertaking hard physical work (e.g., shoveling coal, loading, and operating cement mixers) as well as undertaking - suitably clad in respirators, protective clothing and covered in protective cream - potentially dangerous and unpleasant work, such as producing gases before filling them into shells and bombs. Second, in metal industries 410,100

women worked on the manufacture of motor vehicles and aircraft, compared to 45,200 in 1939. In fact, women’s involvement in aircraft manufacture and repair played a much-lauded role throughout the war and beyond.

Table 6 Group 1 industrial sections with over 15,000 women workers in 1943

Industries and Sections	Thousands
Chemicals and Allied Trades	
Chemicals	65.4
Explosives	180.5
Oil, glue, soap, ink, etc.	32.5
Metal Manufacture	
Iron and steel melting etc.	35.1
Brass, copper, zinc, tin etc.	31.1
Stove, grate, pipe etc. and general iron founding	16.6
Engineering, Shipbuilding and Electrical Goods	
General engineering	531.2
Electrical engineering	78.9
Ship building and ship repair	25.6
Electrical apparatus, cables etc.	172.2
Vehicles	
Construction and repair of motor vehicles, cycles and aircraft	410.1
Metal Goods not Elsewhere Specified	
Hand tool, cutlery etc.	17.4
Bolts, nuts etc.	19.1
Metal industries not elsewhere specified	167.3
Precision Instruments, Jewelry, etc.	
Scientific and Photographic Instruments, etc.	39.1

Source: Ministry of Labour and National Service, Appendix 1X (1947)

At aggregate industrial levels, general and electrical engineering industries employed very significant numbers of female labour. Women also had a strong presence in iron and steel industries and in metal goods industries. Douie (1950, p. 59) points out that in pre-war years women’s employment heavy iron and steel industries was rare. During the war, however, “*women were to be found in practically every branch of the metal working industry. In September 1942, they already constituted*

over 13% of the industry, in which they were doing 950 different jobs. Some were steel smelters and iron puddlers. Others drove overhead electric cranes carrying huge cauldrons of molten metal from the furnaces to the moulding sheds. Some worked as hot and cold sawyers, straighteners, and circular plate burners. One of the most skilled jobs was that of the deseamers, whose work it was to burn away defects in steel billets by means of the flame of oxy-ferrolene jet.” Douie (pp. 93-103) provides a succinct, evocative, and unmatched account of women’s range of skills and their importance within the wartime munitions, aircraft (construction and repair), shipyards, and general (heavy and light) engineering factories.⁹

Among the least expected additions to the employment list in Table 6 was the 25,600 women working in shipbuilding and repair. They numbered 2,700 in 1939. As stated by Douie (1950, p.100), *‘Most revolutionary of all was the introduction of women into the shipyards, with their tradition of all-male labour’*. Women participated in 114 types of jobs that included their abilities in welding and electrical work, but also drilling ships’ plates and driving cranes.

While the extent of women’s recruitment into Group 1 industries was impressive, it represented just one of two vital employment requirements. Given a critical shortage of skilled male employees due to service in the armed forces and civil defence (see Table 2), women had to be trained to perform unfamiliar semi-skilled and skilled job tasks. The fundamental problem was that time was of the essence. A maximum of about 30 weeks of training was provided to replace some of the job skills required of fully apprenticed males. The leading solution to this problem, referred to as work dilution,

⁹ Additionally, the ILO (1946, pp. 56 and 57) provides extensive lists of job categories that were commonly occupied by women in shipbuilding and in iron and steel industries.

was to break-down and systemise production processes into a series of sub-operations such that everyone could be trained to perform at least one of their constituent tasks. Many jobs, for example those involving repetitive use of simple work bench machines, required little training. At higher skill levels, knowledge of the working of more complex machinery was required and this was principally achieved via intensive training within factories.

Based on technical improvements explained in contemporary issues of the *Production and Engineering Bulletin*, the ILO (1946, pp. 52-3) outlines various firm-level dilution solutions to women's job tasks. A firm in the machine-tool industry was engaged in building resistance welding machines. Newly employed women were allocated to smaller scale sub-assembly work before moving on to assembly of valves, pressure switches and transformers of varying sizes. At the top-end of their skill progression they worked in the instrument room helping to make control panels and timers. Another example from the same source concerned a department within a firm that was staffed by women who in 1942 received training with the aim of producing several hundreds of gauges each week. The dilution solution was to create a workforce production line in which each woman could perform at least one of the required sub-operations. Under the supervision of three senior male managers the objective was achieved, reproducing a flow of output that had previously been carried out solely by skilled men.

Sheet metal working provides a well-documented example of the dilution process (see Inman, 1957, pp. 60/1). It was a vital war-related production activity with essential applications in the manufacture of aircraft, vehicles, and ships. Traditional sheet metal work involved highly skilled jobs requiring significant on-the-job experience and know-how. Both during and immediately before the war, technical changes facilitated deskilling. Skilled manual work was increasingly replaced by power presses and automatic tools which could be operated by less skilled operatives. Even where traditional

skilled work was retained – for example, in the use of free hand methods in the shaping of metal – associated operations (like drilling and riveting) could be carried out by semi-skilled workers.

Dilution typically involved allocating labour to various sub-processes that collectively contributed to final production outputs. In aircraft manufacture, for example, sub-assembly work included welding, riveting, metal cutting, fitting aircrafts' skins and the higher skilled manufacture of wooden structures. Their inputs amounted to significant levels of value-added to the construction of new aircraft; for example, women comprised half of the workforce building Halifax bombers. They also gained great expertise in reconditioning damaged aircraft. At the senior level women were trained as inspectors with the responsibility of judging the air-worthiness of completed aircraft.

Dilution provided efficiency gains, especially given the heterogeneous quality of women recruits. Breaking-down work into sub-processes allowed firms to match operational skills with workers who were judged to possess the required skill capabilities. Matching unskilled, semi-skilled and skilled workers to appropriate job requirements allowed differential rates of pay to be applied accordingly. On the demand side this helped employers to avoid costs associated with over-qualified workers performing lower-level tasks. On the supply side it provided opportunities for inexperienced new recruits to be hired to undertake simple operations that required little training. At later stages, the more able workers were selected for training in higher skilled and better paid sub-processes. Piece-work performances especially allowed a means of ranking workers abilities through measurement of their completed output per-period.

Member companies of the EEF covered all Group 1 metal working activities, except for shipbuilding and repair.¹⁰ The Federation made an official distinction between ‘women doing men’s work’ and ‘women doing women’s work’. After a 32-week training period, broadly covering the types of dilution processes discussed above, men’s work referred to skilled job tasks that would normally be undertaken by fully apprenticed men. Women doing men’s work could execute one or more of these tasks but usually not the skill set of fully apprenticed men who had undertaken between 5 to 7 years of apprenticeship training.

Based on 8 industrial sections and 2550 EEF member companies, Table 7 shows the shares of women time-workers (t/w) and pieceworkers (p/w) doing men’s work over the period 1940-1942. During these three years, there were considerable increases in the percentages of women achieving men’s status, often because of training and work application gained through their progressions in various dilution processes. This was especially the case in heavy engineering (t/w and p/w), founders (t/w), allied trades (t/w), light engineering (t/w and p/w), aircraft (t/w and p/w), and textile machinery (t/w). Numerically women pieceworkers exceeded those of timeworkers. Over the 8 sections in 1942, 56% of women doing men’s work and 68% of women doing women’s work were pieceworkers. The higher piecework percentages in part reflect women with lower skills undertaking simpler tasks that were among the least costly to monitor. Noticeably, higher percentages of time-workers achieved men’s work status over the three years.

¹⁰ These are listed in Section V to IX of 1948 Standard Industrial Classification (Central Statistical Office, 2018). The complete EEF employment, wages and hours data are available in the UK Data Archive (Hart and Roberts (2006)) and are referred to here as ‘EEF data’.

Table 7 EEF percentages of women doing men’s work by engineering section, 1940 – 1942

Engineering Section	Time-rated workers			Piece-rated workers		
	1940	1941	1942	1940	1941	1942
Heavy engineering	14.5	42.5	53.6	6.7	25.2	37.0
Founders	5.5	25.6	38.5	0.3	16.7	19.8
Allied trades	3.9	14.8	36.0	0.4	3.1	3.5
Light engineering	9.9	13.3	24.5	3.9	5.9	17.2
Aircraft	2.5	14.5	21.5	5.7	19.2	18.7
Textile machinery	9.0	16.8	20.3	5.2	8.9	7.6
Motors, cars, cycles	0.4	9.8	7.9	0.1	6.3	6.0
Electrical engineers	0.4	2.6	4.5	0.2	1.1	2.9

Notes: **EEF data**. The figures refer to women over the age of 18. Table taken from Hart (2007, Table 1) which includes details of men and women doing women’s work.

There are both cost and productivity considerations that determine whether or not piece-rate contracts are advantageous. Two of these tended to favour wartime piecework. The first involves the costs of valuing 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). Wartime tasks relating to the production of military hardware, munitions, aircraft parts (etc.) tended to be repetitive with generally unchanging specifications in output requirements. This resulted in repetitive task stability over relatively long stretches of time. In the second case, piecework is likely to be favoured by employers if they are in charge of a highly heterogeneous workforce (Lazear 1986). This certainly applied to the mix of new female recruits into Group 1 industries. Piecework monitoring of output helps to sort workers by ranges of ability. Women in the bottom percentiles of the output distribution may be deemed to be unsuited to this type of incentivised working practice. Those in the middle percentiles would be expected to achieve

consistently reliable target output with low error levels. In the top percentile range, women's performances may signal an ability to progress to undertake intensive training in higher skilled tasks commonly associated with men's work.

5 Female/male pay differentials in Group 1 industries, 1935-1951

From Table 3 and 4, it is clear that the majority of women working in Group 1 and Group 2 essential industries were in the 18-40 age range. Not only did 18 mark the minimum age that women were subject to the Control of Engagement Order, it was also the starting age at which adult rates of pay applied. Before the war it was common for women, in both public and private sector employment, to earn considerably less than men for similar job descriptions (Smith, 1981, p. 654)). During the war in Group 1 industries, such inequalities were considerably reduced. Female hourly wages rose more strongly than those of males. Table 8 shows percentage increases in men's and women's average hourly and weekly earnings in Group 1 industries between October 1938 and January 1944. The relative increases in favour of women reflected the fact that female/male percentage differentials were narrowing due to a need to encourage female employment in the face of acute wartime labour shortages as well as to reflect the fact that pay rises were associated with improvements in women's average skill levels and associated job seniority. EEF data on Group 1 metal industries' average time-rates and piece-rates are available at sectional levels. Here, we concentrate on female/male pay differentials in four core sections - aircraft manufacture, light general engineering, heavy general engineering, and motors. Results in respect of these ratios over the period 1935 to 1951 are shown in Table 9.

Table 8 Percentage increases in average hourly and weekly earnings of men and women in Group 1 industries, October 1938 to January 1944

Industries	Men		Women	
	Hourly	Weekly	Hourly	Weekly
Metal, engineering and shipbuilding	70	89	105	115
Chemical, paint, oil etc.	57	73	98	100
Miscellaneous manufacturing	69	83	93	98

Source: Ministry of Labour Gazette, Aug. 1944, pp. 126-128.

Table 9 Female//male average hourly pay differentials for time-workers and piece-workers, 1935-1951 (per-cent)

	All Women	Women (m)	Women (w)	All Women	All Women
	1935-1939 (range)	1940, 1941, 1942		1948	1950
Average hourly time-rates					
General engineering (light)	50 - 46	61, 60, 74	52, 57, 64	62	64
General engineering (heavy)	55 - 46	64, 69, 85	55, 58, 60	63	64
Aircraft manufacture	51 - 45	53, 62, 81	48, 53, 65	57	57
Motors: cars, bicycles etc.	48 - 46	51, 61, 72	53, 56, 57	52	57
Average hourly piece-rates					
General engineering (light)	55 - 50	59, 64, 74	52, 54, 59	62	61
General engineering (heavy)	45 - 41	57, 65, 75	48, 49, 60	60	59
Aircraft manufacture	47 - 45	57, 51, 65	44, 41, 51	59	58
Motors: cars, bicycles etc.	44 - 43	54, 56, 61	44, 47, 52	56	57

Source: EEF data. Women (m) = women doing men's work and Women (w) = women doing women's work.

Between 1935 and 1939, female/male percentage pay differentials over all four engineering sections were contained in the range 45 to 55 for time-workers and 41 to 55 for piece-workers. For 1940 to 1942 the data allow us to differentiate between women doing men's work and women doing women's work. To a greater or lesser extent, wartime differentials narrowed in all four sections for both piece- and time-workers. The following examples are generally representative of changes over the three years. Female/male wage percentage differentials among timeworkers in aircraft manufacture grew from 53 to 81 for women doing men's work and from 48 to 65 for women doing women's work. For piecework in heavy engineering the differentials rose from 57 to 75 for women doing men's work and from 48 to 60 for women doing women's work.

As also shown in Table 8, in 1948 and 1950 all-women's average pay differentials were considerably above the ranges of the comparable differentials from 1935 to 1939. In fact, in 1950 they were the same levels as the 1942 differentials for women doing women's work.¹¹ The post-war differentials were higher than their pre-war equivalents for two main reasons. First, the dilution-related mix of women's skill levels enhanced average pay compared to their lower pre-war average skill base. Second, the notion that women should return to their pre-war differentials were not easily realized among a war-hardened female workforce with a much improved 'voice' combined with employers who recognised their value-added.

¹¹ Based on Ministry of Labour Gazette wage rate data from 1935 to 1948, Gazeley (2006, Table 3) shows female/male labourers weekly time-rate wage differentials in engineering, vehicles, heavy chemicals and fine chemicals. It is hard to make detailed comparisons with the section-level data in Table 9 except that, importantly, after 1940 the female shares show significant improvements in all four labouring occupations between 1940 and 1948.

Despite the narrowing of the female-male wage ratios in relation to women doing men's work, the average differentials fell well short of the notion that equal pay for equal work was a common objective within Group 1 metal industries. This was a highly contentious issue among the government, unions and employers during the war years (Smith, 1981; Inman, 1957 Chpt. 3; Douie, 1950, pp. 117-119.) Douie reports that: *'For a variety of reasons, comparatively few women succeeded in establishing their claim to be doing a man's job'*. Two arguments against equal pay appeared to be relatively important. First, equality should not apply to women doing men's work if they were receiving special male supervision or assistance. Second, the range of women's skilled job tasks were usually narrower than those of fully apprenticed male labour and so should not be rewarded at a comparable level.

In addition to hourly pay rates, Hart (2007) also reports on female-male average weekly earnings in the foregoing EEF sections. While the war years were marked by strong reductions in standard hourly pay differentials, the weekly earnings trends were not so favourable to women. A major reason was that women worked significantly fewer weekly overtime hours compared to their male counterparts.¹² Overtime pay in EEF member companies was generally remunerated at 1.5 times standard wage rates. Evidence for 1941 weekly overtime hours in Table 10 provides two interesting comparisons. First, for both piecework and timework, men worked considerably longer weekly overtime hours than women. Second, piece-working women doing men's work either undertook no or very little weekly overtime. On

¹² Note from Table 8 that for all three sets of industries between October 1938 and January 1944, women's percentage average hourly wages grew significantly more than men's. To a degree this advantage was mitigated by the fact that over the same time period, the growth rates of overtime weekly wages compared to basic hourly wages were much larger for men.

average pieceworkers achieve higher pay than equivalent timeworkers.¹³ It may well have been the case that women earning favourable piece rates were happy to leave work earlier in the day than time workers, thereby allowing more free time for household leisure and/or work purposes.

Table 10 Average weekly overtime hours in the EEF in 1941
(Standard workweek = 47 hours)

	Women (men's work)		Women (women's work)		Men	
	Piece rates	Time rates	Piece rates	Time rates	Piece rates	Time rates
Aircraft manufacture	0.3	3.0	4.9	4.0	7.3	10.9
Heavy general engineering	[45.7]	0.8	3.7	1.4	8.5	11.9
Light general engineering	[46.6]	1.9	2.1	1.9	8.0	8.6
Motors: cars, bicycles etc.	2.0	3.6	1.5	1.2	5.0	7.8

Source: EEF data.

6 Women's transition from war-time to peace-time Group 1 employment, mid-1943 to mid-1947.

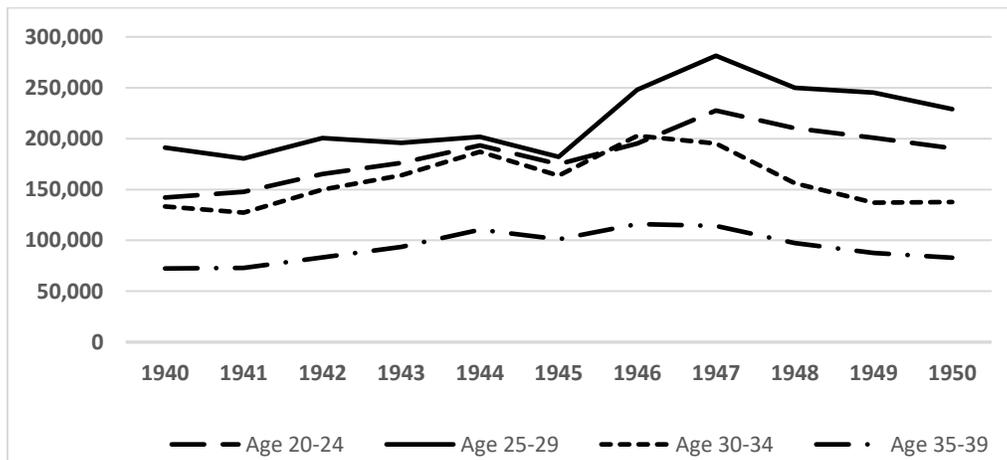
We now consider the war-to-peace transition period. Peak employment for both men and women occurred in 1943. Thereafter, employment declined. A noticeable feature of the women's employment shares in Table 5 is that their mid-1944 share remained virtually the same as that of mid-1943. This

¹³ Time rates are fixed in the short run. Where there is a choice, more able workers will tend to opt for piecework since their incentivised output performances will enable them to achieve higher pay per hour than fixed standard hourly time rates.

arose because between mid-1943 and mid-1944 there were net employment falls for both women (by 97,000) and men (by 125,000). Job losses during the early downturn phase of the employment cycle was not predominantly confined to women. The initial drop in post-1943 labour demand impacted equally on both male and female employees.

However, in a longer time perspective female employment fell considerably more than that of males. Between mid-1943 and mid-1947, women’s employment numbers monotonically fell by 54%. By contrast, men’s employment between mid-1943 and mid-1946 monotonically fell by 19% before an upward turn.

Figure 2 Live births by age of mother, 1940 – 1950 (thousands of births)



Source: Office for National Statistics

There were at least four major reasons behind the 54% reduction in female employment. First, women volunteers simply chose to leave Group 1 industries at the end of their war service. Second, women were made redundant as a result of men returning from full-time military service with guarantees of re-employment. Third, like men, women experienced redundancies in Group 1 industries

as war-related output demand declined. Fourth, extrapolating our estimates in Table 4 that in mid-1943 at least 42% of women aged 18 to 20 and 32% of those aged 21 to 25 were employed in essential war industries suggests strongly that these two cohorts were highly represented in the peak 1946/1947 baby boom as shown in Figure 2.¹⁴

Table 5 shows that, despite women's considerable employment falls between mid-1943 and mid-1947, their Group 1 employment shares in mid- 1946 (25.5%) and mid-1947 (23.2%) were considerably higher than their annual shares from mid-1937 to mid-1940 (see also MLNS 1947, pp. 230/231). This observation provides an early post-war indication that Group 1 employers were in no rush radically to dismantle their female labour forces.

7 Women's post-war employment shares in Group 1 industries, 1948 to 1960.

Two factors served to reverse the tide of women's employment losses at the end of the war and in the early post-war period.

The first and almost certainly the more important related to the performance of the British economy. From the start of the Atlee government (1945-1951) through to the mid-1960s there was a persistently buoyant British labour market. Early post-war output growth in Group 1 industries led to positive longer-term economic expectations by the late-1940s. Post-war unemployment was low, rising briefly to 3% in 1946 before remaining close to 2% for most of the years to the mid-1960s. From the early 1950s, inflation remained below 5% up to 1970. Perhaps the most important performance indicator

¹⁴ Clearly, a significant proportion of births at this time involved mothers with work experience. As an interesting inter-generational effect, based on cross-sectional data Fernández, Fogli and Olivetti (2004) find that the sons of such women tend to marry women who are significantly more likely to work.

was the Debt-to-GDP ratio which over a thirty year period declined monotonically from a peak of 270% in 1945 to 49% in the early 1976.¹⁵ Starting immediately after the war a strong labour market combined with persistent growth provided an abundance of job opportunities.

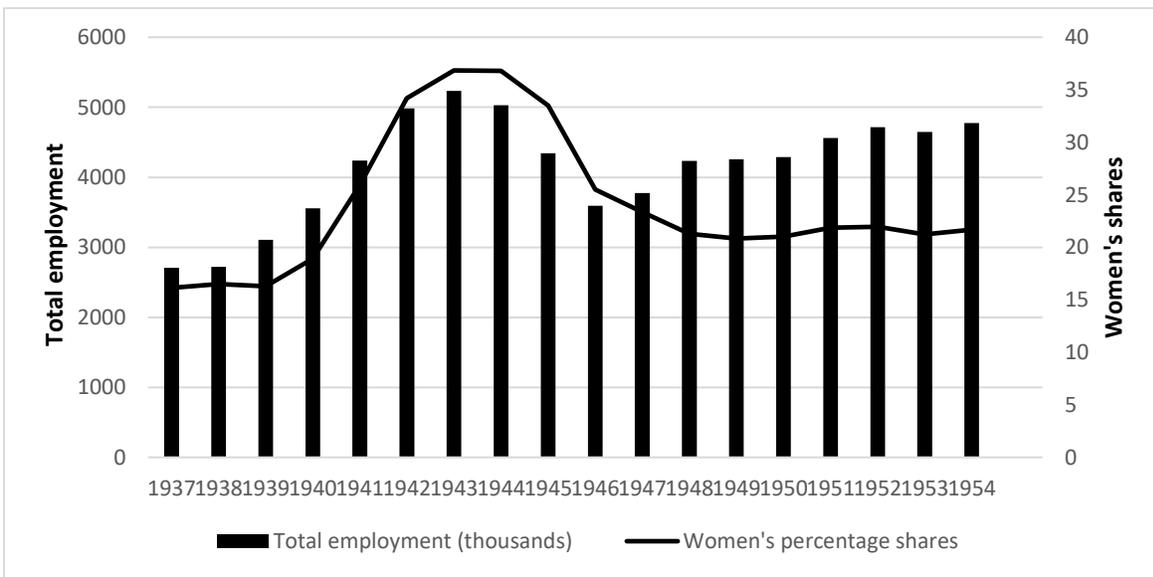
The second influence is slightly more speculative. Labour market tightness was, for different reasons, a feature of both the war-years and the early post-war decades. The post-war boom exerted pressure on companies to find and retain relatively scarce skilled labour. As argued in Section 4, wartime dilution offered cost-effective solutions involving strong use of both semi-skilled and skilled employees that served to lessen production constraints caused by skilled shortages. This provided reasons for retaining women workers and women work-teams that had in-depth experience of war-time dilution processes. In general, it seems likely that significant numbers of enlightened employers would have chosen to retain the advantages of their various wartime dilution solutions into the post-war era. Moreover, women who had acquired valuable skills during of the war and who remained in employment after the war could carry out on-the-job training of the next generation of post-war female recruits.

Figure 3 combines a bar chart showing mid-year total employment combined with a graph line plotting female shares of mid-year total employments. As shown by the graph line, between mid-1948 and mid-1954 the shares virtually flat-lined, averaging 21.4%. However, not only were these shares higher than the period mid-1937 to mid-1940, but they covered considerably larger total employment numbers as also shown by Figure 3's bar chart. From mid-1948 to mid-1954, total employment averaged 4,496,000. From mid-1937 to mid-1940 it averaged 3,024,000. When combining their shares of total employment with employment expansion in the early post-war decades, women's contribution to Group

¹⁵ See Office for Budget Responsibility: <https://obr.uk/box/world-war-ii-debt-reduction> for underlying details.

1 industrial activity was quite impressive. While their employment shares flat-lined, female employment numbers rose from 901,000 in 1948 to 1,035,000 in 1954. As shown in Table 5, female employment shares rose to 23.6% in mid-1960 which, combined with a growth of employment numbers, accounted for a 1,163,000 female workforce.

Figure 3 Women’s share of total Group 1 annual employment, mid-years 1937-1954



Sources: As in Figure 1

To what extent did women’s post-war work activities in metal and chemical sections match their war-time work allocations? The answer is ‘quite significantly’. Table 11 shows Group 1 industrial sections in 1954 employing over 15,000 women. It contains more sectional detail than its equivalent Table 6 for 1943. Both in 1954 and 1943, women featured in chemicals and explosives manufacture. Though, for obvious reasons, the 180,000 women in 1943 working in explosives dwarfed the equivalent 19,000 in 1954. Metal manufacture featured in three sections in both 1954 and 1943, with iron and steel melting common in both eras. We noted Douie’s observation in Section 4 that, unlike the pre-war era, the war created women workers’ in heavy metal industries. Taken together, the three 1954 metal

manufacturing sections accounted for 56,000 women employees. This is a testament to a sea-change in women's accepted integration and status compared to the pre-war years.

Table 11 Group 1 industrial sections with over 15,000 women workers in 1954

Industries and Sections	Thousands
Chemicals and Allied Trades	
Chemicals	46.4
Pharmaceutical preparations, perfumery etc.	32.2
Explosives and Fireworks	19.2
Soap, candles, polishes, ink, matches etc.	19.8
Metal Manufacture	
Iron and Steel Melting, Rolling, etc	19.3
Iron Foundries	17.2
Non-Ferrous Metals Smelting, Rolling, etc.	19.5
Engineering, Shipbuilding and Electrical Goods	
Machine tools and engineers' small tools	18.4
Ordnance and small arms	15.3
Other non-electrical engineering	115.2
Electrical machinery	43.5
Electrical wires and cables	21.0
Telegraph and telephone apparatus	20.0
Wireless apparatus and telephones	52.7
Wireless valves and electrical Lamps	23.5
Other electrical goods	63.0
Vehicles	
Manufacture of motor vehicles and cycles	44.8
Motor repairers and garages	36.1
Manufacture and repair of aircraft	33.7
Manufacture of parts and accessories for motor vehicles and aircraft	41.4
Metal Goods not Elsewhere Specified	
Tools and cutlery	18.6
Hollow-ware	33.1
Brass manufactures	17.4
Metal industries not elsewhere specified	79.8
Precision Instruments, Jewelry, etc.	
Scientific, surgical, photographic instruments	31.6

Source: Ministry of Labour Gazette, 1955

Despite much greater aggregation of data for 1943, it is none-the-less clear that both eras strongly featured women working in general and electrical engineering. Similarly, metal goods not elsewhere specified were of comparable importance. Vehicle and aircraft manufacture and repair employed 411,000 in 1943 while the 1954 data in Table 11 breaks this down into four separate sections summing to 156,000. Finally both in 1954 and 1943 scientific and photographic instrument manufacture featured with quite similar sized female employment levels.

One major industry that featured in Table 6 does not appear in Table 11. In 1943, 25,600 women worked in ship building and ship repair. By 1954 this number had reduced to 8,800, well below our imposed 15,000 minimum. At the 'softer' end of the spectrum, pharmaceutical preparations, perfumery etc. featured in 1954 but not in 1943.

As a final check on post-war women employees in Group 1 industries, we report briefly on their employment allocations in mid-1960. By this time many of the reported compositions of sections had been altered relative to mid-1954 and so exact section-to-section matches with Table 10 are limited. Several comparisons do remain, however. In mid-1960, 45,000 thousand women worked in chemical production. There were 76,000 women working in metal manufacture, including iron and steel production. There were 58,000 working in motor vehicle manufacture, 42,000 in the manufacture and repair of aircraft, 110,000 in metal industries not elsewhere specified, and 45,000 in scientific, surgical, and photographic instruments. As in mid-1954, mid-1960 engineering and electrical goods industries represented the biggest source of female employment, with a total of 559,000 women working across their various sections.

As with the classic example of aircraft manufacture and repair, women had performed exceptionally well in the above areas of Group 1 industries during the war. Fifteen years after the war,

their participation clearly displayed very strongly overlapping labour activities. They comprised an essential core element the Group 1 sections.

The year, 1960 is an appropriate stopping-point in this post-war assessment. By the mid-1960s serious and prolonged industrial relations problems in Group 1 metal working had emerged. Between 1965-1970, Galambos and Evans (1977) report that “*the Vehicles, Aircraft, Metal Manufacture and Engineering groups, already isolated as ‘strike prone’, continue to deteriorate during this period*”. This was especially the case in the major car manufacturing sectors where strike disruptions caused exceptional numbers of working days lost into the 1970s and 1980s.¹⁶ Tracking the progress of women workers in this period would involve conflating the influences of WW2 with that of the sustained and highly damaging employment effects across significant parts of Britain’s heavy manufacturing industries.

8. Conclusion

Smith (1984) reports that at the the end of WW2 government policies combined with trade union attitudes supported a return by women to pre-1939 employment conditions. This translates into facing inferior work status and pay. At least from the government’s perspective, this policy was short lived. Smith also reports that the immediate post-war labour shortage influenced the Ministry of Labour in 1947 to encourage women to seek employment. We have established that this turned out to be prescient labour market advice.

¹⁶ For evidence from 1967 to 1972 see Durcan, et al, 1983, see Table 10,3, p.318.

Encouragement of new post-war female recruits into Group 1 employment would have importantly been aided and abetted by existing women colleagues who had worked with distinction in metal and chemical enterprises during the war and whose careers had thrived under dilution arrangements. Tellingly, at least until the early 1960s, all the major industrial sections of Group 1 enterprises continued to be well populated by women employees.

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