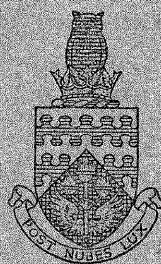


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THE COLLEGE OF AERONAUTICS  
CRANFIELD



PRODUCTION, EMPLOYMENT AND PRODUCTIVITY  
IN THE UNITED KINGDOM 1948-55

by

J. T. HARRIS

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THE COLLEGE OF AERONAUTICS

C R A N F I E L D

Production, Employment and Productivity  
in the United Kingdom, 1948-55

-by-

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SUMMARY

Production movements are analysed statistically according to the contribution of changes in, productivity within industries and activities, employment, and the re-distribution of employment between industries and activities, both singly and in combination. When applied in turn to the Index of Gross Domestic Product and the Index of Manufacturing Production for the period 1948-55, the main contributors to increased output are seen to be improved productivity and higher employment levels. The Index of Gross Domestic Product increased by 27% during the period, the main contributors accounting for 67% and 22% of the value respectively. In the case of Manufacturing industry they accounted for 57% and 32% respectively, of the 42% increase in output. Significantly, all of the increase in employment went into manufacturing industries. The movements for the individual broad groups of industries and activities contributing to the indices were very varied so that a relatively small section of the economy accounted for a large proportion of the overall increase in production and productivity.

1. THE MEASUREMENT OF PRODUCTION MOVEMENTS

The movement over time in the level of output of a heterogeneous group of commodities or services is measured by a volume index. The formula for a Laspeyre volume index as used in the United Kingdom official indices is given by:

$$\sum_r \left( \frac{P_{or} q_{ir}}{\sum_r P_{or} q_{or}} \right) (100)$$

where,  $p_{kr}$  represents the net price of value added to a unit of commodity or service  $r$  in the period  $k$ ,  $q_{kr}$  represents the physical amount of output of that commodity during the period and  $k = i$  represents the period for which it is desired to measure production in relation to that of the base period  $k = 0$ . In such a form the index has a readily understood meaning. It can be defined as the percentage ratio of the net value of the goods produced in period  $i$  at the prices ruling in the base period to that of the net value of the goods produced in the base period.

The index may however be transformed into:

$$\frac{1}{1000} \sum_r [w_{or}] \left\{ \left( \frac{q_{ir}}{q_{or}} \right) (100) \right\}$$

..... A

where:

$$w_{or} = \frac{(1000) (P_{or} q_{or})}{\sum_r P_{or} q_{or}}$$

This is more useful for practical purposes and in this form it can be defined as a base weighted average of quantity relatives. The quantity relatives  $\left\{ \left( \frac{q_{ir}}{q_{or}} \right) (100) \right\}$  are indices of production of each of the homogeneous commodities  $r$ .

The weights  $w_{or}$  are the ratios, expressed per 1,000, of the net values of each of the commodities produced in the base period to that of the total net value of production in that period. Net value is here defined as output value less the input value of goods which are the output of other industries and imports.

## 2. STATISTICAL ANALYSIS OF A LASPEYRE PRODUCTION INDEX

The statistical procedures outlined here will analyse production movements according to:

- (1) Changes in the level of productivity within the several industries.
- (2) Changes in the level of employment.
- (3) Changes in the distribution of employment between industries.

Let:

$n_{ir}$  = the number of persons employed in industry  $r$   
in the period  $i$ .

$$N_i = \frac{\sum_r n_{ir}}{\sum_r n_{or}}$$

$$m_{ir} = \frac{\left( \frac{n_{ir}}{n_{or}} \right)}{N_i}$$

$$l_{ir} = \frac{\left( \frac{q_{ir}}{q_{or}} \right)}{\left( \frac{n_{ir}}{n_{or}} \right)}$$

Productivity

The quantity  $l_{ir}$  is a measure of the movement in the productivity of an industry derived by relating movements in production to movements in employment. As such it makes no adjustment for changes in the relative contribution of the other factors of production or for changes in its own structure. It is an average and not a marginal measure. However, the replacing of labour by machinery does generally represent an increase in efficiency in the use of factors of production particularly at a time of full employment.

An index of production based only on changes in productivity within industries is given by:

$$\frac{1}{1000} \sum_r [w_{or}] \left\{ \left( l_{ir} \right) (100) \right\} \quad \text{... B}$$

Employment

An index based only on changes in the overall level of employment is given by:

$$\begin{aligned} & \frac{1}{1000} \sum_r [w_{or}] \left\{ \left( N_i \right) (100) \right\} \quad \text{... C} \\ & = N_i (100) \end{aligned}$$

It is seen to be the same as the index of employment.

⌘ Changes in the average length of the working week could be taken into account by analysing  $l_{ir}$  into  $\left\{ \left( l_{ir} \right) \left( \frac{t_{or}}{t_{ir}} \right) \right\}$  and  $\left\{ \frac{t_{ir}}{t_{or}} \right\}$  where  $t_{kr}$  is the average length of the working week in industry  $r$  for the period  $k$ . This is not undertaken in the analysis of the official index in this paper owing to the unsuitability of the statistical information available. It is accordingly excluded from the statistical analysis.

Re-distribution of Employment

An index based on changes only in the distribution of employment between industries is given by:

$$\frac{1}{1000} \sum_r [w_{or}] \left\{ \left( \frac{m_{ir}}{n_{or}} \right) (100) \right\}$$

$$= \frac{1}{1000} \left[ \sum_r [w_{or}] \left\{ \left( \frac{n_{ir}}{n_{or}} \right) (100) \right\} \right] \quad \dots D$$

$$N_i$$

It can be transformed into:

$$\frac{1}{1000} \left[ \sum_r \left( \frac{w_{or}}{n_{or}} \right) \left( \frac{n_{ir}}{n_{or}} \right) (100) \right]$$

$$N_i$$

and its value is seen to depend directly on the correlation between relative productivity in the base year and the distribution of employment in the current year.

Combined Movement of Components

The movements in the three indices above do not add up to the movement in the overall index of production. This is because there are additional contributions from the movement of the components together or their interaction.

Combined Productivity and Employment

An index based on these two factors alone is given by:

$$\frac{1}{1000} \sum_r [w_{or}] \left\{ \left( \frac{l_{ir}}{n_{or}} \right) \left( \frac{N_i}{n_{or}} \right) (100) \right\} \quad \dots E$$

$$= \frac{(C)(B)}{100} = \left( \frac{N_i}{N_i} \right) (B)$$

Combined Productivity and Re-distribution

An index based on these two alone is given by:

$$\begin{aligned}
 & \frac{1}{1000} \sum_r [w_{or}] \left\{ \left( l_{ir} \right) \left( m_{ir} \right) (100) \right\} \\
 = & \frac{1}{1000} \left[ \sum_r [w_{or}] \left\{ \left( \frac{q_{ir}}{q_{or}} \right) (100) \right\} \right] \dots F \\
 & \qquad \qquad \qquad N_i \\
 = & \left( \frac{A}{C} \right) (100) = \frac{A}{N_i}
 \end{aligned}$$

This is seen to resolve itself into a crude or unweighted index of productivity for the group of industries as a whole. Its movement will be greater than the sum of the movements of the individual components if movements in productivity and the re-distribution of employment are correlated.

Combined Employment and Re-distribution

An index based on these two alone is given by:

$$\begin{aligned}
 & \frac{1}{1000} \sum_r [w_{or}] \left\{ \left( m_{ir} \right) \left( N_i \right) (100) \right\} \\
 = & \frac{1}{1000} \sum_r [w_{or}] \left\{ \left( \frac{n_{ir}}{n_{or}} \right) (100) \right\} \dots G \\
 = & (N_i)(D)
 \end{aligned}$$

It will be observed that of the paired component effects, F, unlike E and G, does not resolve itself into an employment multiple of the single component effects. Its value derives rather from the interaction of two single components.

Combined Productivity, Employment and Re-distribution

This is given by:

$$\begin{aligned} & \frac{1}{1000} \sum_r [w_{or}] \left\{ (N_i) (m_{ir}) (l_{ir}) \right\} \\ &= (N_i) (F) \\ &= \frac{1}{1000} \sum_r [w_{or}] \left\{ \left( \frac{q_{ir}}{q_{or}} \right) (100) \right\} \end{aligned}$$

It resolves itself into an employment multiple of F and is in fact the index of production A.

The analysis of the movement in the index of production according to the contributions of the three main components separately, the additional contributions from the components in pairs and the further contribution over and above these of the three components together is set out in the following table.

TABLE I.

ANALYSIS OF MOVEMENT IN INDEX OF PRODUCTION

Contribution to the Movement in Index	
1. Productivity	B - 100
2. Employment	$(N_i - 1) (100)$
3. Re-distribution	$(G/N_i) - 100$
4. (1) & (2)	$(N_i - 1)(B - 100)$
5. (1) & (3)	$[(A - G)/N_i] - (B - 100)$
6. (2) & (3)	$(N_i - 1) (G/N_i - 100)$
7. (1), (2) & (3)	$(N_i - 1) [(A - G)/N_i - (B - 100)]$
Total Movement in Index	A - 100



### 3. OFFICIAL AND DERIVED INDICES

Official estimates of the Index of Gross Domestic Product are issued annually in the Official Blue Book. Details are given for broad groups of industries and services and more detailed information is published in the Board of Trade journal for manufacturing industries as part of the Index of Industrial Production. All the figures are gross in so far as they include depreciation allowances.

The weights for the industrial group of activities are derived from the Census of Production for 1948 and those of the remaining industries are based on original studies by the Department of Applied Economics of the University of Cambridge.

The output indices  $\left\{ \left( \frac{q_{ir}}{q_{or}} \right) (100) \right\}$  for the individual activities composing the indices are not all derived from physical output figures. Some are derived from values adjusted for price changes, some from input statistics and some from employment statistics. In view of the very large variety of products and services the values themselves are for the main products only. For these reasons the output indices are termed 'indicators'.

The employment figures are mid-year values constructed from those published in the Monthly Digest of Statistics. Those used here in conjunction with the Index of Gross Domestic Product include employers but those for Manufacturing industries cover employees only. As we are concerned with proportionate movements the effect of the error involved will be minimised and it is in fact insignificant.

Unlike the production values which are for the United Kingdom, those of employment are for Great Britain only. Once again the effect of this disparity is minimised in view of the concern of the paper with only relative movements.

The movement in the indices of Output, Employment and the derived series for Productivity, and the Re-distribution of employment

for the individual series employed in this study are set out in Table III for the years 1948-1955.

4. APPLICATION OF STATISTICAL ANALYSIS TO UNITED KINGDOM VALUE 1948-55

The statistical analysis has been applied to the official Index of Gross Domestic Product and separately to the Index of Manufacturing Production and the results of processing these indices according to Table I are set out in Table II. The main contributors to the movement in production in both cases are productivity and employment and the indices based on these and the production indices themselves are plotted over time in Diagram I.

By 1955 output in the economy as a whole had increased by 27% and in Manufacturing industry alone by 42% compared with 1948. These values represent a geometric rate of increase of 3.5 and 5 per cent respectively though outside the post-Korean recession of 1951-52 rates of 4.4 and 7.6 per cent respectively were consistently maintained.

Diagram II reveals that while Manufacturing industry was the main contributor to the increase in total output this by no means arose from differences in productivity movements. Employment was an important contributor to production movements in Manufacturing industry and significantly all of the 1.1 million increase in employment was absorbed by it. Productivity itself increased by 18 per cent in the economy as a whole and 24 per cent in Manufacturing industry yielding averages of 2.3 and 3.1 per cent respectively, though once again better values were maintained during most of the period. Employment in Manufacturing industry was 13.6 per cent above 1948 in 1955 and for the total of activities the figure was 5.5 per cent.

The contribution of the re-distribution of employment was negligible, though there seems to have been a stronger correlation between increases in productivity and movements in employment in the economy as a whole than in Manufacturing industry as such. As might be expected from the values for the single components the additional

effect of productivity and employment together was more important in the case of Manufacturing industry than in the economy as a whole.

So far as the popularly held belief that we must look to the manufacturing industry to provide us with an increase in living standards is concerned, our analysis does not support it. While production increases have in recent years come from that direction it has only been a little ahead of other activities in its improvements in productivity. What of the claim that we can double our standard of living in 25 years? Provided there is no worsening in the terms of trade, the Government does not spend a greater proportion of our income and the structure of the total and employed population remains constant, an average increase of 2.8 per annum in productivity would be required. Our recent experience shows that it will be necessary to avoid recessions if we are to succeed. So far as the estimating of future production levels are concerned the employment component of this would be better treated as part of a demographic study rather than projected from recent values.

Turning to individual activities we note from Diagram II that there was a great deal of variation within and outside Manufacturing industry. Amongst Manufacturing industries the four groups, Chemicals and allied trades, Engineering, shipbuilding and electrical goods, Vehicles and Paper and printing, while claiming 41 per cent of the weights accounted for nearly two-thirds of the increase in output and together with Gas, electricity and water accounted for 34 per cent of the increase in national output whilst only claiming 16.5 per cent of the weights. Chemicals and allied trades reached the highest increase with 77 per cent while the two activities Leather, leather goods and fur, and Public administration and defence were the only ones to register falls and those of minor amounts.

Productivity was lower in 1955 compared with 1948 only in one industry, that of Food, drink and tobacco. On the whole productivity shows less variation than output or employment and it is, of course, as already discovered, the main cause of the production movements. The

five industries, Chemicals and allied trades, Engineering, shipbuilding and electrical goods, Vehicles, Wood and cork, and Paper and printing representing 47.5 per cent of the weights accounted for 73 per cent of the movement in Manufacturing productivity and together with Gas, electricity and water, Agriculture, forestry and fishing, and Transport and communications representing in all 34 per cent of the total weights accounted for 65 per cent of the increase in the gross domestic productivity.

So far as the distribution of employment is concerned while Manufacturing industry improved its position, Vehicles was outstanding. One half of its increase occurred in the last two years - an indication of the inflationary situation of our economy. Textiles and Clothing were important losers in this respect. Outside Manufacturing industry only Gas, electricity and water made any appreciable gain but Transport and communications and in particular Agriculture, forestry and fishing and Public administration and defence lost their positions appreciably.

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(1956)

TABLE II

ANALYSIS OF U.K. PRODUCTION INDICES 1948-55

IN ACCORDANCE WITH TABLE I

	Index of Manufacturing Production							Index of Gross Domestic Product						
	1949	1950	1951	1952	1953	1954	1955	1949	1950	1951	1952	1953	1954	1955
1. Productivity	5.7	11.8	12.0	8.1	13.9	19.2	24.1	4.1	7.2	8.5	7.9	11.7	15.0	18.0
2. Employment	2.0	4.7	7.6	6.2	7.8	11.1	13.6	.1	.8	2.4	2.2	2.7	3.6	5.5
3. Re-distribution	-7.8	-1.1	.2	.4	.2	.2	.3	.2	.4	.2	.2	.2	.2	.3
4. (1) & (2)	.1	.5	.9	.5	1.1	2.1	3.3	..	.1	.2	.2	.3	.6	1.0
5. (1) & (3)	..	..	.2	..	..	.2	.6	.1	.7	.4	.5	1.3	1.9	1.9
6. (2) & (3)	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7. (1), (2) & (3)	..	..	..	..	..	..	.1	..	..	..	..	..	.1	.1
Total movement in Index	7.0	15.7	21.0	15.3	23.0	32.8	42.0	4.5	9.2	11.7	10.9	16.1	23.3	26.9

TABLE III

MOVEMENTS IN THE INDICES OF OUTPUT, EMPLOYMENT & PRODUCTIVITY  
IN UNITED KINGDOM INDUSTRIES (1948 = 100)

Standard Industrial Classification	INDUSTRY	WEIGHT		1949	1950	1951	1952	1953	1954	1955	Output Employment Productivity Re-distribution
		TOTAL	Relative per Person Employed								
(a)	MANUFACTURING INDUSTRIES										Employment = employees
III	Non-Metalliferous			5	11	16	15	20	24	29	
	mining	38.05	97	0	2	7	7	7	9	10	
	manufactures			5	9	8	8	12	13	17	
				-2	-3	0	0	-1	-2	-3	
IV	Chemical and allied trades	61.98	112	9	24	34	32	51	66	77	
				-1	1	10	10	11	16	18	
				20	22	22	19	36	48	50	
				-3	-3	2	4	3	4	4	
V	Metal Manufacture	78.78	118	2	8	15	17	14	23	33	
				0	2	3	5	3	4	8	
				1	6	12	11	10	22	24	
				-2	-3	-5	-1	-5	-6	-5	
VI	Engineering, Shipbuilding and electrical goods	212.35	95	6	16	27	27	29	40	54	
				-1	0	3	7	7	10	16	
				7	16	23	18	21	27	33	
				-3	-4	-4	1	0	-1	2	

VII	Vehicle			11	21	24	24	38	55	72
		104.61	89	2	5	8	14	17	22	28
				9	15	14	8	18	27	34
				0	0	1	8	8	10	13
VIII	Metal goods			0	5	13	11	3	11	25
	n.e.s.	58.26	92	-3	-2	1	-1	-4	0	12
				3	7	19	11	7	11	22
				-5	-7	-6	-7	-11	-10	-10
IX	Precision instruments, jewellery, etc.	13.53	84	7	10	13	0	8	23	26
				4	7	8	2	3	11	14
				3	3	5	-2	5	11	10
				2	2	0	-4	-4	0	1
X	Textiles			8	18	19	-4	14	17	15
		110.11	95	6	10	11	-3	4	7	3
				2	7	7	-1	9	9	12
				4	5	3	-9	-3	-3	-10
XII	Clothing			9	15	11	5	14	14	18
		55.57	74	11	14	11	3	8	8	5
				-2	1	0	2	6	5	12
				9	9	3	-4	0	-3	-8
XI	Leather, leather goods	10.20	104	1	3	-3	-14	-5	-4	-4
				0	-3	0	-13	-8	-6	-8
				1	6	-3	-1	3	3	4
				-2	-7	-7	-18	-14	-16	-19



XIII	Food			4	7	5	-8	14	16	17
	drink and	129.24	141	0	2	2	15	16	18	21
	tobacco			4	5	-7	-6	-2	-2	-3
				-2	-3	5	9	8	7	6
XIV	Manufacture			13	22	27	15	24	45	47
	of wood	33.51	94	-1	0	7	0	2	5	6
	and cork			14	22	19	15	21	39	39
				-3	-4	-1	-6	-5	-6	-7
XV	Paper and			15	33	40	18	33	55	69
	printing	62.94	108	4	9	12	10	10	15	19
				11	22	25	7	21	35	42
				2	4	4	3	2	3	5
XVI	Other			4	16	21	8	17	32	53
	manufacturing	30.86	101	-4	0	12	10	10	15	18
	industries			8	16	8	6	11	15	30
				-6	-5	4	-4	-2	3	4
III -	Manufacturing			7	16	21	16	23	33	42
XVI	industries	1000	100	2	5	8	6	8	11	14
				5	11	12	9	14	20	25
				0	0	0	0	0	0	0

(b)

## ALL INDUSTRIES AND SERVICES

Employment = employees + employers

III-	Manufacturing			7	16	21	16	23	33	42
XVI	industries	351	97	2	5	7	6	7	11	13
				5	11	13	9	14	20	26
				2	4	5	4	5	7	7
II	Mining and quarrying	36	92	3	4	8	9	9	10	8
				0	-3	-2	0	0	-1	-2
				3	7	10	9	9	11	10
				0	-4	-5	-2	-2	-4	-7
XVII	Building and contracting	62	96	5	5	1	4	11	15	16
				-1	-1	0	-1	-1	-2	2
				6	6	1	5	12	17	13
				-1	-2	-2	-3	-3	-5	-3
XVIII	Gas, electricity and water	20	140	7	16	24	28	34	42	53
				4	10	13	16	16	17	18
				3	5	10	10	16	22	30
				4	9	10	13	13	12	16
I	Agriculture, forestry and fishing	61	117	7	8	11	13	15	15	16
				0	-1	-3	-6	-8	-9	-10
				7	10	15	20	25	27	28
				0	-2	-6	-8	-10	-12	-14

XIX	Transport and communication	95	120	5	9	13	17	20	28	28
				0	0	-2	-2	-3	-5	-4
				5	9	15	19	24	29	34
				0	-1	-4	-4	-6	-8	-9
XX	Distribution	122	111	6	9	7	4	11	18	21
				3	4	5	5	7	9	13
				3	5	2	-1	3	8	7
				3	3	2	3	4	5	7
XXI	Financial,			1	3	4	4	6	5	9
XXIII	Professional and	180	102	-2	0	0	1	1	1	4
XXIV	miscellaneous services			3	3	4	3	5	4	4
				-2	0	-2	-1	-1	-2	-1
XXII	Public admin. and defence	72	70	-3	-6	1	2	1	1	-1
				-6	-11	-6	-5	-6	-7	-10
				3	6	7	7	7	9	9
				-6	-12	-8	-7	-8	-10	-14
I -	All			5	9	12	11	16	22	27
XXIV	industries and services (G.D.P)	1000	100	0	1	2	2	3	4	5
				5	8	9	9	13	18	20
				0	0	0	0	0	0	0

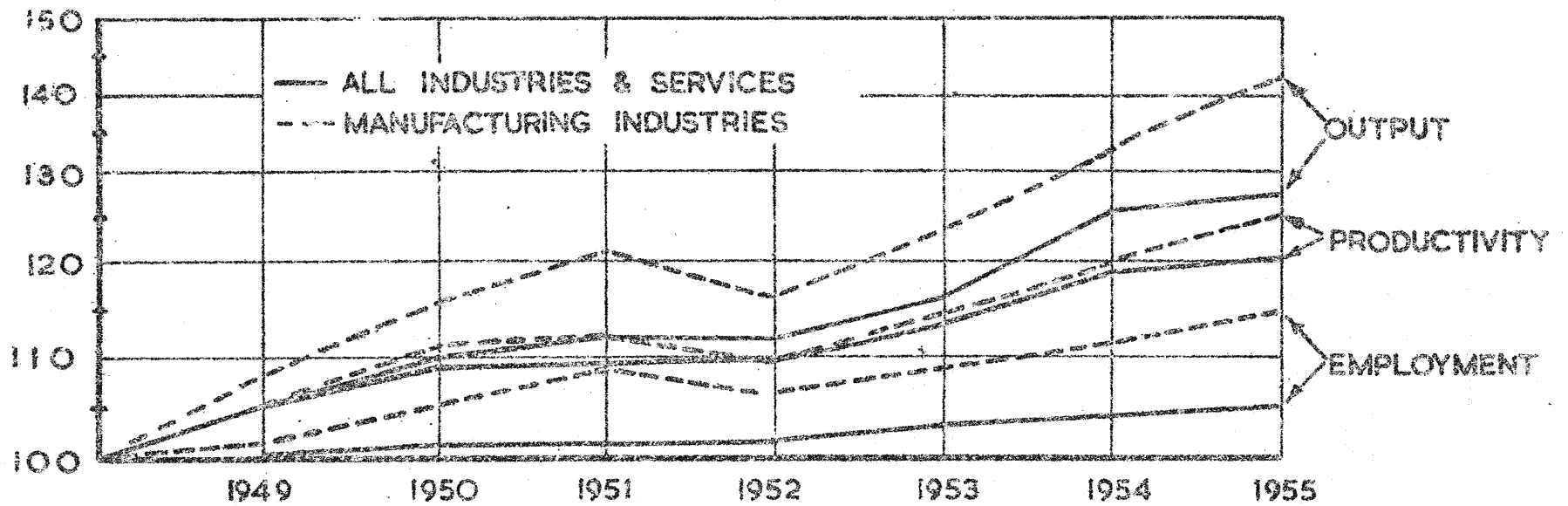


DIAGRAM 1.

OUTPUT, EMPLOYMENT & PRODUCTIVITY  
INDICES (1948 = 100)

MOVEMENT IN PRODUCTION, PRODUCTIVITY AND EMPLOYMENT IN THE INDUSTRIES AND SERVICES  
OF THE UNITED KINGDOM, 1948-55.

THE BASE OF EACH BAR IS PROPORTIONAL TO THE WEIGHT IN THE INDEX OF INDUSTRIAL PRODUCTION AND THE INDEX OF GROSS DOMESTIC PRODUCT (1949=100)

▬ = PRODUCTION

▨ = PRODUCTIVITY

▩ = EMPLOYMENT

